UNITED STATES AIR FORCE AIRCRAFT ACCIDENT INVESTIGATION BOARD REPORT

E-11A, T/N 11-9358

430TH EXPEDITIONARY ELECTRONIC COMBAT SQUADRON
455TH AIR EXPEDITIONARY WING
BAGRAM AIRFIELD, AFGHANISTAN

LOCATION: GHAZNI PROVINCE, AFGHANISTAN

DATE OF ACCIDENT: 27 JANUARY 2020

BOARD PRESIDENT: BRIG GEN CRAIG BAKER

Conducted IAW Air Force Instruction 51-307

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS AIR COMBAT COMMAND
JOINT BASE LANGLEY-EUSTIS VA

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15 NOV 2020

ACTION OF THE CONVENING AUTHORITY

The report of the accident investigation board conducted under the provisions of Air Force Instruction 51-307, *Aerospace and Ground Accident Investigations*, that investigated the 27 January 2020 fatal mishap involving an E-11A, T/N 11-9358, 430th Expeditionary Electronic Combat Squadron, 455th Air Expeditionary Wing, United States Central Command Area of Responsibility, complies with applicable regulatory and statutory guidance, and on that basis it is approved.

MARK D. KELLY
General, USAF
Commander

People First... Mission Always...

EXECUTIVE SUMMARY
UNITED STATES AIR FORCE
AIRCRAFT ACCIDENT INVESTIGATION

E-11A, T/N 11-9358
GHAZNI PROVINCE, AFGHANISTAN
27 JANUARY 2020

On 27 January 2020, at approximately 1309 hours local time (L), an E-11A, tail number (T/N) 11-9358, was destroyed after touching down in a field in Ghanzi Province, Afghanistan (AFG) following a catastrophic left engine failure. The mishap crew (MC) were deployed and assigned to the 430th Expeditionary Electronic Combat Squadron (EECS), Kandahar Airfield (KAF), AFG. The MC consisted of mishap pilot 1 (MP1) and mishap pilot 2 (MP2). The mission was both a Mission Qualification Training – 3 (MQT-3) sortie for MP2 and a combat sortie for the MC, flown in support of Operation FREEDOM'S SENTINEL. MP1 and MP2 were fatally injured as a result of the accident, and the Mishap Aircraft (MA) was destroyed.

At 1105L, the MA departed KAF. The mission proceeded uneventfully until the left engine catastrophically failed one hour and 45 minutes into the flight (1250:52L). Specifically, a fan blade broke free causing the left engine to shutdown. The MC improperly assessed that the operable right engine had failed and initiated shutdown of the right engine leading to a dual engine out emergency. Subsequently, the MC attempted to fly the MA back to KAF, approximately 230 nautical miles (NM) away. Unfortunately, the MC were unable to get either engine airstarted to provide any usable thrust. This resulted in the MA unable to glide the distance remaining to KAF. With few options remaining, the MC maneuvered the MA towards Forward Operating Base (FOB) Sharana, but did not have the altitude and airspeed to glide the remaining distance. The MC unsuccessfully attempted landing in a field approximately 21 NM short of FOB Sharana.

The Accident Investigation Board (AIB) President found by a preponderance of the evidence that the cause of the mishap was the MC's error in analyzing which engine had catastrophically failed (left engine). This error resulted in the MC's decision to shutdown the operable right engine creating a dual engine out emergency.

The AIB President also found by a preponderance of the evidence that the MC's failure to airstart the right engine and their decision to recover the MA to KAF substantially contributed to the mishap.

SUMMARY OF FACTS AND STATEMENT OF OPINION
E-11A, T/N 11-9358
27 JANUARY 2020

TABLE OF CONTENTS

ACRONYMS AND ABBREVIATIONS

A	Ampere
A/T	Autothrottle
A&P	Airframe and Power
AC	Alternating Current
ACC	Air Combat Command
ACPC	AC Power Center
ADC	Air Data Computer
ADO	Assistant Director of Operations
AEG	Air Expeditionary Group
AF	Air Force
AFB	Air Force Base
AFCENT	Air Force Central Command
AFE	Air Flight Equipment
AFI	Air Force Instruction
AFM	Airplane Flight Manual
AFPAM	Air Force Pamphlet
AGL	Above Ground Level
AGP	Aircraft Grounded for Parts
Ah	Ampere-hour
AIB	Accident Investigation Board
AIP	Assignment Incentive Pay
AK	Alaska
ALT	Altitude
AMC	Air Mobility Command
AMD	Air Mobility Division
AMM	Aircraft Maintenance Manual
AMP	Aircraft Mechanic and Propulsion
AOA	Air Operations Area
AOC	Air Operations Center
AOR	Area of Operation
AP	Autopilot
APO	Army Post Office
APU	Auxillary Power Unit
ARINC	Aeronautical Radio Incorporated
ARMS	Aviation Resource Management System
ASCA	APU Start Contactor Assembly
ASCB	Avionics Standard Communication Bus
ATAGS	Advanced Tactical Anti-G System
ATC	Air Traffic Control
ATLC	Authenticate Threats Locate
ATO	Air Traffic Operations
ATP	Airline Transport Pilot
ATS	Auto Turbine Start
AWACS	Airborne Warning and Control System
BACN	Battlefield Airborne Communications Node
BMC	BACN Mission Coordinator
BMS	Battery Master Switch
BRAG	Breathing Regulator/Anti-G
Brig. Gen.	Brigadier General
c.g.	Centre of Gravity
CAE	Civil Aviation Training Facility
CAIMS	Central Aircraft Information Maintenance System
CALs	Continuous Acquisition Life-cycle Support
CAOC	Combined Air Operations Center
Capt	Captain
CAS	Crew Alerting System
CAT	Crisis Action Team
CAUT	Caution
CBT	Combat
CCBP	Cockpit Circuit Breaker Panel
CCIR	Commander Critical Information Requirements
CENTCOM	Central Command
CIP	Core Integrated Processor
CMSgt	Chief Master Sergeant
CCMD	Combatant Command
COD	Combat Operations Division
Col	Colonel
COMMs	Communications
COR	Contracting Officer Representative
CP	Copilot
CRM	Crew Resource Management
CSAR	Combat Search and Rescue
CSMU	Crash Survivable Memory Unit
CT	Certification Training
CTP	Certification Training Program
CVR	Cockpit Voice Recorder
DAU	Data Acquisition Unit
DC	Direct Current
DCPC	DC Power Center
DEOCS	Defense Equal Opportunity Climate Survey
DFDR	Digital Flight Data Recorder
DLA	Defense Logistics Agency
DND	Do Not Dispatch
DO	Director of Operations
DoD	Department of Defense
DTS	Defense Travel System
E	East
ECS	Environmental Control System
EEC	Electronic Engine Control
EECS	Expeditionary Electronic Combat Squadron
EFB	Electronic Flight Book
EFIS	Electronic Flight Instrument System
EGT	Exhaust Gas Temperature
EICAS	Engine Indicating and Crew Alerting System
ELT	Emergency Locator Transmitter
EMER	Emergency
EMS	Electrical Management System
ENG	Engine
EOS	Emergency Oxygen System
EPA	Evasion Plan of Action
EPR	Engine Pressure Ratio
EPS	Emergency Power System
EVMS	Engine Vibration Monitoring System

FAA	Federal Aviation Administration
FADEC	Full Authority Digital Engine Controller
FAF	Final Approach Fix
FAIP	First Assignment Instructor Pilot
FCOM	Flight Crew Operating Manual
FD	Flight Director
FDR	Flight Data Recorder
FL	Flight Level
FLCS	Flight Control System
FLIP	Flight Information Publication
FMS	Flight Management System
FOD	Foreign Object Debris
FPM	Feet Per Minute
FPMP	Pilot/Mission Pilot
FPS	feet per second
FRC	Fault Reporting Codes
FS	Fighter Squadron
FS	Fuselage Station
Ft	Feet
FTU	Flying Training Unit
g	Gravitational Force
GFR	Government Flight Representative
GMT	Greenwich Mean Time
GOPs	General Operating Procedures
GPS	Global Positioning System
HAZMAT	Hazardous Materials
HUD	Heads-Up Display
Hz	Hertz
IAW	In Accordance With
IBIT	Initiated Built-in Test
ICAWS	Integrated Caution, Advisory and Warning System
IDF	Installation Defense Force
IFDL	Intra-Flight Data Link
IFE	In-flight Emergency
IFR	In-flight Refueling
IG	Inspector General
ILS	Instrument Landing System
IMC	Instrument Meteorological Conditions
IMIS	Integrated Maintenance Information System
INMARSAT	International Maritime Satellite
IP	Instructor Pilot
IP	Issue Paper
IRC	Instrument Refresher Course
ISB	Interim Safety Board
ISOPREP	Isolated Personnel Report
ITT	Interstage Turbine Temperature
IVSC	Integrated Vehicle Subsystem Controller
JBER	Joint Base Elmendorf-Richardson
JDAM	Joint Direct Attack Munitions
JPRC	Joint Personnel Recovery Center
JTAC	Joint Terminal Attack Controller
K	Thousand
KAF	Kandahar Airfield
KCAS	Knots Calibrated Airspeed
Kg	Kilograms
KTAS	Knots True Airspeed
kts	Knots
kVA	Kilovolt-ampere
L	Left
L	Local Time
LAX	Los Angeles International Airport
lat	Latitude
lbs	Pounds
LCV	Load Control Valve
LM-Aero	Lockheed Martin Aeronautics Company
LNO	Liaison Officer
LOFT	Line-oriented Flight Training
Long	Longitude
Lt Col	Lieutenant Colonel
LTMs	Language Training Mission
LWD	Left Wing Down
M	Mach
MA	Mishap Aircraft
MAC	Mean Aerodynamic Chord
Maj	Major
MAJCOM	Major Command
MC	Mishap Crew
MCT	Maximum Continuous Thrust
MDS	Model Design Series
MES	Main Engine Start
MFL	Mishap Flight Lead
MIRC	Military Intelligence Readiness Command
MMO	Maneuver Speed
MOA	Military Operating Area
MP	Mishap Pilot
MPC	Message Processing Centre
MQ	Mission Qualification
MQT	Mission Qualification Training
MRE	Meals Ready to Eat
MS	Mishap Sortie
MSgt	Master Sergeant
MSL	Mean Sea Level
MSN	Manufacturer Serial Number
MWSIP	Major Weapons System Instructor Pilot
N	North
N1	Engine Fan
N2	Engine Core
NAV	Navigation
NAVCOM	Navigation Communication
ND	Nose Down
NDTM	Non-destructive Testing Manual
NET	No Earlier Than
NG	Northrup Grumman
NiCad	Nickel Cadmium
NLT	No Later Than
NM	Nautical Miles
NMC	Non Mission Capable
NOTAMs	Notices to Airmen
NVGs	Night Vision Goggles
NVM	Non-volatile Memory
OBIGGS	On-board Inert Gas Generating System

OBOGS	On-board Oxygen Generating System
OCF	Operational Check Flight
OCONUS	Outside the Contiguous United States
OG	Operations Group
OMEs	Operational Mission Evaluations
OPR	Officer Performance Report
Ops Sup	Operations Superintendent
Ops Tempo	Operations Tempo
ORM	Operational Risk Management
OSHA	Occupational Safety and Health Administration
OSS	Operation Support Squadron
OWE	Operating Weight Empty
P	Pilot
P/N	Part Number
P&W	Pratt and Whitney
PA	Public Affairs
PACAF	Pacific Air Forces
PAO	Polyalphaolefin
PAR	Precision Approach Radar
PAX	Passengers
PBA	Pushbotton Annunciator
PCS	Permanent Change of Station
PDM	Programmed Depot Maintenance
PEM	Pilot Event Number
PF	Pilot Flying
PFD	Primary Flight Display
PHA	Physical Health Assessment
PIC	Pilot in Command
PMC	Partially Mission Capable
PMP	Packaged Maintenance Plan
PMR	Program Management Review
POC	Point of Contact
PPE	Personal Protection Equipment
PR	Pre Flight
PRESS	Pressure
PSI	Pounds Per Square Inch
PWR	Power
QA	Quality Assurance
QAE	Quality Assurance Evaluator
QRH	Quick Reference Handbook
R	Right
R-NAV	Area Navigation
R&R	Rest and Recuperation
RAD ALT	Radio Altimeter
RAT	Ram Air Turbine
RIPS	Recorder Independent Power Supply
RPA	Remotely Piloted Aircraft
Rpm	Rotations per Minute
RSI	Restriction and Special Instructions
RTB	Return-To-Base
RVSM	Reduced Vertical Separation Minima
RWD	Right Wing Down
S/N	Serial Number
SA	Situational Awareness
SAR	Search and Rescue
SARM	Squadron Aviation Resource Management
SAT	Surface Attack Tactics
SATCOM	Satellite Communications
SB	Service Bulletin
SDP	Special Departure Procedure
SEBPT	Scenario Based Emergency Procedures Training
SIB	Safety Investigation Board
SII	Special Interest Item
SIM	Simulator
SIPR	Secure Internet Protocol Router
SIPRNET	Secure Internet Protocol Router Network
SMEs	Subject Matter Expert
SMSgt	Senior Master Sergeant
SOF	Supervisor of Flying
SOP	Standing Operating Procedure
SPDA	Secondary Power Distribution Assembly
SPO	Special Programs Office
SRM	Structural Repair Manual
SSCVR	Solid-State Cockpit Voice Recorder
SSgt	Staff Sergeant
SSPC	Solid-State Power Controller
Stan Eval	Standardization and Evaluation
STC	Supplemental Type Certificate
T/N	Tail Number
TC	Type Certificate
TCTO	Time Compliance Technical Order
TDY	Temporary Duty
TLMC	Time Limits / Maintenance Checks
TO	Training Officer
TOD	Tech Order Data
TRU	Transformer Rectifier Unit
TSgt	Technical Sergeant
UHF	Ultra High Frequency
ULN	Unit Line Number
U.S.	United States
USAF	United States Air Force
VAC	Volts AC
VDC	Volts DC
VFG	Variable Frequency Generator
VFR	Visual Flight Rules
VHF	Very High Frequency
VIB	Vibrations
VMC	Visual Meteorological Conditions
VOSIP	Voice Over Secure Internet Protocol
VSG	Virtual Support Group
VVI	Vertical Velocity Indication
Wps	words per second
Z	Zulu

The above list was compiled from the Summary of Facts, the Statement of Opinion, the Index of Tabs, and Witness Testimony (Tab V).

SUMMARY OF FACTS

1. AUTHORITY AND PURPOSE

a. Authority

On 5 February 2020, General James M. Holmes, Commander, Air Combat Command (ACC), appointed Brigadier General Craig Baker to conduct an aircraft investigation of the 27 January 2020 mishap of an E-11A Global Express, tail number (T/N) 11-9358 in Ghazni Province, Afghanistan (AFG) (Tab Y-5 to Y-6). The investigation occurred at Shaw Air Force Base (AFB), South Carolina, from 15 July 2020 to 14 August 2020. The following board members were subsequently appointed on 29 June 2020: Medical Member (Major), Legal Advisor (Lieutenant Colonel), Pilot Member (Lieutenant Colonel), Maintenance Member (Master Sergeant), and Recorder (Master Sergeant) (Tab Y-3 to Y-4).

b. Purpose

In accordance with AFI 51-307, *Aerospace and Ground Accident Investigations*, this accident investigation board conducted a legal investigation to inquire into all the facts and circumstances surrounding this Air Force aerospace accident, prepare a publicly-releasable report, and obtain and preserve all available evidence for use in litigation, claims, disciplinary action, and adverse administrative action.

2. ACCIDENT SUMMARY

On 27 January 2020, at 1309 hours local (L), the mishap aircraft (MA), an E-11A, T/N 11-9358, unsuccessfully attempted landing in Ghazni Province, AFG after encountering a catastrophic left engine failure, and the mishap crew (MC) causing a dual engine out emergency after shutting down the operable right engine (Tabs DD-2 to DD-4, J-11 to J-14, J-180, L-91, and L-99). Mishap pilot 1 (MP1) and mishap pilot 2 (MP2) were assigned to the 430th Expeditionary Electronic Combat Squadron at Kandahar Airfield (KAF), AFG (Tab G-256). The mishap sortie (MS) was a Mission Qualification Training – 3 (MQT-3) sortie for MP2 (Tab R-1.6). The MS was also an Air Tasking Order (ATO) mission supporting Operation FREEDOM'S SENTINEL, an operation in support of the continuing global war on terrorism and training Afghan security forces (Tabs K-4 and CC-24). The MA was destroyed (Tab P-1). MP1 and MP2 were fatally injured in the mishap (Tab X-2).

3. BACKGROUND

a. Air Combat Command (ACC)

ACC is one of the ten major commands in the United States Air Force (Tab CC-2). As lead command for fighter, command and control, intelligence, surveillance and reconnaissance, personnel recovery, persistent attack and reconnaissance, electronic warfare, and cyber operations, ACC is responsible for providing combat air, space, and cyber power and the combat support that assures mission success to America's warfighting commands (Tab CC-2). The command has over 1,097 assigned aircraft, with 27 wings, 1,122 units at more than 201 non-expeditionary locations and an additional eight wings, 222 units at 57 locations supporting expeditionary operations for a total of 35 wings, 1,344 units at more than 258 locations (Tab CC-2). The command's personnel combine for a total of 157,549 (Tab CC-2). These are organized under four active duty numbered air forces, a named-air force and the Air Force Warfare Center (Tab CC-2).

b. United States Air Forces Central Command (USAFCENT)

USAFCENT is the air component of United States Central Command (USCENTCOM), a regional unified command (Tab CC-5). USAFCENT, in concert with coalition, joint, and interagency partners, delivers decisive air, space, and cyberspace capabilities for USCENTCOM, ally nations, and America (Tab CC-5). USAFCENT is comprised of seven expeditionary wings to include the 455th Air Expeditionary Wing (Tab CC-5 to CC-6).

c. 455th Air Expeditionary Wing

The 455th Air Expeditionary Wing (455 AEW) is composed of more than 2,100 Airmen located at Bagram, Jalalabad, and Kandahar airfields (Tab CC-8). The wing consists of five groups: the 455th Expeditionary Operations Group, the 455th Expeditionary Mission Support Group, the 455th Expeditionary Maintenance Group, the 455th Expeditionary Medical Group, and the 451st Air Expeditionary Group (AEG) (Tab CC-8 to CC-9). The 455th AEW is an Air Force wing located in Afghanistan and provides decisive airpower throughout the country in support of Operation FREEDOM'S SENTINEL and North Atlantic Treaty Organization's (NATO) RESOLUTE SUPPORT mission (Tab CC-8).

d. 451st Air Expeditionary Group

The 451st Air Expeditionary Group (451 AEG) out of KAF, AFG provides a persistent and powerful airpower presence in the Afghanistan area of operations (Tab CC-14). The group's Airmen provide world-class close air support, intelligence, surveillance, reconnaissance, command and control, personnel recovery and airborne datalink capabilities whenever and wherever needed (Tab CC-14).

e. 430th Expeditionary Electronic Combat Squadron

The 430th Expeditionary Electronic Combat Squadron (430 EECS) is a squadron in the 451 AEG and is the only unit in the U.S. Air Force that operates the E-11A with the Battlefield Airborne Communications Node (BACN) payload (Tab CC-15). The mission of the 430 EECS and the E-11A is to serve as a BACN, which is a communications system that provides radio connectivity across the battlespace for airborne and surface operators (Tab CC-15 to CC-16).

f. E-11A Global Express

The Bombardier E-11A is the military variant of the civilian Bombardier BD-700 Global Express for use as an overhead commincations-relay platform in southwest Asia (Tab CC-21). It carries the Northrup Grumman Battfield Airborne Communications Node (BACN), allowing different battlefield communication systems to share data (Tab CC-21). The BACN has the capability to relay voice, video, imagery and data between warfighters in the air and on the ground, 24 hours a day and seven days a week (Tab CC-22). All U.S. Air Force E-11As with the BACN payload are assigned to the 430th Expeditionary Electronic Combat Squadron and operate solely out of KAF (Tab CC-21).

4. SEQUENCE OF EVENTS.

a. Mission

The MS was directed on 27 January 2020 in support of Operation FREEDOM'S SENTINEL, an operation in support of the continuing global war on terrorism and training Afghan security forces (Tabs K-4 and CC-24).

b. Planning

As is typical for this type of mission, established routes were used and the Operations Supervisor (Ops Sup) prepared Mission Data Cards, directed fuel loading, and ensured survival equipment was available and correct (Tab R-10.6 to R-10.9). The Ops Sup also ensured Electronic Flight Books (EFBs), hosted on iPads, were updated with current publications (Tab R-10.13 to R-10.14). The MC was briefed by the Ops Sup and the BACN Mission Coordinator (BMC) responsible for mission tasking (Tab R-10.6 to R-10.7).

c. Preflight

The MC used the standard briefing guide and reviewed the mission tasking and routing, forecast weather, active Notices to Airmen (NOTAMs), takeoff and landing data (TOLD), and airspace considerations (Tab R-10.6). The MC also ensured that administrative items were complete, verifying their currencies and that the flight authorization was complete (Tab R-10.6). The Ops Sup reviewed Operational Risk Management (ORM) and determined the overall risk for the MS was low (Tab R-10.7 to R-10.8). The MS was accomplished under Visual Flight Rules (VFR) (Tabs N-5 and N-16). Weather was provided to the crew with a series of products, including detailed information for KAF, Terminal Aerodrome Forecasts (TAFs) for ten divert fields (including Kabul International Airport and Bagram Airfield), and hazard/wind charts for the mission area and times (Tab F-4 to F-10). Preflight was uneventful; MP2 was on a Mission Qualification Training – 3 (MQT-3) sortie, and MP1 provided instruction throughout the preflight (Tab N-5 to N-8). Checklist procedures and engine starts were standard, and the MC took off at 1105L (Tab DD-11).

d. Summary of Accident

(1) INITIAL EVENT

Takeoff occurred at 1105L and was uneventful (Tabs DD-11 and N-9 to N-14). The MC reported VFR weather at KAF, with a cloud deck at higher altitudes, and proceeded to their assigned orbit using standard departure/climb procedures (Tab N-14 to N-23, and Tab R-4.5). The MC assumed a circular orbit just west of Kabul at 42,000 feet altitude at about 1136L (Tab N-23).

At 1250L, the MC requested and was cleared by ATC to climb from 42,000 feet altitude to 43,000 feet altitude (Tab N-42). The engine revolutions per minute (RPMs) advanced and the MC initiated the climb with the autopilot, gaining about 300 feet (Tab DD-12). At 1250:52L, a fan blade broke free and separated from the N1 first-stage turbofan of the left engine, causing major damage and resulting in the immediate shutdown of that engine by the Electronic Engine Controller (EEC), a subsystem of the Full Authority Digital Engine Controller (FADEC) (Tab J-11 and DD-11). This was accompanied by a bang recorded from the cockpit by the Cockpit Voice Recorder (CVR) (Tab J-177). Simultaneous with the bang, the CVR recording stopped and CVR data is unavailable after 1250:52L (Tab J-177).

Due to the loss of the CVR, the experience of the MC cannot be fully ascertained following the CVR shutdown (Tab J-177). To address this gap, the Board researched the example of a civilian crew piloting a Global Express (GE) XRS that experienced an identical engine failure in 2006, as the GE XRS is equivalent to the E-11A in all particulars except the cabin (Tab N-45 to N-46 and Tab DD-6). This event is referred to in this report as the Global Express event (Tab DD-11).

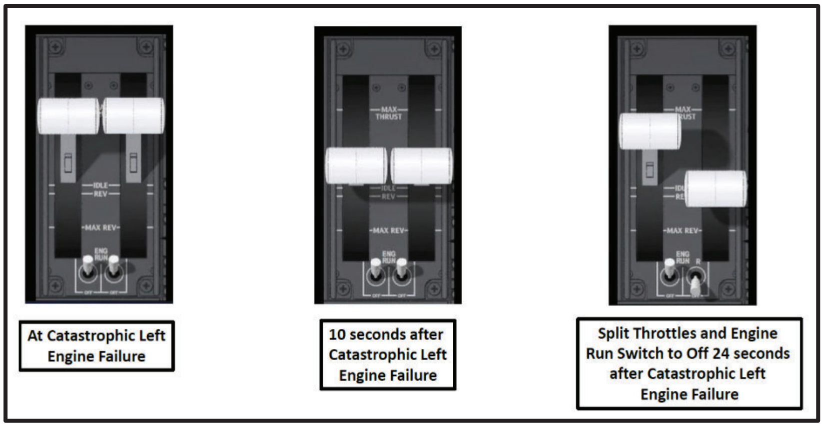
The pilot in command of the GE XRS in the Global Express event reported the first moments following blade separation as disorienting initially, with airframe vibrations of such magnitude as to lead the crew to wonder if they had experienced a mid-air collision (Tab V-5.3). He described a loud bang, and sustained vibration through the rest of the flight, sufficient to break stemware in the galley (Tab V-5.3 and V-5.6). The pilot in command also stated that he could not determine which engine had failed based on aircraft vibration and sensation alone without looking at the instruments (Tab V-5.5).

Digital Flight Data Recorder (DFDR) indications from the E-11A MA are limited but show vibrations in both the X and Y axes (up/down and left/right) (Tab J-119). For the left and right accelerations, anaylsis indicates that the nose of the aircraft would have yawed to the left initially, but then rapidly right when the left throttle was moved up from 14 degrees to 26 degrees and then back down to 16 degrees (Tab DD-13). The overall vibrations were 25% greater with the MS than the Global Express event, making it more likely the MC perceived the event as severe and concluded they needed to react immediately (Tab J-176 and J-112).

(2) RECORDED ACTIONS

Within one to two seconds after the initial event, the autothrottles disengaged automatically (Tab DD-12). The autopilot was engaged, controlling the aircraft's turning and vertical movements, and it remained engaged (Tab DD-12). Bank angles remained essentially constant, consistent with a circular orbit, and the MA descended from an altitude of 42,300 feet to 41,000 feet between 1251:01L and 1251:29L (Tab DD-12).

Ten seconds after the catastrophic left engine failure, the MC retarded both throttles to just less than halfway (14 degrees; total throttle range is from 0 – 40 degrees) for one second, then slightly advancing the left throttle separately (26 degrees) for one second, then retarding it to align with the right throttle (both at 16 degrees) for one second, and finally splitting the throttles to advance the left throttle (to 31 degrees) while retarding the right to idle (0 degrees) (Tab DD-13 to DD-14). Nine seconds after moving the right throttle to idle, the MC placed the right engine run switch to off, shutting down the right engine (Tab DD-15). Finally, at 1251:19L, the left throttle was advanced to full power (40 degrees), briefly cycled then brought to idle (Tab DD-15). At 1251:23L, both throttles were advanced from idle to full power (Tab DD-15).



Tab Z-12 (Simulated)

The first throttle movements may represent an attempt to first reduce vibration by reducing power, then to isolate the affected engine by moving the left throttle separately. Airframe vibrations did dampen slightly, but then resumed, roughly coincident with the power reduction and the advancement of the left throttle at 1251:08 (Tab DD-12 to DD-13). However, the moves were very brief and the vibrations in the left and right and up and down directions were cyclical but not regular (Tab DD-13). In any case, the left engine did not respond – the engine N1 (fan RPM) had spiked to a maximum value, but other engine instruments continued to roll back consistent with an engine shutdown (Tab DD-13).

The second sequence of throttle movements and the shut off of the engine run switch are consistent with the engine shutdown procedures described in the Bombardier Global Express Flight Crew Operations Manual Volume 1 (FCOM). The operations manual directs that the throttle for an engine to be shut down first be brought to idle, then the run switch be placed to off (Tab DD-13). Given that the engine run switch is held in position by spring tension, and the use of checklist procedures, it is certain that the shutdown was deliberately accomplished by the MC (Tab DD-12 to DD-13).

Seven to eight seconds after the right engine shutdown, recorded airframe vibrations drop appreciably (Tab DD-13). The recorded evidence does not provide a cause for this drop.

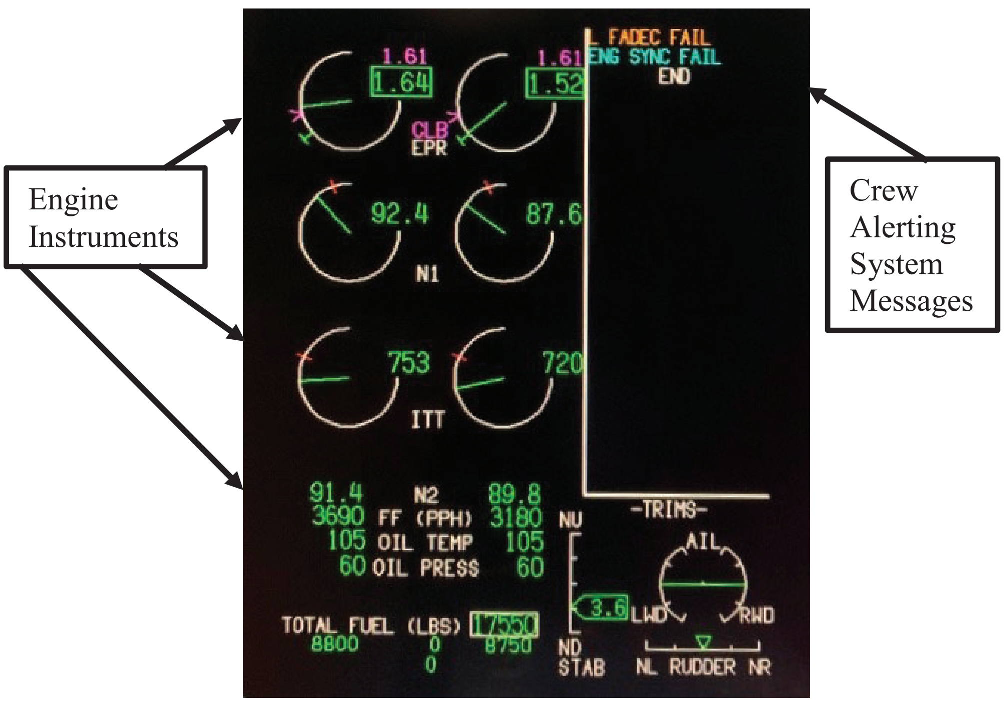
The purpose of the last throttle movements cannot be determined, but neither engine responded and both continued to roll back having been separately shutdown as described in detail above (Tab DD-13). This is followed by the end of the DFDR recording at 1251:29L (Tab J-180).

(3) COCKPIT MESSAGES

Twenty-four seconds is the total time from the catastrophic left engine failure to the MC initiated right engine run switch placement to off (Tab J-116). The action step of moving the right throttle to idle is 20 seconds, suggesting that a decision was made and analysis effectively ended as early as 20 seconds and no later than 24 seconds (Tab J-116). It is likely the MC's first actions, including the shutdown, were hastened by a sense of urgency due to MA vibrations and other auditory/sensory cues, reinforced by the startle response (Tab G-23).

The design of the MA's crew alerting system display and supporting inputs displayed an amber "**L (Left) FADEC FAIL**" caution crew alerting system message, accompanied by the amber Master Caution light at MC eye level (on the cockpit glareshield), derived from the software-directed shutdown of the left engine at 1250:52L (Tab J-179). A large majority of squadron E-11A pilots interviewed understood this message to indicate a failure of the software, but not necessarily to affect the engine in the short term (Tabs V-2.4 to V-2.6, V-3.4, V-7.4 to V-7.5, V-11.5 and V-22.3 to V-22.5). The checklist for "**L FADEC FAIL**" lists three possible consequences of the failure, one of which is eventual engine shutdown (Tab AA-20). The disengagement of the auto-throttles would have caused an audible warning, though the throttles would be expected to, and did, remain in place (Tab J-116 and J-136). Finally, a cyan "**ENG (Engine) SYNC FAIL**" advisory crew alerting system message was displayed (Tab J-179). Collectively, in the first moments, the crew alerting system did not directly indicate the left engine failure (Tab Z-13).

EICAS Display #1: A representative image of the crew alerting system messages within 1-2 seconds of the initial event and the left engine's FADEC-directed shutdown (Tab DD-6)



Tab Z-13 (Simulated)

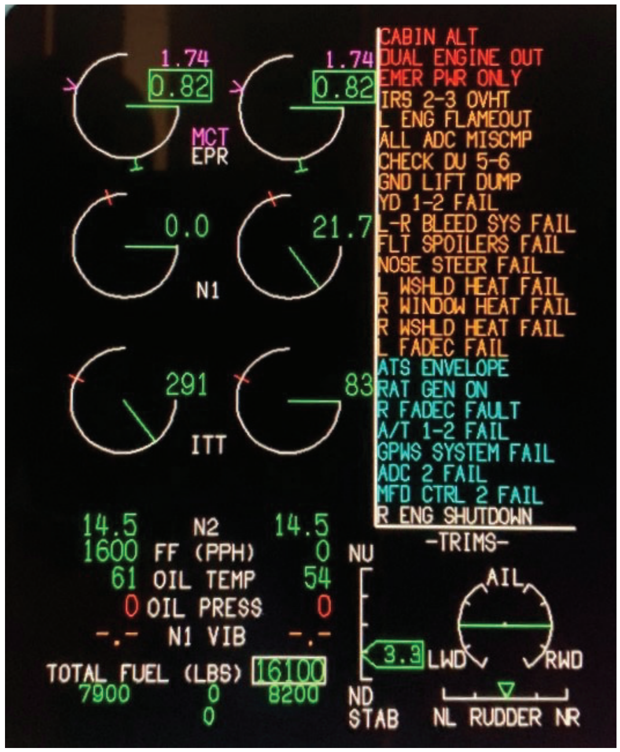
When the right engine was shut down at 1251:16L, the crew alerting system would have posted a status crew alerting system message of "**R (Right) ENG SHUTDOWN**," displayed in white and below the other crew alerting system messages (Tabs J-180 and Z-17).

EICAS Display #2: A representative image of the crew alerting system messages just after the right engine shutdown.

Tab Z-17 (Simulated)

Dual engine failure indications from the crew alerting system occurred later, estimated at 1252L (Tab J-180). The red "**DUAL ENGINE OUT**" warning crew alerting system message indicates that both engines have failed/been shutdown (Tab AA-3). This message is designed to display when both the left and right engines indicate either an amber "**ENG FLAMEOUT**" caution crew alerting system message or white "**ENG SHUTDOWN**" status crew alerting system message (Tab J-180). Thus, rather than displaying immediately when the right engine run switch was placed to off and the left engine had been shut down by the FADEC, the red "**DUAL ENGINE OUT**" warning crew alerting system message and an associated red Master Warning light on the glareshield did not appear until the "**L ENG FLAMEOUT**" was triggered as that engine's internal RPM dropped below 35%, estimated some 30-45 seconds later (in accordance with system logic (Tab J-180 and Z-16)). Note that the flameout caution and dual engine warning would have preceded the red "**CABIN ALT**" (altitude) warning crew alerting system message, and several other systems messages (Tab Z-16 to Z-17).

EICAS Display #3: A representative image of cockpit indications following the amber "L ENG FLAMEOUT" caution, red "DUAL ENGINE OUT" warning , and red "CABIN ALT" warning crew alerting system messages with associated systems messages.



Tab Z-16 (Simulated)

(4) ENGINE INDICATIONS

Along with the crew alerting system indications, the left engine N1 (fan RPM) gage, based on DFDR data, and within five seconds of the left engine catastrophic failure, dropped to 7.6% then spiked to an unreliable 255.9% where it remained until the DFDR stopped recording (Tab J-113). If observed, this erratic display may have been interpreted as a faulty reading, rather than the consequence of engine and sensor damage. Several contemporary pilots said they believed that the condition(s) associated with a FADEC failure might diminish the reliability or timeliness of engine instruments (Tabs V-2.6, V-3.5, V-6.5, and V-11.4). The left engine's Engine Pressure Ratio (EPR) and Inter Turbine Temperature (ITT) decayed predictably, but not immediately (Tab J-114 and J-120). While a display of N2 vibration (not normally visible) appeared with amber dashes for the left engine, this would have been displayed below the oil pressure and fuel flow and would have been an infrequent target for an E-11A pilot's attention (Tab J-137).

Conversely, the right engine read normally (Tab J-179). The only discrepancy for the right engine was a reading for N2 vibration (not normally present, but sparked by the left engine's reading of dashes) (Tab J-137). The vibration reading was displayed in green, indicating normal operation (Tab J-137).

In addition to the engine messages and instruments, several other crew alerting system indications would have appeared concerning systems affected by the primary malfunctions. These indications are not separately addressed in this report, with the relevant complications arising from the loss of the engines addressed below. (See EICAS Display #3 above, Tab Z-16 and Tab DD-14).

Preceding the crew alerting system messages of the amber "L ENG FLAMEOUT" caution and red "DUAL ENGINE OUT" warning, a red "EMER PWR ONLY" (emergency power only) warning crew alerting system message would have appeared as the aircraft lost primary power from the engine-driven generators at 1251:29L (Tab J-180). Most essential systems would have been restored automatically by the Ram Air Turbine (RAT, a wind-driven alternate source of hydraulic and electrical power) within 20 seconds of generator loss based on aircraft logic (Tab J-83).

In addition, the loss of engines would have resulted in the gradual loss of cabin pressure and a red "CABIN ALT" warning crew alerting system message (Tabs AA-33 and DD-14). Emergency procedures for the loss of pressure would accordingly direct the use of supplemental oxygen, and the MC's use of oxygen is inferred by Kabul Air Traffic Control (ATC) at 1258L (Tabs AA-33 and N-2). Simulations suggest that the warning would have occurred 5-6 minutes after the engine loss, which is consistent with Kabul ATC transcripts (Tabs DD-6 and N-2). The Board found no evidence to directly confirm the use of oxygen, but also found no evidence of hypoxia or other physiological issues.

(5) CHECKLIST ACTIONS

The MC twice announced to Kabul ATC that they had lost both engines, shortly after the initial event and again shortly prior to impact, at 1254:55L and 1307:36L, respectively (Tab N-1 to N-2). In addition, the DFDR did not resume operation, indicating that neither engine was restarted (Tab J-109).

The MC would have received multiple cautions and advisories, in addition to warnings for the red "DUAL ENGINE OUT" and red "EMER POWER ON" warning crew alerting system messages (Tab Z-13 to Z-17). However, once the red "DUAL ENGINE OUT" warning crew alerting system message was displayed at approximately 1252L, the DUAL ENGINE OUT checklist should have taken priority over other checklists (Tab DD-14). The evidence indicates that the MC ran the DUAL ENGINE OUT checklist, with some deviations that are consistent with potential perceptions and conclusions about the status of the engines (Tab DD-14).

Of note, the MC held a higher airspeed than the 200 knots initially directed by the checklist (Tabs AA-3, J-48 and DD-14). The checklist later directs descent and eventual acceleration for a windmill airstart. Thus, the MC may have prioritized these actions over glide speed and distance (Tab AA-3). The MC delayed starting the Auxiliary Power Unit (APU) (Tab J-181). This may have been due to prioritizing an immediate windmill airstart, which would require 258 knots once the MC was in the airstart envelope (Tab AA-4). Eventually, the APU was started, indicating the MC likely later used it in an attempted Auto Turbine Start (ATS-)-assisted airstart (Tab J-181 and DD-15).

The airstart procedures in the DUAL ENGINE OUT checklist direct the start of both engines, but the MC may have concluded that the right engine suffered damage and therefore only elected to airstart the left engine (Tab AA-23). Not airstarting a damaged engine would be consistent with specific stipulations in the E-11A Single Engine Procedures Checklist (Tab AA-21).

(6) AIRSTART ATTEMPTS

The need to attempt an airstart would be evident to the MC, and the checklist directs an engine airstart (Tab AA-4). In their contact with Kabul ATC, the MC declared that they intended to proceed to KAF, which was well outside the E-11A glide capabilities, a fact known to the MC (Tab V-26.9). This intent suggests that the MC was confident of airstarting one or both engines, and is consistent with a prior discussion in which MP1 stated that he was confident in being able to airstart an engine if he encountered engine loss (Tab V-3.10).

Hydraulic power was provided to the flight controls after the dual engine out condition, consistent with the capabilities of the RAT and demonstrated by the MA's controlled flight path (Tab Z-5). Glide time for the aircraft's weight from 30,000 feet is approximately 12 minutes, using conservative estimates for terrain height (Tab AA-31). Once airstart is attempted on an engine, initial relight is expected within 15 seconds, with additional time to stabilize if the relight is successful (Tab AA-4 and AA-8). With time available in controlled flight, it is assessed that the MC attempted several restarts. The airspeed and later use of the APU suggest that both windmilling and APU-assisted airstarts were attempted (Tab DD-7, Tab J-181).

The Rolls Royce engines on the E-11A are highly reliable and have demonstrated airstart capability in several flight test scenarios (Tab J-29 to J-30). While the MC would have waited, in accordance with the checklist, to 30,000 feet to attempt an airstart, an airstart of the right engine should have been successful, whether accomplished with windmilling airspeed or with the assistance of the APU (Tab J-36). However, airstarts of the left engine would have failed due to the original damage (Tab J-35). There is no DFDR data to definitively confirm whether an engine airstart attempt was made (Tab J-36).

(7) DIVERTS

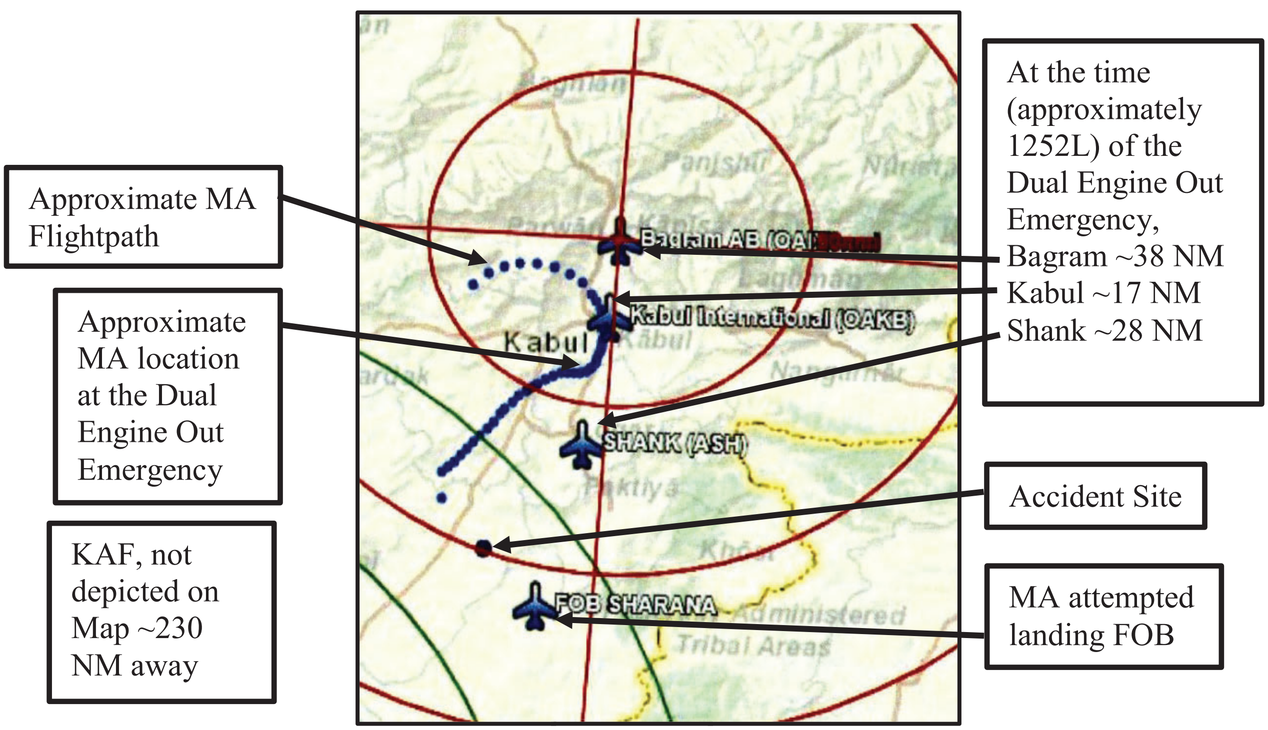
Performance data indicates, and simulation confirms, that for approximately three to five minutes after the initial event the MC could have glided to and landed at Bagram or Kabul airports, respectively (Tab DD-16). For approximately eight minutes, the MC could have glided to FOB Shank (Tab DD-16). Even if the MC realization of the dual engine out emergency was delayed until their radio call to Kabul ATC at 1254:55L, when they announced "…Mayday, Mayday, Mayday … it looks like we have an engine failure on both motors, we are proceeding direct to Kandahar at this time," the MC had two minutes to glide to Kabul and five minutes for FOB Shank (Tab DD-16, Tab N-1).

After experiencing the catastrophic loss of the left engine the MA turned briefly westward, then back to a southwest heading toward KAF about one minute after the dual engine out emergency, consistent with the MC's declaration to ATC (Tab N-1). Later in the sequence, at 1303:30L, the

MC announced to ATC that they were going to land at FOB Sharana (Tab N-2). Specifically, at 1304:15L, the MC tells Kabul ATC that "…looks like we're heading to Sharana..." (Tab N-2). By this point, the MA's altitude and glide performance were insufficient to reach FOB Shank (Tabs DD-7 and AA-31).

While the MA's capabilities can be established, the MC's knowledge of landing options can only be inferred indirectly. Consistent with the MC's announced intentions, many squadron pilots agreed that there was a strong preference for returning to KAF rather than landing at another airfield (Tab DD-15). However, Bagram and Kabul were routinely briefed by aircrews as a group of divert fields, to be used if KAF was unavailable (Tab DD-15). Discussion of emergency fields or scenarios where a crew might be forced to land with both engines out was rare (Tabs DD-15 and DD-17).

Even with the loss of both engines, backup E-11A systems would have allowed the MA to be controlled through an emergency landing. Additionally, both performance data and flight simulation profiles suggest that a divert to another airfield was still possible after the dual engine emergency (Tabs DD-6 to DD-7). However, the probability of a successful dual engine out landing cannot be determined, since it has never happened, and the MC would have had to accomplish a divert procedure not executed for at least several months prior to the mishap (Tab V-26.14). The MC would need to alter the flight plan, accomplish normal, emergency and divert checklists,



Tab Z-4

initiate communications, and manage their descent and routing to arrive at the divert airfield in a position to land without thrust to correct any miscalculations (Tab AA-37 to AA-42) .

e. Impact

At approximately 1309L, the MA impacted the ground approximately 21 NM short of Sharana, on a heading of roughly 140 degrees, consistent with a direct flight path towards Sharana (Tab S-79) The terrain was unpopulated, largely flat, and covered in snow (Tabs S-79 and S-15 to S-21). The wings show the slats out and the flaps appear to be extended, suggesting that the aircraft had been configured for, and presumably slowed for, landing (Tab S-23 to S-27). It is likely that the MC attempted to make a forced landing (Tab S-23 to S-27).

While the terrain was largely flat, the MA impacted berms and ditches, roughly estimated between 3-6 feet high (Tabs S-85 and S-93). Weather at Sharana was reported to have 1000 foot ceilings, and pilot testimony confirms approximately 1000 foot ceilings in the vicinity of the accident site (Tabs F-17 and V-19.4). Accordingly, the MC may have had less than a minute to maneuver after exiting the clouds and seeing the terrain (Tab AA-31). It appears that while the MA touched down, it impacted a smaller berm almost immediately, then more completely impacted the ground and skidded to a halt in approximately 340 meters (Tab S-79). During this time the wings were ripped from the MA, and subsequently much of the cockpit and cabin were destroyed by fire (Tabs S-79 and Tab S-9 to S-21).

f. Egress and Aircrew Flight Equipment (AFE)

USAF Aircrew Flight Equipment from the MA, consisting only of backpack survival kits, was not recovered but is not considered material to the mishap sequence (Tab DD-17). The E-11A's integrated emergency oxygen mask, discussed previously, was not recovered (Tab DD-17).

g. Search and Rescue (SAR)

At approximately 1309L, the MA's Emergency Locator Transmitter (ELT) activated (Tab J-72). A-10's in the area were diverted to the search area and began to try to locate the MA/MC (Tab DD-8). The MA was located; however, weather obscured the area preventing a recovery the day of the mishap (Tab DD-3 and DD-8). The recovery of remains occurred the next day 28 January 2020 (Tab DD-8). The recovery team also recovered the CVR (Tab DD-8). Subsequently, a second team was tasked to recover the DFDR. The MA was destroyed in place by U.S. assets (Tab DD-8).

h. Recovery of Remains

A recovery team arrived at the crash site on 28 January 2020 at approximately 1430L (Tab DD-3). After scene clearance from Explosive Ordanance Disposal, the recovery team collected the remains of the MC (Tab DD-3 and DD-8). The remains were brought back to the KAF medical facility (Tab G-4). Mortuary affairs transferred the remains to Dover AFB (Tab DD-8).

5. MAINTENANCE

a. Forms Documentation

Northrup Grumman (NG) maintained the MA and used its own forms for tracking maintenance, discrepancies, inspections or status (Tab D-1 to D-2938). Specifically, NG maintained standardized corporation generated Status Reports, History Reports, Flight Briefs, Daily inspection Logs and Maintenance Logs for tracking maintenance on the MA and all documentation was in order (Tab D-1 to D-2938).

b. Scheduled Maintenance (Inspections)

The MA's last major inspection was a recurring 4500-hour inspection that was complied with as scheduled on 13 January 2020 by an Airframe and Powerplant (A&P) certified NG employee (Tab D-700). The last documented daily aircraft inspection was conducted on 26 January 2020 and at that time there were no aircraft discrepancies identified (Tab D-1159 to D-1162). The daily inspection on 27 January 2020 was conducted, documented, and with the MC on the MA (Tab V-9.5). The AIB found no evidence to indicate that maintenance inspections were a factor in the mishap (Tab D-4 to D-817 and D-1053 to D-1162).

c. Maintenance Procedures

In the 24 hours prior to the mishap two daily inspections were performed. They both included left and right engine intake inspections (Tabs D-1159 to D1162, V-9.5, and V-24.5 to V-24.7). They were completed by two separate NG mechanics and verified by Quality Assurance (Tabs D-1052, D-1159 to D-1162, V-9.5, V-20.3 to V-20.4 and V-24.5 to V-24.7). The inspectors did not identify any notable discrepancies with the MA or engines prior to the mishap (Tab D-1052 and D1159 to D-1162). The AIB found no evidence to indicate that maintenance procedures were a factor in the mishap (Tab D-1 to D-2938).

d. Maintenance Personnel and Supervision

NG employees performed all base-level maintenance on the MA (Tab D-1 to D-2938). All employees responsible for maintaining the MA were Federal Aviation Administration (FAA) certified Airframe and Powerplant (A&P) technicians (Tab V-20.6). NG supervision and quality control measures for its assigned personnel and maintenance practices were found to be satisfactory (Tab V-20.3 to V-20.6). The AIB found no evidence to indicate that maintenance personnel and supervision were a factor in the mishap (Tab V-14.5 to V-14.9 and V-20.3 to V-20.6).

e. Fuel, Hydraulic, and Oil Inspection Analyses

Due to the hostile environment of the mishap site, hydraulic and oxygen samples were not recovered from the MA. A fuel sample from the truck that last serviced the MA was analyzed by Air Force Petroleum Office (AFPET) Laboratory, and the results indicated that it was a JP-8 type fuel with no detectable volatile contamination (Tab D-992 to D-994). An engine lubricating oil sample was extracted from the MA and analyzed by AFPET Laboratory which confirmed that that the oil sample was consistent with the standard grade MIL-PRF-23699-STD (Tab D-989 to D-991). The AIB found no evidence to indicate fuel, hydraulic, oil or oxygen systems or contamination to be a factor in the mishap (Tab D-989 to D-994).

f. Unscheduled Maintenance

A comprehensive review of all discrepancy records maintained by NG showed several unscheduled minor and unrelated maintenance actions since the last major inspection (Tab D-1348 to D-2938). The AIB found no evidence to indicate a relationship between the unscheduled maintenance performed and the mishap (Tab D-1348 to D-2938).

6. AIRFRAME SYSTEMS

a. Structures and Systems

(1) LEFT ENGINE CONDITION

The left engine catastrophically failed in flight due to a first stage fan blade separation (Tabs J-11, L-91, and S-49 to S-57). Prior to the fan blade separation event at 1250:52L, there were no signs of abnormal operation (Tab J-11). The event was heard on the CVR audio file and the DFDR information showed parameters indicative of normal left engine shutdown with the exception of unreliable N1 vibrations and N1 (fan RPM) (Tabs J-179 and L-91 to L-113). Specifically, within five seconds of the left engine catastrophic failure, the N1 (fan RPM) dropped to 7.6% then spiked to an unreliable 255.9% where it remained until the DFDR ceased recording (Tabs J-179 and L-91). The fan blade separation unbalanced the N1 turbofan, and as designed the unbalanced fan damaged the associated speed probe (Tab J-11). This made N1 (fan RPM) data unreliable which in turn caused the FADEC to initiate an automatic engine shutdown, autothrottle disengagement and amber "**L FADEC FAIL**" caution, and cyan "**ENG SYNC FAIL**" advisory crew alerting system messages on the EICAS display (Tab J-179 and J-11). The unreliable vibration reading would have caused the EICAS to display N1 vibration readings below the oil pressure indication, and for the remainder of the DFDR recording the left engine displayed an amber "--"(Tab J-179).

Within 10 seconds of the event, the left engine throttle lever was reduced by the MC from 36 to 14 degrees where it remained for one second before its position was advanced five times in the remaining 29 seconds of DFDR information (Tab DD 12 to DD-13). The left engine run switch in the crew compartment was not placed in the "off" position at any time during the DFDR data (Tab J-11).

The MC would not receive an amber "**L ENG FLAMEOUT**" caution crew alerting system message on the EICAS display until engine N2 (core RPM) fell below 35% which did not happen prior to the DFDR cutout at 1251:29L (Tab J-179). Based on trend data, it is estimated that the engine N2 (core RPM) would have fallen to 35% at 1252L at which time the EICAS would display an amber "**L ENG FLAMEOUT**" caution crew alerting system message followed by a red "**DUAL ENGINE OUT**" warning crew alerting system message due to the MC initiated right engine shutdown (Tab J-180). There is no DFDR data to validate whether or not a left engine airstart attempt was made; however, the applicable checklists would have directed an airstart attempt (Tab AA-3 to AA-15). Attempts to airstart the left engine would have been aborted by the

FADEC due to the damaged N1 (fan RPM) probe (Tab J-35). Post-mishap photos of the left engine showed a missing fan blade with no evidence of damage to the exterior or rear of the engine (that would be consistent with damage caused by the fan blade exiting the engine) (Tab S-49 to S-63).

(2) RIGHT ENGINE CONDITION

The right engine was functioning within its designed parameters with no faults throughout the duration of reliable DFDR data and should have continued to operate normally if it was not MC initiated shutdown (Tab J-35). Following the left engine catastrophic failure, the right engine started to display N1 vibration data below the oil pressure indication (Tab J-179 and J-35). All operating parameters to include N1 vibration displayed on the EICAS display for the right engine were within limits and would have been displayed in green (Tab J-179 and J-35). Within 10 seconds of the left engine catastrophic failure, the throttle was reduced from 36 degrees to 14 degrees where it remained for four seconds until it was further reduced to zero degrees (Tab DD-12 to DD-13). At 1251:16L, 24 seconds after the left engine catastrophic failure, the right engine run switch was placed in the "off" position and the EICAS would have displayed a white "**R ENG SHUTDOWN**" status crew alerting system message (Tabs J-180, L-99 and Z-17). This indicates that the MC intentionally shut down the right engine (Tab J-180). The checklists only direct a shutdown of a damaged engine therefore it is logical to assume that the MC believed the right engine was the damaged engine (Tab AA-23). The right engine run switch was not moved from the "off" position to "on" for the duration of available DFDR data (Tab DD-13). DFDR information remains reliable for 13 seconds after the right engine shutdown and operating parameters indicate normal right engine shutdown (Tab DD-13). At 1251:24L, five seconds prior to the loss of DFDR data, both the left and right engine throttles are advanced to 40 degrees; however, the right engine run switch remained in the "off" position and the engine does not respond (Tab DD-13). There is no DFDR data to validate whether or not a right engine airstart attempt was made; however if the MC believed the right engine was damaged, they likely would not have attempted to restart it. All evidence indicates that it should have been capable of airstart (Tab J-36 and J-39). Post-mishap there is no apparent evidence of major mechanical damage (Tab J-39).

(3) FLIGHT CONTROLS

The DFDR information indicates that flight controls were functioning properly and auto-pilot was enabled throughout the duration of valid data (Tab DD-12).

(4) DIGITAL FLIGHT DATA RECORDER

The DFDR stores 25 hours of flight data (Tab J-109). It begins recording when aircraft power is turned on and an engine is started (Tab J-109). The DFDR will cease recording when both engines stop operating due to loss of electrical power from the generators (Tab J-109). DFDR data ends at 1251:29L (Tab J-180).

(5) COCKPIT VOICE RECORDER

The CVR design incorporates an impact switch to cut power to the unit in the event of an aircraft mishap for data preservation (Tab J-177 to J-178). CVR data ends at 1250:52L due to the impact switch being triggered by airframe vibrations following the catastrophic left engine failure (Tab J-177 to J-178).

(6) RAM AIR TURBINE (RAT)

The MA was under positive control indicating the RAT deployed and functioned as designed (Tab M-2). The RAT is normally stowed on the lower right side of the aircraft behind the nose (Tab J-83 to J-84). It incorporates a ram air driven pump and generator to provide emergency electric and hydraulic power in the event of total power loss or dual engine out (Tab J-83 to J-84). The RAT would be automatically deployed within 14 seconds following a loss of power and would begin to supply essential systems within six seconds (Tab J-83). If deployed at the time of impact the RAT would most likely separate early in the wreckage trail (Tab J-72). It can only be stowed from the ground and is not visible in video or photo evidence of the MA's final resting position indicating it was deployed during flight (Tabs J-72, J-83, and Z-7 to Z-10).

(7) AUXILIARY POWER UNIT (APU)

The auxiliary power unit is a single shaft, self-contained turbine engine that provides pneumatic and electrical power to the aircraft (Tab J-85). Photographs from the MA wreckage show that the auxiliary power unit intake door was open, indicating that it was operating at the time of impact (Tabs J-181, S-5 and S-9). ATC recordings of the MA transponder's outputs were evaluated, and it was determined that the APU was not operating above an altitude of approximately 28,300 feet (Tab J-181). This indicated the APU was started somewhere between 28,300 feet and the ground (Tab J-181).

b. Evaluation and Analysis

The AIB found no evidence that any results of evaluation and analysis were a factor in the mishap.

7. WEATHER

a. Forecast Weather

Kandahar Airfield, Bagram Airfield and Kabul International Airport, were forecasted with ceilings and visibility at or above 2,000 feet altitude above the ground and three NM, respectively (Tab F-13-15). FOB Shank was forecast with a ceiling of 3,000 feet altitude above the ground and visibility of 2400 meters (Tab F-16). Intermediate clouds were forecast in the vicinity of these airfields and the MA's orbit (Tab F-5 to F-7).

b. Observed Weather

Weather at the airfields listed above was at or better than forecast (Tab F-13 to F-15). Weather at FOB Sharana on the day of the mishap was reported as cloudy and overcast at 1,000 feet altitude (Tab F-17). Visibility was reported at 4,000 meters and light rain showers with snow was reported as well (Tab F-17). Post-mishap weather was unfavorable for recovery operations due to a low cloud layer (Tabs DD-8 and V-28.13).

c. Space Environment

Not applicable.

d. Operations

Weather at FOB Sharana was reported to have 1000 foot ceilings, and pilot testimony confirms approximately 1000 foot ceilings in the vicinity of the accident (Tab F-17 and Tab V-19.4). Accordingly, given the MA's glide performance, the MC may have had little time to adjust their landing vector after exiting the weather and seeing the terrain (Tab AA-31).

8. CREW QUALIFICATIONS

a. Mishap Pilot 1 (MP1)

MP1 was a current and qualified instructor and evaluator pilot in the E-11A at the time of the mishap (Tab G-180). MP1 had a total of 4736.9 military flying hours of which 1053.3 hours were in the E-11A (Tab G-168 to G-169). He also flew the KC-10, RQ-4, MC-12 and T-1 (Tab G-168). MP1 had 1022.6 combat hours, and 504.2 instructor hours in the E-11A (Tab G-168 to G-169). He obtained his initial E-11A mission qualification on 11 November 2017 as annotated on the AF Form 8, *Certification of Aircrew Qualification*, and subsequently requalified on 1 September 2019 (Tab G-94, G-96, and DD-16). His initial E-11A instructor pilot qualification was on 26 December 2017 (Tab G-94, G-96, and G-100).

Recent flight time is as follows:

MP1	Hours	Sorties
30	97.3	11
60	168.2	19
90	233.5	27

b. Mishap Pilot 2 (MP2)

MP2 completed ground and flight training with a subcontractor of the Northrop Grumman System Corporation on 10 November 2019, and he received his basic qualification in E-11A on 17 January 2020 (Tab G-103 and G-163). He completed his first two Mission Qualification Training (MQT) sorties and was on his third MQT sortie in the E-11A at the time of the mishap (Tab R-1.6). MP2 had a total of 1343.5 military flying hours of which 27.6 hours were in the E-11A (Tab G-165 to G-166). MP2 had 27.6 combat hours (Tab G-165 to G-166). To note, MP2 had 755.1 instructor pilot hours in the T-6 and a total of 721 sorties (Tab G-165 to G-166). MP2 also had 127.4 hours in the B-1 (Tab G-165 to G-166).

Recent flight time is as follows:

MP2	Hours	Sorties
30	27.6	3
60	27.6	3
90	27.6	3

c. Detailed E-11A Training

(1) Overview

The E-11A initial training program is accomplished by CAE, a civilian company, in Dallas, Texas (Tab R-12.5 to R-12.7). Mission Qualification Training is completed in AFG, in conjunction with operational missions (Tab R-12.5 to R-12.7). Both pilots completed the initial training as stated above (Tab DD-16). Dual engine out recovery/landing scenarios are not practiced as part of the formal syllabus, though some E-11A pilots reported accomplishing them outside the syllabus (Tabs V-3.7, V-6.8, V-11.8, and V-22.7). Further, dual engine out scenarios were considered by many pilots to be improbable and were not frequently discussed (Tabs V-3.8, V-7.7, V-22.7, V-25.14, and V-26.10).

(2) Divert Checklist

The divert checklist was last updated on 4 January 2020 (Tab AA-37). It states divert procedures for Bagram and Kabul and would have been available (Tab AA-37 to AA-38). Further, those airfields were routinely briefed as diverts and the MC received weather and NOTAMs concerning their status before the flight (Tab R-10.6).

(3) Single Engine Out & Restart Procedures

The initial civilian training described above emphasizes single engine procedures, as does the initial checkride (Tab DD-16). Both MP2 and MP1 trained on engine failure, shutdown and restart procedures (Tab DD-16).

9. MEDICAL

a. Qualifications

At the time of the mishap, MP1 and MP2 were medically qualified for flight duty (Tab G-10 and G-12). A review of MP1 and MP2's medical records, records from Aerospace Information Management System (ASIMS) and Aeromedical Information Management Waver Tracking System (AIMWTS), did not show any discrepancies in health qualifications (Tab G-12 to G-13 and G-56 to G-81). MP2 had a valid and current aeromedical waiver approved by Headquarters Global Strike Command (Tab G-50 to G-54). MP1 and MP2 were current on all required medical examinations and had current DD 2992, *Medical Recommendation for Flying or Special Operational Duty*, valid through 13 Sep 2020 and 3 Mar 2021, respectively (Tab G-10 and G-135). There is no evidence that medical factors contributed to the mishap.

b. Health

MP1 and MP2 were in good health on the day of the mishap (Tab G-12 to G-13 and G-56 to G-81). There is no evidence that MC health was a factor in the mishap.

c. Pathology

Review of the autopsy report for MP1 showed the cause of death to be multiple injuries sustained during the mishap as well as thermal injuries (Tab X-2). Review of the post mortem toxicology was negative for any alcohol or illicit drugs (Tab X-2). Of note, there was temazepam (a commonly used sleep aid) and its byproduct, as well as fexofenadine (an antihistamine) and its byproduct, showing positive on the toxicology report (Tab X-2). MP1 was approved to use both medications in accordance with United States Air Force directives and Aerospace Medicine Approved Medications (Tabs G-12 to G-13, T-2 and BB-6). There is no evidence to suggest the above medications were relevant to the mishap.

Review of the autopsy report for MP2 showed the cause of death to be from multiple blunt force trauma injuries sustained during the mishap as well as thermal injuries (Tab X-2). Review of the post mortem toxicology report was negative for any alcohol or illicit drugs (Tab X-2). There were positive findings for acetaminophen, dextromethorphan, guaifenesin, and chlorpheniramine, all of which are common over the counter cough/cold medications approved for use by flight crews in duty status. (Tab X-2 and BB-6). There is no evidence to suggest the above medications were relevant to the mishap.

All maintenance personnel associated with the mishap provided samples for toxicology testing (Tab G-32 to G-48). All toxicology samples were negative (Tab G-32 to G-48).

There is no evidence to suggest toxicological substances were a factor in the mishap.

d. Lifestyle

The medical records, toxicology reports, and witness testimonies did not reveal any mishap-contributing lifestyle factors or unusual habits (Tab G-29 to G-30). There is no evidence to suggest lifestyle factors were a factor in the mishap.

e. Crew Rest and Crew Duty Time

United States Air Force pilots are required to have proper crew rest, as defined by AFMAN 11-202v3, *Flight Operations*, Chapter 3, prior to performing in-flight duties (Tab BB-3). Crew rest consists of a minimum 12-hour non-duty period before the designated flight duty period starts (Tab BB-3). During this time, aircrew may participate in meals, transportation, or rest which allows for the opportunity for at least eight hours of continuous sleep (Tab BB-3). MP1 and MP2 complied with crew rest and duty time requirements (Tab K-4).

10. OPERATIONS AND SUPERVISION

The squadron operated in three main shifts with five to six pilots per shift (Tab R-1.15). Most pilots generally flew two to three flights per week (Tab R-1.15). MP2 flew MQT-1 on 21 January 2020 and MQT-2 on 23 January 2020, respectively (Tab R-1.19). MP2's MQT performance was above average, in fact, he demonstrated knowledge of the aircraft systems, high situational awareness, asked great questions and was a great student (Tabs R-2.5 to R-2.6 and V-6.20). MP1 was a highly regarded evaluator and instructor pilot who demonstrated detailed instruction throughout the MS (Tabs N-5 to N-42 and Tab V-21.17). The MS was MP1 and MP2's first flight together and the flight briefing was attended by the Operations Supervisor (Tabs R-1.6 and R-10.6 to R-10.7).

11. HUMAN FACTORS ANALYSIS

a. Introduction

The Department of Defense (DoD) Human Factors Analysis and Classification System Version 7.0 (HFACS) defines potential human factors for assessment in a mishap (Tab BB-7). DoD HFACS are divided into four parts: acts, preconditions, supervision, and organizational influences (Tab BB-9 to BB-10). Without the CVR, it is difficult to fully assess the human factors and understand why certain decisions were made.

b. AE107 Rushed or Delayed a Necessary Action

HFACS code AE107 is a factor when an individual takes the necessary action as dictated by the situation but performs these actions too quickly or too slowly (Tab BB-11).

Based upon DFDR data, there were only 24 seconds between the catastrophic left engine failure and the shutdown of the right engine (Tab J-117). The civilian pilots in the Global Express event took approximately one to two minutes to specifically check engine indications and determine the failed engine prior to initiating shutdown (Tab DD-9). Additionally the same pilots' testimony demonstrates that auditory and sensory cues would have been significant and distracting. (Tab V-5.8 to V-5.9).

There is research in the aviation community that reviews the effects of startle. The FAA Advisory Circular, 4 January 2017, defines startle reflex as the uncontrollable, autonomic muscle reflex, similar to fight or flight, that is elicited by exposure to a sudden, intense event that violates a pilot's expectations (Tab G-21). It also identifies the startle response (surprise) is the reaction to an "unexpected event that violates a pilot's expectations and can affect the mental processes used to respond to the event" (Tab G-21). The startle reflex lasts up to 1.5 seconds, while the startle response lasts 30 seconds or more (Tab G-21).

c. AE206 Wrong Choice of Action During an Operation

HFACS code AE206 is a factor when the individual, through faulty logic or erroneous expectations, selects the wrong course of action (Tab BB-12).

Performance data indicates, and simulation confirms, that for approximately three to five minutes after the initial event the MC could have glided to and landed at Bagram or Kabul airports, respectively (Tab DD-16). For approximately eight minutes, the MC could have glided to FOB Shank (Tab DD-16). After experiencing the catastrophic left engine failure, the MA turned briefly westward, then back to a southwest heading toward KAF about one minute after the dual engine out emergency (Tab Z-3 to Z-5). Later in the sequence, at 1304:15L, the MC announced to Kabul ATC that they were going to land at FOB Sharana (Tab N-2). Even if the MC realization of the dual engine out emergency was delayed until their radio call to Kabul ATC at 1254:55L, based on simulation, the MC would have had two minutes to glide to Kabul and five minutes for FOB Shank (Tabs DD-16).

d. PC206 Overconfidence

HFACS code PC206 is a factor when the individual overvalues or overestimates personal capability, capability of others or the capability of aircraft/vehicles or equipment (Tab BB-17).

In their contact with Kabul ATC, the MC declared they would proceed to KAF, which was well outside the E-11A glide capabilities, a fact known to the MC (Tab V-26.9). This intent suggests that the MC were confident of airstarting one or both engines, and is consistent with a prior discussion in which MP1 stated that he was confident in being able to airstart an engine if he encountered engine loss (Tab V-3.10).

e. AE102 Checklist Not Followed Correctly

HFACS code AE102 is a factor when the individual, either through an act of commission or omission, makes a checklist error or fails to run an appropriate checklist (Tab BB-11).

The MC would have received multiple cautions and advisories, in addition to warnings for the red "DUAL ENGINE OUT" and red "EMER POWER ON" warning crew alerting system messages (Tabs DD-14 and DD-16). However, once the red "DUAL ENGINE OUT" warning crew alerting system message was displayed at approximately 1252L, the DUAL ENGINE OUT checklist should have taken priority over other checklists (Tab DD-14). The evidence indicates that the MC ran the DUAL ENGINE OUT checklist, with some deviations that are consistent with potential perceptions and conclusions about the status of the engines.

Of note, the MC held a higher airspeed than the 200 knots initially directed by the checklist (Tab DD-14). The MC also delayed starting the APU (Tab DD-15). This may have been due to prioritizing an immediate windmill airstart, which would require 258 knots once the MC was in the airstart envelope (Tab AA-4). The MC may have deviated regarding prescribed airstarts, but this cannot be directly confirmed (Tab DD-15).

12. GOVERNING DIRECTIVES AND PUBLICATIONS

a. Publically Available Directives and Publications Relevant to the Mishap

(1) AFI 51-307, *Aerospace and Ground Accident Investigations*, 18 March 2019 (Updated per AFI 51-307_AFGM2020-01, 26 February 2020)
(2) AFI 51-307 ACC Supplement, *Aerospace and Ground Accident Investigations,* 3 December 2019
(3) AFI 91-204, *Safety Investigations and Hazard Reporting*, 27 April 2018 (Updated per AFI 91-204_AFGM2020-01, 7 July 2020)
(4) AFMAN 11-202, Volume 3, *Flight Operations*, 10 June 2020 (Updated per AFMAN11-202V3_AFGM2020-01, 10 September 2020)
(5) AFI 11-301, Volume 1, *Aircrew Flight Equipment (AFE) Program*, 10 October 2017

NOTICE: All directives and publications listed above are available digitally on the Air Force Departmental Publishing Office website at: https://www.e-publishing.af.mil.

b. Other Directives and Publications Relevant to the Mishap

c. Known or Suspected Deviations from Directives or Publications

(1) *Bombardier Global Express Flight Crew Operating Manual* (Rev 80), 3 June 2014, pages 03-03-3 to 03-03-13, Dual Engine Out. As stated above, there were deviations known or possible from the prescribed airspeed, APU start, and directed airstart procedures (Tab DD-14 to DD-15).

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CRAIG R. BAKER, Brig Gen, USAF
President
Accident Investigation Board

STATEMENT OF OPINION

E-11A, T/N 11-9358
GHAZNI PROVINCE, AFGHANISTAN
27 JANUARY 2020

Under 10 U.S.C. § 2254(d) the opinion of the accident investigator as to the cause of, or the factors contributing to, the accident set forth in the accident investigation report, if any, may not be considered as evidence in any civil or criminal proceeding arising from the accident, nor may such information be considered an admission of liability of the United States or by any person referred to in those conclusions or statements.

1. OPINION SUMMARY

On 27 January 2020, at 1105 local time (L) an E-11A, tail number (T/N) 11-9358 (the Mishap Aircraft – MA), departed Kandahar Airfield (KAF), Afghanistan (AFG). The mishap crew (MC) were deployed and assigned to the 430th Expeditionary Electronic Combat Squadron (EECS). The MC consisted of mishap pilot 1 (MP1) and mishap pilot 2 (MP2) and it was their first flight together. The mission was both a Mission Qualification Training – 3 (MQT-3) sortie for MP2 and a combat sortie for the MC, flown in support of Operation FREEDOM'S SENTINEL. The mission was uneventful and flew as planned for the first one hour and 44 minutes.

At one hour and 45 minutes into the mission (1250:52L), the left engine catastrophically failed when a single fan blade separated and was ingested but contained within the left engine. This catastrophic failure produced a bang (heard in the cockpit) as recorded by the Cockpit Voice Recorder (CVR) and produced aircraft vibrations as recorded by the Digital Flight Data Recorder (DFDR). As such, the left engine computer, known as the Full Authority Digital Electronic Control (FADEC), after sensing an unreliable signal from the fan Revolutions Per Minute (RPM) sensor (N1), initiated shutdown of the left engine. This was translated to the MC on the Engine Indication and Crew Alerting System (EICAS) display by an amber "**L (Left) FADEC FAIL**" caution crew alerting system message, and changes to left side engine instruments. Additionally, the amber Master Caution light on the glareshield came on (about MC eye level). Due to MA vibrations and CVR design, the CVR stopped recording at the bang (1250:52L) and never recorded again.

In analyzing the situation, the MC improperly assessed that the right engine (not the left engine) had failed and/or been damaged. Consequently, the MC initiated shutdown of the right engine leading to a dual engine out emergency (because the left engine was automatically shut down by the FADEC). This action would have triggered a white "**R (Right) ENG SHUTDOWN**" status crew alerting system message on the EICAS display. Subsequently, a red "**DUAL ENGINE OUT**" warning crew alerting system message on the EICAS display and a red Master Warning light on the glareshield would have appeared approximately 30 seconds later, when the flameout threshold triggered these warnings (approximately 1252L). Of note, a dual engine generator loss causes the DFDR to stop recording. In this case, since one engine failed and the other was shutdown, the DFDR stopped recording (1251:29L) and never recorded again.

At the point of the dual engine out emergency, the MA's position was approximately 38 nautical miles (NM) from Bagram Airfield, 17 NM from Kabul International Airport, 28 NM from Forward Operating Base (FOB) Shank, and 230 NM from KAF. Each location, with the exception of an intermediate cloud layer, had observed ceilings and visibility at or above 2,000 feet altitude above the ground and three NM respectively. Otherwise, there was no significant weather and therefore, the weather would have permitted for a safe landing. However, the MC attempted to fly the MA back to KAF as evidenced by the following MC initiated radio call to Kabul Air Traffic Control (ATC) at 1254:55L: "…Mayday, Mayday, Mayday…it looks like we have an engine failure on both motors, we are proceeding direct to Kandahar at this time…"

Evidence shows that neither engine airstarted to provide any usable thrust. This resulted in the MA unable to glide the distance remaining to KAF. Additionally, the MA eventually flew outside of gliding distance to Bagram Airfield, Kabul International Airport, and FOB Shank, demonstrated through flight simulator profiles.

With few options remaining, the MC maneuvered the MA towards FOB Sharana, but did not have the altitude and airspeed to glide the distance remaining. The MC attempted landing in a field approximately 21 NM short of the Sharana FOB, but the MA was significantly damaged upon touchdown, coming to rest approximately 340 meters from the touchdown point. MP1 and MP2 were fatally injured as a result of the accident and the MA was destroyed.

The Accident Investigation Board (AIB) President found by a preponderance of the evidence that the cause of the mishap was the MC's error in analyzing which engine had catastrophically failed (left engine). This error resulted in the MC's decision to shutdown the operable right engine creating a dual engine out emergency.

The AIB President also found by a preponderance of the evidence that the MC's failure to airstart the right engine and their decision to recover the MA to KAF substantially contributed the mishap.

I developed this section through evidence, and determined the mishap sequence of events by analyzing factual data from the CVR and DFDR, video animation, engineering analysis, testimonies, simulation of the mishap sequence and MC options, information provided by technical experts, the Bombardier Global Express Flight Crew Operating Manual Volume 1 (FCOM) and checklists, and Air Force directives and guidance. I note with concern that the stoppage of CVR and DFDR recordings for the majority of the mishap sequence denied the board direct evidence of certain events.

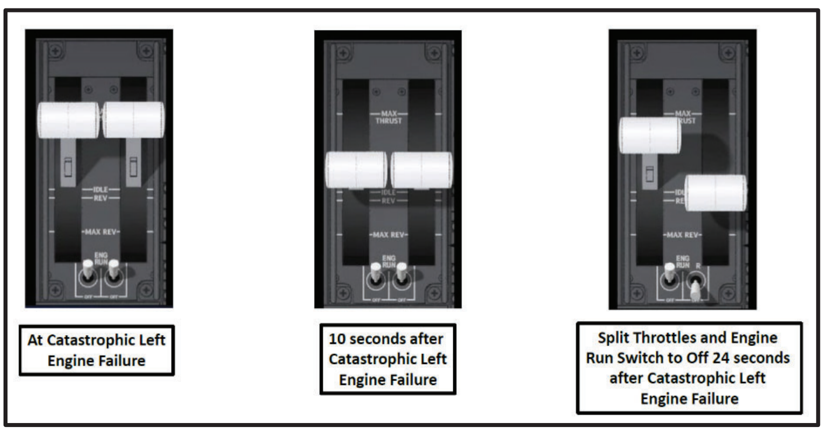
2. CAUSES

a. Error in Analyzing which Engine had Catastrophically Failed (The Left Engine)

Evidence suggests that an error in analysis resulted in the MC shutting down the operable right engine instead of the catastrophically failed left engine. The analysis could have included throttle movements, cockpit display information and aircraft vibration (sensation). The total time from the catastrophic left engine failure to the MC initiated right engine shutdown was 24 seconds as reported by the DFDR, suggesting insufficient time to properly analyze the situation. The pilot in command (flying a civilian Global Express equivalent to the E-11A), who had a very similar experience with catastrophic left engine failure caused by a fan blade separation, stated that his crew took 1-2 minutes to shut down the left engine. However, his testimony also demonstrated that due to the auditory and sensory cues, the MC may have perceived that the emergency dictated minimal response time (this testimony referred to hereafter Global Express event).

(1) THROTTLE MOVEMENTS

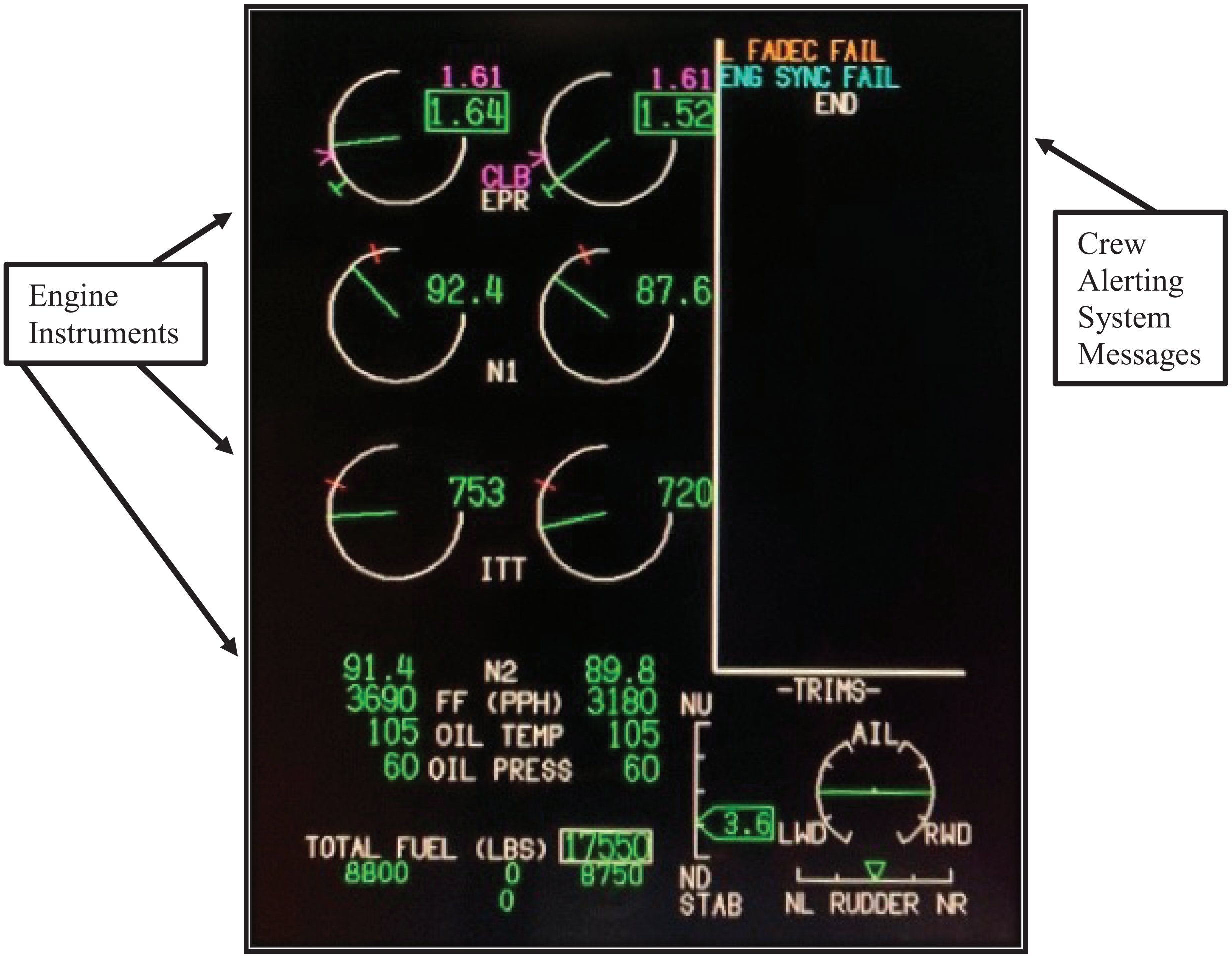
Ten seconds after the catastrophic left engine failure, the MC retarded both throttles to just less than half way (14 degrees; total throttle range is from 0 – 40 degrees) for one second, then slightly advancing the left throttle separately (26 degrees) for one second, then retarding it to align with the right throttle (both at 16 degrees) for one second, and finally splitting the throttles to advance the left throttle (to 31 degrees) while retarding the right to idle (0 degrees). Nine seconds after moving the right throttle to idle, the MC placed the right engine run switch to off (moving the throttle to idle before switching the engine run switch to off is a FCOM checklist procedure when it is a crew initiated engine shutdown), effectively shutting down the right engine. See Figure **Tab Z-12**, which is a representative image of the throttles and engine run switch panel. Because of the minimal time spent in each throttle position, the above throttle movements could not be used reliably to assess engine response.



Tab Z-12 (Simulated)

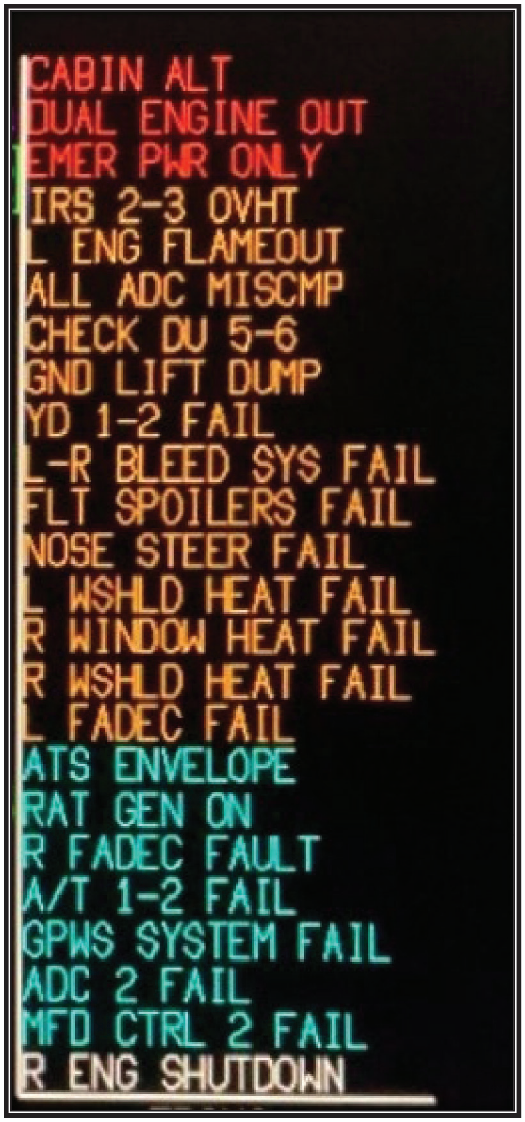
(2) FAULT AND ENGINE INSTRUMENT DISPLAYS

The E-11A's EICAS displayed an amber "L FADEC FAIL" caution crew alerting system message with an amber Master Caution light on the glareshield concurrent with the FADEC shutdown of the left engine (a consequence of the L FADEC FAIL message). Figure **Tab Z-13** depicts a representative image of the EICAS display and shows crew alerting system messages 1-2 seconds after the catastrophic left engine failure and the FADEC-directed engine shutdown. Importantly, the engine instruments do not reflect those of the MA and may differ.



Tab Z-13 (Simulated)

In the first 24 seconds after the catastrophic left engine failure, the EICAS crew alerting system display did not necessarily suggest an engine failure. However, when the MC initiated shutdown of the right engine, it would have triggered an immediate white "**R ENG SHUTDOWN**" status crew alerting system message. Then, once the left engine RPM decreased below 35% (approximately 30 seconds after the right engine shutdown), an amber "**L ENG FLAMEOUT**" caution crew alerting system message would have been displayed followed by a red "**DUAL ENGINE OUT**" warning crew alerting system message, and a red Master Warning light (approximately 1252L). Of note, other EICAS crew alerting system messages would have been displayed, but are not important in this analysis of determining the affected engine. Figure **Tab Z-16** depicts a representative image of the crew alerting system part of the EICAS display and the crew alerting system messages showing the right engine shutdown, dual engine out, and left engine flameout messages indicating a dual engine out emergency.



Tab Z-16 (Simulated)

If the first EICAS crew alerting system messages, i.e. "**L FADEC FAIL**" were not indicative of an engine failure, then one of the three digital round dial engine instruments (N1 (fan RPM)) on the EICAS display (See Figure **Tab Z-13** for what notional engine instruments look like) may have also caused confusion. The left engine N1, within five seconds of the left engine catastrophic failure, dropped to 7.6% then spiked to an unreliable 255.9% where it remained until the rest of the DFDR recording (1251:29L). Notably, pilot testimony suggests that the FADEC failure message combined with erratic engine instrument displays could have been perceived by the MC that the left engine instruments were unreliable/failed. However, the remaining two digital round dials Engine Pressure Ratio (EPR) and Inter Turbine Temperature (ITT), and the digital readouts

Fuel Flow (FF), N2 (RPM core), and oil pressure decayed predictably given the left engine failure. Finally, N1 vibration (not normaly displayed but would have appeared at the bottom of the digital readouts and below the oil pressure digital readout) would have been amber dashes indicating unreliable N1 information. The right engine instruments, based on engine parametric data and the DFDR, would have read normally.

(3) AIRCRAFT VIBRATION

Aircraft vibration started three seconds after the catastrophic left engine failure and continued until the DFDR failed (1251:29L), although it reduced 27 seconds (coincident to the right engine shutdown) after beginning. Parametric data and the Global Express event suggested this would have felt like the aircraft shaking (sometimes violently) with accelerations up and down, and left and right (Of note, the E-11A vibrations were 25% greater as compared to the Global Express event). The Global Express event pilot in command also stated that he could not determine which engine had failed based on aircraft vibration and sensation alone. For the left and right accelerations, analysis indicates that the nose of the aircraft would have yawed to the left initially, but then rapidly right when the left throttle was moved up from 14 degrees to 26 degrees and then back down to 16 degrees. This analysis suggests that the sensation the MC felt with the throttle movement may have factored in their decision thinking the right engine had failed. Additionally, the reduced vibration following the right engine shutdown may have been interpreted by the MC as confirmation that the correct engine was shutdown.

(4) HUMAN FACTORS AND TRAINING

Two human factors could have contributed to the MC's hurried decision making: startle reflex and response (reflex lasts up to 1.5 seconds, while startle response lasts 30 seconds or more). Startle response (surprise) is the reaction to an "unexpected event that violates a pilot's expectations and can affect the mental processes used to respond to the event." The E-11A initial training program in Dallas, TX, done prior to the deployment to AFG, emphasizes single engine procedures, and specifically single engine failure shutdown and airstart procedures. Dual engine out procedures are not practiced as part of the formal syllabus, though some E-11A pilots reported accomplishing them outside the syllabus. Finally, dual engine out procedures leading to to an engine-out landing were considered by many pilots to be very unlikely and were not frequently discussed.

(5) CAUSAL CONCLUSION

Although crew alerting system messages may have been limited at first and the N1 RPM erratic, the remaining engine instruments would have indicated that the amber "**L FADEC FAIL**" caution crew alerting system message was in fact coinicident with a left engine shutdown. The EPR at minimum value, and the continued decay of oil pressure and ITT, the lack of fuel flow, and the eventual illumination of the amber "**L ENG FLAMEOUT**" caution crew alerting system message would have made this clear within approximately a minute after the left engine fan blade separation. The MC's initiated rapid throttle movements could not have been used reliably to assess engine response. Finally, MA vibrations and MC sensations (after the bang), with the human factor startle response, may have convinced the MC to react immediately (because of potential catastrophic aircraft damage), and prevented them from recognizing the exact condition of the left engine, and instead to conclude that the right engine should be shutdown.

3. SUBSTANTIALLY CONTRIBUTING FACTORS

a. No Engine Airstart Achieved

The E-11A FCOM checklist procedures direct the attempt to airstart both engines after a dual engine out emergency. It is inconclusive whether one or both engines attempted airstart, however, the Auxiliary Power Unit (APU) door was open at the accident site confirming the MC started the APU, consistent with airstart procedures. Additionally, the FADEC would have prevented left engine airstart. The E-11A uses two methods to airstart an engine: the windmill airstart and the Air Turbine Starter (ATS)-assisted airstart. For the windmill airstart, the aircraft uses air flow generated from airspeed to turn the fan and core sections of the engine, and airstart is attempted once fuel flow and ignition are enabled through the FADEC by turning on the engine run switch (crew initiated). The FCOM-specified windmill airstart envelope is at or below 30,000 feet altitude and at or above 250 knots indicated airspeed. For the ATS-assisted airstart, the APU (or bleed air from the other engine if functioning properly) is the air source to turn the fan and core sections of the engine, and airstart is attempted once fuel flow and ignition are enabled through the FADEC by turning on the engine run switch. The FCOM-specified ATS-assisted airstart envelope is at or below 30,000 feet altitude and below 250 knots indicated airspeed. Each envelope (one or the other) would have been displayed to the MC on the EICAS display. Once either airstart is attempted, it takes an average of 90 seconds until usable thrust is reached. Of note, the aircraft APU envelope is at or below 37,000 feet altitude at any airspeed.

Evidence suggests and flight simulation profiles demonstrate that the time the MA was at or below 30,000 feet in either the windmill or the ATS-assisted airstart envelope was approximately 14 minutes. As long as the engine run switches were on (directed in the FCOM DUAL ENGINE OUT checklist), there is a high probability that a right engine airstart should have occurred. It is possible, that if the MC initially assessed the right engine as having suffered structural damage, they may have concluded not to attempt to airstart it.

b. MC Decision to Recover the MA to KAF

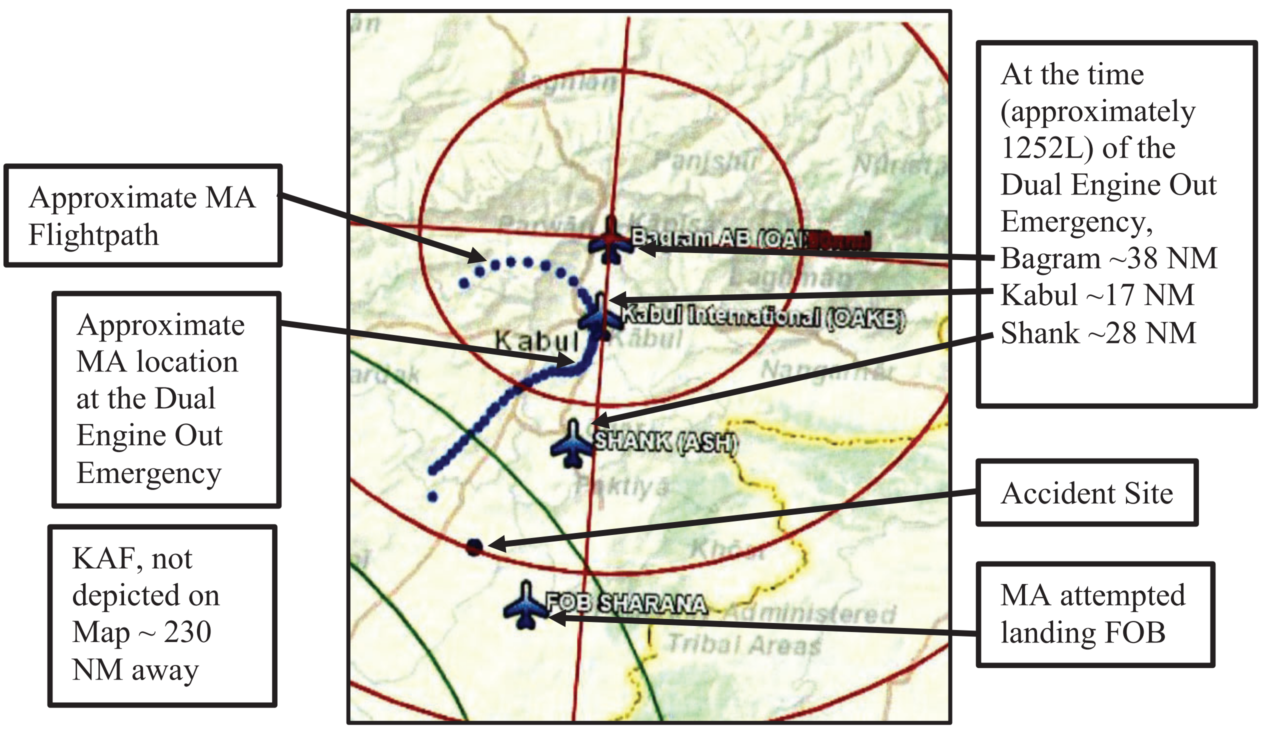
At the time of the dual engine out emergency (1252L), the MA position was approximately 38 NM from Bagram Airfield, 17 NM from Kabul International Airport, 28 NM from FOB Shank, and 230 NM from KAF. The weather would have permitted for a safe and executable landing at Bagram, Kabul, and Shank. In fact, flight simulation profiles prove that for approximately three to five minutes after the dual engine out emergency, the MC could have turned to and glided to Bagram or Kabul respectively. For approximately eight minutes, the MC could have glided to Shank. Conversely, recovery to KAF was never possible with the loss of both engines. Notably, even if the MC realization of the dual engine out emergency was delayed until their radio call to Kabul ATC at 1254:55L, the MC had two minutes to glide to Kabul and five minutes to Shank.

After the catastrophic left engine failure, the MC turned the MA briefly westward. Then approximately one minute after the dual engine out emergency, the MC turned the MA slowly back to a southwest heading toward KAF. This turn suggests the MC did not consider Bagram or

Kabul, and their continued flightpath toward KAF (southwest heading) suggests the MC never considered Shank. The MA flightpath shows that after approximately 10 minutes from the loss of both engines, the MC turned toward FOB Sharana. The MC initiated a radio call to Kabul ATC to announce their intentions. Specifically, at 1304:15L, the MC tells Kabul ATC that "…looks like we're heading to Sharana..."

Squadron pilots agreed that there was a strong preference for returning to KAF with most emergencies or other issues. While Bagram was a divert possibility, diverting was usually anticipated because of weather or other issues (combat related) denying the use of KAF, rather than driven by emergencies. Discussion of emergency airfields was rare. Of note, for several months prior to the mishap, an E-11A never diverted to another airfield.

Even with the loss of both engines, backup E-11A systems allow the aircraft to be controlled through an emergency landing, and both performance data and flight simulation profiles suggest that a divert to another airfield was still possible even after the dual engine emergency. However, the exact probability of a successful dual engine out landing, since it has never happened, cannot be determined. In fact, the MC would have had to accomplish a procedure only considered hypothetically. During the mishap, the MC would need to alter the flight plan, accomplish checklists, initiate communications, and manage their descent and routing to arrive at the divert airfield in a position to land without the ability to correct any miscalculations.



Tab Z-4

4. CONCLUSION

I find by a preponderance of the evidence that the cause of the mishap was the MC's error in analyzing which engine had catastrophically failed (left engine). This error resulted in the MC's decision to shutdown the operable right engine creating a dual engine out emergency.

I also find, by a preponderance of the evidence, that the MC's failure to airstart the right engine and their decision to recover the MA to KAF substantially contributed to the mishap.

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CRAIG R. BAKER, Brig Gen, USAF
President
Accident Investigation Board

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