UNITED STATES AIR FORCE AIRCRAFT ACCIDENT INVESTIGATION BOARD REPORT

TU-2S, T/N 80-001068

1ST RECONNAISSANCE SQUADRON
9TH RECONNAISSANCE WING
Beale Air Force Base, California

LOCATION: SUTTER COUNTY,
NEAR BEALE AIR FORCE BASE, CA

DATE OF ACCIDENT: 20 SEPTEMBER 2016

BOARD PRESIDENT: BRIGADIER GENERAL DAVID S. NAHOM

Conducted IAW Air Force Instruction 51-503

Volume One of Two

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

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23 MAR 2017

ACTION OF THE CONVENING AUTHORITY

The Report of the Accident Investigation Board, conducted under the provisions of AFI 51-503, that investigated the 20 September 2016 mishap involving TU-2S, T/N 80-001068, 1st Reconnaissance Squadron, Ninth Reconnaissance Wing, Beale Air Force Base, California, complies with applicable regulatory and statutory guidance; on that basis it is approved.

//SIGNED//

JAMES M. HOLMES
General, USAF
Commander

* Incorporates ACC/SJA correction, with Board President concurrence, of typographical error (duplicated word in Executive Summary) on 3 April 2017.

EXECUTIVE SUMMARY
UNITED STATES AIR FORCE
AIRCRAFT ACCIDENT INVESTIGATION

TU-2S, T/N 80-001068
BEALE AFB, CA
20 SEPTEMBER 2016

On 20 September 2016 at 0908 local (L) time, a two-seat TU-2S crashed 18 nautical miles west of Beale Air Force Base (AFB), California (CA). Mishap Instructor Pilot (MIP) and Mishap Pilot (MP) egressed the Mishap Aircraft (MA) at approximately 8,500 feet mean sea level. MIP did not survive ejection, and MP sustained non-life threatening injuries. MA, tail number 80-001068, was assigned to the 1st Reconnaissance Squadron, 9th Reconnaissance Wing (9 RW), Beale AFB, CA. MA impacted private property 5 miles northwest of Sutter, CA, resulting in a grass fire that burned most of a 262 acre pasture. MA was completely destroyed. There were no injuries on the ground.

The mishap occurred during the first of three Acceptance Flight (AF) mission profiles for the MP. AF missions are for the screening of prospective U-2 pilots. MA launched at 0855L, with MIP executing the takeoff and transferring aircraft control to the MP en route to the maneuver area, 15-20 nautical miles west of Beale AFB. On the recovery from a third no-flap "approach to stall" maneuver, MA entered a full aerodynamic secondary stall with the left wing sharply dropping 70-80 degrees and the nose falling 35-40 degrees below the horizon. It could not be determined what actions MIP took to recover MA. However, with MA rapidly approaching the minimum uncontrolled ejection altitude, MIP commanded ejection. Immediately after ejection and while still seated in the ejection seat, MIP and his seat impacted the last 5 feet of MA's right wing, fatally wounding the MIP. MIP's parachute automatically deployed, with MIP landing within a quarter mile of MP, just over one mile from the MA wreckage. MP received minor facial burns from MIP's ejection seat rocket motor and injuries to his left ankle during the parachute landing.

Beale AFB first responders arrived at the crash site at 0959L. Local civilian first responders were already on scene fighting the grass fire. MIP and MP were located before 1000L by a 9 RW T-38/A and a civilian helicopter. MP was evacuated by civilian helicopter, arriving at a civilian hospital at 1228L. MIP was recovered and transported by the Sutter County Coroner.

The Accident Investigation Board President found by a preponderance of evidence that the cause of the mishap was the MP's flight control inputs during the recovery phase of a no-flap "approach to stall" maneuver that led MA into an unintentional secondary stall and uncommanded sharp left wing drop, with 70-80 degrees of bank and the nose 35-40 degrees below the horizon. As MA approached the minimum uncontrolled ejection altitude, MIP commanded ejection. During the subsequent ejection, MIP and his seat struck the MA's right wing, resulting in fatal injuries.

SUMMARY OF FACTS AND STATEMENT OF OPINION
TU-2S, T/N 80-001068
20 SEPTEMBER 2016

TABLE OF CONTENTS

ACRONYMS AND ABBREVIATIONS

1 RS	1st Reconnaissance Squadron
2D	Two-Dimensional
3D	Three-Dimensional
9 RW	9th Reconnaissance Wing
11 B	11 Bomber Pilot
11 F	11 Fighter Pilot
99 RS	99th Reconnaissance Squadron
AC	Aircraft Commander
ACC	Air Combat Command
ACSC	Air Command and Staff College
ADC	Area Defense Counsel
ADI	Attitude Direction Indicator
ADO	Assistant Director of Operations
AF	Acceptance Flight
AF-1	Acceptance Flight One
AFB	Air Force Base
AFE	Aircrew Flight Equipment
AFI	Air Force Instruction
AFIP	Acceptance Flight Instructor Pilot
AFLOA	Air Force Legal Operations Agency
AFMC	Air Force Material Command
AFMES	Armed Forces Medical Examiner System
AFPA/PTPLA	Air Force Petroleum Agency
AFRL/RXSA	Air Force Research Laboratory Materials Integrity Branch
AFTO	Air Force Technical Order
AGL	Above Ground Level
AIB	Accident Investigation Board
AIMWTS	Aeromedical Information Management Waiver Tracking System
AMC	Air Mobility Command
AMXS	Aircraft Maintenace Squadron
AOA	Angle of Attack
AOC	Air Officer Commanding
ARMS	Automated Record Management System
ATV	All Terrain Vehicle
BCP	Base Command Post
BFM	Basic Fighter Maneuver
BFO	Basic Fighter Operations
BMC	Basic Meteorological Conditions
BP	Board President
BPO	Basic Post-flight Inspection
BQ	Basic Qualification
BRI	Briefing Room Interactive
C-Collar	Cervical Collar
C2	Command and Control
CA	Califonia
CAD/PAD	Cartridge Actuated Device/ Propellant Actuated Device
CAOC	Combined Air Operations Center
Capt	Captain
CAT	Crisis Action Team
CC	Commander
CG	Center of Gravity
CH1	Fire Chief
CH2	Deputy Fire Chief Two
CH3	Deputy Fire Chief Three
CHP	California Highway Patrol
CIP	Contract Instructor Pilot
CIV	Civilian
Col	Colonel
COS	Chief of Safety
C-P U-2	Chief Pilot U-2
CPT	Cockpit Procedural Trainer
CT	Continuation Training
CTP	Companion Trainer Program
DC	Direct Current
DD	Department of Defense
DMZ	De-Militarized Zone
DNIF	Duties Not Involving Flying
DO	Director of Operations
DoD	Department of Defense
DS	Director of Staff
DSN	Defense Switching Network
EMS	Emergency Medical Service
EOC	Emergency Operations Center
EOD	Explosive Ordinance Disposal
EOR	End of Runway
EP	Evaluator Pilot
EP	Emergency Procedure
EPS	Emergency Power System
ERS	Expeditionary Reconnaissance Squadron
ESS	Emergency Start System
EW	Electronic Warfare
FAIP	First Assignment Instructor Pilot
FAR	Family Assistance Representative
FBO	Fixed Base Operations
FCF	Functional Check Flight
FCIF	Flight Crew Information File
FLCS	Flight Control System
FOIA	Freedom of Information Act
FPM	Feet Per Minute
FPS	Fire Protection System
FS1	Flight Surgeon One
FS2	Flight Surgeon Two
FS3	Flight Surgeon Three
FSS	Force Support Squadron
FTU	Formal Training Unit
Ft	Feet
GF	Gravitational Force
HFACS	Human Factors Analysis and Classification System
HPO	Hourly Post-flight Inspection
HQ	Headquarters

IAW	In Accordance With
IC	Incident Commander
IDE	Intermediate Developmental Education
IG	Inspector General
ILS	Instrument Landing System
IMDS	Integrated Maintenance Data System
IC	Incident Commander
ICC	Installation Control Center
IG	Inspector General
IP	Instructor Pilot
ISB	Interim Safety Board
ISR	Intelligence, Surveillance and Reconaissance
K	Thousand
KCAS	Knots Calibrated Airspeed
KGS	Knots Ground Speed
KIAS	Knots Indicated Airspeed
KTAS	Knots True Airspeed
KTS	Knots
L	Local Time
LA	Legal Advisor
LM-Aero	Lockheed Martin Aeronautics Company
Lt Col	Lieutenant Colonel
M	Mach
MA	Mishap Aircraft
Maj	Major
MAJCOM	Major Command
MCC	Medical Control Center
MIP	Mishap Instructor Pilot
MMI	Mishap Mobile Instructor
MMO	Mishap Mobile Officer
MOA	Military Operating Area
MP	Mishap Pilot
MPT	Maintenance Personnel and Training
MQ	Mission Qualification
MSL	Mean Sea Level
MWS	Major Weapons System
MXS	Maintenance Squadron
NATO	North Atlantic Treaty Organization
NM	Nautical Miles
NORCAL	Northern California
NOTAM	Notice to Airmen
O2	Oxygen
OG	Operations Group
OGV	Outlet Guide Vanes
OH	Ohio
OJT	On the job training
OK	Oklahoma
OPR	Officer Performance Report
OPR	Office of Primary Responsibility
OPS	Operations
Ops Tempo	Operations Tempo
ORM	Operation Risk Management
OSI	Office of Special Investigations
OSS	Operations Support Squadron
OVC	Overcast
PA	Public Affairs

PCA	Permanent Change of Assignment
PCS	Permanent Change of Station
PDM	Program Depot Maintenance
PE	Project Engineer
PEO	Program Executive Officer
PFD	Personal Flotation Device
PFT	Program Flight Training
PHA	Physical Health Assessment
PIT	Pilot Instructor Training
PLF	Parachute Landing fall
PLI	Pre-Launch Inspection
PM	Pilot Member
POV	Personally-Operated Vehicle
PR	Pre-Flight Inspection
PRC	Portable Radio Communications
PSI	Pounds per Square Inch
PSPTS/PSD	Physiological Support Squadron
Q&A	Question and Answer
QA	Quality Assurance
R	Recorder
RS	Reconnaissance Squadron
RW	Reconnaissance Wing
SA	Situational Awareness
SAC	Sacramento
SAP	Special Access Program
SAR	Search and Rescue
SAS	Stability Augmentation System
SAAS	School of Advanced Aerospace Studies
SCIF	Sensitive Compartmentalized Information Facility
SEPT	Safety and Emergency Procedures Training
SF	Security Forces
SFD	Secondary Flight Display
SFO	Simulated Flight Out
SIB	Safety Investigation Board
SII	Special Interest Item
SIM	Simulator
SMF	Sacramento International Airport
SODO	Senior Offensive Duty Officer
SOF	Supervisor of Flying
SOJ	Sea of Japan
SP	Student Pilot
Spatial-D	Spatial Disorientation
SPO	Systems Programs Office
SUPT	Specialized Undergraduate Pilot Training
T-Speed	Threshhold Speed
TCI	Time Change Item
TCTO	Time Compliance Technical Order
TDY	Temporary Duty
TERA	Temporary Early Retirement Authority
TFR	Temporary Flight Restriction
TH	Thru-Flight Inspection
T/N	Tail Number
TLF	Temporary Lodging Facility
TMI	Too Much Information
TO	Technical Order

TRACON	Terminal Radar Approach Control	UXO	Unexploded Ordnance
TRB	Training Review Board	VFR	Visual Flight Rules
TU-2S	Trainer U-2S	VHF	Very High Frequency
TX	Texas	VML	Vulnerable Mover List
UC	University of California	VSP	Voluntary Separation Program
UCMJ	Uniform Code of Military Justice	VVI	Vertical Velocity Indication
UHF	Ultra High Frequency	WA	Washington
UPT	Undergraduate Pilot Training	WAI	Walk-around Inspection
USAF	United States Air Force	Z	Zulu
USAFA	United States Air Force Academy		
USC	Universal Servicing Cart		

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 23 September 2016, General Herbert J. Carlisle, Commander, Air Combat Command (ACC), appointed Brigadier General David S. Nahom to conduct an aircraft accident investigation board (AIB) of the 20 September 2016 mishap involving a TU-2S reconnaissance aircraft, tail number 80-001068, in Sutter County, California (CA), near Beale Air Force Base (AFB), CA (Tab Y-3). The TU-2S accident investigation was conducted in accordance with Air Force Instruction (AFI) 51-503, *Aerospace and Ground Accident Investigations* at Beale AFB, CA from 24 October 2016 through 18 November 2016. Board members were the Legal Advisor (Colonel), Pilot Member (Lieutenant Colonel), Medical Member (Captain), Maintenance Member (Master Sergeant), Aircrew Flight Equipment Member (Master Sergeant), and the Recorder (Technical Sergeant) (Tab Y-3 to Y-8).

b. Purpose

In accordance with AFI 51-503, *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 20 September 2016 at 0908 local time (L), a TU-2S crashed 18 nautical miles west of Beale AFB in the vicinity of the Sutter Buttes mountain range (Tabs M-6 and P-3). While recovering from a no-flap "approach to-stall" maneuver, the Mishap Aircraft (MA) entered a full aerodynamic secondary stall with the aircraft nose falling 35-40 degrees nose low and the left wing sharply dropping to 70-80 degrees of bank (Tab V-1.4). With MA rapidly approaching minimum uncontrolled ejection altitude, the Mishap Instructor Pilot (MIP) commanded ejection (Tab V-1.5). Immediately after ejection and while still seated in the ejection seat, MIP and his seat impacted with the last 5 feet of the MA right wing, separating the wing tip from MA and fatally wounding MIP (Tabs H-16, EE-22, and EE-97). The Mishap Pilot (MP) received minor facial burns from MIP's ejection seat rocket motor and injuries to his left ankle during his parachute landing fall (PLF) (Tabs V-11.5, V-15.5, V-16.7, and X-8). MA, tail number 80-001068 was assigned to the 1st Reconnaissance Squadron (1 RS), 9th Reconnaissance Wing (9 RW), Beale AFB, CA (Tab Q-5 to Q-7). MA, valued at $32,797,414, was completely destroyed (Tab P-4). MA impacted private property northwest of Sutter, CA (Tab P-3), resulting in a grass fire that burned most of a 262 acre pasture (Tab P-3). There were no injuries on the ground.

3. BACKGROUND

a. Air Combat Command (ACC)

Air Combat Command, headquartered at Joint Base Langley-Eustis, Virginia, is a major command created June 1, 1992, by combining its predecessors Strategic Air Command and Tactical Air Command. ACC is the primary provider of air combat forces to America's warfighting commanders. As a force provider and Combat Air Forces lead agent, ACC organizes, trains, equips and maintains combat-ready forces for rapid deployment and employment while ensuring strategic air defense forces are ready to meet the challenges of peacetime air sovereignty and wartime air defense. Additionally, ACC develops strategy, doctrine, concepts, tactics, and procedures for air and space-power employment. The command provides conventional and information warfare forces to all unified commands to ensure air, space and information superiority for warfighters and national decision-makers. The command can also be called upon to assist national agencies with intelligence, surveillance and crisis response capabilities (Tab CC-3 to CC-8).

b. 25th Air Force

The 25th Air Force, headquartered at Joint Base San Antonio--Lackland, Texas, provides multisource intelligence, surveillance, and reconnaissance (ISR) products, applications, capabilities and resources, to include cyber and geospatial forces and expertise. Additionally, it is the Service Cryptologic Component responsible to the National Security Agency/Central Security Service for Air Force matters involving the conduct of cryptologic activities, including the full spectrum of missions directly related to both tactical warfighting and national-level operations. With the inclusion of the 9th Reconnaissance Wing and 55th Wing, 25th Air Force missions include electronic warfare, airborne national command and control (C2), reconnaissance in support of nuclear operations, and some aspects of nuclear C2 (Tab CC-9 to CC-12).

c. 9th Reconnaissance Wing (9 RW)

The 9th Reconnaissance Wing (9 RW), headquartered at Beale Air Force Base, California, is responsible for providing national and theater command authorities with timely, reliable, high-quality, high-altitude reconnaissance products. To accomplish this mission, the wing is equipped with the nation's fleet of U-2 Dragon Lady and RQ-4 Global Hawk reconnaissance aircraft and associated support equipment. The wing also maintains a high state of readiness in its expeditionary combat support forces for potential deployment in response to theater contingencies. Activated as the 9th Strategic Reconnaissance Wing on May 1, 1949, it is composed of more than 4,500 personnel in four groups at Beale AFB, one group at Grand Forks AFB, North Dakota, and multiple overseas operating locations (Tab CC-13 to CC-16).

d. 1st Reconnaissance Squadron (1 RS)

The 1st Reconnaissance Squadron is assigned to the 9th Operations Group (9 OG), located at Beale Air Force Base, California. It is responsible for training all High-Altitude Intelligence, Surveillance, and Reconnaissance aircrew for the U-2S Dragon Lady and the RQ-4 Global Hawk. Aircrew members consist of pilots and mission planners for the U-2S, and pilots and sensor operators for the RQ-4. Training for all U-2S pilots includes additional qualification in the T-38/A Talon, the companion trainer to the U-2S (Tab CC-17 to CC-19).

e. U-2S / TU-2S – Dragonlady

The U-2S is a single-seat, single-engine aircraft that provides high-altitude/near space, all-weather surveillance and reconnaissance, day or night, in direct support of U.S. and allied forces. It delivers critical imagery and signals intelligence to decision makers throughout all phases of conflict, including peacetime indications and warnings, low-intensity conflict, and large-scale hostilities. The TU-2S is the two-seat training version of the U-2S used for U-2S pilot basic qualification (Tab CC-20 to CC-22).

f. TU-2S Flight Characteristics and "Approach to Stall" Maneuver

(1) TU-2S Flight Controls

The TU-2S primary control surfaces are similar to most modern aircraft and control the three axes of flight: roll, pitch and yaw (Tab BB-89). Aircraft roll is controlled primarily through ailerons, which are located on the outer, trailing edge of each wing (Tab BB-89). In the TU-2S, roll control is assisted by roll spoilers that are extended from the top of each wing (Tab BB-89). Aircraft pitch (nose up or down) is controlled primarily by the elevator, located on the tail of the aircraft (Tab BB-89). Aircraft yaw (nose right or left) is controlled by the rudder, also located on the aircraft tail (Tab BB-89). Aircraft pitch and roll is controlled through a control column, and yaw is controlled through foot pedals (Tab BB-89).

(2) Aerodynamic Stall

Aerodynamic stall occurs when the wings no-longer produce enough lift to keep the aircraft flying (Tab BB-89). Aerodynamic stall occurs at slower airspeeds, or when the angle between the aircraft wing and the relative wind becomes too steep (also known as the angle of attack (AOA)) (Tab BB-89). Different parts of the wing may stall at different times, depending on the wing's design (Tab BB-89). In the TU-2S, aerodynamic stall begins at the wingtips and progresses inboard until a full aerodynamic stall, at which time the ailerons are marginally effective while the rudder and elevator are still very effective (Tabs Z-7 and Tab BB-89). See Figure 1.

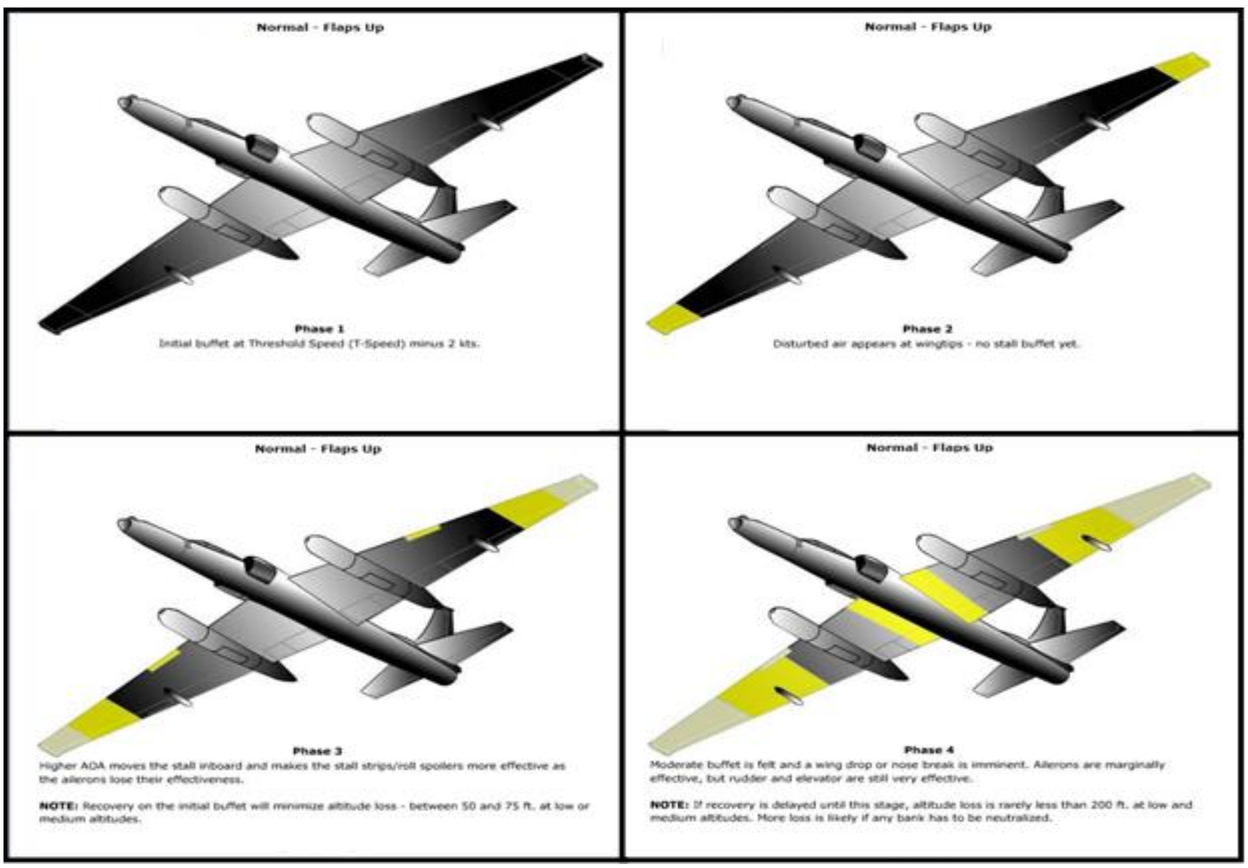

Figure 1. U-2S Stall Characteristics (Tab Z-7)

A full aileron input during a stall generates a large amount of adverse yaw (tendency of the aircraft nose to turn in the opposite direction of aircraft roll) if rudder is not applied appropriately (Tab BB-6). If the wings are not held level and corrected for yaw just prior to the stall, the aircraft may roll moderately (Tab BB-7). Testimony from Acceptance Flight (AF) Instructor Pilots (IPs) and TU-2S Functional Check Flight (FCF) pilots noted that using full opposite aileron to counter a wing drop at low speeds will induce yaw and may lead to a spin, particularly if aileron inputs are not coordinated with rudder inputs (Tab V-6.12, V-7.3, V-17.3, V-17.22, and V-20.3 to V-20.4).

(3) "Approach to Stall" Maneuver

Most conventional aircraft are designed with a landing approach airspeed 30 percent greater than the aircraft stall airspeed (Tab BB-15). The TU-2S landing approach airspeed is only 10 percent greater than its stall airspeed, bringing the aircraft much closer to stall airspeeds when landing (Tab BB-15). To prevent aircraft stalls at inappropriate times during the landing phase, TU-2S pilots conduct "approach to stall" training at higher altitudes to help them recognize and mitigate the stall warning signs they may encounter when landing (Tabs V-2.5 to V-2.6 and BB-15). The maneuver generally consists of reducing power to Idle and raising the nose slightly to slow the aircraft (Tabs V-2.5 to V-2.6 and BB-15). As the aircraft approaches stall airspeed, the pilot will hear a series of stall warning tones and the airframe may buffet (Tabs V-6.9 to V-6.10 and BB-15). TU-2S pilots are taught to recover from the "approach to stall" maneuver before the aircraft enters a full aerodynamic stall (Tab V-6.9 to V-6.10). Recovery consists of pushing the control column forward to drop the aircraft nose while simultaneously adding Full power (Tab BB-15). Once the aircraft regains sufficient airspeed, the pilot begins pulling back on the control column to bring the nose level with the horizon (Tab BB-15). Pulling back too soon, or too hard, can result in a secondary stall (Tab BB-15). The wings should be level throughout the maneuver (Tab BB-15). Due to the marginal effectivenss of ailerons near stall airspeeds, the pilot should use rudder rather than ailerons if the aircraft starts to roll (Tabs Z-7, BB-15 and BB-89).

(4) Minimum Uncontrolled Ejection Altitude

If the TU-2S becomes uncontrollable and the pilot decides to eject, the minimum uncontrolled ejection altitude is 5,000 feet above ground level (AGL) (Tab BB-4). The maximum terrain elevation over the Sutter Buttes mountain range is 2,500 feet mean sea level (MSL), making the minimum uncontrolled ejection altitude 7,500 feet MSL over Sutter Buttes (Tab Z-12).

g. U-2S Interview and Acceptance Flight Process

The United States Air Force (USAF) generally recognizes the U-2S is a difficult aircraft to fly, requiring a skill level not normally achieved through standard military pilot training courses (Tab BB-84). Due to the uniquely difficult reconnaissance mission of the U-2S, as well as its challenging flying characteristics, U-2S pilots are competitively selected from some of the USAF's most highly qualified aviators (Tab BB-84). Applicants must pass a demanding 2-week interview process that includes three AFs in the TU-2S (Tab BB-84). These flights gauge the interviewee's overall flying skill and ability to safely fly the U-2S (Tab BB-84). AFs are conducted not as typical Basic Qualification sorties, but as evaluation/interview sorties to assess the interviewee's ability to recognize deviations in performance and make the appropriate corrections (Tab BB-84). AF

IPs look for a positive learning curve over the three AF rides with little regression in the interviewee's performance from flight to flight (Tab BB-84).

4. SEQUENCE OF EVENTS

a. Mission

The mishap occurred during the first of three AF missions. The first AF flight (AF-1) is designed to familiarize interviewees with U-2S flight characteristics, normal traffic patterns and normal landings (Tab BB-84 to BB-86). Additionally, AF-1 introduces interviewees to TU-2S stall characteristics by conducting "approach to stall" training (Tab BB-86). "Approach to stall" instruction and technique varies by AF IP (Tab V-2.6, V-3.5, V-4.5, V-4.8 to V4.10, V-5.6 to V-5.8, V-6.9 to V-6.10, V-7.7, V-10.11, V-11.6, V-22.4 to V-22.5 and V-22.7). AF IPs regard the "approach to stall" maneuver and recovery as benign (Tab V-2.3, V-4.3, V-5.7 and V-7.9).

Due to the difficulty in landing the U-2S, a mobile officer in a chase vehicle is required to assist the pilot during takeoff, landing and emergency procedures (Tab BB-60 and BB-65). Mobile officers are fully qualified U-2S pilots who chase after aircraft during takeoffs and landings, and give altitude "callouts" to assist the pilot in effectively landing the U-2S (Tab BB-60 and BB-65).

The mishap included MIP, MP, the Mishap Mobile Instructor (MMI) who is a fully qualified AF IP, and the Mishap Mobile Officer (MMO) who was in upgrade training to become an AF IP (Tab AA-3). The mission occurred at Beale AFB, CA to include the airspace approximately 15-20 miles west of Beale AFB over the Sutter Buttes mountain range (Tabs M-2 to M-6 and Z-3). The mission was authorized by the operations supervisor (Tab K-2). The mishap crew was scheduled to launch in a different aircraft, but due to mechanical issues, the mishap crew was redirected to the MA, which was the designated spare aircraft (Tabs V-11.2 and AA-3). MA launched slightly later than planned at 0855L (Tabs V-11.2 and DD-14).

b. Planning

The MIP, MP and MMO followed the standard planning process for an AF-1 sortie outlined in the U-2S syllabus (Tabs V-24.2 to V-24.3, BB-48 to BB-49, and BB-89). Mission planning began on 19 September 2016 with a detailed 4-hour briefing (Tab V-24.2 to V-24.3). MP then received TU-2S rear-cockpit familiarization on the flight line, followed by flying/cockpit familiarization in the Cockpit Procedural Trainer (CPT) (Tab V-24.4). On the morning of 20 September 2016, MIP arrived approximately 15 minutes late for the pre-mission briefing; however, this did not affect the mission as takeoff was delayed due to maintenance (Tab V-6.4 to V-6.5, and V-11.2 to V-11.3). MIP briefed the mission syllabus to MP, MMI, and MMO in accordance with established procedure (Tabs V-6.5, BB-48 to BB-49, BB-67 to BB-68, and BB-89). As is typical, no squadron supervisory personnel attended the briefing (BB-89).

c. Preflight

The MIP, MP, MMI and MMO received a standard preflight briefing from the operations supervisor, often referred to as a "step brief" (Tabs K-2, V-11.3, BB-78 to BB-79, and BB-89). The step brief included updates to local airfield, airspace weather and Notices to Airman

(NOTAMs) (Tabs V-11.3, BB-78 to BB-79, and BB-89). When the mishap crew was redirected to the spare (MA), operations duty desk personnel requested a change in MA's fuel load from an R-2 fuel load (888 gallons), to an R-3 fuel load (1088 gallons), which is the accepted standard fuel load for an AF mission (Tabs U-6 to U-7, and V-10.7). The step brief, flight plan filing, travel to the aircraft, inspection and donning of flight gear, preflight of the aircraft, pilot/aircraft integration by Physiological Support Squadron (PSPTS) personnel, and engine start procedures were all uneventful (Tab V-11.2, V-14.5 to V-14.7, V-24.5 to V-24.6, and BB-89).

d. Summary of Accident

Engine start, taxi and takeoff were uneventful (Tabs V-24.6 and Z-11). The MA took off at 0855L under the control of MIP (Tabs M-3, V-1.2, and DD-14). The route of flight consisted of a takeoff to the south on Runway 15 with an immediate right turn to the northwest towards the Sutter Buttes mountain range and climb to a final altitude 9,000 feet MSL (Tabs M-5 and Z-3). See Figure 2.

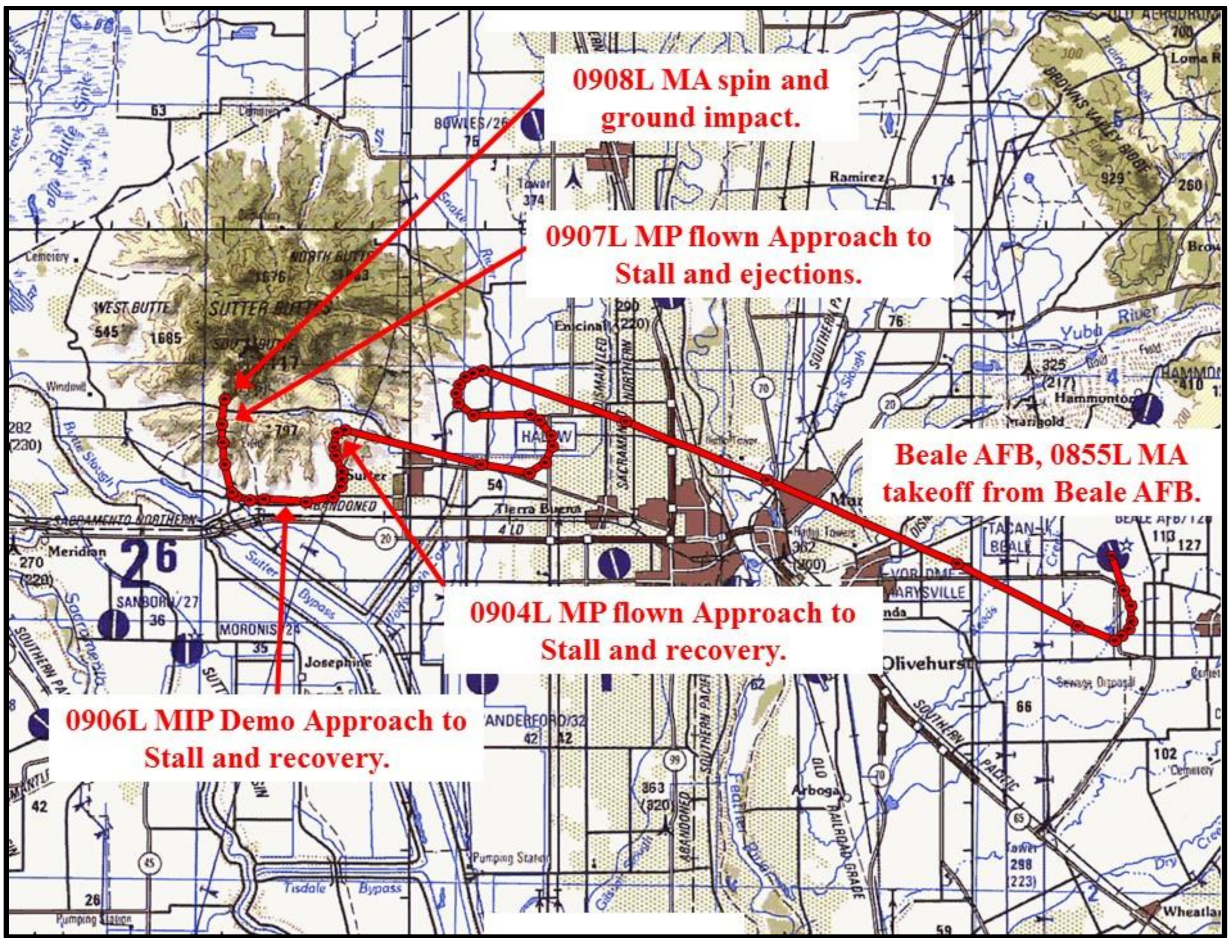

Figure 2. MA Flight Route (Tab Z-3)

At an undetermined point during the departure, MIP transferred aircraft control to MP (Tab V-1.2). While en route to the maneuver area, MP computed the no-flap stall threshold speed (T-speed) of 85 knots indicated airspeed (KIAS) in preparation for the planned "approach to stall" maneuver training (Tab V-1.2). Post-mishap analysis suggests MA was configured with landing gear down, stall strips extended, no flaps, and no speed brakes (Tab EE-82 to EE-83, and EE-87 to EE-88).

At approximately 0904L, MP reduced the throttle to Idle, focused on the Attitude Direction Indicator (ADI) to maintain wings level, and waited for the stall indications as instructed by the MIP (Tabs M-5, and V-1.2 to V-1.3). MP began to slow the aircraft on an approximate heading of 285 degrees while maintaining 8,900 feet MSL for the no-flap "approach to stall" maneuver (Tab M-5). MIP instructed the MP on MA's visual and audible stall indications throughout the maneuver (Tab V-1.3). As the MA approached full aerodynamic stall, MIP instructed MP to recover from the approach to stall (Tab V-1.3).

To recover from the approach to stall, MP lowered MA's nose approximately 5 degrees below the horizon by pushing forward on the control column, while simultaneously increasing power to Full (Tab V-1.3). Once the initial approach to stall was broken, MP levelled MA's nose by pulling back on the control column (Tab V-1.3). During the recovery, MIP indicated MP's control inputs were too aggressive and cautioned MP not to exceed MA's G-limit (Tab V-1.3). MA also experienced an uncommanded left wing drop during this first maneuver, which led MP to use what he described as "stabbing" right aileron inputs to keep the wings level (Tab V-1.3). During the maneuver, MA lost approximately 500 feet in altitude and its heading changed by approximately 80 degrees (Tab M-5). After recovering, MA climbed to 8,900 feet MSL on a heading of 188 degrees and accelerated to 139 knots ground speed (KGS) (Tab M-5). See Figure 3.

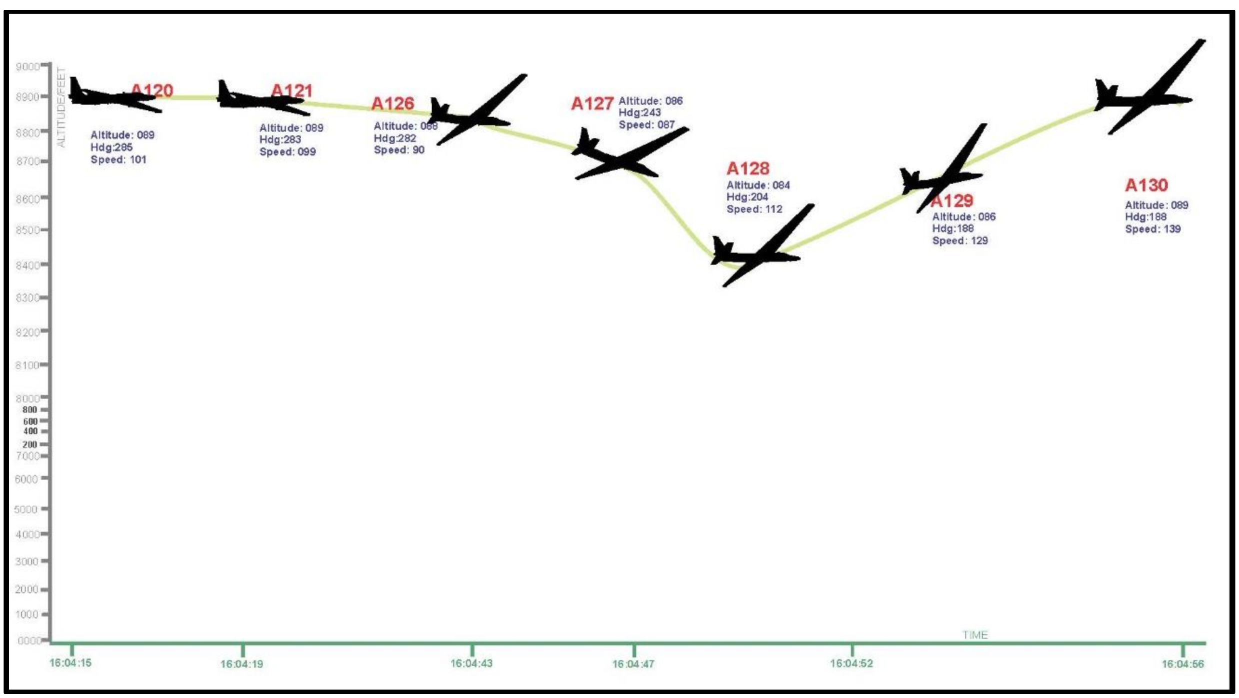

Figure 3. MA First "Approach to Stall" Maneuver (Flown by MP) (Tab Z-4)

After MP completed the first maneuver, he transferred aircraft control to the MIP for a no-flap "approach to stall" demonstration (Tab V-1.3). At approximately 0905L, MIP demonstrated a no-flap "approach to stall" and subsequent recovery by maintaining an approximate heading of 276 degrees, an altitude of 8,900 feet MSL and slowing the aircraft to approximately 88 KGS until the "approach to stall" indication (Tab M-5). MP "shadowed" (followed along the yoke without interfering) during the demonstration (Tab V-1.4). MP noticed and was surprised that MIP used nearly full right yoke (aileron) throughout the recovery to keep the wings level, but he did not note how much rudder MIP used (Tab V-1.4). MIP recovered the MA with a maximum altitude loss of 300 feet, to 8,600 feet MSL. MIP maintained a 275-degree heading, accelerated from a minimum of 88 KGS to 102 KGS, and climbed to 9,000 feet MSL (Tab M-5). Throughout the maneuver, MIP demonstrated how to be less aggressive with MA's controls and to use smoother yoke movement (Tab V-1.4). MP noted that the recovery was "smoother" than the one he attempted (Tab V-1.4). See Figure 4.

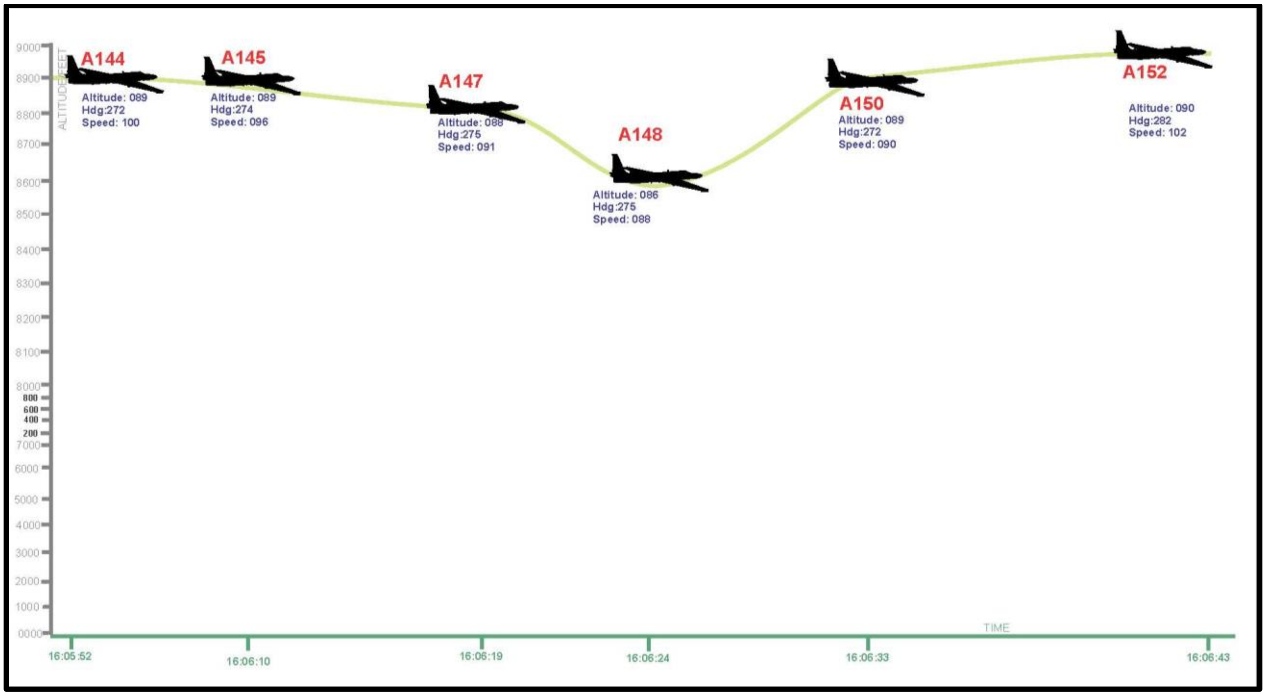

Figure 4. MA Second "Approach to Stall" Maneuver (Flown by MIP) (Tab Z-5)

At approximately 0907L, MIP climbed to 9,200 feet MSL with an initial heading of 355 degrees and transferred aircraft control to MP (Tabs M-6, and V-1.4). MP reduced throttle to Idle to set up for another no-flap "approach to stall" maneuver and recovery (Tab V-1.4). During the recovery, MP recalled using what he described as much "more even yoke application" to lower MA's nose, while simultaneously moving the throttle to Full (Tab V-1.4). As MA gained airspeed, MP applied slower and more deliberate backpressure on the control column to raise the nose (Tab V-1.4). MP also compensated for a "little bit" of left roll by applying full right yoke (aileron), as he saw MIP demonstrate (Tab V-1.4, V-15.4 to V-15.5, and V-16.3). He also used an indeterminate amount right rudder to keep MA's wings level (Tab V-1.4). As the nose began to rise, MA rapidly entered an uncommanded left roll (Tab V-1.4). MP was surprised by the sudden left wing drop (Tab V-1.4). See Figure 5.

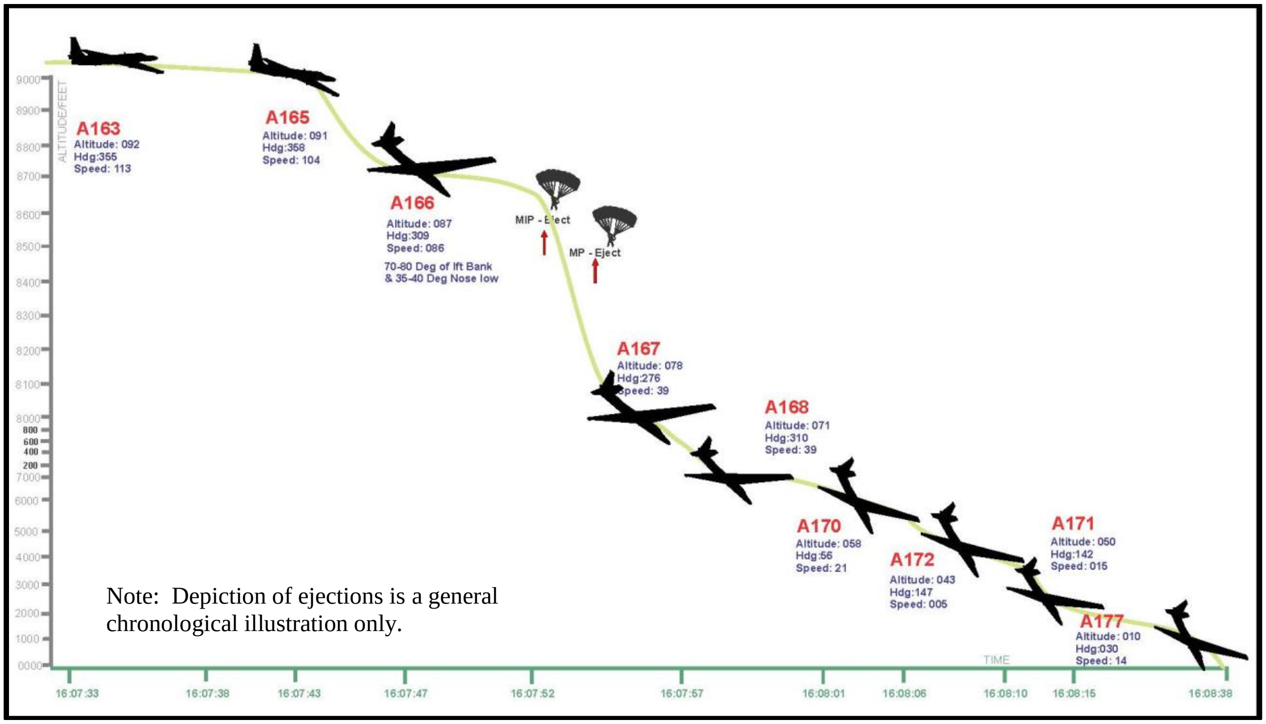

Figure 5. MA Third "Approach to Stall" Maneuver (Flown by MP) (Tab Z-6)

At approximately 8,500 feet MSL, the MA rapidly rolled to approximately 70-80 degrees of left bank with the nose 35-40 degrees below the horizon (Tabs M-6 and V-1.4). MP recognized the situation was "not normal" but was not alarmed due to his experience with similar attitudes as a T-38/A instructor pilot (Tab V-1.4). With MA rapidly approaching minimum uncontrolled ejection altitude of 7,500 MSL, MIP commanded ejection (Tabs V-1.5, Z-12, and BB-4). TU-2S guidance does not provide recovery techniques or procedures for departure uncontrolled flight or from a spin and directs ejection from the aircraft (Tab BB-4 to BB-5).

MP stated he did not not have time to attempt recovery because MIP immediately commanded ejection (Tab V-1.5). MIP calmly commanded bailout by stating "Eject, dude" (Tab V-1.5). MP responded "Eject?" and then ejected (Tab V-1.5). MP believes MIP ejected first because he saw "red and black" prior to pulling his ejection ring (Tab V-1.5). During the ejection sequence, MIP and his seat struck the right wing, breaking off a 5-foot section of the wing tip (Tabs H-16, EE-22, and EE-97).

MIP and MP ejected while MA was rapidly rolling to the left (Tab V-1.4) Although the TU-2S ejection seat is stabilized for pitch and yaw once the drogue chute deploys, it is not stabilized for roll (Tab H-16). During an ejection from an aircraft in a left roll, the top of the ejection seat rails will exert force on the ejection seat causing it to roll right (Tab V-21.2 to V-21.3). A rolling moment on the ejection seat can dramatically affect the trajectory of the seat prior to pilot-seat separation (Tabs H-16 and V-21.2).

e. Impact

MA entered into a left spin after both the MIP and MP ejected, impacting the uninhabited foothills south of the Sutter Buttes mountain range (Tabs M-6 and S-16). See Figure 6. Post-mishap analysis of the wreckage concluded MA hit the ground with minimal forward velocity in a 25-30 degrees nose down, 20-25 degrees left wing down attitude relative to the terrain (Tab EE-12). At impact, MA's landing gear was down; stall strips were extended; the flaps, lift spoilers and speed brakes were retracted; the ailerons and roll spoilers were configured for a left turn; and the engine was at a low power setting (Tab EE-87 to EE-88, and EE-190).

Figure 6. MA Main Impact Site (Tab Z-8)

f. Egress and Aircrew Flight Equipment (AFE)

The TU-2S egress system incorporates two ejection seats and a canopy removal system designed to provide safe pilot egress at any altitude or airspeed, including zero altitude and zero airspeed (Tab H-2). MIP's and MP's ejections were accomplished within the performance envelope of the TU-2S egress system (Tab H-8 and H-16).

As the TU-2S ejection seats are not automatically sequenced, the established procedure is for the pilot in the rear cockpit to initiate ejection first to lessen the chance of seat interference (Tabs H-2, and BB-48 to BB-49). MP recalled seeing a bright flash from MIP's ejection seat, indicating that MIP's ejection from the front cockpit occurred prior to MP's ejection (Tab V-1.5). Both pilots initiated ejection using the primary D-ring ejection handle (Tabs H-9, H-13, and V-1.5). Both cockpit canopies jettisoned, both ejection seats successfully cleared the cockpit, and both ejection seat drogue chutes deployed as designed (Tab H-6 to H-7).

The location of MP's facial burns, testimony, and post-mishap photographs indicate both pilots were wearing their lightweight helmets with oxygen masks attached at the time of ejection (Tabs V-15.4 to 15.5, X-8, and Z-10). There is no evidence to suggest either helmet or oxygen mask malfunctioned (Tab H-18 to H-20). MIP's helmet landed 520 feet from the main impact site, more than a mile from where MIP landed (Tab EE-11). The final location of MIP's helmet and the nature of MIP's injuries suggests his helmet and mask came off during the collision with the wing (Tabs H-8, X-7, and Z-10). MP successfully cleared the MA during ejection (Tabs H-7 and V-1.5). Other than minor burns on MP's face from MIP's ejection seat rocket motor, there was no evidence of interference between the two ejection seats or drogue chutes (Tabs H-8, H-17, X-8, and V-1.5).

The TU-2S ejection system includes metal lanyards attached to the pilot's heels that retract the pilot's legs before the seat is ejected from the cockpit (Tab H-3 to H-4). After the seat leaves the cockpit, the lanyards are cut as part of the system that separates the pilot from the seat (Tab H-4). Post-mishap inspection revealed MIP's lanyards were cut at lengths longer than expected, indicating MIP's legs may not have been fully retracted prior to ejection (H-16). All other components of the MIP's ejection system functioned as designed (Tab H-16). MP's ejection system was not subjected to any additional inspection or testing, but there were no discrepanicies noted in MP's successful ejection (Tab H-2 and H-7).

After man-seat separation, both personal parachutes deployed properly and automatically (Tab H-19). MP stated he was not able to find one of the six line jettison straps during descent to help steer away from the main crash site (Tab V-15.6 and V-16.7). Subsequent inspection revealed the right six-line release lanyard was stowed correctly on the riser assembly with no irregularities (Tab H-19). Both personal locator beacons integrated with the parachute activated upon ejection as designed (Tab H-19). MIP's and MP's AFE records show all inspections were current (Tab U-86 to U-162).

Both ejection seat kits containing survival equipment deployed properly upon man-seat separation (Tab H-19 to H-20). A review of maintenance and inspection records for MIP's seat kit revealed one discrepancy; MIP's PRC-112 survival radio did not have a current almanac update performed during its periodic inspection (Tab H-20). MP's seat kit was overdue for an overhaul but had an approved extension until 28 February 2017 (Tab U-108). No other discrepancies were noted. (Tabs H-7 and U-108). MP made several voice calls on his PRC-112 survival radio, but he received only one call back from the overhead U-2S (Tab V-1.5). Post-mishap inspection and testing indicated MP's survival radio operated as designed (Tab H-20).

MIP landed approximately 6,400 feet north-northwest of the main crash site (Tab EE-11). MP landed on the sloped side of a ravine approximately 5,400 feet north of the main crash site, and approximately 1,000 feet southwest from MIP (Tab EE-11). Prior to landing, MP indicated he was looking at the ground instead of the horizon, resulting in an improper PLF (Tab V-16.7). MP suffered non-life threatening injuries to his left leg during the PLF on sloped terrain (Tabs V-16.7, V-18.3, and X-8).

MIP's seat landed 270 feet southeast of the MA impact site (Tab EE-11). It did not appear to bounce after impact, but it sustained significant structural damage (Tab H-6). MP's seat landed 560 feet southeast of the MA impact site (Tab EE-11). It appears to have bounced after impact, sustaining significant structural damage (Tab H-7). MIP's canopy was recovered 2,900 feet to the northeast of the MA impact site (Tab EE-11). MP's canopy was recovered 1,850 feet southeast of the MA impact site (Tab EE-11). There were no signs of burn marks, unusual abrasions, aircraft impact marks or foreign fibers on either canopy (Tab H-7 to H-8).

MIP's helmet landed 520 feet northwest of the main impact site and more than a mile from where MIP landed (Tab EE-11). MIP's helmet was severely burned in the grass fire (Tab Z-9 to Z-10). Recognizable components in post-mishap photographs include half of the right ear cup, right and left bayonet receivers, and the integrated chin and nape strap assembly button (Tab Z-10). MIP's oxygen hose was recovered near his touchdown location (Tab H-19). Both ends of the communication cord were torn off (Tab H-19).

Testimony indicates MIP's and MP's lap belts and shoulder harnesses were properly secured prior to take off (Tab V-1.9 and V-14.5). However, post-mishap inspection and testing of MIP's lap belt suggest MIP may not have been secured by his lap belt and shoulder harness when he ejected (Tab H-16). MP testified that he did not know whether MIP was properly secured at the time of ejection, but he also indicated he had no reason to believe MIP was not secured (Tab V-1.9).

During normal lap belt operations, a metal connecting linkage fixed to the right lap belt is secured to the left lap belt by a locking lever (Tab H-11). See Figure 7. In addition to securing the pilot's lap belt, the connecting linkage attaches the pilot's shoulder harness to the lap belt (Tab H-16). During an ejection sequence, the shoulder harness retracts to pull the pilot into the proper ejection alignment with the seat before the seat departs the aircraft (Tab H-3 and H-5).

Once the seat departs the aircraft, and after the first and second stage ejection seat rocket motors stop firing, a gas-operated ballistic disconnect mechanism releases the connecting linkage from the right lap belt (Tab H-5 and H-11). This feature automatically separates the right and left lap belts, releases the shoulder harness, and frees the pilot from the ejection seat. If the left and right lap belts are properly secured prior to ejection, the connecting linkage should remain locked onto the left lap belt by the locking lever (Tab H-11). MP's left lap belt was found in this post-ejection configuration (Tab Z-13). See Figure 8.

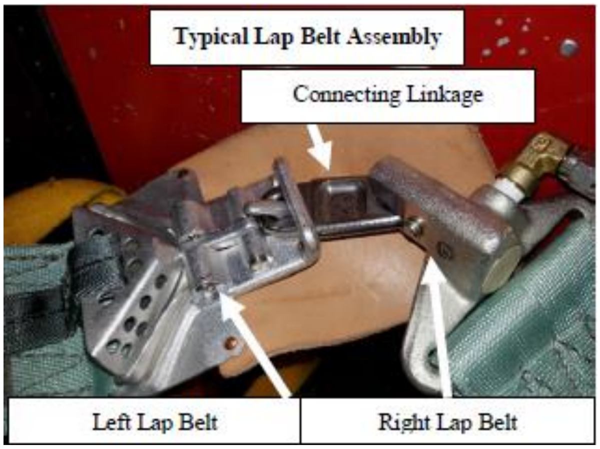

Figure 7. Typical Lap Belt Assembly (Tab Z-13)

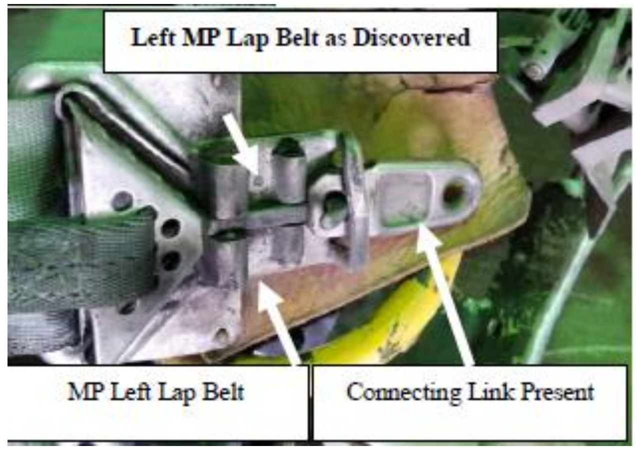

Figure 8. Left MP Lap Belt as Discovered (Tab Z-13)

Post-mishap inspection revealed the ballistic disconnect mechanism on MIP's right belt functioned properly and released the connecting linkage as designed (Tab H-11). The locking lever on MIP's left belt was found in the locked position with no damage or excessive wear; however, the connecting linkage was missing and was not recovered (Tab H-11). See Figure 9. From these observations, engineers from the Air Force Life Cycle Management Center concluded MIP may not have been secured by his lap belt at the time of ejection (Tab H-16).

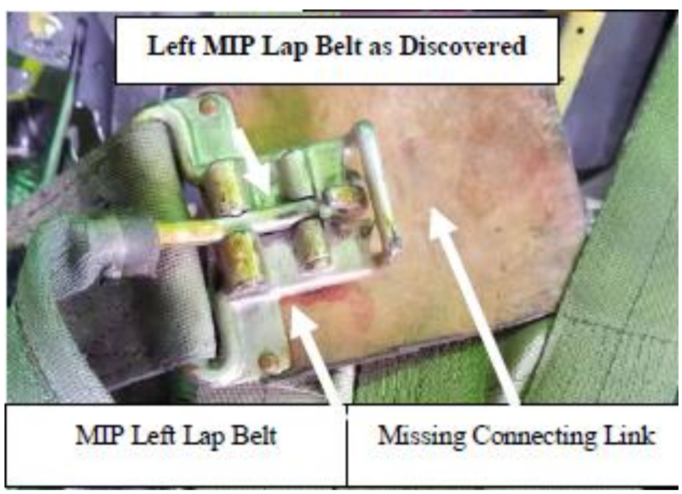

Figure 9. Left MIP Lap Belt as Discovered (Tab Z-13)

Post-mishap inspection also revealed the nylon area adjacent to the lever mechanism on MIP's left lap belt was blackened (Tab Z-13). See Figure 10. Subsequent chemical analysis of the blackened area disclosed the presence of lead, which is a component of the the propellant used in the ejection seat rocket motor (Tab EE-200). Chemical analysis also revealed low levels of antimony, another element frequently found in propellants (Tab EE-202). Unblackened regions of the belt analyzed for comparison did not contain lead or antimony (Tab EE-205). This chemical analysis indicates

MIP’s left lap belt was exposed to the ejection seat rocket motor exhaust near the bottom of the seat while the rocket was firing. As the lap belt ballistic disconnect mechanism is not designed to function until after the rocket motor has completed firing, the chemical analysis suggests MIP’s lap belt may not have been secured at the time of ejection (Tab H-5).

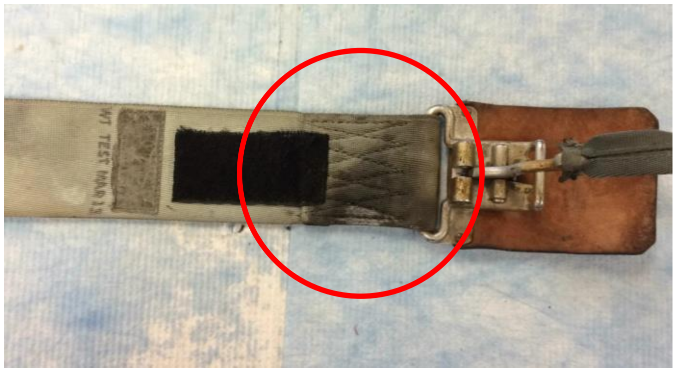

Figure 10. Blackened Area on MIP’s Left Lap Belt (Tab Z-13)

If MIP’s lap belt was not secured at the time of ejection, the shoulder harness would not have restrained MIP’s torso to the seat back, which could have shifted the ejection seat’s center of gravity and resulted in an unpredictable ejection trajectory (Tabs H-16 and BB-89 to BB-90). However, there was insufficient data to re-create MIP’s ejection trajectory to determine conclusively whether MIP’s lap belt configuration caused him to strike the right wing tip (Tabs H-16 and BB-89). Specifically, the MA’s exact attitude and configuration at the time of MIP’s ejection could not be determined due to limited witness testimony and the lack of recorded flight data (Tab BB-89 to BB-90). Additionally, the ejection seat was likely in an unstabilized roll due to MA’s rolling motion, and there is no test data modeling the U-2S ejection seat’s expected trajectory from a rolling aircraft (Tabs H-16 and BB-89 to BB-90).

9th Physiological Support Squadron (9 PSPTS) and 9th Operations Support Squadron (OSS) AFE personnel performed all required inspections, documentation, and servicing of the equipment prior to flight (Tab U-86 to U-162). Personnel involved with MA’s preparation for flight had the training, experience, expertise and supervision to perform their assigned tasks (Tab U-164). Three months prior to the mishap, a quality inspection of the low flight torso harnesses and regulators was signed by an individual not fully qualified/trained to perform this task. (Tabs H-18 to H-20, U-88, U-102, and U-165). However, analysis of the low flight torso harnesses and regulators indicated that they functioned as designed (Tab H-18 to H-20).

There is no evidence to suggest that 9 PSPTS or 9 OSS AFE personnel, supervision, maintenance and inspections were a factor in this mishap.

g. Search and Rescue (SAR)

(1) Initial Notification and Response

The mishap occurred at 0908L (Tab M-6). At 0910L, Northern California Terminal Radar Approach Control called the Beale AFB tower to report that it had lost radar and voice contact with MA (Tabs V-13.2, and DD-26). After several attempts to contact MA, the Beale AFB Supervisor of Flying (SOF) noticed smoke near the Sutter Buttes mountain range (Tab V-13.2). The SOF notified the 9 OG Deputy Commander and started the downed aircraft checklist (Tab V-13.2). The SOF initiated a stop launch and a recall of airborne 9 RW aircraft (Tab V-13.2).

After notification, the on-duty Deputy Fire Chief (CH2) assembled a team of five Beale AFB Fire Department personnel, including the Beale AFB Fire Chief (CH1) and another Deputy Fire Chief (CH3), departing for the mishap site in two Fire Department vehicles at approximately 0930L (Tabs V-23.8, and DD-19).

CH2 and his team arrived at the main crash site at 0959L (Tabs V-23.8, and DD-19). His arrival was delayed by approximately 4 minutes due to uncertainty of the location of the mishap site and the best route of travel (Tab V-23.2). Upon arrival, the Sutter County Fire Department was already on scene fighting the grass fire ignited by the mishap (Tab V-23.2 to V23.3). Other civilian agencies already on scene included the California Highway Patrol (CHP), a CHP helicopter, a Reach aeromedical transport helicopter, and the Sutter County Sheriff's Office (Tab V-23.3, and V-23.8).

CH2 assumed responsibilities as the on-scene Incident Commander (IC), with responsibility for managing the efforts of Beale AFB first-responders and coordinating response and recovery actions with local authorities (Tabs V-23.3, and DD-19). CH2 directed the deployment of a major crash vehicle and a fire engine from Beale AFB (Tab V-23.3). The fire engine experienced a brake fire en route and had to return to Beale AFB (Tabs V-23.3 to V-23.4, and DD-11). Multiple witnesses noted that communications among first responders at the site and with Beale AFB were hampered by limited cellular phone service throughout the mishap area, as well as the limited range of land mobile radios (Tab V-18.3 to V-18.4, V-19.5, V-23.4 to V-23.5, and V-25.5).

Other Beale AFB agencies that responded to the scene shortly after 1000L included Safety, Public Affairs, Air Force Office of Special Investigations, Explosive Ordnance Disposal (EOD), Security Forces, Aircraft Maintenance (Egress), Hydrazine Response Team, Mortuary Affairs, and Flight Medicine (Tab V-8.7 and V-23.6). The 9 OSS Director of Operations travelled to the mishap site to serve as the senior military officer on scene, subordinate to the IC (Tab V–25.2). At approximately 1200L, the 9 RW Director of Staff arrived and assumed responsibilities as the senior military officer assisting the IC (Tab V-8.6 to V–8.7). Civilian law enforcement controlled access to the mishap area (Tab V-23.6, and V-25.6).

Beale AFB leadership recalled the Crisis Action Team (CAT) and Emergency Operations Center (EOC) at 0924; both were active by 1015 (Tab DD-5).

By 1000L most of the grass fire around the main impact site had burned away from the MA (Tab V-23.6 to V-23.7). The response to the fire around the impact site was delayed due to potential hazards associated with the MA, including hydrazine and live explosive charges in the ejection seats (Tab V-23.6). To avoid exposing ground personnel to these hazards, CH2 elected to control the spread of the fire by starting a controlled back-burn upwind from the MA (Tab V-23.6). Additionally, at 1035L, an S-2 fixed wing air tanker from the California Department of Forestry and Fire Prevention, as well as a helicopter from the U.S. Forest Service, began a series of fire retardant and water airdrops around MA (Tab V-23.6). The grass fire eventually reached MIP's ejection seat and helmet, resulting in significant damage to the helmet (Tabs S-14 and Z-9).

EOD and Egress personnel rendered the two ejections seats safe by 1343L (Tab DD-19). The Hydrazine Response Team located the intact hydrazine bottle at 1415L (Tab DD-19). Beale AFB Fire Department response and recovery operations ended at 1749L (Tab DD-19).

(2) Search and Rescue

Beale AFB's on-call Flight Surgeon (FS1) overheard radio traffic about a downed aircraft at approximately 0915L (Tab V-18.2). FS1 grabbed a medical response bag and assembled a team consisting of another Flight Surgeon (FS2) and three medical technicians (Tab V-18.2). The medical team departed Beale AFB in a base ambulance at approximately 0920L (Tab V-18.2).

A Beale AFB T-38/A companion trainer scheduled for a routine training flight was directed to launch at 0919L and assume airborne on-scene commander responsibilities over the mishap site (Tabs V-13.2 to V-13.3, and DD-26). The T-38/A crew located both pilots' parachutes before 1000L and relayed their general location to the SOF (Tab DD-26). Shortly after 1000L, a U-2 returning from a training mission assumed responsibility for overhead support and the T-38 returned to Beale AFB, landing at 1012L (Tab DD-26).

The CHP helicopter located MIP before Beale AFB first responders arrived at the mishap site (Tab DD-11). After landing near MIP, a CHP paramedic on the helicopter hiked to MIP's location and determined MIP had no vital signs (Tab DD-11). MIP's status was reported to the Beale AFB EOC at approximately 1000L (Tab DD-11). At approximately 1006L, the Reach helicopter paramedic and nurse arrived at MP's location and began treating MP (Tabs DD-11, V-1.5, and V-18.3).

The Beale AFB medical team arrived at the main mishap site at approximately 1005L (Tab V-18.2). The team's response was delayed 5-10 minutes due to uncertainty about the location of the crash site and the route of travel (Tab V-18.2). A third Flight Surgeon (FS3) arrived in his personal vehicle shortly thereafter (Tab V-18.3). Within 15 minutes of arrival, the medical team was informed that both pilots had been located, and that one was injured and one was deceased (Tab V-18.2).

The medical team departed the main crash site in the ambulance at approximately 1020L and followed directions from the CHP and Reach helicopters to the injured pilot's (MP) location (Tab V-18.3). The route consisted of approximately 10 minutes of travel on an unimproved road, and a 10-15 minute hike through steep terrain (Tab V-18.3). Prior to hiking to MP, the Reach helicopter advised the medical team that there were no suitable landing locations near MP, so evacuation would be by ground (Tab V-18.3). Accordingly, the three Flight Surgeons and two medical technicians hiked in with a backboard and medical response bag (Tab V-18.3). They arrived at MP's location at approximately 1040L, where they found MP was being treated by two Reach personnel (Tab V-18.3).

Communications between the medical team and CH2 were hampered by limited cellular service throughout the mishap area, causing them to coordinate most recovery operations through the CHP and Reach personnel (Tab V-18.3 to 18.4, V-19.5, V-23.4, and V-25.5). The medical team was able to communicate with the Medical Group at Beale AFB, which relayed medical response information to CH2 (Tab V-19.5).

MP's injuries were assessed as non-life threatening, and the medical team determined hiking MP out was not safe (Tab V-18.3). Because the site was not accessible by wheeled vehicles, arrangements were made to evacuate MP by air using the CHP helicopter hoist (Tab V-18.4, and V-19.3). The CHP helicopter pilot indicated he needed to pick up the CHP paramedic at MIP's location to operate the hoist, so FS2 was tasked to replace the paramedic (Tab V-19.3). FS2 hiked down from MP's location and boarded the CHP helicopter (Tab V-19.3). At approximately 1100L, FS2 dropped the hoist kit from the CHP helicopter to the team at MP's location (Tab V-19.3). The helicopter proceeded to MIP's location and FS2 arrived shortly after 1100L (Tab V-19.3). After a short turnover brief, the CHP paramedic boarded the helicopter (Tab V-19.3). The CHP helicopter returned to MP's location and hoisted MP out between 1120 and 1130 (Tab V-18.5). The CHP helicopter transported MP to a staging area where MP was transferred to the Reach helicopter (Tab V-23.4). The Reach helicopter then transported MP to the University of California-Davis Medical Center, where he was admitted at 1228L (Tab X-8).

h. Recovery of Remains

After MP was hoisted, FS3 hiked to MIP's location to join FS2, arriving at approximately 1200L (Tab V-19.3). At approximately 1300L, the CHP helicopter transported CH3 to MIP's location (Tab V-19.4). A short time later, a Beale AFB Security Forces member arrived by foot (Tab V-19.4). At approximately 1500L, an all-terrain vehicle (ATV) arrived with representatives from the 9th Force Support Squadron, the fire department, and Security Forces (Tab V-19.4). The ATV returned at 1530L with the Sutter County Coroner and a member of the Beale AFB Safety Office (Tab V-19.4). Under the supervision of the Coroner, MIP's body was transported from the site by ATV at 1700L (Tab V-19.4). At the staging area, MIP's body was transferred to the Coroner's vehicle and taken to a mortuary in Yuba City, CA (Tab V-19.4).

5. MAINTENANCE

a. Aircraft Forms Documentation

The Air Force Technical Order (AFTO) 781 series forms collectively documented maintenance actions, inspections, servicing, configuration, status, and flight activities for the maintained aircraft (Tab BB-57). The Integrated Maintenance Data System (IMDS) is a comprehensive database used to maintenance actions, flight activity, and schedule future maintenance (Tab BB-55).

Review of the active 781 forms and IMDS revealed no overdue inspections or open Time Compliance Technical Orders (TCTOs) that would affect MA flight operations (Tab U-3 to U-36). A comprehensive review of the 781 K Cartridge Actuated Device/Propellant Actuated Device (CAD/PAD) and Time Change Items (TCI's) revealed that 17 items were granted temporary service life extensions from the appropriate engineers (Tab U-37 to U-45). A review of MA's active forms binder and pulled forms revealed minor documentation errors, such as missing page numbers, Technical Order (TO) references, and omitted dates. However, there is no evidence to suggest forms documentation was a factor in the mishap (Tabs U-3 to U-45, and U-53 to U-85).

b. Aircraft Inspections

The Pre-Flight Inspections (PR) includes visually examining the aircraft and operationally checking certain systems and components to ensure no serious defects or malfunctions exist (Tab BB-52 to BB-53). Thru-Flight Inspections (TH) are conducted between flights and are accomplished after each flight when a turnaround sortie or a continuation flight is scheduled (Tab BB-53). The Basic Post-flight Inspection (BPO) is conducted after the last flight of the flying period and includes visually examining the aerospace vehicle of certain components, areas, or systems to ensure no defects exist. The Hourly Post-flight Inspection (HPO) is accomplished upon accrual of specified number of flying hours and will augment the BPO (Tab BB-54). The HPO consists of checking certain components, areas, or systems to determine that no defects exist. Phase inspections are a thorough inspection of the entire aircraft (Tab BB-54). Walk-Around Inspections (WAI) or Pre-Launch Inspections (PLI) are abbreviated PRs and are completed as required prior to launch in the applicable TO (Tab BB-53).

The total airframe operating time of MA at takeoff of the mishap sortie was 13,342.7 hours (Tab U-5 and U-17). MA had flown 81.5 hours since the last scheduled inspection, which was a 200 hour HPO completed on 21 July 2016 (Tab U-18). The last PR inspection occurred on 19 September 2016 at 1200L (Tabs U-5 to U-6, U-13, and BB-53). The PR was conducted in accordance with approved maintenance procedures and the AFTO Form 781A did not identify any discprepancies with MA (Tabs U-13, and BB-53).

There is no evidence to suggest that inspections were a factor in the mishap.

c. Aircraft Maintenance Procedures

Pre-flight Servicing: The AFTO 781H indicated that 145 gallons of fuel was added to the MA on 20 September 2016, and the current fuel load was changed from an R-2 (888 gallons) to an R-3 (1088 gallons) (Tab U-6 to U-7). All documentation was annotated on the AFTO 781H (Tab U-6 to U-7).

Engine Maintenance History: A review of the records dating from 11 July 2016 to 20 September 2016 revealed that MA's engine was removed on 13 July 2016 to replace a bad wing flap selector control valve (Tab U-57 and U-60). The 200 Mesh Fuel Strainer was removed and cleaned on 25 August 2016 (Tab U-66).

There is no evidence to suggest maintenance procedures were a factor in the mishap.

d. Aircraft Maintenance Personnel and Supervision

9th Aircraft Maintenance Squadron (9 AMXS) personnel performed all required inspections, documentation, and servicing for MA prior to flight (Tab U-5 to U-36). A detailed review of maintenance activities and documentation revealed no significant documentation errors. Personnel involved with MA's preparation for flight had adequate training, experience, expertise, and supervision to perform their assigned tasks (Tab U-163). There is no evidence to suggest that maintenance personnel and supervision were factors in this mishap.

e. Fuel, Hydraulic, and Oil Inspection Analyses

Fuel samples were taken from the fuel truck used to refuel MA prior to the mishap sortie on 20 September 2016 (Tab U-46 to U-47). Analysis of the Thermally Stable Aviation Turbine Fuel revealed no contamination (Tab U-46 to U-47). Analysis of oil cart, hydraulic fluid, and Aviator Breathing Liquid Oxygen samples revealed no contamination (Tab U-48 to U-52). There is no evidence to suggest fuel, oil, hydraulic fluid and liquid oxygen were factors in the mishap (Tab U-46 to U-52).

f. Unscheduled Maintenance

The AIB conducted a review of unscheduled maintenance events for MA for the previous 66 days before the mishap (Tab U-53 to U-85). MA had 22 unscheduled maintenance actions which were performed by 9 AMXS and 9th Maintenance Squadron (9 MXS) personnel (Tab U-53 to U-85). MA also had 12 pending unscheduled life support equipment maintenance actions due by the end of September 2016 (Tab U-18, and U-37 to U-45). An Exceptional Release for MA was completed and MA was deemed airworthy (Tab U-5 and U-15). The Exceptional Release serves as a certification that an authorized individual has reviewed the active forms to ensure the aircraft is safe for flight (Tab BB-58).

There is no evidence to suggest that unscheduled maintenance was a factor in this mishap.

6. AIRFRAME, MISSILE, OR SPACE VEHICLE SYSTEMS

a. Structures and Systems

MA was intact at impact, with the exception of the right wing tip which was separated from MA prior to impact with the ground (Tab EE-20 to EE-21). MA sustained impact and fire damage to the nose, aft fuselage section, center fuselage, left and right wings, and the empennage (Tab E-11). The nose was separated from the fuselage and the center fuselage was broken into four sections (EE-15). The aft fuselage was separated from the center fuselage (Tab EE-15). The aft cockpit fairing broke into ten pieces and was scattered around the impact site (Tab EE-16). The removable nose was found separated from the forward fuselage with minor fire damage (EE-15). The fiberglass nose cone was separated from the nose with impact damage (Tab EE-15). Both wings had lower surface impact damage and extensive fire damage (Tab EE-20 to EE-21). The right folding wing tip was found intact, approximately 1,050 feet north of the main impact site, with the wing tip and outboard aileron intact (Tab EE-11, and EE-20 to EE-21).

b. Evaluation and Analysis

Lockheed Martin Aeronautics (LM-Aero) conducted a post-mishap evaluation of the MA wreckage (Tab EE-3 to EE-89). LM-Aero's analysis included the following findings:

(1) MA was within documented Center Gravity (CG) limits and was laterally balanced at takeoff (Tab EE-10 and EE-57).

(2) With the exception of the right wing tip, the airframe was structurally intact at the time of ejection (Tab EE-21). The right wing tip separated as a result of impact with MIP and his ejection seat (Tab EE-22, and EE-138 to EE-139).

(3) The Avionics Processor (data recorder) was destroyed in the mishap and no data could be recovered (Tab EE-23).

(4) MA's ailerons and roll spoilers were configured for left wing down (left roll) at impact (Tab EE-33).

(5) MA's flaps were near-faired at impact (Tab EE-56).

(6) The forward and aft control column stowing mechanism functioned as designed during the ejection sequence (Tab EE-43).

(7) Rudder pedal rigging and operation could not be verified due to impact and fire damage. However, all cables were intact and secured prior to impact (Tab EE-48).

(8) Both lift spoilers were retracted at impact (Tab EE-63).

(9) The horizontal stabilizer trim was set at 1.0 degree nose up at impact (Tab EE-71).

(10) Both speed brakes were retracted at impact (Tab EE-66).

(11) Both stall strips were deployed at impact (Tab EE-68).

(12) Forward and aft throttle settings prior to ground impact could not be determined (Tab EE-76)

(13) The left Angle of Attack (AOA) indicator showed a deep stall at the time of impact (Tab EE-77). The AOA of the right wing at impact could not be determined (Tab EE-77).

(14) The Emergency Start System (ESS) was not used for in-flight engine restart (Tab EE-79).

(15) The Direct Current (DC) ESS Primary Bus was functioning up to the point that MA lost radar contact. The status of other electrical systems could not be assessed due to impact and fire damage (Tab EE-82).

(16) Hydraulic system functioning after takeoff could not be determined due to impact and fire damage (Tab EE-83).

(17) The main and tail landing gear were fully down and locked at impact (Tab EE-83).

LM-Aero found no evidence MA's flight controls were not functioning as designed prior to the mishap (Tab EE-87 to EE-88). There was no evidence MA's electrical or hydraulic systems malfunctioned (Tabs V-1.1 to V-1.7, and EE-82 to EE-83). Separate engine analysis by the Air Force Life Cycle Management Center indicated MA's engine was operating at a low power setting at impact (Tab EE-190).

There is no evidence to suggest that aircraft structural failure or system malfunctions were a factor in the mishap.

7. WEATHER

a. Forecast Weather

The Beale AFB Weather Flight provided the mission execution forecast on 20 September 2016 (Tab F-2). The forecast included winds from 150 degrees at 10 knots with gusts to 15 knots, clear skies, 22 degrees Celsius (71.6 degrees Fahrenheit), altimeter 29.90 pounds per square inch, and 7 statute miles of visibility (Tab F-2). Forecast weather remained approximately the same except for slight wind shift to 180 degrees and increase to 12 knots with gust to 18 knots (Tab F-2).

b. Observed Weather

The observed weather at Beale AFB included winds from the south at 14 knots, clear skies, 24 degrees Celsius (75.2 degrees Fahrenheit), altimeter 29.91 pounds per square inch, and 10 statute miles of visibility (Tab W-3). Subsequent hourly observations reported varying wind intensities at 12 and 15 knots (Tab W-3).

c. Space Environment

Not applicable.

d. Operations

There is no evidence to suggest MA was operating outside its prescribed weather operational limitations.

8. CREW QUALIFICATIONS

a. Mishap Instructor Pilot

MIP was a current qualified TU-2S Acceptance Flight (AF) Instructor Pilot (IP) (Tab G-2, G-4 to G-5). MIP was a Navy inter-service transfer with 3,783 hours in the TC-12B, P-3C, T-34C and C-9 (Tabs G-5, T-3 to T-4, T-6, and T-10). Additionally, MIP was a Naval Aviation Training and Operational Procedure Standardization pilot and carried a Special Instrument rating initially in the T-34C and the C-9 (Tab T-3, and T-5 to T-6). MIP separated from the Navy on 9 July 2009 and entered active duty service in the Air Force on 10 July 2009 at Beale AFB (Tab T-11). MIP completed T-38/A Instrument Qualification in 2009 (Tab T-8), followed by U-2S Initial and Mission qualification in 2010 (Tab T-16 to T-17). MIP completed single-seat U-2S IP training in 2011, FCF training in the U-2S in 2012 (Tab T-14 to T-15), and two-seat TU-2S instructor training in 2013 (Tab G-2). The MIP became a U-2S Evaluator and AF IP in 2014 (Tabs G-2 and T-13). MIP completed T-38/A IP training in 2015 and became a T-38/A Evaluator in 2016 (Tab T-7 and T-9). MIP was the Chief U-2 FCF pilot for the U-2S program at Beale AFB (Tab V-9.4). He had 952 hours in the U-2S, 323 hours in the TU-2S, and 470 hours in the T-38/A (Tab G-5). His recent flight time was as follows (Tab G-6):

MIP	Hours	Sorties
Last 30 Days	19.2	14
Last 60 Days	36.6	27
Last 90 Days	49.9	36

b. Mishap Pilot

MP completed the required training to occupy and fly the TU-2S from the rear-cockpit during the AF missions, through he was not qualified in the TU-2S (Tab G-19 to G-22). MP completed Undergraduate Pilot Training (UPT) at Sheppard AFB, Texas (TX) in 2010 where he flew the T-6 and T-38 (Tab T-25). Following UPT, MP earned first pilot instrument qualification and mission qualification in the C-17/A at the 58th Airlift Squadron, Altus AFB, Oklahoma (OK) (Tab T-21 to T-22). MP became an aircraft commander in the C-17/A in the 10th Airlift Squadron at McChord AFB, Washington (WA), in 2011 (Tab T-19 to T-20). MP attended Pilot Instructor Training (PIT) and completed initial instructor training in the T-38/C at Randolph AFB, TX in 2014 (Tab T-26 to T-27). MP was later assigned to the 1 RS as a T-38/A IP in 2014 (Tab G-18). MP was designated a T-38/A evaluator in 2015 (Tab G-15). MP has 570.4 hours in the T-38 and 1,348.6 hours in the C-17 (Tab G-23). His recent flight time was as follows (Tab G-25):

MP	Hours	Sorties
Last 30 Days	17.2	14
Last 60 Days	38.3	33
Last 90 Days	58.9	51

9. MEDICAL

a. Qualifications

(1) Mishap Instructor Pilot

MIP was medically qualified for flight duties without restriction at the time of the mishap (Tab X-7 to X-8). MIP had a “Medically Cleared” Department of Defense (DD) Form 2992 from his annual Physical Health Assessment on 1 July 2016, with an expiration of 28 September 2017 (Tab X-3). A review of his medical records revealed MIP had no acute or chronic medical conditions requiring an aeromedical waiver (Tab X-7). Additionally, MIP had no waivers in the Aeromedical Information Management Waiver Tracking System (AIMWTS) (Tab X-5).

(2) Mishap Pilot

MP was medically qualified for flight duties without restriction at the time of the mishap (Tab X-7 to X-8). MP had a “Medically Cleared” DD Form 2992 from 18 April 2016 after a Return to Flying Status Exam, with an expiration of 14 November 2016 (Tab X-4). A review of his medical records reveals MP had no acute or chronic medical conditions requiring aeromedical waiver (Tab X-8). Additionally, MP had no waivers in the AIMWTS (Tab X-6).

(3) Other Personnel

Review of medical records of MMI, MMO, SOF, AFE and maintenance personnel was unremarkable (Tab X-7 to X-8).

There is no evidence to suggest medical qualifications were a factor in this mishap (Tab X-7 to X-8).

b. Health

(1) Mishap Instructor Pilot

The AIB reviewed MIP’s medical records, as well as the 72-hour and 7-day history completed by his spouse (Tab X-7 to X-8). Medical records revealed he was in good health and had no performance-limiting illnesses prior to the mishap (Tab X-7 to X-8). MIP had a current physical health assessment as mentioned above (Tab X-3, and X-7 to X-8). No relevant medical information was noted in the medical records (Tab X-7 to X-8).

(2) Mishap Pilot

MP’s medical records were reviewed, but a 72-hour and 7-day history was not available for review (Tab X-8). Medical records revealed he was in good health and had no recent performance-limiting illnesses prior to the mishap (Tab X-8). There is no evidence to suggest that MP’s health was a factor in this mishap (Tab X-8).

MP suffered non-life-threatening burns to his face due to MIP's ejection seat rocket motor, a dislocated left ankle, and fractures to his left ankle suffered during his PLF (Tabs V-1.5, V-15.5, V-16.7, V-18.3, and X-8).

c. Toxicology

The Armed Forces Medical Examiner System (AFMES) tested blood and urine samples in accordance with AFI 91-204, *Safety Investigations and Reports* (Tab BB-23 to BB-24). These tests identify carbon monoxide and ethanol levels in the blood and detect traces of drugs (amphetamine, barbiturates, benzodiazepines, cannabinoids, cocaine, opioids, phencyclidine, and sympathomimetic amines) in urine (Tab X-7).

The following personnel were tested: MIP, MP, MMO, MMI, SOF, as well as all relevant PSPTS, AFE and maintenance personnel (Tab X-7 to X-8).

(1) Mishap Instructor Pilot

MIP's toxicology results were positive for diphenhydramine, but the amount consumed and time of ingestion could not be determined (Tab X-7 to X-8). Diphenhydramine is most commonly known by the brand name "Benadryl," but is also a component of many other over the counter medications (Tab EE-192 to EE-195). Common side effects of diphenhydramine include drowsiness and sedation (Tab EE-194 to EE-195). MIP's toxicology results were otherwise normal (Tab X-7 to X-8).

Diphenhydramine is not listed under either the *Official Air Force Aerospace Approved Medications* (11 September 2016) (Tab BB-25 to BB-44), or the list of *Over the Counter (OTC) Medications Aircrew Are Allowed to Take Without Flight Surgeon Approval* (09 January 2014) (Tab BB-45 to BB-47). Although MIP should have been restricted to Duties Not Involving Flying if he ingested diphenhydramine within the 24 hours before the mishap, the time of ingestion could not be determined (Tab X-8). Witnesses indicated MIP was alert, excited, and ready to fly the morning of the mishap (Tab V-6.4 to V-6.5, V-10.8, V-11.2 to V-11.3, V-14.2 to V-14.3, and V-24.5).

(2) Mishap Pilot

MP's toxicology results showed trace amounts of acetone in his blood sample (Tab X-8). Acetone is a breakdown product from both alcohol and fats (Tab EE-196 to EE-197). Acetone can also be present if a person is fasting (Tab EE-197). MP's toxicology report did not show evidence of ethanol present in his blood (Tab X-8).

(3) Other Personnel

One 9 PSPTS member was positive for Oxymorphone (Tab X-7 to X-8). The day prior to the mishap, this member conducted supervisory checks of MA's survival equipment, and signed off that the equipment was loaded correctly on the MA (Tab D-10 to D-11). Post-mishap inspection and analysis of the Aircrew Flight Equipment concluded that all survival equipment worked correctly (Tab H-19 to H-20). All other personnel tested had negative results (Tab X-7 to X-8).

d. Pathology

The Sutter County Coroner drove the body of the MIP to a mortuary in Yuba City, CA (Tab V-19.4). FS2 and FS3 travelled to the mortuary to verify MIP was present, arriving at approximately 1830L (Tab V-19.4). The Sutter County medical examiner concluded MIP died of blunt force injuries to the head and neck, and that these injuries were instantanously fatal (Tab X-8).

AFMES published a consultation autopsy report (Tab X-7). The medical examiner also concluded MIP died from blunt force injuries to the head and neck due to the aircraft mishap (Tab X-7).

e. Lifestyle

There is no evidence that the lifestyles of the MP, MMI, MMO, SOF, AFE, PSPTS, or maintenance personnel were a factor in this mishap (Tab X-7 to X-8). There was anecdotal evidence MIP had trouble sleeping, but there was no evidence in MIP's medical records or in the 72-hour history prepared by MIP's spouse suggesting MIP experienced sleeping problems in the days preceding the mishap (Tabs X-7 and V-6.5).

f. Crew Rest and Crew Duty Time

In accordance with AFI 11-202, Volume 3, *General Flight Rules*, aircrew members are required to receive a minimum of 12 non-duty hours of crew rest prior to performing flight duty (Tab BB-19 to BB-20). During this time, a crewmember may participate in meals, transportation, or rest (Tab BB-19). This time must include an opportunity for at least 8 hours of uninterrupted sleep (Tab BB-19 to BB-20). Crew rest period cannot begin until after the completion of official duties (Tab BB-19 to BB-20).

A review of MIP's and MP's duty cycles leading up to the mishap indicate they received the required crew rest time (Tabs X-7 to X-8, and V-24.4 to V-24.5). On the day of the mishap, MIP was approximately 15 minutes late to the morning pre-brief, reportedly due to oversleeping (Tab V-V-6.4 to V-6.5, and V-24.5). As noted above, witness testimony indicated MIP was alert, excited, and ready to fly when he arrived.

Both MIP and MP were within their 12-hour duty day when the mishap occurred (Tab V-24.6 to 24.7). There is no evidence to suggest crew rest or crew duty times were factors in the mishap (Tab X-7 to X-8).

10. OPERATIONS AND SUPERVISION

a. Operations

(1) Mishap Instructor Pilot

MIP flew 14 sorties/19.2 hours in the 30 days preceding the mishap. Of the 14 sorties, MIP flew one in the U-2S, three in the TU-2S, and 10 in the T-38/A (Tab G-6). There was nothing remarkable about MIP's operations tempo the week preceding the mishap (Tab T-29 to T-46).

(2) Mishap Pilot

MP flew 14 sorties/17.2 hours in the T-38/A in the 30 days preceding the mishap (Tab G-25). In the week preceding the mishap, MP followed the AF 2-week interview schedule, which consists of non-flying events the first week followed by the three AF sorties the second week (Tab T-29 to T-46). There was nothing remarkable about MP's operations tempo the week preceding the mishap (Tab T-29 to T-46).

b. Supervision

On the morning of 20 September 2016, the 1 RS operations supervisor validated Go/No-Go items, verified the mishap crew's Risk Management matrix, and authorized the flight in accordance with established guidance (Tabs K-2, V-11.2; V-24.5, AA-4 to AA-5, and BB-78 to BB-79).

There is no evidence to suggest operations or supervision were a factor in this mishap.

11. HUMAN FACTORS ANALYSIS

The AIB considered all human factors as prescribed in the Department of Defense Human Factors Analysis and Classification System 7.0 (DoD HFACS 7.0) (Tab BB-80 to BB-82).

The AIB identified one human factor relevant to the mishap: "Rushed or Delayed a Necessary Action" (AE107), which 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-82).

Because the ejection seats in the TU-2S are not automatically sequenced to de-conflict the seats during ejection, the ideal manual ejection sequence is for the rear pilot to eject first (Tab BB-49). During the mishap ejection sequence, MP believes the forward pilot (MIP) ejected before the aft pilot (MP), resulting in burns to MP's face from MIP's ejection seat rocket motor (Tabs V-1.5, V-15.5, and X-8).

The standard command for ejection is "bail out, bail out, bail out" (Tab BB-49). In this case, MIP commanded ejection using non-standard terminology. MP, who was surprised by the command and did not immediately understand the need to eject, queried the command (Tab V-1.5, and V-16.3). The evidence suggests that MIP's use of a non-standard command to eject, combined with MP's failure to appreciate the need to eject, delayed MP's processing of the command to eject. (Tab V-1.5).

12. GOVERNING DIRECTIVES AND PUBLICATIONS

a. Publically Available Directives and Publications Relevant to the Mishap

(1) AFI 91-204, *Safety Investigation and Reports*, 11 January 2016
(2) AFI 51-503, *Aerospace and Ground Accident Investigations*, 14 April 2015
(3) AFI 11-202 Volume 3, *General Flight Rules*, 10 August 2016
(4) AFI 11-2U-2 Volume 3, *Operations Procedures*, 15 August 2013
(5) AFI 11-418, *Operations Supervision, Beale AFB Supplement*, 23 December 2013

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

b. Other Directives and Publications Relevant to the Mishap

(1) TO 00-20-1 *Aerospace Equipment Maintenance Inspection, Documentation, Polices, and Procedures*, 1 July 2016
(2) *Air Force Tactics, Techniques, and Procedures* 3.3 U-2, 4 June 2015
(3) 1U-2S-1, *Flight Manual*, 1 May 2016
(4) 1U-2S-6, *Aircraft Scheduled Inspection and Maintenance Requirements,* 1 April 2016
(5) 9th Operations Group U-2 Briefing Standards, 1 March 2013
(6) 9th Operations Group U-2 Mobile Standards, 1 February 2015
(7) U-2S Basic Pilot Qualification Training Syllabus, May 2015
(8) Air Force Aerospace Medicine Approved Medications, 11 September 2016
(9) OTC, Air Force Aerospace Medicine Approved Medications, 9 January 2014
(10) Department of Defense Human Factors Analysis and Classification System (DoD HFACS) Version 7.0

c. Known or Suspected Deviations from Directives or Publications

Not applicable.

//SIGNED//

18 NOVEMBER 2016

DAVID S. NAHOM
Brigadier General, USAF
President, Accident Investigation Board

STATEMENT OF OPINION

TU-2S, T/N 80-001068
BEALE AFB, CA
20 SEPTEMBER 2016

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 20 September 2016 at 0908L local time, a two-seat TU-2S crashed in Sutter County, California (CA), 18 nautical miles west of Beale Air Force Base (AFB), CA. Mishap Instructor Pilot (MIP) and Mishap Pilot (MP) egressed Mishap Aircraft (MA) at approximately 8,500 feet mean sea level (MSL). MIP did not survive ejection, and MP sustained injuries to his left leg and burns to his face. MA, tail number 80-001068, was assigned to the 1st Reconnaissance Squadron, 9th Reconnaissance Wing (9 RW), Beale AFB, CA. The MA, valued at $32,797,414, was completely destroyed. MA impacted private property 5 miles northwest of Sutter, CA, resulting in a grass fire that burned most of a 262 acre pasture. There were no injuries on the ground.

I found by a preponderance of evidence that the cause of the mishap was the MP's flight control inputs during the recovery phase of a no-flap "approach to stall" maneuver that led MA into an unintentional secondary stall and uncommanded sharp left wing drop, 70-80 degrees of bank with the nose 35-40 degrees below the horizon. With the MA rapidly approaching minimum uncontrolled ejection altitude, MIP commanded ejection. Immediately after ejection, and while still seated in the ejection seat, MIP and his seat struck the MA's right wing resulting in fatal injuries.

I developed my opinion by in-person and telephonic interviews with MP, supervisory pilots, instructor pilots, functional check flight pilots, first responders, squadron supervision, and medical personnel. I also reviewed directives, technical orders, established Tactics, Techniques, and Procedures, U-2S syllabi, information provided by technical experts, and post-mishap forensic reports and mishap re-creations.

2. CAUSE

The mishap occurred on the first of three Acceptance Flight (AF) missions for the MP. The cause of the mishap was the MP's flight control inputs during the recovery phase of a no-flap "approach to stall" maneuver that led the MA into an unintentional secondary stall and uncommanded sharp left wing drop, 70-80 degrees of bank with the nose 35-40 degrees below the horizon. During the subsequent ejection, MIP and his seat struck the MA's right wing, resulting in fatal injuries.

a. Acceptance Flight Mission Profile

AF missions are for the screening of prospective U-2S pilots, assessing their ability and fitness to succeed as a U-2 pilot prior to beginning the Basic Qualification syllabus. A prospective pilot will spend 2 weeks at Beale AFB for interviews and to fly three AF missions. The first AF flight (AF-1) is designed to familiarize interviewees with U-2S flight characteristics, normal traffic patterns and normal landings. Additionally, AF-1 introduces interviewees to U-2S stall characteristics by conducting "approach to stall" training. Witness interviews revealed AF-1 "approach to stall" instruction and technique varies by AF IP and there is limited formal guidance or squadron standardization.

As applicants have not received formal U-2S academic or simulator training, they are expected to demonstrate only very limited proficiency in the U-2S during the AF missions. With the mishap sortie being MP's first flight in a TU-2S, he had yet to establish proficiency in any of the maneuvers that were to be introduced. Although applicants are "hands-on" flying during much of the AF syllabus, the instructor pilot is ultimately responsible for the safe execution of AF sorties.

b. No-flap "Approach to Stall" Maneuver

The mishap occurred during the third no-flap "approach to stall" maneuver as part of MP's AF-1 sortie. During the MP's first no-flap "approach to stall" maneuver, MP used a significant amount of right aileron and an undetermined amount of right rudder to counter a left rolling tendency during the recovery. MP described his aileron inputs as abrupt "stabbing" motions to attempt to maintain a wings-level attitude. MA recovered with 80 degrees of heading change and 500 feet of altitude loss. During the recovery, MIP instructed MP to "ease up" on the yoke backpressure and cautioned MP on the G-limitation on the TU-2S. On the second "approach to stall" maneuver, MIP demonstrated the maneuver and recovered with minimal heading change and less than 300 feet of altitude loss. MP recalled being surprised that MIP used almost full right aileron throughout his recovery, but did not recall how much rudder MIP applied.

c. Secondary Stall

On the third no-flap "approach to stall" maneuver, MP was flying and again used a significant amount of right aileron during the recovery. As the MA approached the stall indication, MP applied forward elevator control and simultaneously put the throttle to Full while using nearly full right aileron and an undetermined amount of right rudder to counter a slight left rolling tendency. As the nose was raised toward the horizon in the recovery, MA entered a secondary stall with the left wing sharply dropping off. At the time of the secondary stall, the controls were nearly full right aileron, Full power, and an undermined amount of right rudder. MP was not able to determine whether his rudder application was sufficient due to his inexperience in the TU-2S. At an approximate altitude of 8,500 feet MSL, MA rapidly approached 70-80 degrees of bank and 35-40 degrees nose low.

With the aircraft having departed controlled flight and rapidly approaching an inverted condition, it is not apparent what actions MIP attempted to effect a recovery; if the aircraft was at all recoverable; and if it was recoverable, whether there was sufficient altitude to recover. The TU-2S does not have a cockpit voice or data recorder that would have assisted with the analysis.

Additionally, MP reported his situational awareness was low throughout the sortie. MP stated he left the throttle in Full as the aircraft departed controlled flight. However, post-impact analysis indicates the engine was in a low power setting at impact. It is likely MIP pulled the power back as part of an attempt to recover prior to commanding ejection.

During an "approach to stall" recovery, overly aggressive elevator control to bring the nose back to the horizon can put the TU-2S into a secondary aerodynamic stall. Excessive aileron control can aggravate this condition and lead to a rapid wing drop. Uncorrected, this condition will likely put the aircraft in a spin. U-2S guidance does not provide recovery techniques or procedures from a spin or departure from uncontrolled flight and directs ejection from the aircraft.

d. Ejection sequence

With the MA approaching the minimum uncontrolled ejection altitude, MIP made the decision to command ejection. When ejection was commanded, MP was initially surprised by the command and the non-standard verbiage used. This resulted in a momentary delay before MP applied the ejection critical action procedure. Due to this delay, the front seat occupant (MIP) ejected slightly before the rear seat occupant (MP). There was no evidence of any interference between the two seats, though MP did sustain minor burns to the face from MIP's ejection seat rocket motor.

MIP's seat ejection functioned automatically and properly, though it did contact the right wing tip. As MIP's seat traveled up the seat rails, the aircraft was in a rapid left rolling motion. This left rolling motion of the MA likely imparted a right rolling motion to MIP's seat. When ejecting from an aircraft in a roll, an ejection seat will likely roll in the opposite direction of the aircraft roll. Additionally, the TU-2S ejection system is not stabilized in the roll axis. The seat rolling right created an unstable trajectory during rocket motor initiation vectoring MIP's seat into the last 5 feet of the right wing tip.

Evidence indicates it is probable MIP was not secured by his lap belt at the time of ejection, which could have exacerbated an already unstable trajectory during rocket motor initiation. However, there was insufficient data to re-create MIP's ejection trajectory to determine conclusively whether MIP's lap belt configuration caused him to strike the right wing tip. Specifically, the MA's exact attitude and configuration at the time of MIP's ejection could not be determined due to limited witness testimony and the lack of recorded flight data. Additionally, the ejection seat was likely in an unstabilized roll due to MA's rolling motion, and there is no test data modeling the U-2S ejection seat's expected trajectory from a rolling aircraft.

MIP and his seat struck the wing tip almost simultaneously, breaking off a 5 foot section of the wing, significantly damaging the top left portion of the seat, and fatally wounding MIP. MIP did receive a full parachute and landed within a quarter mile of MP, just over one mile from the main aircraft wreckage. In addition to the minor facial burns, MP sustained significant injuries to his left ankle during the parachute landing fall.

3. SUBSTANTIALLY CONTRIBUTING FACTORS

The cause of the mishap is identified in paragraph 2. No other factors were conclusively determined to have substantially contributed to the mishap.

One area of concern during the investigation was MIP's positive toxicology results for diphenhydramine, a medication commonly know by the brand name Benedryl. Common side effects of diphenhydramine include drowsiness and sedation. Although MIP should have been restricted to "Duties Not Involving Flying" if he ingested diphenhydramine within the 24 hours before the mishap, the time and amount of ingestion could not be determined. Witnesses indicated MIP appeared alert, excited, and ready to fly the morning of the mishap. Consequently, there is insufficient evidence to support the conclusion that this medication affected MIP's performance during the mishap sortie, or that it substantially contributed to the mishap.

4. CONCLUSION

I found by a preponderance of evidence that the cause of the mishap was the MP's flight control inputs during the recovery phase of a no-flap "approach to stall" maneuver which allowed the MA to enter an unintentional secondary stall and uncommanded sharp left wing drop, with 70-80 degrees of bank and the nose 35-40 degrees below the horizon. From this point, it is not apparent what actions MIP took to recover MA, or if there was sufficient altitude available to effect a recovery. With the MA rapidly approaching minimum uncontrolled ejection altitude, MIP commanded ejection. Immediately after ejection, and prior to separating from his ejection seat, MIP and his seat struck the MA's right wing resulting in fatal injuries.

//SIGNED//

18 NOVEMBER 2016

DAVID S. NAHOM
Brigadier General, USAF
President, Accident Investigation Board

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