THE COLLINGS FOUNDATION
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The Collings Foundation's Party Submission to the National Transportation Safety Board's Investigation of the October 2, 2019 B-17G Accident

Windsor Locks, Connecticut

ERA20MA001

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In accordance with Title 49, CFR Section 831.14, The Collings Foundation ("TCF") submits its proposed findings of fact and proposed probable cause and contributing factors relating to the October 2, 2019 accident involving a B-17G aircraft that it operated at Hartford-Bradley International Airport in Windsor Locks, Connecticut.[1] TCF's submission does not attempt to address all of the issues that arose during the course of its participation in the investigation. The submission focuses on what TCF believes are the most significant factual and causation findings to be drawn from the evidence made available to TCF. TCF reserves the right to provide an addendum when, and to the extent, it becomes aware of additional facts or is presented with additional evidence.

[1] TCF became a party to the NTSB investigation after the NTSB offered it party status on February 26, 2020, and did not participate in investigation activities before that date. TCF has no record of being offered party status on October 3, 2019, the day after the accident, and, in any event, was not in a position to make an informed decision regarding party status at that time due to the immediacy of the tragedy that took place the day before.

I. The Collings Foundation Background

TCF is a 501(c)(3) charitable trust whose primary mission is to organize and support "living history" events and the presentation of historical artifacts and content that enable Americans to learn more about their heritage through direct participation. Over the last 23 years, a key component of TCF's mission has been allowing people to experience flight on rare World War II bombers, including the B-17G "Nine-O-Nine" aircraft, through the Living History Flight Experience ("LHFE") program. For decades, through 2019, TCF's Wings of Freedom ("WoF") Tour regularly made over 100 stops with historical aircraft nationwide each year in an effort to bring this truly unique aspect of American military heritage to life for as many people as possible.

An almost all-volunteer crew piloted the B-17G[2] (and, in fact, TCF's entire fleet of operational WoF warbirds) safely and without injury to crew or passengers for 30 years prior to October 2, 2019.[3]

II. LHFE Background

The FAA has described the purpose and benefits of the LHFE program as follows:

> *The FAA has historically found the preservation of U.S. aviation history to be in the public interest, including preservation of certain former military aircraft transferred to private individuals or organizations for the purpose of restoring and operating these aircraft. In 1996, the FAA received exemption requests from not-for-profit organizations to permit the carriage of persons for compensation in both Limited and Experimental category, former-military, historically-significant aircraft.[4] These requests offered to provide a short in-flight experience to these aircraft in exchange for compensation, leading to the term Nostalgia Flights, then later Living History Flight Experience (LHFE), and provided a means for private civilian owners to offset the considerable restoration, maintenance and operational costs. The FAA determined that, in certain cases, operators could conduct LHFE flights at an acceptable level of safety and in the public interest, in accordance with appropriate conditions and limitations.*
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> *These original requests involved large, crew-served, piston-powered, multi-engine World War II (WWII) vintage aircraft. In order to maintain safe*

[2] As of the date of the accident, 35 volunteer pilots and two employee pilots were qualified to fly the B-17G.

[3] Although the accident B-17G was operated by TCF, it was owned by a separate entity, The CCT of 1979 B-17 Series LLC B-17 Series, and leased to TCF.

[4] TCF was one of the first non-profit organizations to make an exemption request; in fact, the FAA's first LHFE exemption was granted to TCF, Number 6540, in 1996.

> *operations of these aircraft, the FAA required flight crewmembers to meet certain qualifications and training requirements that included FAA-approved training, maintaining training records, and reporting procedures. As the public availability of purchase for former military aircraft increased, along with an increase in public interest for maintaining and operating these aircraft, so grew the requests for LHFE relief.*
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> *In 2004…[t]he policy [was revised to] limit[] LHFE relief to slower, piston-powered, multi-engine airplanes of WWII or earlier vintage, citing the unique opportunity to experience flight in aircraft such as the B–17 Flying Fortress and B–24 Liberator which could still be operated safely, considering limited parts and specialty fuel supplies... The policy detailed that, in permitting the carriage of passengers, flight crewmembers were required to meet more stringent pilot qualifications as well as training requirements that included an FAA-approved training program, maintenance of training records, and reporting procedures.*
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> *In 2007…the FAA refined and expanded its previous list of criteria, requiring numerous aircraft operation components, including crew qualification and training, aircraft maintenance and inspection, passenger safety and training, safety of the nonparticipating public, as well as manufacturing criteria, and a petitioner's non-profit status.*[5]

In order to comply with a 2015 update to the FAA's LHFE policy, TCF authored and implemented a Manual System governing all aspects of its flight operations, including a General Operations Manual, a Pilot Qualifications and Training Manual, a General Maintenance Manual, Safety Management System (SMS) Manual, and an Approved Inspection Program (also known as the Continuous Airworthiness Inspection Program ("CAIP")).[6] The FAA reviewed and approved TCF's Manual System in 2017, and TCF's LHFE exemption renewal application was granted by the FAA on March 22, 2018. This renewal was valid through the date of the accident, with a stated termination date of March 31, 2020. The FAA's North Florida Flight Standards District Office ("Orlando FSDO") supervised TCF's LHFE operations.

III. TCF's Wings of Freedom Tour

Through its Wings of Freedom Tour, TCF has been educating the world for nearly 30 years about our nation's courageous World War II veterans. As of the date of the accident, the WoF Tour featured a B-17G, B-24, and B-25, all of which could host passengers on flight experiences. The WoF Tour also offered flight instruction in a P-51 aircraft. These aircraft

[5] 80 Fed. Reg. 43012-13 (2015).

[6] All LHFE manuals were available to WoF pilots and maintenance personnel (including maintenance personnel such as Mitch Melton) electronically; a link to the manuals was included in the WoF scheduling electronic system and on other electronic platforms that regularly were visited by WoF personnel.

stood as tributes to the crews that flew them in World War II, and as a means of enlightening the public through living history.

From an operational standpoint, the WoF Tour was highly choreographed, and ran on a very detailed schedule. The WoF Tour full-time staff consisted of a Chief Pilot, Crew Chief, Director of Maintenance, Flight Coordinator, and three mechanics. Flight crews typically began their duties each day between 8:00 a.m. and 9:00 a.m., depending on the day's flight activity. As a general rule, the B-17 and B-24 flew in the morning and afternoon, and were open for static tours in between those flights. Monday mornings were the only times when the Tour did not offer LHFE opportunities to the public; these days typically were used only for relocation to the next Tour stop.[7] The Tour at times relocated on Wednesdays and Fridays as well, but typically would offer flights in the morning prior to departing to the next Tour stop.

IV. The Collings Foundation's LHFE Operations

The SMS Manual set forth the standards regarding, and means of achieving, safe flight and maintenance practices governing TCF's LHFE operations. Safety Officer Will Dismukes ensured compliance with these practices through periodic audits of WoF operations, making visits to the tour throughout the year, and auditing operations with a focus on identifying and addressing any potential areas of concern.[8] Mr. Dismukes periodically would discuss his

[7] Because it typically was the case that no passengers were on board during relocation flights, these flights also were used for training, proficiency, and to fulfill pilot currency requirements.

[8] As the son of former Chief Scientist for Human Factors at NASA's Ames Research Center, Dr. Key Dismukes, and as a former U.S. Air Force pilot and a current American Airlines Captain and Check Airman, Mr. Dismukes brings intimate knowledge of modern aviation safety programs, trends and standards to his role with TCF.

findings with the WoF Chief Pilot, and included presentation of the key trends and other observed issues that needed to be brought to all pilots' attention at TCF's annual ground school. One of the most significant safety programs implemented by Mr. Dismukes during his time as Safety Officer was the creation of the SMS submission program, through which a crew member could report - either through an online, fillable form located in the same location in which crewmembers could access the LHFE manuals, or in paper format - any potentially unsafe situation he or she experienced during either LHFE or relocation operations. In the three years since the program started in 2017, 33 submissions were received and addressed by TCF.[9] These submissions were evidence of the strong safety culture at TCF and the wide participation in its SMS program.

TCF's volunteer pilots were highly credentialed and brought to the WoF Tour a wealth of experience and airmanship. For example, on average, the roster of pilots in 2017 had over 13,400 flight hours and over 4 type ratings. Unlike some other warbird organizations, a volunteer pilot could not secure a flying position with TCF by making a donation to the organization. Instead, a volunteer pilot typically came to TCF through a recommendation of a current TCF pilot.

In order to fly as a pilot-in-command of the B-17, a pilot had to have either: 4,000 total flight hours, 100 multi-engine hours and 25 B-17 flight hours; 2,500 total flight hours, 1,000 multi-engine hours and 25 B-17 flight hours; or 1,000 total flight hours, 500 multi-engine hours and 100 hours in the B-17 or cumulatively between the B-17, B-24, and B-25 (due to the similarity of the aircraft). In order to fly as a co-pilot/second-in-command in the B-17G, a pilot had to have 1,500 total flight hours and 250 multi-engine flight hours, or 500 total flight hours and 100 multi-engine flight hours with 25 B-17 flight hours.

All pilots had to complete annual LHFE training and a checkride administered by TCF's Chief Pilot or his designee, which evaluated pre-flight planning, ground operations, takeoffs and departures (including powerplant failures), in-flight maneuvers (including powerplant failure), landings and approaches to landings (including maneuvering to a landing with a simulated powerplant failure, and landing from a no flap or nonstandard flap approach), normal and abnormal procedures (including powerplant and aircraft and personnel emergency equipment), emergency procedures (including emergency evacuation), and post-flight procedures. All pilots also had to complete three (3) takeoffs and landings within the preceding ninety day period to be considered current. All pilots and maintenance personnel also attended annual ground training (in person, to the extent possible), which typically occurred in January of each year. At the annual ground training, pilots were given refresher training on the respective aircraft in which they were qualified, were administered written general knowledge examinations, were trained on SMS and Crew Resource Management ("CRM"), received instruction on LHFE requirements

[9] 27 SMS submissions were related to B-24 operations, 2 were related to the B-25, 2 were related to the B-17, 1 was related to the A1E, and 1 was related to the P-51. The B-17 submissions involved passengers moving during taxi operations on May 11, 2017, and a cowl panel falling off the aircraft on May 11, 2018. The issues raised in these submissions were addressed promptly by TCF.

and the LHFE manuals, and were instructed on safety-related issues and trends observed on the last year's Tour. The FAA annually attended TCF ground school until 2017.

Under the LHFE, TCF was required to notify the Orlando FSDO whenever it had any of several unusual flight occurrences (*e.g.*, "engine shutdown or propeller feathering, and the reason for such shutdown or feathering," and "[e]ach malfunction, failure, or defect in any system or component that requires taking emergency action of any type during the course of any flight"). TCF made all required notifications, including for a May 24, 2019 in-flight shutdown of the B-17G's number 2 engine due to a vibration (which was followed by an uneventful landing).

The FAA also regularly inspected and observed TCF's flight operations for many years - approximately six times per year - and always found those operations safe and all pertinent standards met or exceeded. Three different FAA Principal Operations Inspectors ("POIs") observed TCF check rides on an annual basis until 2017. In 2018, an AFS-610 (*i.e.*, specialty aircraft) inspector observed a TCF check ride. For example, FAA Operations Safety Inspector John Murphy reported the following about his check ride with TCF in February of 2005: a "very good demonstration of [pilot proficiency examiner] skills and knowledge. I am impressed at the standards that the gang operates the aircraft."

Whenever the FAA observed or evaluated WoF Tour flight operations over a 30 year period, all required or evaluated standards were met or exceeded. This includes the accident flight; in a letter to TCF dated January 21, 2020 - nearly four months after the accident flight - the FAA's Windsor Locks, CT FSDO did not identify any violations arising from the accident flight.[10]

V. The Accident B-17G

The accident aircraft, registration number N93012, painted in the historic "Nine-O-Nine" aircraft livery, was built in 1944. While it did not see service in World War II, the aircraft did serve as part of the Air/Sea 1st Rescue Squadron and later in the Military Air Transport Service.

In April 1952, the accident aircraft was instrumented by the government and subjected to the effects of three different nuclear explosions. After a thirteen-year "cool down" period, it was sold as military surplus, and Aircraft Specialties Company began restoration of the aircraft.

For twenty years after its restoration, without any reported incidents, the aircraft served as a fire bomber dropping water and borate on forest fires. In January 1986, after another entity acquired the aircraft, the Collings Foundation restored the aircraft back to its original wartime configuration.

[10] A copy of the FAA's January 21, 2020 "no violation" letter is enclosed as Attachment A.

In August 1987, while performing at an airshow in western Pennsylvania with a different flight crew, "Nine-O-Nine" was caught by a severe crosswind after touchdown. The right wing lifted in the air, finally coming down far down the runway. The aircraft rolled off the end of the runway, crashed through a chain link fence, sheared off a power pole and rolled down a 100-foot ravine. The landing gear sheared off, the chin turret was smashed and pushed into the nose; the Plexiglas nose was shattered; bomb bay doors, fuselage, ball turret, wing and nacelles all took a tremendous beating. Engines and propellers also were damaged. Fortunately, there were no fatalities to those on the aircraft, although there were injuries.

After the 1987 accident in Pennsylvania, the accident aircraft was fully repaired and restored. Since that accident, it flew for nearly 10,000 hours, and had visited over 3,000 WoF Tour stops. The FAA granted the B-17 a Special Limited Category Airworthiness Certificate in June 1994.

While flying in the WoF Tour, Nine-O-Nine principally was maintained by Ernest McCauley, TCF's Director of Maintenance and an A&P mechanic, with the assistance of three full-time A&P mechanics.[11] Maintenance activity on Tour would be logged in daily flight forms ("dailies"), and transcribed into the appropriate logbook at the end of the Tour. During the Tour, the dailies were kept in the aircraft. If any repairs on tour were made by an outside maintenance agency, a record of the repair containing the name of the individual making the repair and the corrective action taken was obtained and included in daily maintenance records.

[11] Mitch Melton was one of the A&P mechanics who provided maintenance support for the B-17G. In his role as Director of Maintenance, Mr. McCauley provided Mr. Melton with daily on-the-job training. Records of Mr. Melton's training activity would have been kept on the accident aircraft. TCF does not know if those training records survived the accident and post-impact fire.

The FAA-approved B-17G CAIP consisted of: a preflight inspection before the first flight of each day; number 1 through 4 inspections which generally included the respective engine (*i.e.*, the number 1 inspection would include inspection of the number 1 engine and other designated areas of the aircraft) and other aircraft systems and components as set forth in the CAIP. Each numbered inspection was to take place 25 hours after the preceding inspection, so that each engine was inspected every 100 hours.[12] For example, the number 2 inspection would take place 25 hours after the number 1 inspection, the number 3 inspection would take place 25 hours after the number 2 inspection, and so on. The most recent 25 hour increment inspections took place on: July 28, 2019 (Number 1); August 17, 2019 (Number 2); September 7, 2019 (Number 3); and September 23, 2019 (Number 4).

In the "off-season," the aircraft was based in New Smyrna Beach, Florida, at which time it received an annual inspection. In the off-season between the 2018 and 2019 WoF Tours, engines 1 and 2 received an overhaul. Engine number 3 was overhauled following the 2017 Tour, and engine number 4 was overhauled on May 13, 2015.[13]

All passenger seats in the B-17G were approved by the FAA. The FAA's 2002 Limiting Category Operating Limitations (LTC-AL-1-3) provides that "In addition to the pilot and co-pilot seats, an approved seat shall be those seats which meet the structural requirements of CAR 4b and are installed using data provided in Aerodesign Report Number 1194-1 and subsequent revisions. There are 10 such seats in this aircraft." All passenger seats were installed in accordance with the Aerodesign Report, and were regularly inspected and the seatbelts and cushions replaced when needed. Also in addition to the pilot and co-pilot seats, there was an

[12] Each engine and ignition system inspection required the following non-exhaustive list of items:

- inspect magnetos for condition and security;
- check point clearance (.008 to .010 in.);
- check magneto timing;
- inspect ground lead to switch for security and broken shielding on both magnetos;
- inspect carburetor for condition, security, and fuel leakage;
- inspect ignition harness for damage and loose condition;
- remove, clean, recap, and test spark plugs. Reinstall using new gaskets and lubricate threads with thread lubes. Torque plugs to 300 to 360 in. lbs.;
- clean and inspect spark plug lead terminals. Replace any that are cracked, broken, or show carbon tracks;
- check plug leads for security at harness and at plugs;
- perform operational check on all engine controls; and
- perform engine run-up.

[13] Although an annual inspection is not required under the CAIP, certain aircraft components such as the emergency locator beacon, ATC transponders, and Air Data System require an inspection every 12 months, and these also were grouped together for inspection purposes after the aircraft's tour season ended.

original-equipment, manufacturer-designed radio operator seat, which also was available for use. The mechanics who flew as crew members and assisted with passenger operations also had an FAA-approved seat located to the left of the ball turret.

Before the accident flight, the last previous flight of the accident aircraft was on September 30, 2019. No discrepancies related to the aircraft's engines were reported from that flight, and TCF understands that no instances of failure to produce commanded power had been reported for the number 3 or number 4 engines during the 2019 WoF Tour.[14]

VI. The Accident Pilots

The pilots of the accident flight were Ernest "Mac" McCauley, 75, pilot-in-command, and Michael Foster, 71, co-pilot. With over 7,000 hours logged flying the B-17 (6,700 of which were as the pilot-in-command), it is widely accepted that Mr. McCauley had the most B-17 pilot flight time and experience of any pilot since the introduction of the aircraft. Mr. McCauley had over 13,000 hours total flight time, 11,500 as pilot-in-command, and held commercial single- and multi-engine land and instrument ratings. He started flying with TCF in 1999, and had been the primary B-17G pilot-in-command for 15 years. He also had flown two other B-17s, including for the Lyon Air Museum. During the NTSB interviews of Mr. McCauley's most recent co-pilots, he was described as "masterful in the airplane" and "one with the airplane," a "stickler for details," always using the checklist, and "warm and just full of knowledge."

Mr. Foster also had a wealth of experience in many different aircraft types, including as a Naval aviator flying the F-18 and A-7, and as an airline pilot for Northwest and Delta Airlines, flying the B-737, B-757, B-767, DC-10, and LR-Jet. He had over 25,000 total flight hours, with 22,500 hours of multi-engine time. Mr. Foster started flying with TCF in approximately 2016 following the recommendation of another TCF pilot, and had at least 23 hours in the B-17. He held an airline transport rating and was an instrument instructor pilot. TCF pilots who had flown with Mr. Foster said that he was "one of the more professional, most professional aviators I've ever flown with. He obviously was a professional aviator, very high time experienced aviator, very enthusiastic about the mission and airplanes in general," and would not have had any issues speaking up when he was uncomfortable with something in the cockpit because "he was a captain on airliners and a military aviator. I think he would speak up if he saw anything at all."

Both pilots completed B-17 checkrides in 2019. Mr. McCauley completed 2 checkrides - one an FAA Pilot-in-Command Proficiency checkride administered by Mark Henley in Fort Myers, FL on January 28, 2019, and the other an LHFE checkride administered by Chief Pilot Rob Pinksten in Gulfport, MS on February 26, 2019. Mr. McCauley successfully completed both evaluations with no issues noted. Mr. Foster completed his LHFE checkride on the B-17 in

[14] TCF bases this statement on the combined recollection of those who were on the 2019 WoF Tour, including TCF's Chief Pilot and Executive Director, and the daily "flight reports" that have been recovered from the accident aircraft, where any such reports and maintenance would be annotated.

Pensacola, FL on February 24, 2019, with Mr. McCauley serving as his evaluator pilot. No issues were noted on this evaluation.

VII. The Accident Flight

Prior to boarding the accident aircraft on October 2, 2019, each passenger was informed in writing that the FAA had issued a limited airworthiness certificate for the B-17G. The document specifically notified the passengers that "The FAA has not established nor has it approved the standards that a limited category airworthiness certificated aircraft are built under. In contrast, a standard category airworthy certificated aircraft are built to FAA approved standards, including standards about life limit parts."

That same written notice also explained to the passengers the differences between a standard category airworthiness certificate and a limited category airworthiness certificate, including the statements that standard category airworthiness certificated aircraft are built in accordance with type certification standards established by the FAA, are maintained in accordance with standards established by the FAA, and are inspected in accordance with applicable Federal Aviation Regulations, whereas aircraft with limited category airworthiness certificates conform to a previously issued limited category type certificate, are in a good state of preservation and repair, and are in a safe operating condition. The document further advised the passengers that the FAA had exempted the flight from various Federal Aviation Regulations, including 91.135 (operations in Class A airspace), 91.319(a) (experimental certificate operating limitations), 119.5 (g) (certifications, authorizations and prohibitions), and 119.21 (a) (commercial operators).

The passengers acknowledged they saw and reviewed this information by signing the document. Their signatures also attested that they assumed the risk of flight on the B-17G.

Crew member Mitch Melton walked the passengers to the B-17G, assisted them with boarding, assigned them and showed them to their seats, and delivered a passenger briefing that included the location of emergency exits, instruction not to "grab hold" of flight control cables, that he had sick bags should any passenger need one, that they should not take selfies with the pilots or otherwise disturb the pilots by "poking them on the shoulder" or "asking them what they're doing," and that they must be "seated and seat-belted for taxi, takeoff and landing."[15] Before the aircraft departed, Mr. Melton observed that all passengers were properly seated with seat belts fastened, and made himself available to address any questions regarding seatbelt operation. According to Mr. Melton, at no time did any passenger raise any questions relating to the content of his briefing or the operation of the seatbelts, and no passenger expressed concerns or asked to deplane.

When the crew attempted to start engines, engine number 3 (normally the first engine started) would not start. The crew determined that moisture in the magnetos was preventing the engine from starting, and decided to use pressurized nitrogen to "blow out" the magnetos; in

[15] Transcr. of Mitchell Melton NTSB Interview, Nov. 6, 2019, at 16:9-25.

other words, a stream of compressed nitrogen would remove the moisture that was impeding engine ignition.[16] This was successfully done on engine 3 and the engine started without issue. Then, number 4 would not start for the same reason. The crew shut down engine number 3 so Mr. Melton could safely approach engine number 4, at which time he used the same procedure of applying pressurized nitrogen to remove moisture from the engine number 4 magnetos. At this point, all engines were started without incident, Mr. Melton returned to the aircraft, and the normal sequence of events from engine start through takeoff occurred without incident.

After engine start and warm-up, the B-17G taxied normally to runway 06 for an intersection takeoff. The engines operated normally during taxi operations. As referenced in the B-17 Pilot's Checklist under the heading "RUN UP," before takeoff the accident pilots verified the correct operation of all four engines' ignition systems by momentarily operating each engine solely on one of its two magnetos, returning to operation on both magnetos, then solely on the other magneto, while assessing any drop in engine RPMs during the process. Per the B-17 Pilot's Manual, "The rpm drop should not exceed 100 when switching from two magnetos to one." The B-17G passed this engine ignition system test without excessive RPM drop immediately prior to takeoff for the accident flight. Mitch Melton, who was on the flight deck at the time, stated that the results were "perfect. I mean, we had no drop, we had no backfire. We had nothing. I mean, there was no reason not to fly..."[17]

After the successful run-up and engine ignition test, the accident B-17G took off from runway 06 at the intersection of runway 33. Air traffic control ("ATC") assigned it a right turn to a 095 degree heading after departure, and informed the pilots that the winds were light and variable. After the aircraft was airborne, Mr. Melton left the flight deck to advise the passengers that they could get out of their seats to move around the cabin as he had instructed during his passenger briefing.[18] At some point shortly after takeoff, and before Mr. Melton returned to the flight deck, an unknown problem appears to have occurred on the number 4 engine, prompting the pilots to request to return to the field. The ATC audio in TCF's possession is partially garbled and unintelligible, but TCF understands one of the pilots to have informed departure control that they wanted to return due to a problem with the number 4 engine, and that they needed to "blow it out." Mr. Melton stated during his NTSB interview that he observed the number 4 engine "losing power," but did not hear the engine backfiring and did not recall any

[16] As also set forth in section VIII, this was an accepted maintenance practice in the warbird community that had developed over the years, but was not found in contemporary maintenance manuals. In fact, there is no procedure in the manual for addressing a wet magneto impeding engine start. This issue is brought about by the design of the magnetos, as they need to be able to vent to prevent corrosion, but that exposure to ambient air also enables moisture to develop in the magneto.

[17] Melton Transcr., at 22:19-22.

[18] Melton Transcr., at 25:5-11.

issue with the number 4 engine "running rough," symptoms which could be associated with a magneto failure in flight.[19]

The B-17G typically rotated for takeoff at 110 MPH. According to the NTSB's ADS-B Study, the peak airspeed reached by the accident aircraft was 124 MPH, which was recorded just after takeoff. It was normal to climb at approximately 120 MPH, and it appears from the ADS-B data that the accident aircraft did climb at or near that speed for approximately one minute, until 09:48:50, at which point the aircraft began to decelerate, never again reaching the speed of 120 MPH. If one engine was lost during this phase of flight, it would be expected that the aircraft could continue to climb and eventually accelerate to the targeted single engine-out airspeed of 135 MPH. However, the accident aircraft did not climb or accelerate, suggesting the existence of some other or additional cause for the apparent inability to achieve climb airspeed. Possible causes could include loss of power in another engine, fuel starvation, fuel contamination, or a magneto switch or ignition master switch malfunction. TCF did not have access to sufficient information to permit it to evaluate potential causes for the inability to achieve climb airspeed.

As noted above, a potential cause of a failure of two engines on the same side of the accident aircraft that should be further investigated is failure of the magneto switches for the engine number 3 and/or 4 magnetos, or failure of the right side ignition master switch.[20] TCF understands that one of the historical reasons the ignition master switch was part of the aircraft design was because it was conceivable that an entire side's electrical or fuel system would need to quickly be shut down as a result of combat damage, in an effort to prevent catastrophic aircraft damage, or if the aircraft had to ditch. The ignition master switch is not checked as part of regularly scheduled maintenance or CAIP-compliant maintenance practices, and is encased in a sealed container, which prevents a check of the internal functionality and integrity. Further, TCF understands that incidents involving an electrical short inside the sealed ignition master switch (*i.e.*, activating without pilot command) and causing a loss of power to an entire side or system have occurred. TCF does not know whether the ignition master switch for the number 3 and 4 engines survived the accident.

Assuming for the purpose of this discussion a loss of power for unexplained reasons in the number 3 and number 4 engines at an airspeed of approximately 120 MPH and at approximately 560 feet above ground level ("AGL"), pilots McCauley and Foster were faced with a scenario for which they could not have fully trained and from which recovery was highly questionable.[21] For example, it appears that if the number 4 engine was failed and feathered, and

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[19] Melton Transcr., at 25:12-26:3.

[20] Failure modes for the ignition master switch that controls the ignition systems for engine numbers 3 and 4, including for total and intermittent failure of the switch, should be investigated. In addition, failure modes and possible intermittent failure of the ignition systems on the aircraft's right side also should be investigated as a possible cause for the loss of engine power in this accident.

[21] There is no B-17G simulator in which to conduct multiple engine-out training, and for obvious reasons, multiple engine-out training could not be done safely in flight..

if the number 3 engine also lost some degree of engine power, the airplane likely was being flown right on the minimum limit of its controllable airspeed, with the pilots commanding as much power as possible from the number 1 and 2 engines within the rudder and aileron authority of the aircraft. Stories of B-17s making it back to base after losing one or two engines in World War II certainly have been told, under circumstances where those aircraft lost engines at higher altitudes and at higher speeds, likely over 150 MPH in most cases. In the accident situation, at 560 feet AGL and at a relatively low airspeed, maintaining directional control and any sort of performance would have been nearly impossible for the pilots at the aircraft's low airspeed. There would not have been sufficient aileron and rudder authority to maintain directional control of the aircraft while operating engines 1 and 2 at maximum available power.[22]

While the manufacturer of the B-17G did not create a low-energy state, multiple engine-out checklist or guidance for pilots in such an emergency scenario,[23] TCF over the years developed the following guidance, which was taught at its annual ground school for flight crew members and during checkout of pilots in the B-17G:

- If enough runway remains abort takeoff.
- Keep the Ball Centered.
- Critical airspeed is 115 -125 mph. Below this speed the aircraft will not sustain flight - 145 ideal.
- The airplane will not accelerate on two engines below critical airspeed, regardless of power, it is only possible through lowering the nose.
- Use full power.
- Positive rate gear up.

[22] The B-17 was not designed to be a transport category airplane, and accordingly does not have well documented Vmc numbers or data for engine out performance at low speeds. However, experience and testing over the years has given operators expectations regarding the airplane's actual engine out performance. The general consensus in the B-17 community is that for one outboard engine out, 135 MPH is a satisfactory speed for some climb performance, and a speed of 145-155 MPH is needed for two failed engines on one wing. The peak documented airspeed in the NTSB's ADS-B study, 124 MPH (which appears to have been reached before engine failure and at low altitude), was insufficient for the pilots to utilize anywhere near full power on engine numbers 1 and 2 with two engines out on the right side, and possibly even with just one failed outboard engine. TCF understands that no actual flight testing was conducted during the investigation to address these controllability issues and limitations on the power that could be commanded from the number 1 and 2 engines under the circumstances of this accident.

[23] As one of the first military aircraft to provide a checklist for crews, the B-17's checklist did not provide a checklist for all, or even nearly all, conceivable emergency procedures, as one would expect from a modern complex, multi-engine aircraft checklist.

- Be sure to feather failed engines only after you are sure that they are not creating any power.
- Do not use aileron or climb until critical speed is reached.

Under the scenario faced by the accident crew, it would not have been possible to reach "critical airspeed" without trading altitude for airspeed. However, they did not have sufficient altitude to trade for airspeed. This could explain the increasingly slow airspeeds and very gradual descent noted in the NTSB's ADS-B report - the crew was doing all they possibly could under extraordinarily challenging circumstances to maximize their very unfavorable energy state.

Further complicating an already difficult situation, runway 33 was closed and unavailable to the accident crew, as reported in the active NOTAMs[24] and noted by BDL tower while speaking to another aircraft while the accident aircraft was approximately on downwind for runway 06 and communicating on tower frequency. Even after the accident crew alerted ATC of a problem and need for immediate return, the controller only offered runway 06. Thus, the crew had to enter a right downwind for runway 06 instead of a right base for runway 33, which extended the ground track the accident aircraft would have to fly before reaching a usable runway.

After the severely damaged aircraft came to rest off the right side of runway 06, most normal egress routes from the aircraft were unavailable to the occupants in the forward section of the aircraft. Despite the presence of fire and substantial impact damage, Mr. Melton did exceedingly well to keep his composure and kick out a flight deck window, and thereby permitted egress by himself and two of the passengers.

TCF disagrees with any characterization of the landing under these extraordinary emergency circumstances as "precautionary." If two engines are not producing commanded thrust, as is suspected here, it is an "emergency" landing. The fact that the accident pilots did not declare an emergency can be explained by the time-sensitive nature of the emergency and the need for the pilots to focus all their efforts on aircraft control at low altitude in a critical engine and energy state, while maneuvering to the available runway for landing. Under these circumstances, with approach and landing to Runway 06 already approved by ATC, any further communication with ATC was unnecessary and not a priority use of the pilots' attention and actions. The pilots' priorities complied with the age-old adage "aviate-navigate-communicate."

VIII. The Accident Engines

As set forth above in Section VII, there was no reason from an engine or powerplant standpoint not to takeoff on October 2, 2019.

[24] A copy of the NOTAM showing runway 33 closed during the accident flight is enclosed as Attachment B.

While it was not an everyday occurrence to use pressurized nitrogen to clear moisture from the magnetos in order to start one or more of the engines, such a procedure was an accepted and necessary practice among operators of this vintage equipment that operate in humid or wet environments. An initial question is: why was moisture present in the ignition system in the first place? On the B-17, and, in fact, in all radial engines, the magnetos need to vent corrosive gas and elements that are created during normal operation of the system to protect internal components; otherwise, corrosion can occur quickly and render the magneto inoperative or cause malfunctions. During normal operation, the temperature inside the magneto rises from the rotation of components, as well as thermal conduction from the engines and engine environment. When the engine is shut down, the magnetos cool. That cooling causes a condensation reaction that draws moisture into the magneto through the vent. During exceedingly humid downtimes, or when it rains heavily, that atmospheric moisture also can enter the magnetos through the vents. If a sufficient level of moisture accumulates inside the magneto, a normal engine start may not be possible. In that scenario, using compressed nitrogen to "blow out" the magneto is an approved solution in the warbird community. After the moisture in a magneto is eliminated, and an engine is started, TCF is aware of no instances where an engine experienced subsequent problems in flight related to a previously moist or wet magneto.

While this procedure is not found in a maintenance manual, it is an accepted practice in the warbird community. There are other maintenance procedures in the warbird community that are done pursuant to common knowledge because they are not found in maintenance manuals, as manuals for the B-17 and aircraft of its generation were not written to cover every possible step a maintainer might have to take, as one would expect to see in more modern aircraft maintenance manuals. Furthermore, the manufacturer of the B-17G has not updated the B-17 Pilot's Manual or otherwise supported the aircraft for over 50 years.

Additionally, as discussed in section VII above, the engine run-up check - where the overwhelming majority of ignition problems are expected to be discovered - was "perfect." The aircraft had been flying on the 2019 WoF Tour since January 18, 2019, and TCF is aware of no problems reported during this time related to the ability of the number 3 and 4 engines to generate commanded power.

The question is unresolved as to what caused the loss of power after takeoff in the number 4 engine, and apparently, at least to some degree also in the number 3 engine. We understand that the number 1 and 2 engines and their accessories were not disassembled or investigated to compare to observed, post-crash conditions in the number 3 and 4 engines. TCF is not aware of any investigation of engines in service on other B-17G aircraft, and is not aware that any testing was done on other magnetos with gaps as reported after this accident. Under these circumstances, additional investigation and testing is warranted before reaching a conclusion about the cause or causes of loss of engine power.

The NTSB powerplant investigation appears to report that clips - which secured the "P-leads" to the magnetos to prevent the retaining nuts from rotating off - were not secured or were otherwise displaced, and reported the presence of safety wire around the Y-fittings of those P-leads. The report photographs show that the retaining nuts on both number 4 engine magnetos

were in place. The clip condition observations are consistent with an impact-related material failure at the magneto Y-fitting. The report appears to imply that the safety wire was the *sole* mechanism used to secure the P-leads to the magnetos, which is inconsistent with the clips observable in the photographs. In addition, the investigation did not address a potential key factor in the use of the safety wire: the fact that the hex nut attaching the Y-fitting to the magneto housing *normally* is reinforced with safety wire to provide *additional* security to the clip to keep the P-lead in place. Furthermore, even though the Y-fitting appears to be broken in the investigation photos,[25] it has not been determined whether that break occurred during the accident sequence as a result of a hard impact with the ground and obstructions and subsequent fire, since it is undisputed that this engine was torn off the nacelle and wing after ground impact. Comparison to magnetos from other engines, including engines number 1 and 2, would be useful in evaluating the extent to which the accident sequence potentially caused the condition of the number 4 engine magneto Y-fittings. Also potentially beneficial would be testing of the magneto Y-fitting to determine whether, if the fitting came loose or broke off in the air before ground impact, it would cause an electrical short inside the magneto.

The existence of a broken or separated Y-fitting does not necessarily mean the magneto will short out and produce a corresponding drop in engine performance. The amount of separation between the Y-fitting and housing could be expected to impact the degree to which loss of engine power would be expected. Further testing is suggested to determine whether the amount of spacing shown in the NTSB's powerplant report (Photos 2 and 3) would produce any negative engine performance and, if so, to what degree. In addition, the function of the P-lead is to provide grounding for the magneto. If a P-lead becomes disconnected, the respective magneto would not have grounding protection.[26] It does not necessarily mean the magneto will fail in flight, but it would be expected to prevent a successful magneto check prior to takeoff. TCF also is not aware of the performance of any continuity or resistance check on any P-lead harness during the course of the investigation.

Also with respect to the magnetos, the NTSB observed that the engine number 4 magneto point gaps were 0.004 inches below the allowable range for the right magneto, and 0.004 inches above the allowable range on the left. However, the right magneto gap was measured as 0.002 inches below the allowable gap range in photo 7 of the powerplant report, with no explanation provided for the different measurements which, to the best of TCF's knowledge, were taken at different times, at different locations, and by different vendors. The magnetos on the number 4 engine were overhauled on December 28, 2018 and had just under 300 hours of service time before the accident. There has been no explanation of which TCF is aware, other than the extreme conditions to which the number 4 engine was exposed in the accident impact sequence, for magnetos with only just under 300 hours of service time to be in the condition observed in

[25] NTSB Powerplant Group Chairman's Factual Report, Photo Nos. 2 and 3.

[26] The fact that Mr. Melton stated that he observed a drop of 30-40 RPMs during the magneto check in the pre-takeoff run-up is indicative that the P-lead was operational. Otherwise, there would have been no RPM drop, since the P-lead would not have been capable of grounding out its associated magneto.

the powerplant report. Additional investigation is warranted to determine whether the impact forces and conditions (including the number 4 engine being torn from the nacelle and wing) and subsequent exposure to fire were contributing causes for the magneto conditions and point gap spacing indicated in the powerplant report, and to determine the condition (including point gap measurements) of the number 3 engine magnetos, which TCF understands passed post-accident functionality checks. Further inquiry also is needed regarding how the magneto check would have been successfully performed during the run-up check immediately prior to takeoff on October 2, 2019, and why no abnormal noises were heard during the accident sequence, if the point gaps were out of tolerances before the magnetos were subjected to impact forces and fire.

As noted in Section VII above, TCF also believes that further inquiry is needed into other possible causes of magneto failure, including the possibility of the magneto switch or ignition master switch failing or operating intermittently.

The powerplant report also noted what could have been evidence of detonation on the number 3 engine, number 4 piston. The observed conditions are not conclusive evidence that detonation occurred in this engine. Detonation in the R-1820 engines typically resembles continuous blowtorch operation on metal. In other words, the metal melts, a hole typically is created in the piston, and molten metal blows down the outside of the piston. Instead of evidence of detonation, the photos in the NTSB powerplant report appear to depict a fractured top compression ring in the number 3 engine, number 4 cylinder. When such a failure occurs, there typically is no noticeable effect on engine operation. This fractured ring could have been caused by impact forces during the accident sequence. It also is possible that this type of visual condition could have been caused on a previous flight due to throttle manipulations, and would not necessarily have been detected through adverse engine performance or operation. Further investigation is needed about the possible cause(s) of this condition.

In addition, when detonation occurs on this model engine it typically is very noticeable to the crew because it produces a loud, banging noise and large RPM drop that would be accompanied by engine back- or after-firing. As Mr. Melton observed in his interview, he did not recall hearing any sounds like these from the number 3 or number 4 engines during the accident flight. One passenger said he thought the engines sounded like cement mixers when he moved into the bombardier compartment after takeoff, which is expected under normal engine operation due to operation of the engine's planetary gears, which can be heard in the nose compartment, but not as clearly in the back of the aircraft.[27] None of the other passengers stated that they heard any abnormal engine noises.

The powerplant report also observed the buildup of a significant amount of grease inside the number 4 engine right magneto. This buildup could have been the result of the exposure of the magneto and its grease to the accident sequence, where it appears that this magneto was

[27] In general, normal operation of the engines is perceived differently in the nose section of the B-17G than in the more aft sections of the aircraft. For example, it is easier to perceive reduction gearbox noises in the forward area of the aircraft, and more difficult to perceive exhaust noises.

exposed to extreme temperatures during the fire; normally grease is located elsewhere in the magneto. Further investigation is needed to determine whether the grease melted and poured into the inside of the magneto, which could have prevented a successful post-accident initial bench run. There is insufficient evidence at this time to conclude that this condition existed prior to the accident flight; it is difficult to imagine the pre-takeoff engine run-up magneto check would have been successfully accomplished had this condition existed at that time.

With respect to the spark plugs, TCF is not aware of the actual gap measurements determined by the NTSB in its investigation, as many of the plug gaps are only reported as ">0.022 inches," reportedly exceeding the manufacturer's recommended gap limit. It is important to determine the exact gap measurements, as TCF expects that a plug that is out of tolerances by, for example, 0.001 inches would perform differently - and more satisfactorily - than would a plug gap that was further out of tolerances. Additionally, there is no indication that any spark plugs were tested to determine whether they would fire, which is important to determine whether the spark plugs still were firing despite the reported gap measurements. Finally, TCF notes that spark plugs often become oil-soaked once an engine stops running, and rely on normal engine heating and combustion to remove that oil when the engine is operating. The presence of oil in the plugs that were examined in the NTSB's investigation - particularly where the plugs were pulled from engines that had sustained significant impact and fire damage, including being torn from the nacelle and subjected to g-forces far outside the normal operating parameters - is a normal and expected occurrence in radial engine spark plugs.

Finally, TCF believes that additional investigation is warranted to compare the post-accident condition of the number 3 and number 4 engines with the condition of the number 1 and number 2 engines from the accident aircraft. TCF also believes that there should be inquiry into the condition of the engine number 4 carburetor, and any potential findings relevant to the power loss experienced on takeoff.

IX. Proposed Findings of Fact

1. The accident crew, PIC McCauley and SIC Foster, was current and qualified to fly the LHFE accident flight on October 2, 2019, and had received all training as required under TCF's FAA-approved LHFE Manual System.

2. The accident crew was rested and otherwise not fatigued on the morning of October 2, 2019.

3. All required inspections under the B-17G CAIP were complied with as of October 2, 2019. The engine number 3 100-hour inspection was completed on September 7, 2019, and the engine number 4 100-hour inspection was completed on September 23, 2019.

4. No issues related to ability to generate commanded engine power, including any circumstances requiring the declaration of an in-flight emergency or a precautionary engine shutdown, had been reported for the accident aircraft's number 3 or number 4 engines during the 2019 WoF Tour.

5. Prior to the accident flight, the accident aircraft last flew on September 30, 2019 without incident, and had accumulated approximately 270 flight hours on the 2019 WoF Tour.

6. Since the aircraft last flew on September 30, 2019, the weather at Windsor Locks, CT had been wet and humid, with 1/10th of an inch of rain falling on October 1, 2019, and humidity reaching as high as 90% within three hours of takeoff on October 2, 2019.

7. All passengers were made aware of the accident B-17's limited category airworthiness certification through a document that each of them signed prior to boarding the LHFE flight, including acknowledgement that: the subject B-17G held a limited airworthiness certificate; the flight was authorized under an exemption from federal regulations granted by the FAA; and that the FAA has not established, nor has it approved, the standards under which a limited category airworthiness certificated aircraft is built.

8. The passengers received a pre-flight briefing that included location of emergency exits, and crew member Mitch Melton ensured all passengers were properly seated, with seatbelts fastened, prior to departure.

9. Wind, visibility, and ceiling were not factors in the accident.

10. After the number 3 engine initially did not start, Mr. Melton applied compressed nitrogen air to "blow out," or dry, the number 3 engine's magnetos. This is an accepted industry procedure done on radial engines following an extended ground time in heavy rain or high humidity. After this was accomplished, the number 3 engine started normally. The number 4 engine also would not start due to suspected moisture in the magnetos, and again Mr. Melton applied compressed nitrogen to dry the magnetos in that engine. After this sequence, all engines started normally.

11. After starting the engines, the crew performed an engine run-up prior to taking off, as was required by the applicable checklist. The run-up was normal, with the results at or above the required performance levels for proceeding with the flight. Takeoff with Captain McCauley at the controls took place without incident after clearance was received from the control tower.

12. Within approximately one minute after takeoff, the accident aircraft reached its peak speed for the flight, 124 MPH, and peak altitude, 560 feet AGL.

13. Approximately one minute after takeoff, the crew reported a number 4 engine problem to air traffic control, and requested to return to BDL. The crew was instructed to enter a downwind leg for Runway 06.

14. Runway 33 at BDL was closed and not available for landing.

15. The aircraft experienced a loss of power in engine number 4, and the engine was shut down by the crew. The crew then feathered the number 4 propeller.

16. Mr. Melton was on the flight deck and observed that the number 4 engine was "losing power" on the corresponding engine RPM gauge before engine shutdown. However, he did not also observe, with the observed loss of power, any back- or after-firing, and otherwise did not observe or hear any nonstandard engine performance in engine number 4.

17. At an undetermined time and for an undetermined cause during this flight sequence, engine number 3 began producing thrust below that which was commanded by the crew.

18. The accident crew flew a right traffic pattern for runway 06.

19. During the accident aircraft's emergency return to BDL, airspeed and altitude began to decrease slowly, to approximately 97 MPH and 330 feet AGL within two minutes of impact, and to approximately 94 MPH and 150 feet AGL within one minute of impact.

20. At this low airspeed and altitude, with two engines out or producing insufficient thrust, increasing the power to MAX on the operational engines was not possible due to a lack of aileron and rudder flight control authority in such an asymmetric thrust condition.

21. The accident aircraft impacted short of runway 06 and veered to the right, ultimately colliding into a de-icing area located slightly southeast of the intersection of runway 06 and taxiway C.

22. The initial impacts with the ground likely incapacitated the pilots. There is no evidence the pilots purposely advanced the throttles after ground impact, nor would there have been a reason to do so after initial ground impact.

23. The entire right wing separated from the fuselage during the crash sequence and impacted a nearby building, and sustained considerable post-impact damage. Engine number 3 was found on top of a glycol tank, near the top turret and cockpit. It was heavily damaged in the crash sequence. Engine number 4 separated from the nacelle in the crash sequence and was found in a nearby building, also heavily damaged.

24. Although heavily damaged in the crash sequence, the damage to the number 3 propeller was consistent with the propeller being in the normal operating position at the time of impact. Also heavily damaged in the crash sequence, the condition of the number 4 engine propellers was consistent with the propeller being in the feather position at the time of impact.

25. The condition of the number 1 and 2 engines was not investigated during the course of this investigation.

26. Mr. Melton was unable to egress through normal emergency exits in the forward area of the aircraft due to aircraft damage, fire and obstructions, and instead was forced to kick out a flight deck window, enabling himself and two passengers to escape the accident aircraft.

27. There was insufficient evidence to determine the cause of engine power loss in the number 3 and number 4 engines.

28. The loss of power on the number 3 and 4 engines, at low altitude and airspeed and in a deficient energy state, presented the crew with an unprecedented emergency situation and adverse control situation from which they were unable to execute a safe landing on runway 06 at BDL, through no fault of the flight crew.

X. Proposed Probable Cause and Contributing Factors

The probable cause of this accident is the unexplained loss of engine power from the number 3 and number 4 engines after takeoff at a low altitude and airspeed that did not permit the accident flight crew to have sufficient directional control to safely land the aircraft at the departure airport.

Contributing factors are: 1) the B-17G's inherent lack of flight control surface authority in the two engines out on one wing flight scenario, and in the energy state in which the accident crew found itself shortly after takeoff on October 2, 2019; (2) the lack of Vmc and two engine out performance and procedural information relating to low energy states available to aircrews from the aircraft manufacturer for this 75 year-old, vintage World War II-era military aircraft; and 3) the closure of runway 33 at BDL, which, had that runway been available, would have allowed for a shorter ground track for the accident aircraft to cover before reaching a usable runway.

Respectfully submitted,

/s/ Robert Pinksten

Robert Pinksten
On Behalf of THE COLLINGS FOUNDATION

Attachments
Attachment A - FAA No Violation Letter
Attachment B - BDL Runway 33 Closure NOTAM

Attachment “A”

U.S. Department
of Transportation
**Federal Aviation
Administration**

**WINDSOR LOCKS FLT STDS DIST OFFICE
BUILDING 85-214 1ST FLOOR
BRADLEY INTERNATIONAL AIRPORT
WINDSOR LOCKS, CT 06096-1009
(860)654-1000**

January 21, 2020

THE COLLINGS FONDATION
137 BARTON ROAD
STOW, MA 01775

File Number: 2020EA630003
Reporting Inspector: HERMAN E. CARVACHE

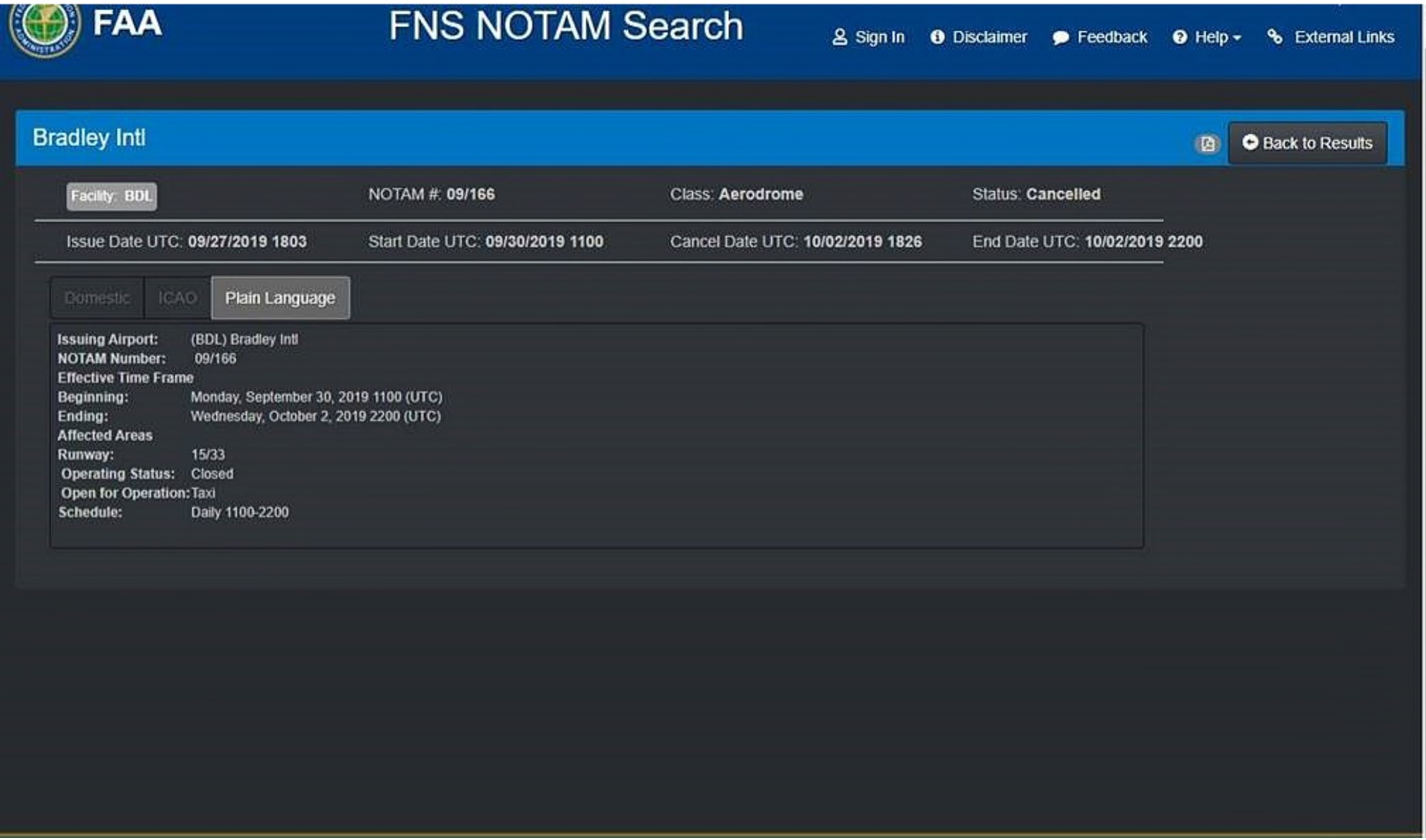
The Federal Aviation Administration (FAA) has investigated an alleged violation that reportedly occurred on Wednesday, October 02, 2019 in the vicinity of WINDSOR LOCKS, CT.

This letter is to inform you that the investigation did not establish a violation of the Federal Aviation Regulations, and you may consider the matter closed.

Should you have questions, feel free to contact our office.

Additional Information On Back

Attachment “B”


FAA
FNS NOTAM Search
Sign In
Disclaimer
Feedback
Help
External Links
Bradley Intl
Back to Results
Facility: BDL
NOTAM #: 09/166
Class: Aerodrome
Status: Cancelled
Issue Date UTC: 09/27/2019 1803
Start Date UTC: 09/30/2019 1100
Cancel Date UTC: 10/02/2019 1826
End Date UTC: 10/02/2019 2200
Domestic
ICAO
Plain Language
Issuing Airport: (BDL) Bradley Intl
NOTAM Number: 09/166
Effective Time Frame
Beginning: Monday, September 30, 2019 1100 (UTC)
Ending: Wednesday, October 2, 2019 2200 (UTC)
Affected Areas
Runway: 15/33
Operating Status: Closed
Open for Operation: Taxi
Schedule: Daily 1100-2200