Aviation Investigation Final Report

Location:	Brownsboro, Alabama	**Accident Number:**	ERA12FA565
Date & Time:	September 16, 2012, 15:15 Local	**Registration:**	N2207X
Aircraft:	Yakovlev YAK 52	**Aircraft Damage:**	Substantial
Defining Event:	Aerodynamic stall/spin	**Injuries:**	2 Fatal
Flight Conducted Under:	Part 91: General aviation - Personal		

Analysis

During a fly-in, the private pilot was participating in a three-airplane formation aerobatics demonstration with a student pilot-rated passenger onboard. Several witnesses observed the three airplanes flying from west to east in trailing formation, each slightly lower than the one in front. The first two airplanes in the formation performed a barrel roll. The third airplane, which was being flown by the private pilot, then entered a barrel roll; however the nose of the airplane "dropped" into an extremely low attitude as it came through the inverted arc of the roll. The roll then stopped, but the airplane was almost full nose-down in a vertical descent. The airplane then appeared to immediately begin pitching up, and the airplane's pitch attitude decreased to about 45 degrees nose-low. The pitch attitude continued to decrease, but the airplane began to oscillate rapidly about the roll and pitch axis. A few seconds later, the airplane's heading changed about 180 degrees while the airplane continued descending at a 30- to 45-degree nose-low attitude and continued to oscillate about the roll and pitch axis until it was lost from sight behind. The sound of impact was then heard and smoke rose from behind the trees.

Examination of the accident site, airplane, and engine, did not reveal any evidence of any preimpact failure or malfunction that would have prevented normal operation of the airplane.

During a barrel roll maneuver, it is critical to raise the nose high enough during the first 45 degrees of turn. Not doing so could result in a corresponding nose-low attitude and proportionally high airspeed when recovery is made. Insufficient back pressure could then result in a "dish out" (the airplane falling out of the maneuver) during the inverted portion of the roll.

The pilot of the accident airplane was an experienced aerobatic pilot, but the co-owner of the airplane advised that, like all such pilots, he got rusty after long periods of inactivity. A few weeks before the accident, the pilot had commented to the co-owner that he would like for him to ride in the back cockpit and help him "brush up" on his barrel rolls. The co-owner agreed to ride with him, but they did not set aside a specific time to do that, and it was never accomplished.

During the formation sortie, at first the accident pilot's rolls were crisp and tight, but the pilot fell farther and farther behind and his rolls were getting slower. The airplane's co-owner observed that the final barrel roll "dished out very badly" (the airplane fell out of the maneuver), which resulted in an extremely nose-low attitude followed by an accelerated stall. It is likely that the pilot recognized his position in relationship to the ground and aggressively applied aft stick in an effort to recover from the nose-low attitude, which resulted in the stall.

On the day of the accident, the pilot had flown several formation sorties. The day was hot, and the formation activities were demanding. The accident flight was relatively long, and the co-owner of the airplane guessed it was about 45 minutes long. Most formation sorties were 30 minutes or less. The accident pilot was in his early 70s and was by far the oldest member of the flight. Due to the pilot's age, the demanding schedule, and the length of the formation sorties, fatigue could have been a factor, although it could not be conclusively determined.

Probable Cause and Findings

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

The pilot's loss of control while performing a low-level aerobatic maneuver, which resulted in collision with terrain.

Findings

Personnel issues	Incorrect action performance - Pilot
Aircraft	Pitch control - Incorrect use/operation
Aircraft	Angle of attack - Not attained/maintained
Aircraft	Altitude - Not attained/maintained

Factual Information

History of Flight

Maneuvering-aerobatics	Abrupt maneuver
Maneuvering-aerobatics	Loss of control in flight
Maneuvering-aerobatics	Aerodynamic stall/spin (Defining event)
Uncontrolled descent	Collision with terr/obj (non-CFIT)

On September 16, 2012, about 1515 central daylight time, a, Yakovlev Yak-52, N2207X, registered to Matrushka LLC and operated by an individual, was substantially damaged when it impacted terrain after a loss of control at Moontown Airport (3M5), Brownsboro, Alabama. The pilot and the student pilot rated passenger were fatally injured. Visual meteorological conditions prevailed, and no flight plan was filed for the Title 14 Code of Federal Regulations (CFR), Part 91, personal flight.

The accident occurred on the last day of the "Moontown Airport Annual Grass Strip Fly In" which was organized by Experimental Aircraft Association, Chapter 190, and the Moontown Airport. Several witnesses observed three Yak-52 airplanes flying from west to east in trailing formation, each slightly lower than the one in front. When they were southeast of the airport, the lead airplane performed a barrel roll, followed by the second airplane in the formation which also performed a barrel roll. The third airplane then entered a barrel roll however the nose of the airplane "dropped" into an extremely low attitude as it came through the inverted arc of the roll. The roll then stopped but, the airplane was almost full nose down in a vertical descent. The airplane then appeared to immediately begin pitching up, and the airplane's pitch attitude decreased to about 45 degrees nose low. The pitch attitude continued to decrease but, the airplane began to oscillate rapidly about the roll and pitch axis. A few seconds later the airplane's heading changed approximately 180 degrees (from west to east) while the airplane continued descending at a 30 to 45 degree nose low attitude, and continued to oscillate about the roll and pitch axis until it was lost from sight behind trees that separated an open field from the airport's grass runway. The sound of impact was then heard and smoke was observed to rise from behind the trees.

Pilot Information

Certificate:	Private	**Age:**	74
Airplane Rating(s):	Single-engine land	**Seat Occupied:**	Front
Other Aircraft Rating(s):	None	**Restraint Used:**	5-point
Instrument Rating(s):	Airplane	**Second Pilot Present:**	Yes
Instructor Rating(s):	None	**Toxicology Performed:**	Yes
Medical Certification:	Class 2 With waivers/limitations	**Last FAA Medical Exam:**	February 29, 2012
Occupational Pilot:	No	**Last Flight Review or Equivalent:**	July 15, 2011
Flight Time:	6150 hours (Total, all aircraft), 95 hours (Total, this make and model), 5951 hours (Pilot In Command, all aircraft)		

Student pilot Information

Certificate:	Student	**Age:**	17
Airplane Rating(s):	Single-engine land	**Seat Occupied:**	Rear
Other Aircraft Rating(s):	None	**Restraint Used:**	5-point
Instrument Rating(s):	None	**Second Pilot Present:**	Yes
Instructor Rating(s):	None	**Toxicology Performed:**	Yes
Medical Certification:	Class 3 With waivers/limitations	**Last FAA Medical Exam:**	November 21, 2011
Occupational Pilot:	No	**Last Flight Review or Equivalent:**	
Flight Time:	12 hours (Total, all aircraft), 1 hours (Total, this make and model)		

According to Federal Aviation Administration (FAA) records, the pilot held a private pilot certificate with ratings for airplane single-engine land, and instrument airplane. His most recent FAA second-class medical certificate was issued on February 29, 2012. He had accrued 6,150 total hours of flight experience.

According to FAA and pilot records, the student pilot rated passenger held a student pilot certificate with third-class medical which was issued on November 21, 2011. At the time of the examination he reported that he had accrued 12 total hours of flight experience.

Aircraft and Owner/Operator Information

Aircraft Make:	Yakovlev	**Registration:**	N2207X
Model/Series:	YAK 52	**Aircraft Category:**	Airplane
Year of Manufacture:	1982	**Amateur Built:**	
Airworthiness Certificate:	Experimental (Special)	**Serial Number:**	822014
Landing Gear Type:	Retractable - Tricycle	**Seats:**	2
Date/Type of Last Inspection:	August 31, 2012 Condition	**Certified Max Gross Wt.:**	2844 lbs
Time Since Last Inspection:	2 Hrs	**Engines:**	1 Reciprocating
Airframe Total Time:	1575.7 Hrs as of last inspection	**Engine Manufacturer:**	Vendeneyev
ELT:	C91A installed, activated, did not aid in locating accident	**Engine Model/Series:**	M14P
Registered Owner:	On file	**Rated Power:**	360 Horsepower
Operator:	On file	**Operating Certificate(s) Held:**	None

The accident aircraft was a low wing, two seat monoplane of conventional metal construction. It was equipped with retractable landing gear and wing flaps, and was powered by 9-cylinder, 360 horsepower radial engine equipped with a two-bladed, counter-clockwise rotating, variable pitch, wood and fiberglass, laminated propeller. It was capable of performing all of the aerobatic maneuvers in the Aresti catalog up to a positive load of 7 Gs and a negative load of 5 Gs.

According to FAA and airplane maintenance records, the airplane was manufactured in 1982 and was issued a special airworthiness certificate in the exhibition category on November 19, 1999.

The airplane's most recent conditional inspection was completed on August 31, 2012. At the time of the inspection, the airplane had accrued approximately 1,575.7 total hours of operation. The engine had accrued 1008.1 total hours of operation and had accrued 384.4 hours of operation since its last major overhaul which had occurred on April 11, 2006.

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual (VMC)	**Condition of Light:**	Day
Observation Facility, Elevation:	MDQ,230 ft msl	**Distance from Accident Site:**	8 Nautical Miles
Observation Time:	15:15 Local	**Direction from Accident Site:**	145°
Lowest Cloud Condition:	4900 ft AGL	**Visibility**	10 miles
Lowest Ceiling:	Broken / 6000 ft AGL	**Visibility (RVR):**	
Wind Speed/Gusts:	/	**Turbulence Type Forecast/Actual:**	/ None
Wind Direction:		**Turbulence Severity Forecast/Actual:**	/ N/A
Altimeter Setting:	30.03 inches Hg	**Temperature/Dew Point:**	27°C / 17°C
Precipitation and Obscuration:	No Obscuration; No Precipitation		
Departure Point:	Brownsboro, AL (3M5)	**Type of Flight Plan Filed:**	None
Destination:	Brownsboro, AL (3M5)	**Type of Clearance:**	None
Departure Time:	14:50 Local	**Type of Airspace:**	Class E;Class G

The recorded weather at Madison County Executive Airport (MDQ), Huntsville, Alabama, located approximately 8 nautical miles northwest of the accident site, at 1415, included: winds calm, visibility 10 miles; broken clouds at 4,900 feet, temperature 28 degrees C, dew point 17 degrees C, and an altimeter setting of 30.03 inches of mercury.

Airport Information

Airport:	Moontown 3M5	**Runway Surface Type:**	Grass/turf
Airport Elevation:	655 ft msl	**Runway Surface Condition:**	Dry;Vegetation
Runway Used:	27	**IFR Approach:**	None
Runway Length/Width:	2180 ft / 160 ft	**VFR Approach/Landing:**	None

Moontown Airport was a privately owned, uncontrolled airport, open for public use. It was located approximately 7 nautical miles east of Huntsville, Alabama.

According to the Airport Facility Directory, 3M5 had one runway oriented in a 09/27 configuration. The runway was turf covered, and in good condition. The total length of the runway was 2,180 feet, and its width was 160 feet.

Approximately 86 aircraft were based at the field and annual aircraft operations averaged 43 per day.

Wreckage and Impact Information

Crew Injuries:	2 Fatal	**Aircraft Damage:**	Substantial
Passenger Injuries:		**Aircraft Fire:**	On-ground
Ground Injuries:	N/A	**Aircraft Explosion:**	On-ground
Total Injuries:	2 Fatal	**Latitude, Longitude:**	34.743888,-86.45861

Accident Site and Airplane Wreckage Examination

Examination of the accident site, and wreckage revealed no evidence of any preimpact malfunctions or failures which would have precluded normal operation of the airplane.

The airplane's energy path at the accident site was on an approximate 90-degree heading. The airplane's initial collision point was with the ground occurred at an elevation of 686 feet above mean sea level and was marked by an approximately 3 foot diameter crater about 2 feet deep. One of the two wooden propeller blades was also imbedded into the ground at that location.

The engine, along with its cowling was separated from the airframe and had come to rest about 50 feet along the energy path from the crater. The propeller hub assembly had remained attached to the engine minus the propeller blades.

A section of the left outboard wing was located about 90 feet along the energy path from the crater. The main wreckage came to rest about 150 feet from the crater on an estimated 290-degree heading. Remnants of wing's flight control surfaces, engine parts, nose gear, right main gear, and canopy debris were located along the energy path leading up to the main wreckage which consisted of the fuselage, wings, and empennage with its flight control surfaces.

The engine firewall to the rear cockpit area had sustained thermal damage from the post impact fire which had ensued. Some instrument panel components and the wing's cross spar beam were discernible among the melted metal, and the front seat to rear seat flight control connecting tube was visible. Examination of the tube revealed that it was fractured at the rivet holes at the connection to the rod end clevis fitting. Examination of the mating fracture sides of the control tube revealed however, that the fractures were oriented at an approximately 45 degree angle through the wall thickness which was consistent with overstress separation.

The right wing was intact with impact damage to the leading edge and thermal damage near the wing root area. The left wing was separated from the wing root area and bent back to the fuselage. The left main gear remained attached to the wing. The empennage areas sustained impact damage and the fabric covered flight control surfaces had thermal damage.

Engine Examination

Examination of the engine did not reveal evidence of any preimpact failures or malfunctions which would have precluded normal operation of the engine.

The engine was intact, but due to impact damage, the drivetrain could not be rotated. Continuity of the drive train was able to be established however from the propeller hub to the back of the engine by removal of the cylinders for internal examination.

Examination of spark plugs from each cylinder revealed that they were normal in appearance.

Examination of the intake and exhaust valves revealed that they appeared normal and there were no obstructions discovered in the intake system.

Examination of the carburetor revealed that it had remained attached to the engine. No anomalies were discovered, and all of its linkages were still intact and connected.

The magnetos were still attached and secured.

Medical and Pathological Information

Autopsies were performed on the pilot and the student pilot rated passenger by the Alabama Department of Forensic Sciences. Cause of both deaths was blunt force injuries.

Toxicological testing of the pilot and student pilot rated passenger was conducted at the FAA Bioaeronautical Sciences Research Laboratory, Oklahoma City, Oklahoma.

The pilot's specimens were negative for carbon monoxide, cyanide, basic, acidic, and neutral drugs.

The pilot rated passenger's specimens were negative for carbon monoxide, cyanide, basic, acidic, and neutral drugs with the exception of Ibuprofen, which was detected in Urine, and is a nonnarcotic analgesic and anti-inflammatory agent, available in prescription and nonprescription, forms.

Tests and Research

Barrel Roll

According to the International Aerobatic Club, the barrel roll is a combination between a loop and a roll. When doing the maneuver, the pilot completes one loop while completing one roll at the same time. The flight path of the aircraft during a barrel roll has the shape of a horizontal cork screw. During a barrel roll, the pilot always experiences positive Gs up to a maximum of about 2.5 to 3 Gs, and a minimum of about 0.5 Gs.

Examination of the Barrel Roll Maneuver

Examination of the flight path of an airplane during a barrel roll revealed that the maneuver included a constant variation of airplane attitude and position of the airplane's nose in all three axes. It consists of a rotation along the pitch axis (nose rotates upward, in a direction perpendicular to the wings) through the application of elevator input, followed by aileron input to rotate the airplane along its roll axis. Rudder input would then be applied to help assist the roll through the yaw axis (nose rotates sideways), by swinging the tail over the top. At the midpoint (top) of the roll, the airplane would be flying inverted, with the nose pointing at roughly a right angle to the general flight path. The airplane will have also gained altitude and travelled a short distance from the original flight path. Flying inverted, the airplane would continue through the roll, descending in altitude and returning to the original flight path. Upon completing the roll, the airplane should end up flying along the same flight path, and at roughly the same altitude at which the maneuver began.

Further examination of a barrel roll maneuver also revealed that failure to raise the nose high enough during the first 45 degrees of turn could result in a correspondingly nose low attitude and proportionally high airspeed when recovery was made and insufficient back pressure could result in a "dish out" (the airplane falling out of the maneuver) during the inverted portion of the roll. An insufficient roll rate would also result in an overshoot of the intended recovery heading while an excessive roll rate would result in an undershoot. Too much or too little rudder would also produce the same results as too fast or too slow a rate of roll. Additionally, failing to scan ahead for the reference point and/or section line could result in a loss of orientation.

FAA Low Altitude Waiver and Aviation Event Authorization

According to the FAA, No aerobatic practice area or aerobatic contest box existed at, or in the vicinity of 3M5. A low altitude waiver for aerobatics was not requested by any of the pilots in the formation flight, nor was a certificate of waiver or authorization requested by the fly-in organizers or the airport in accordance with FAA Advisory Circular 91-45C.

Aerobatic Flight

According to the FAA, aerobatic flight means an intentional maneuver involving an abrupt change in an aircraft's attitude, an abnormal attitude, or abnormal acceleration, not necessary for normal flight.

Review of 14 CFR Part 91.303 revealed that "No person may operate an aircraft in aerobatic flight—
(a) Over any congested area of a city, town, or settlement;
(b) Over an open air assembly of persons;
(c) Within the lateral boundaries of the surface areas of Class B, Class C, Class D, or Class E airspace designated for an airport;
(d) Within 4 nautical miles of the center line of any Federal airway;
(e) Below an altitude of 1,500 feet above the surface; or
(f) When flight visibility is less than 3 statute miles."

Examination of the formation flights indicated however, that even though the formation flights occurred at an altitude of 1,500 to 2,000 feet above ground level in Class E airspace, near V54 which is a low altitude airway, the airspace was not associated with the surface area of the airport. Comparison of the formation flight's flight path to the Rocket Very High Frequency Omni-Directional Radio Range, 080

degree radial, also indicted that the formation flights were conducted more than 4 nautical miles from the centerline of the airway.

Moontown Airport Annual Grass Strip Fly In Operations Manual

Review of the section titled: "Flight Ops" in the Moontown Airport Annual Grass Strip Fly In Operations Manual revealed that it contained guidance specifying that:

1. Single aircraft low passes were at pilot discretion.
2. Formation passes were to be accomplished at treetop level or higher.
3. Pilots should not direct aircraft energy at the crowd below traffic pattern altitude.
4. Aircraft that were not capable of operating from the airfield should not perform "touch/go" maneuvers.
5. Missed "Op" or "Low and Dirty" passes were acceptable at pilot's discretion.

No guidance however, was discovered in the "Flight Ops" section or in the rest of the document regarding aerobatic demonstrations during the fly in.

Moontown Airport Managers guidance

Moontown Airport also did not provide any guidance regarding aerobatics during the fly-in with the exception of an old poster that was hung in the fixed base operation at the airport and was written by the pilot involved in the accident when he was the airport manager several years before.

Review of the document revealed that it referenced 14 CFR Part 91.303 though it referred to the regulation as "91.301". It also did not provide any specific guidance regarding aerobatic demonstrations during the fly in, but only contained general information from the airport manager which stated that:

"Moontown Airport is beside the south edge of the 4 nautical mile airway clearance. The chart above depicts the airway outlined in purple. I continue to recommend aerobatic flight over the fields between Moontown Airport and Gurley, south of US 72 between 2200 feet MSL and 3500 feet MSL. Avoid Madison County High School on the north side of US 72 and the Hampton Cove community on the south side of the hills south of US 72. A good reference for the north boundary of this area is to be no further north than the line projected east of 3M5 runway 9-27. Huntsville approach limits approaching traffic to above 3700 feet in the Moontown area."

Experimental Operating Limitations

Review of the Experimental Operating Limitations Exhibition (Group III, Phase 2) that were issued by the FAA for the airplane revealed that a restriction existed in the document which stated that; "No person may be carried in this aircraft during the exhibition of the aircraft's flight capabilities, performance, or unusual characteristics at air shows, motion picture, television, or similar productions, unless essential for the purpose of the flight."

According to the FAA, an airshow is an aviation event defined as an aerial demonstration by one or more aircraft before an invited assembly of persons.

Additional Information

Airplane Co-owner's Statement

According to the co-owner of the airplane, the pilot of the accident airplane was an experienced aerobatic pilot but, he advised that like all such pilots, he got rusty after long periods of inactivity. Many times he had watched him practice and any errors he observed were minor (mainly errors of style) and within the realm of safety.

A few weeks before the accident the pilot had commented to him that he would like for him to ride in the back cockpit and help him "brush up" on his barrel rolls. He said that he had lately developed a tendency to "dish out." According to the Co-owner, a dish-out is not normally a dangerous error if enough altitude is available for recovery and he advised that the pilot always practiced aerobatics with plenty of extra altitude. The Co-owner agreed to ride with him, but they did not set aside a specific time to do that and it was never accomplished.

On the day of the accident, the pilot had flown several formation sorties. The day was hot and the formation activities were demanding. All of the planes in the 4-ship flight were alike except for one, a Nanchang CJ-6, but the Nanchang was very similar to the Yak-52. All the pilots knew each other and were very experienced in formation flight. All were current and qualified Red Star Pilots Association Formation and Safety Team (FAST) members. Several formation flights were launched the day of the accident by this same group and all of the flights were briefed and debriefed. The co-owner had sat in on most of the briefings and debriefings and had also flown four formation sorties in the accident aircraft with the same pilots the prior day.

The accident flight was a relatively long one, and the co-owner guessed it was about 45 minutes long. Most formation sorties the group of local pilots was accustomed to were 30 minutes or less. The accident pilot was in his early 70s and was in excellent physical condition, but he was by far the oldest member of the flight.

The Nanchang departed the flight after about 30 minutes, as they had briefed, and the final three pilots continued maneuvering with the accident pilot as number three. The leader kept the aerobatic portion of the maneuvering over the wooded area south of the private airport and they had stayed above the FAA minimum aerobatic altitude of 1500 above ground level. The co-owner watched as the three went into extended trail formation, which is normally flown, according to the FAST formation manual, at 300 to 500 feet between airplanes. The flight began performing lazy eights and barrel rolls. At first the accident pilot's rolls were crisp and tight but the co-owner noticed that he was falling farther and farther behind and his rolls getting slower.

The co-owner observed that the accident pilot's last roll "dished out very badly" which resulted in an extremely nose low attitude. The co-owner felt that the pilot could have recovered with the altitude under him if he was careful not to pull back too aggressively. That's when he observed the airplane enter

an accelerated stall.

Administrative Information

Investigator In Charge (IIC):	Obregon, Jose
Additional Participating Persons:	Jack E Clark; FAA/FSDO; Birmingham, AL
Original Publish Date:	January 27, 2015
Last Revision Date:	
Investigation Class:	Class
Note:	The NTSB traveled to the scene of this accident.
Investigation Docket:	https://data.ntsb.gov/Docket?ProjectID=85048