UNITED STATES AIR FORCE
AIRCRAFT ACCIDENT INVESTIGATION
BOARD REPORT

T-38C, T/N 65-0395
&
T-38C, T/N 67-4950

25th FLYING TRAINING SQUADRON
71st FLYING TRAINING WING
VANCE AIR FORCE BASE, OKLAHOMA

LOCATION: VANCE AIR FORCE BASE, OKLAHOMA

DATE OF ACCIDENT: 21 NOVEMBER 2019

BOARD PRESIDENT: BRIGADIER GENERAL EVAN L. PETTUS

Conducted IAW Air Force Instruction 51-307

EXECUTIVE SUMMARY
UNITED STATES AIR FORCE
AIRCRAFT ACCIDENT INVESTIGATION

T-38C, T/N 65-0395 & T/N 67-4590

VANCE AIR FORCE BASE, OKLAHOMA
21 NOVEMBER 2019

At approximately 1506 Zulu (9:06 a.m. Local Time) on 21 November 2019, two T-38C Talon aircraft collided during an attempted formation landing on Runway 35 Center at Vance AFB, OK. Mishap Student Pilot 1 (MSP1) and Mishap Instructor Pilot 1 (MIP1) flew the local student formation training mission in Mishap Aircraft 1 (MA1), tail number (T/N) 65-0395. Mishap Student Pilot 2 (MSP2) and Mishap Instructor Pilot 2 (MIP2) flew in Mishap Aircraft 2 (MA2), T/N 67-4950, in direct support. Both aircraft were assigned to the 25th Flying Training Squadron (25 FTS), 71st Flying Training Wing. MIP1 was assigned to the 5th Flying Training Squadron as an Active Guard Reserve officer who flew with the 25 FTS. MIP2 was assigned to the 25 FTS. MSP1 and MSP2 were assigned to the 71st Student Squadron and flew with the 25 FTS.

Immediately after touchdown, MA1, flying in the left wing position, became briefly airborne, rolled rapidly to the right, then touched down once more in a right bank. MA1 entered a skid and crossed the runway centerline from left to right toward MA2. MA1 lifted off the runway again then struck MA2 with its right main landing gear. The collision caused MA1 to roll over the top of MA2 then impact the ground in a nearly inverted attitude, fatally injuring MIP1 and MSP1. MA1 slid approximately 700 feet before coming to a stop in a grassy area. Following the collision with MA1, MA2 departed the prepared surface of the runway, remained upright, travelled through the grass and came to a stop. MIP2 and MSP2 shut down and safely egressed their aircraft.

The Board President found by a preponderance of the evidence the causes of the mishap were MIP1 failing to take control of MA1 as a precarious situation developed and MSP1 subsequently making an inappropriate flight control input. During the landing sequence, MSP1 prematurely initiated an aerodynamic braking maneuver (aerobrake) immediately after MA1 initially touched down, causing MA1 to lose contact with the runway surface. Almost simultaneously, MSP1 applied and held right rudder in an attempt to steer MA1 away from the left edge of the runway. MSP1's use of rudder under these conditions--airborne, configured for landing and at an increased angle of attack--caused MA1 to roll and yaw to the right and placed MA1 on a collision course with MA2. The Board President found MIP1 could not have successfully prevented a collision after MSP1's rudder input had taken effect, but that MIP1 would have already intervened to take control of MA1 had he made an accurate real-time risk assessment in the preceding moments. Additionally, the Board President found the following factor substantially contributed to the mishap: MSP1 lacked an effective visual scan during the formation approach. Due to his focus on MA2, MSP1 did not adequately crosscheck his runway alignment prior to touchdown. Instead, he used rudder in an attempt to steer MA1 as his premature aerobrake lifted the weight from MA1's wheels after MA1 initially touched down.

SUMMARY OF FACTS AND STATEMENT OF OPINION
T-38C, T/N 65-0395 & T-38C, T/N 67-4950
21 NOVEMBER 2019

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ACRONYMS AND ABBREVIATIONS

19 AF	19th Air Force
25 FTS	25th Flying Training Squadron
340 FTG	340th Flying Training Group
35C	(Runway) 35 Center
35L	(Runway) 35 Left
5 FTS	5th Flying Training Squadron
71 FTW	71st Flying Training Wing
71 OG	71st Operations Group
71 STUS	71st Student Squadron
AD	Active Duty
ADO	Assistant Director of Operations
Aerobrake	Aerodynamic Braking
AETC	Air Education and Training Command
AETCMAN	Air Education and Training Command Manual
AF	Air Force
AFB	Air Force Base
AFE	Air Flight Equipment
AFGM	Air Force Guidance Memorandum
AFI	Air Force Instruction
A-Firm	Affirmative
AFLCMC	Air Force Life Cycle Management Center
AFMAN	Air Force Manual
AFMES	Air Force Medical Examiner System
AFRC	Air Force Reserve Command
AFSOC	Air Force Special Operations Command
AFTO	Air Force Technical Order
AGL	Above Ground Level
AIB	Accident Investigation Board
AIMWTS	Aeromedical Information Management Waiver Tracking System
AMC	Air Mobility Command
AOA	Angle of Attack
A&P	Air and Powerframe (Mechanic)
ATC	Air Traffic Control
ATIS	Automatic Terminal Information System
BP	Board President
BPO	Basic Post-Operation
BUFF	B-52 Aircraft
BWC	Bird Watch Conditions
CAF	Combat Air Forces
CAP	Combat Air Patrols
CAP	Commander's Awareness Program
Capt	Captain
CC	Commander
Col	Colonel
COMACC	Commander Air Combat Command
CT	Close Trail
CTR	Contractor
CTS	Course Training Standards
DIBI	Definite Increase in Buffet Intensity
DNF	Duties Not Including Flying
DO	Director of Operations
DoD	Department of Defense
DOH	H-Flight
DOI	I-Flight
DOK	K-Flight
DOS	Director of Safety
DOT	Director of Training
DTS	Data Transfer System
EMS	Emergency Medical Services
EOD	Explosive Ordinance Disposal
EOR	End of Runway
EP	Emergency Procedure
ER	Exceptional Release
F	Fair
FCF	Functional Check Flight
FCIF	Flight/Crew Information File
FCP	Forward Cockpit
FE	Flight Examiner
FLAB	Fuels Laboratory
FLT	Flight
FOD	Foreign Object Damage
Form	Formation
Freq	Frequency
FS	Flight Safety
FTG	Flying Training Group
FTS	Flying Training Squadron
FTT	Flight Test Techniques
FTU	Formal Training Unit
FTW	Flying Training Wing
g	Gravitational Force
GK	General Knowledge
GPS	Global Positioning System
HAF	Headquarters Air Force
HF	Human Factors
HFACS	Human Factors Analysis and Classification System
HUD	Head-Up Display
IFF	Introduction to Fighter Fundamentals
IFR	Instrument Flight Rules
IG	Inspector General
IGI	Inspector General Inspections
ILS	Instrument Landing System
IMDS	Integrated Maintenance Data System
IO	Investigating Officer
IP	Instructor Pilot
ISS	Inter-seat Sequencing System
JSUPT	Joint Specialized Undergraduate Pilot Training
KIAS	Knots Indicated Airspeed
KS	Kansas
L	Local Time
LA	Legal Advisor

LA	Los Angeles
LG	Logistics
LOX	Liquid Oxygen
Lt Col	Lieutenant Colonel
M	Maintenance
MA	Mishap Aircraft
MAG	Magnetic
Maj	Major
MAJCOM	Major Command
MASS	Merit Assignment Selection System
MC	Mishap Crew
MD	Medical
MDG	Medical Group
MEF	Mission Execution Forecast
MIF	Maneuver Item File
MIL	Military
MIN	Minimum
MINs	Minimums
MIP	Mishap Instructor Pilot
MOA	Military Operating Area
MS	Mishap Sortie
MSAT	Mode S Analysis Tool
MSL	Mean Sea Level
MSM	Maintenance Schedule Module
MSP	Mishap Student Pilot
MWS	Military Weapon System
NATO	North Atlantic Treaty Organization
ND	Nondisclosure
NOTAM	Notice to Airmen
OCF	Operational Check Flight
OCS	Officer Candidate School
OG	Operations Group
OI	Operating Instruction
OK	Oklahoma
Ops	Operations
Ops Tempo	Operations Tempo
ORM	Operational Risk Management
OSS	Operation Support Squadron
OSU	Oklahoma State University
OTS	Officer Training School
OU	Oklahoma University
P	Pilot
PA	Public Affairs
PAPI	Precision Approach Path Indicator
PE	Periodic Inspection
P-Factor	Pucker Factor
PHA	Periodic Health Assessment
PIO	Pilot Induced Oscillations
PIT	Pilot Instructor Training
PIRD	Powered Inertia Reel Device
PRF	Pilot Read File
PSI	Pounds Per Square Inch
PUBs	Publications
QA	Quality Assurance
R	Recorder
RCP	Rear Cockpit
Rog	Roger (Yes)
ROTC	Reserve Officer Training Corps
RPMs	Revolutions per Minute
RSU	Runway Supervisory Unit
RTB	Return-To-Base
RTU	Replacement Training Unit
RWY	Runway
SA	Situational Awareness
SCR	Safety Center Representative
SI	Safety Information
SIB	Safety Investigation Board
SIM	Simulator
SJA	Staff Judge Advocate
SOF	Supervisor of Flying
SP	Student Pilot
SPO	System Program Office
SQ	Squadron
SSK	Seat Survival Kit
SSR	Special Syllabus Requirement
STURON	Student Squadron (Informal Name)
STUS	Student Squadron (Formal Name)
SUP	Support
SUPE	Supervisor
TAC	Tactical
TACAN	Tactical Air Navigation
TCTO	Time Compliance Technical Order
TE	Technical Expert
TI	Training Instruction
TIMS	Training Information Management System
T/N	Tail Number
TO	Technical Order
TP	Traffic Pattern
U	Unsatisfactory
UPT	Undergraduate Pilot Training
USEM	Unit Standardization and Evaluation Monitor
UT	Utah
VEN	Variable Exhaust Nozzle
VFR	Visual Flight Rules
VMC	Visual Meteorological Conditions
VOR	Very High Frequency Onmidirectional Range
VVI	Vertical Velocity Indication
Z	Zulu

SUMMARY OF FACTS

1. AUTHORITY AND PURPOSE

a. Authority

On 22 November 2019, Lieutenant General Marshall B. Webb, Commander, Air Education and Training Command (AETC), appointed Brigadier General Evan L. Pettus to conduct an Accident Investigation Board (AIB) for a 21 November 2019 mishap involving two T-38C aircraft at Vance Air Force Base (AFB), Oklahoma (OK) (Tab Y-3 to Y-4). The AIB was conducted in accordance with Air Force Instruction (AFI) 51-307, *Aerospace and Ground Accident Investigations*, at Vance AFB, OK, from 17 December 2019 to 4 February 2020. The board members included a Legal Advisor (Lieutenant Colonel), a Pilot Member (Lieutenant Colonel), a Medical Member (Lieutenant Colonel), a Recorder (Technical Sergeant) and a Maintenance Member (Wage Grade-10) (Tab Y-5 to Y-6). In accordance with the requirements of AFI 51-307, Paragraph 2.2.4, the Pilot Member is a member of the United States Air Force Reserve (V-2.6).

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 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

At approximately 1506 Zulu (Z) (9:06 a.m. Local Time) on 21 November 2019, two T-38C Talon aircraft collided during an attempted formation landing on Runway 35 Center (35C) at Vance AFB, OK (Tabs O-3, O-9, O-10 and Z-14).

Mishap Student Pilot 1 (MSP1) and Mishap Instructor Pilot 1 (MIP1) flew the local student formation training mission in Mishap Aircraft 1 (MA1), tail number (T/N) 65-0395 (Tabs H-2, V-4.5 to V-4.6, AA-3 and AA-5). Mishap Student Pilot 2 (MSP2) and Mishap Instructor Pilot 2 (MIP2) flew in Mishap Aircraft 2 (MA2), T/N 67-4950, as formation direct support on the mishap sortie (MS) (Tabs H-2, V-5.4, AA-3 and AA-5). Both aircraft were assigned to the 25th Flying Training Squadron (FTS), 71st Flying Training Wing (FTW) at Vance AFB (Tab AA-3).

Immediately after touchdown, MA1, flying in the left wing position, initiated an aerodynamic braking (aerobrake) maneuver (Tabs V-22.3, Z-7, DD-4 and DD-37). MA1 became briefly airborne, rolled rapidly to the right, then touched down once more in nearly 30 degrees of right bank (Tab DD-6 and DD-38). MA1 entered a skid and crossed the runway centerline from left to right on a collision course with MA2 (Tab DD-6 and DD-38). MA1 lifted off the runway yet again and struck MA2 with its right main landing gear (MLG) followed by its right wing (Tab DD-7 and

DD-38). The collision caused MA1 to roll over the top of MA2 then impact the ground inverted or nearly inverted, fatally injuring MIP1 and MSP1 (Tabs X-3, DD-4 and DD-9). MA1 slid approximately 700 feet before coming to a stop in a grassy area roughly 300 feet east of the runway surface (Tab DD-4).

Following the collision with MA1, MA2 departed the prepared surface of the runway, remained upright, travelled approximately 1,700 feet and came to a stop (Tab DD-4 and DD-10). MIP2 and MSP2 shut down and safely egressed their aircraft (Tabs V-5.9, CC-37 and CC-39).

3. BACKGROUND

a. Air Education and Training Command (AETC)

The primary mission of AETC is to recruit, train and educate Airmen (Tab EE-3). AETC includes Air Force Recruiting Service, two numbered air forces and the Air University (Tab EE-4). The command operates 12 major installations and supports tenant units on numerous bases across the globe (Tab EE-4). There are 16 active-duty and seven reserve wings in AETC (Tab EE-4).

b. 71st Flying Training Wing (71 FTW)

The mission of the 71st Flying Training Wing is to develop professional Airmen, deliver world-class U.S. and Allied pilots and deploy combat-ready warriors (Tab EE-14). The wing provides Joint Specialized Undergraduate Pilot Training (JSUPT) Phase 1 pre-flight training, Phase II primary training, and Phase III advanced training in fighter-bomber track or tanker-airlift track (Tab EE-14).

c. 71st Student Squadron (71 STUS)

The mission of the 71st Student Squadron is to grow leaders, groom Airmen, and graduate the best-trained joint and international military aviators in the world's premier Air Force (Tab EE-17). All students at Vance AFB are administratively assigned to the 71 STUS, but fly with one of the Flying Training Squadrons (Tab V-3.3). Students in T-38 training fly with the 25th Flying Training Squadron (Tab V-3.3 and Tab V-6.2). The 71 STUS is informally called the STURON (Tab EE-17).

d. 25th Flying Training Squadron (25 FTS)

The mission of the 25 FTS is to conduct Phase III fighter-bomber track (T-38C) advanced training (Tab EE-14). The training is 120 days long and is split into five units: 60 hours of ground training, 80 hours of academic training, including T-38C systems, aerodynamics, flight planning, and an instrument qualifying examination; three hours of cockpit familiarization; 29 hours of simulator training; and 119 hours of aircraft flying training (Tab EE-14).

e. 340th Flying Training Group (340 FTG)

The 340th Flying Training Group, headquartered at Joint Base San Antonio, supports AETC's Specialized Undergraduate Pilot Training, Joint Primary Pilot Training, Pilot Instructor Training, Introduction to Fighter Fundamentals, Euro-NATO Joint Jet Pilot Training, Basic Military Training and the United States Air Force Academy (USAFA) (Tab EE-16). The 340th consists of 425 instructor pilots assigned to six squadrons at Vance AFB, Joint Base San Antonio, Columbus AFB, Laughlin AFB, Sheppard AFB, and USAFA (Tab EE-23).

f. 5th Flying Training Squadron (5 FTS)

The mission of the 5 FTS is to train and provide a reserve of experienced instructor pilots to augment the Air Education and Training Command's instructor cadre in the event of wartime mobilization (Tab EE-16). During wartime, or in the event of hostilities, the unit is mobilized to offset the anticipated loss of experienced active duty pilot inputs into AETC's Pilot Instructor Training pipeline (Tab EE-16). Members of the 5 FTS provide instructor support to the 25 FTS and other 71 FTW units (Tab V-1.2 and V-2.2).

g. T-38C Talon

The T-38C Talon is a twin-engine, high-altitude, supersonic jet trainer used in a variety of roles because of its design, economy of operations, ease of maintenance, and high performance (Tab EE-20). The first Talon flew in 1959 (Tab EE-21). As the T-38 fleet has aged, specific airframe, engine and system components have been modified or replaced (Tab EE-21). Pacer Classic is the name given to the sustainment program that integrates essential modifications, and includes major structural replacements into one process (Tab EE-21). AETC is the Air Force's primary user of the T-38 (Tab EE-20). 71 FTW uses the T-38C to prepare pilots for front-line fighter and bomber aircraft such as the F-15C Eagle, F-15E Strike Eagle, F-16 Fighting Falcon, B-1B Lancer, A-10 Warthog, F-22 Raptor, and F-35 Lightning II (Tab EE-21). The National Aeronautics and Space Administration also uses the T-38 as a trainer for astronauts and as a chase plane (Tab EE-21).

(1) Formation Techniques

Air Education and Training Command Manual (AETCMAN) 11-251, *T-38C Flying Fundamentals*, and generally accepted operational practices, define two-ship formation roles and responsibilities (Tab BB-19 to BB-29). The aircraft flying in the flight lead role, or simply, "lead," is to focus on avoiding traffic, maintaining a safe altitude above the ground, planning for the formation, and managing the mission (Tab BB-19). The aircraft flying in the wingman role, or simply, "wing," is to ensure deconfliction from lead, maintain directed formation position, and provide mutual support (Tab BB-19 to BB-23).

During the final phases of a formation approach to landing, the wingman maneuvers to a "stack level" position in preparation for touchdown (Tab BB-26). "Stack level" places the wingman at abreast of the flight lead at the same altitude, though slightly staggered aft, with approximately 10

to 50 feet of wingtip clearance between the two aircraft (Tab BB-26 to BB-27). The lead aircraft aligns to the center of its half of the runway and the wing aircraft aligns to the center of the opposite half (Tabs V-5.10, Z-17, and BB-26).

During a formation approach, a commonly accepted practice is for flight leads to maintain an airspeed slightly faster than the calculated final approach speed until transition to landing (Tab V-5.8 and V-5.10). This reduces the risk the wingman will become dangerously slow while making corrections to maintain formation position (Tab V-1.12).

At 1000 feet before the runway overrun (the beginning of the paved surface), the flight lead transitions to prepare for landing by slightly decreasing the rate of descent (Tab BB-14). As the formation closes in to 500 to 300 feet before the overrun, the flight lead will slightly raise the nose of his or her aircraft and smoothly reduce power to idle (Tabs V-3.15 and BB-28). This is called the flare (Z-16). The wing aircraft matches the flight lead's maneuvers (Tab BB-19). The two aircraft should touch down nearly simultaneously, approximately 500 to 1000 feet down the runway (Tabs V-5.10 and BB-26).

(2) Aerobrake

After touch down, once the aircraft have slowed below flying airspeed, each pilot will raise the nose to enter an aerodynamic braking maneuver (aerobrake) (Tabs V-5.10 and BB-16). Raising the nose in this manner blocks airflow and creates significant aerodynamic drag, slowing the aircraft to a speed at which the pilot can safely employ mechanical brakes (Tab BB-16). It is a widely accepted practice for the flight lead to delay initiating an aerobrake until after the wingman, which creates separation during the landing rollout, allowing the wingman to fall into trail on the runway (Tab V-5.8 and V-22.3).

(3) Ejection Seats

The T-38C uses the Martin-Baker MKUS16T ejection seats (Tab DD-39). The system is equipped with an Inter-seat Sequencing System (ISS) (Tab DD-39). This system can be set to three modes: SOLO, BOTH, or CMD FWD (Tab DD-40). The mode of operation selected by the crew of MA1 was BOTH (Tab DD-47). In this setting, the ejection system is designed to initiate if either pilot pulls their respective ejection control handle (Tab DD-41 to DD-43). Once the handle is pulled, the Powered Inertia Reel Device (PIRD) retracts the harness to hold the pilot in the proper position for ejection (Tab DD-41). Then the ISS time-delay cartridges ensure the canopies and seats separate in a specific sequence: rear canopy jettisons, rear seat fires, front canopy jettisons, front seat fires (Tab DD-41).

(4) Data Limitations

The T-38C systems do not record actual control inputs, but do capture parametric data from certain gauges and sensors (Tab DD-28).

h. Commander's Awareness Program (CAP)

Air Education and Training Command Instruction (AETCI) 36-2605, Volume 1, Formal Flying Training Administration and Management, 17 September 2019, requires units to have a CAP program (Tab E-25). The 25 FTS uses 25 FTS Operating Instruction (OI) 11-01 to implement their program Tab BB-47 to BB-50). The OI requires the squadron commander to consider placing a student on CAP for flying if the student has two consecutive flights or simulators with a Fair or Unsatisfactory grade, or demonstrates slow overall progression (Tab BB-48). When a student is on CAP, instructors must notify the flight commander if the student receives a grade of Fair or Unsatisfactory on any syllabus aircraft or simulator sortie; a grade below required levels for an emergency procedure or general knowledge item on a sortie; or demonstrates procedural knowledge deficiencies affecting progress or substandard officership (Tab BB-48). When a student is on CAP, the flight commander must ensure continuity of instructors (limiting the number of different instructors interacting with the student) and ensure the student is scheduled for a maximum of two activities per day (Tab BB-49).

i. Zulu Time

Zulu time is used in military operations as a standardized time across the globe (Tab EE-24). On the day of the accident, the local time at Vance Air Force Base was six hours behind Zulu time (Tab EE-24).

4. SEQUENCE OF EVENTS

a. Mission

The Mishap Sortie (MS) was a local training mission at Vance AFB, OK, using the training profile found in item F5487 of the T-38C Specialized Undergraduate Pilot Training (SUPT) syllabus (Tabs V-4.5, AA-3, AA-6, BB-58 and BB-65). The "87" denotes the sortie was additional training in the formation (F54XX) block of the syllabus (Tab BB-58 and BB-65). The 25 FTS Operations Supervisor authorized the MS as a two-ship formation sortie to be conducted in a nearby Military Operations Area (MOA) (Tabs H-2, V-4.5 and AA-3).

b. Planning

The Mishap Crewmembers (MC) completed flight planning prior to the MS in accordance with applicable regulations and standard operational practices (Tab V-5.5 and 5.6). Actions included mission profile planning, review of applicable training records, review of notices to airmen (NOTAMs) and bird watch conditions (BWC), and reference to appropriate weather forecast conditions (Tab V-6.5). The MC completed the 25 FTS Operational Risk Management (ORM) worksheet, a standardized checklist identifying common risk factors; as cumulative risk increases, the level of the authority required to approve the mission profile also increases. The MC calculated a low level of risk for the MS (Tab AA-5 to AA-6). Risk factors identified for the MS included: two-ship formation, gusty winds forecast above five knots speed, weather forecast ceilings less than 1500 feet, and an MC report time earlier than 1230 Zulu (Z) (Tab AA-5 to AA-6).

The MS was conducted as a two-ship formation under the overall flight leadership of MIP1 flying in MA1 using the callsign STATE 81 (Tabs AA-3 and H-2). MIP1 occupied the rear cockpit (RCP) and MSP1 occupied the front cockpit (FCP) (Tab AA-5). The MC flew the MS in order to meet the objectives of training sortie F5487 for MSP1 with MIP1 as the instructor of record (Tabs H-2, V-5.5, AA-3, BB-58 and BB-65). MA2 flew as the needed second aircraft for the formation with MSP2 in the FCP and MIP2 in the RCP (Tabs AA-5 and V-5.4). MSP2 flew solely as an observer on the sortie without syllabus objectives (Tabs V-5.5 and BB-57). The MS was the first sortie flown by each crewmember that day (Tabs T-69, V-5.5, and V-6.4).

MIP1 conducted the pre-mission briefing of the planned sortie (Tab V-5.5). MSP1 was to lead the formation takeoff, the departure to the MOA, and the first half of the MOA profile, to include the g-awareness exercise, tactical formation maneuvering and rejoins, wingwork, close trail, and extended trail from a perch setup (Tab H-2). Following a lead change in the MOA, MSP1 was to accomplish the remainder of the sortie from the wing position, to include tactical maneuvering and rejoins, wingwork, close trail, practice lost wingman, extended trail from a perch setup, recovery from the MOA, and a battle damage check (Tabs H-2, O-3 to O-10 and BB-65). Due to the weather conditions, MIP1 initially briefed a formation split for separate landings via individual instrument approach recoveries (Tabs H-2 and V-5.6). He subsequently briefed MSP1 would accomplish a formation approach and landing from the wing position if the weather improved sufficiently (Tab V-5.6). This would allow MSP1 more time and fuel for tactical formation maneuvering in the MOA (Tab O-3).

c. Preflight

The MC received a final briefing from the Operations Supervisor, reviewed go/no go items, obtained their aircraft assignments, and donned their aircrew flight equipment (AFE) (Tab V-6.6). They completed engine start and taxi as planned and briefed (Tab V-6.6).

d. Summary of Accident

MA1 led the first portion of the MS as planned and briefed (Tab V-6.6). After the lead change, MIP1 contacted the T-38 Operations Supervisor to request the current T-38 flying status at Vance AFB (Tab O-3). The Operations Supervisor informed MIP1 the status had improved to "Restricted Pattern – Straight-In Only," which indicated weather conditions permitted a two-ship formation approach and landing (Tab O-3). MIP1 then informed MSP1 they would accomplish the formation approach and landing (Tab O-3). Upon MSP1's acknowledgement and concurrence, MIP1 informed MIP2 of the updated flying status and directed a formation approach and landing (Tab O-3). The rest of the profile in the MOA proceeded as planned (Tabs O-3 to O-10 and V-5.7).

Once assuming the role of formation lead, MIP2 used the call sign STATE 81 for all radio transmissions in accordance with accepted practice (Tabs O-5 and BB-22). On the return from the MOA to Vance AFB, MIP2 requested to enter the pattern from Air Traffic Control (ATC) (Tab O-6). ATC informed him an instrument or visual recovery to Runway 35C was all that was available (Tab O-6). MIP2 requested an instrument approach with vectors to final for an Instrument Landing System (ILS) approach to Runway 35C (Tab O-6). "PAROS" was the name of the GPS fix point for the approach (Tab O-9). Vectors to final for ILS approach to Runway 35C proceeded without incident (Tab O-10).

For the formation approach and landing, MA2 would land on the right side of the runway and MA1 on the left (Tabs V-6.7, V-6.8 and DD-4). The MC completed all landing checks in visual meteorological conditions (VMC) once below the overcast cloud layer (Tabs O-9, O-10 and V-5.7). MA1 and MA2 reached the final approach fix ("PAROS") at 1504:36Z appropriately configured and within planned parameters (Tab O-9 and O-10).

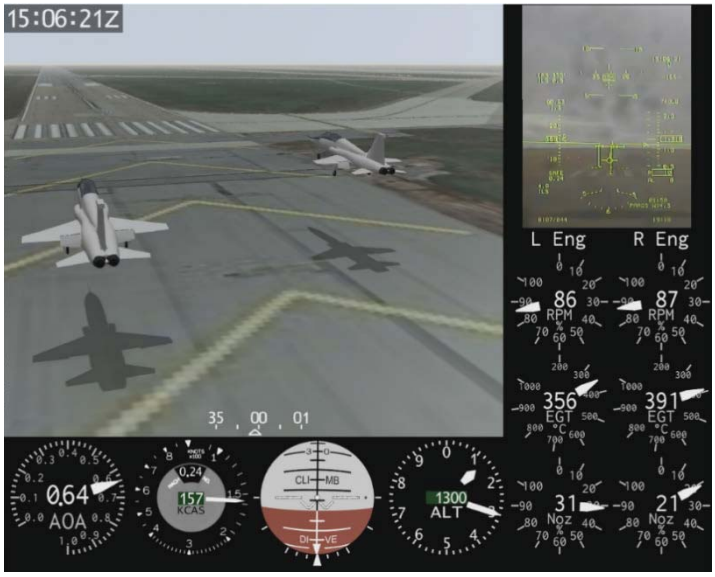
(1) MA1

On final approach, descending through 500 feet above ground level (AGL), MSP1 maneuvered to a "stack level" position in accordance with standard practices in preparation for landing (Tabs Z-17 and BB-26 to BB-27). The MC planned for each aircraft to land in the center of its respective half of the runway (Tabs V-5.10 Z-17). On Runway 35C this equates to 50 feet of wingtip clearance between aircraft (Tab Z-17).

Head Up Display (HUD) video indicated MA1's spacing relative to MA2 was wider than 50 feet between aircraft throughout the majority of the formation approach (Tab Z-17). At 1506:00Z, descending through 280 feet AGL, MIP1 prompted MSP1 to tighten his lateral spacing to ensure MA1 was properly aligned with the runway (Figure 1 – Red Arrow is MA1's alignment, Blue Arrow is runway,) (Tabs O-10, Z-3 and Z-17).

(Figure 1)

MSP1 subsequently corrected MA1's alignment to the left half of Runway 35C and maintained appropriate lateral spacing until 1506:15Z, descending through 90 feet AGL (Tab Z-17). At that time, MA1 began to drift towards the left edge of the runway (Tab Z-16). Throughout this period, the speed and pitch of MA1 relative to MA2 appeared to be within normal parameters (Figure 2) (Tab Z-12 and Z-17).



(Figure 2)

At 1506:22Z, as MA1 crossed the runway overrun, the HUD showed increased pitch consistent with a shift of aimpoint further down the runway in accordance with standard T-38 landing technique (Figure 3 and Figure 4) (Tab Z-4, Z-5 and Z-17). During this shift, however, MA1's HUD video showed a further drift toward the left boundary of the runway so that MA1 was 10 feet wider than planned and continuing to drift left (Tab Z-17). Three seconds later, at 1506:25Z, approximately 600 feet past the runway threshold, MA1's main wheels touched down (Tabs Z-17 and DD-38). HUD video showed MA1 was traveling at approximately 143 knots indicated airspeed (KIAS) on a heading 1 to 2 degrees left of run alignment, with the left main tire approximately 15 feet from the left edge of the runway (Tab Z-17). MA1 briefly settled on its main tires, but then slightly lifted off the runway once more as the result of a premature aerodynamic braking maneuver (Figure 5) (Tabs, V-22.3, Z-10, Z-17, and DD-38).

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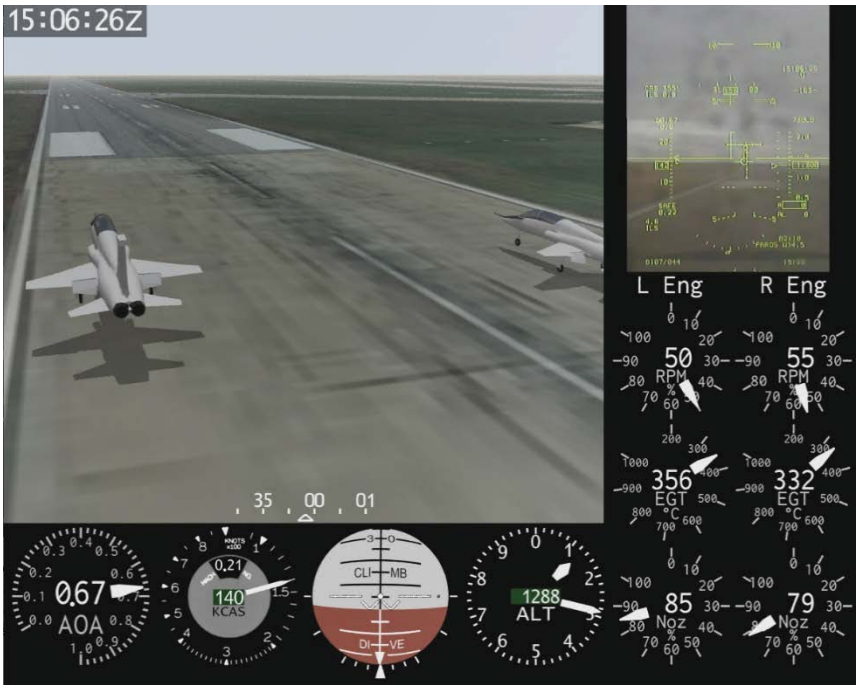
(Figure 3)

(Figure 4)

(Figure 5)

For the next three seconds (1506:25Z to 1506:28Z), MA1 was either slightly off the ground or so lightly planted that there was essentially no weight on its wheels (Figure 6) (Tabs V-22.3 and Z-17). Both of MA1's engines initially remained in the lowest selectable power settings (idle); HUD video showed pitch increasing from approximately 4.5 degrees nose high to 8 degrees nose high attitude (Tab Z-13 and Z-17).



(Figure 6)

In conjunction with MA1's rising pitch attitude, HUD video showed a very slight left roll followed by right yaw (Tabs Z-17 and DD-38). At 1506:26Z, MA1 yawed from a heading of 353 degrees to 358 degrees (Figure 7, Figure 8 and Figure 9) (Tab Z-6, Z-7, and Z-17). MIP1 verbally directed MSP1 to "go around" (Tab O-10).

(Figure 7)

(Figure 8)

(Figure 9)

At 1506:27Z, approximately 2 seconds after touchdown, HUD video showed a continued right yaw accompanied by a pronounced right rolling movement (Tabs Z-18 and DD-37). MA1's post-flight engine parametric data indicates the throttles were advanced to full (military) power at this time (Tab Z-18). One second later, at 1506:28Z, MA1's right main wheel forcefully contacted the runway and the aircraft entered a skid, converging with MA2 (Tab Z-18). HUD video showed a heading of 006 degrees, 129 KIAS, 0.80 Angle of Attack (AOA), pitch approximately five degrees nose high, and approximately 30 degrees of right bank (Figure 10) (Tab Z-8 and Z-18).

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(Figure 10)

After another second, at 1506:29Z, MA1's nose wheel struck the runway forcefully; all three tires were then on the ground (Tabs V-22.3 and Z-18). HUD video showed MA1 heading 008 degrees, 132 KIAS, 0.79 AOA, near level pitch and slight left bank (Tab Z-18). At this time, MIP1 likely took the controls. (Tab DD-37) At 1506:30Z, in an apparent attempt by the pilot flying MA1 to avoid colliding with MA2, and possibly to affect a safe go-around, MA1's pitch attitude rose rapidly to approximately 8 degrees nose high (Figure 11) (Tab Z-9 and Z-18). HUD video indicated a wings level attitude, 128 KIAS, and 0.61 AOA (Tab Z-18). As AOA indications in the T-38C HUD lag real time conditions by approximately one half second, actual AOA may have been higher (Tab V-22.4).

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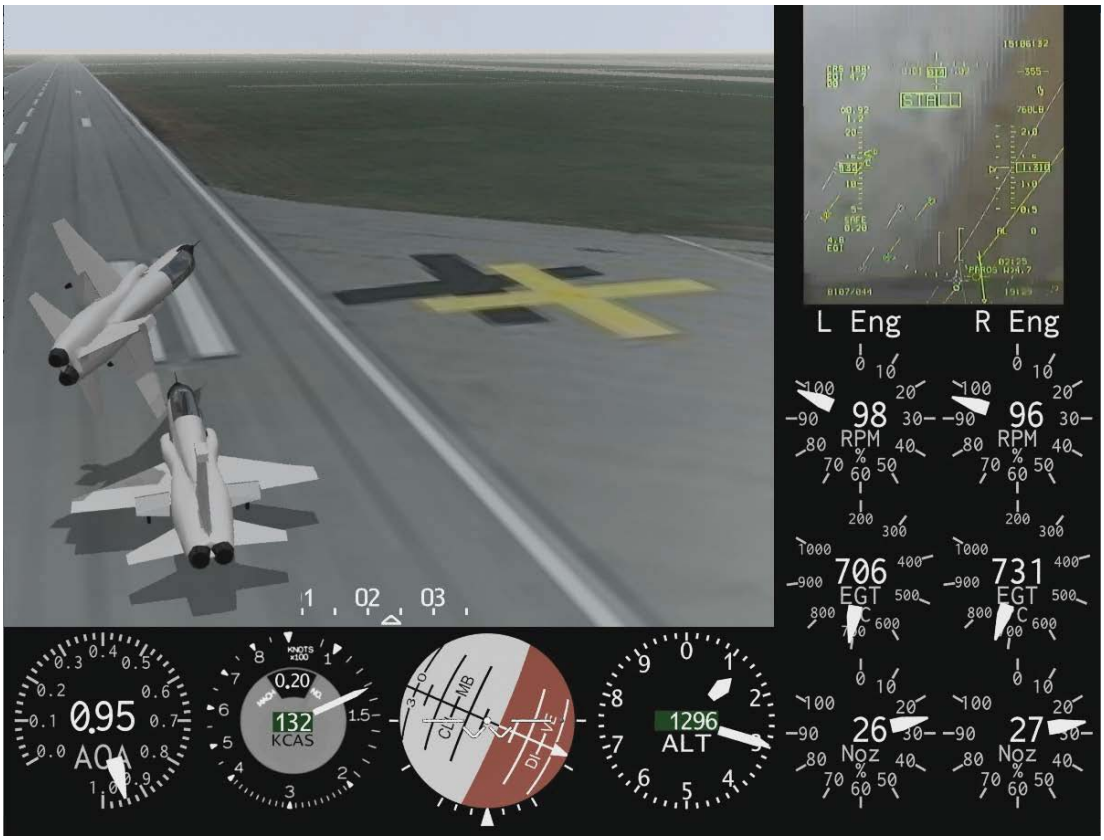
(Figure 11)

The pilot flying MA1 arrested the skid but MA1 remained on a collision course with MA2 (Tab Z-19). The pilot aggressively pulled back on the stick, attempting to avoid the collision by overflying MA2, but lacked sufficient airspeed to generate enough altitude (Figure 12) (Tabs Z-13, Z-19 and DD-37). MA1's right outboard gear door made contact with MA2's left wingtip, trapping MA2's wing between MA1's right main landing gear tire and the door (Tab DD-8). The contact caused MA1 to roll rapidly right, where its wingtip struck MA2 near the upper wing root (Tab DD-8). There are no available aircraft parameters for MA1 after 1506:32Z (Tab Z-19). At that time, HUD video showed MA1 at 132 KIAS, approximately eight degrees pitch, approximately 45 degrees of right roll, 0.92 AOA, and "STALL" indications (Tab Z-19). MA1 continued to roll to the right, passed over the top of MA2, and impacted the ground upside down with engines in full military power (Tab DD-30 and DD-33). MSP1 and MIP1 were killed on impact (Tab X-3). The total time from when MA1 crossed the runway overrun until impact was approximately eight (8) seconds (Tab Z-12 and Z-14).



(Figure 12)

(2) MA2

MIP2 flew a stable visual formation approach "backed up" with ILS glideslope to Runway 35C in accordance with standard practices and MIP2's stated techniques (Tabs V-5.8 and Z-18). MIP2 maintained appropriate airspeeds throughout the approach and landing (Tab V-5.8). MIP2 stated that he planned to fly the formation approach 5-10 knots above calculated final approach airspeed or "green speed" (Tab V-5.8). Based on Technical Order (TO) 1T-T38C-1 and AETCMAN 11-251 guidance for MS's fuel state, calculated final approach speed was 160 KIAS and landing speed between 140 KIAS and 135 KIAS (Tab Z-18). This guidance further directs aircrew to increase the final approach and landing speed by one-half the gust factor. At 1504:38Z the surface wind conditions reported by the tower controller with the landing clearance were 360 at 16 knots, gusting to 22 knots, indicating that final approach and landing speeds should be increased an additional three knots (Tabs O-10 and Z-18). Based on this guidance, the appropriate final approach speed was 163 KIAS; landing speed was 143 KIAS to 138 KIAS (Tab Z-18). MA2 remained at or above these computed airspeeds throughout the final approach and landing (Tabs V-5.8 and Z-18).

At 1505:26Z, MIP2 aligned MA2 to "my half of the runway" descending through 780 feet AGL (Tabs V-5.10 and Z-18). At 1506:21Z, when MA2 and MA1 were approximately 500 to 300 feet from the Runway 35C landing threshold, MIP2 smoothly raised the nose of MA2 from four degrees nose high to five degrees nose high and reduced throttles to idle in accordance with general

accepted practices for transitioning to land (Tab Z-18). MIP2 then held an attitude of approximately four to five degrees nose high and touched down at 1506:24Z, approximately 350 feet beyond the approach end, near the center of the right (east) half of Runway 35C (Tab Z-18). MA2's HUD video showed a slightly incomplete flare resulting in a touchdown speed of approximately 142 knots (Tab Z-18). A slightly incomplete flare is a commonly accepted lead formation landing technique in the T-38C (Tab V-5.7). This technique has proven to be effective to guard against the wingman getting dangerously slow while airborne (Tab V-1.12).

MIP2 stated that he last observed MA1 in proper position as he shifted his focus entirely to the final stages of the transition and flare (Tab V-5.7 to V-5.8). Further, MIP2 stated that he did not see MA1 from that point until after landing (Tab V-5.8). After touchdown, MA2 remained on the runway and held landing pitch (Tab V-5.8). MIP2 stated that he was not alarmed at MA1's position during the landing and believed that the two aircraft touched down "about the same time" with MA1 "where they should be" (Tab V-5.7). MIP2 observed his airspeed dropping through 140 KIAS "a couple of seconds after" landing (Tab V-5.8). In his peripheral vision, he noticed "more jet than I would expect" and MA1's "nose go up and towards me" (Tab V-5.8). MIP2 testified he then knew collision was imminent (Tab V-5.8). At 1506:32Z and approximately 1800 feet past the landing threshold, MA1 collided with MA2's left side, causing MA2 to abruptly veer right from a 354 degree heading to a 007 degree heading while traveling at 122 KIAS (Tab Z-18). MIP2 attempted to prevent MA2 from departing the prepared surface, but MA2 exited Runway 35C at 1506:35Z (Tab Z-19). MIP2 considered ordering an ejection, but did not do so because he did not know MA1's location relative to MA2 (Tab V-5.8).

e. Impact

After MA1 collided with MA2, MA1 rolled right over the top of MA2 then impacted the ground upside down with engines in full military power (Tab DD-30 and DD-33). MSP1 and MIP1 were killed on impact (Tab X-3).

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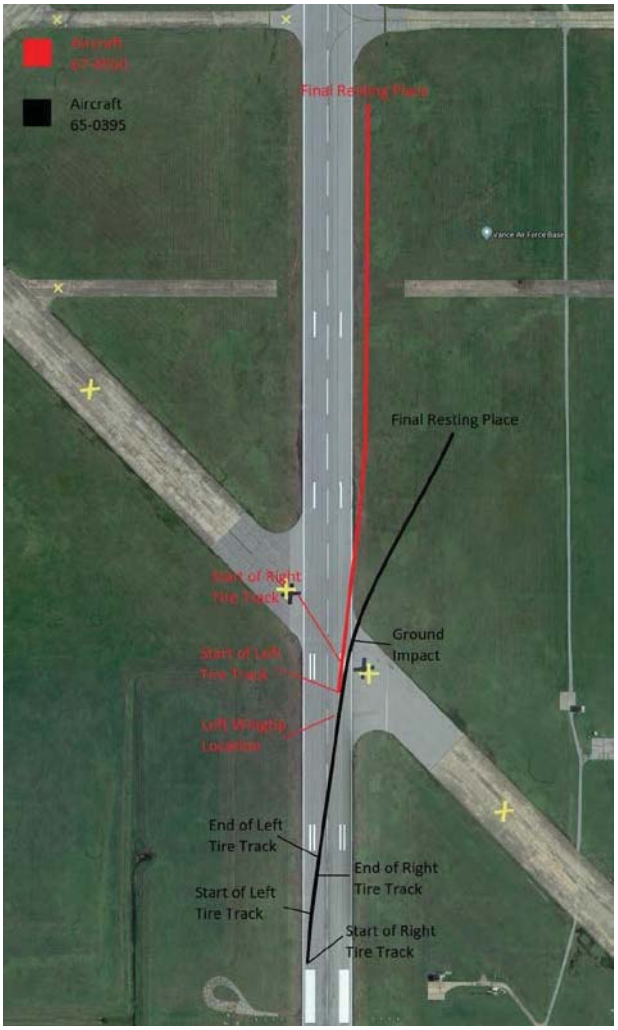
Technical analysis determined MA1 struck the ground inverted or nearly inverted slightly to the east of Runway 35C on the remnants of a decommissioned taxiway approximately 2200 feet past the landing threshold (Tab DD-5 and DD-9 to DD-10). MA1 continued to slide on the infield grass to the east of Runway 35C for approximately 700 feet and came to rest approximately 300 feet east of the runway (Figure 13 in black) (Tab DD-5 and DD-10).

After leaving the prepared surface, MA2's right wingtip struck the 6000 feet runway remaining marker on the east side of Runway 35C (Tab DD-10). At 1506:47Z, with MA2 still in motion, MIP2 made an emergency radio transmission on the Vance Tower frequency (Tab O-10). MIP2 was able to slow MA2 to a stop in the grass east of Runway 35C at 1506:50Z and approximately 3500 feet from the approach end (Figure 13 in red) (Tabs O-10, V-5.9, DD-5 and DD-10).



(Figure 13)

f. Egress and Aircrew Flight Equipment (AFE)

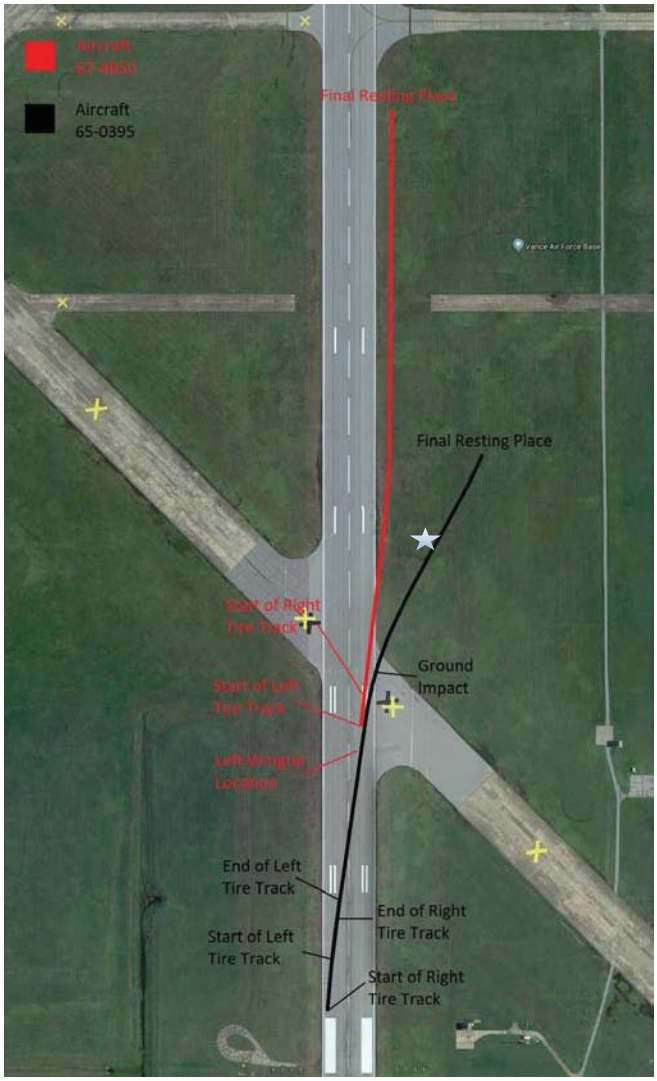
(1) MA1 Ejection Seats

Post-mishap engineering analysis determined neither pilot in MA1 initiated ejection (Tabs V-19.2, DD-49, and DD-52).

MSP1 remained in MA1's front seat. MSP1's ejection control handle was found seated (un-fired) (Tab DD-46 and DD-52).

MIP1 was found strapped to the rear seat, approximately 325 feet southwest of the aircraft (Figure 14 blue star) (Tabs C-2 and DD-46). MIP1's ejection control handle was found unseated (fired), but engineering analysis concluded MIP1 did not voluntarily initiate ejection for two reasons (Tab DD-46).

First, no portions of the ejection system were activated other than the rear seat (Tabs V-19.3, DD-46 and DD-49 to DD-50). When the aircraft impacted the ground inverted, the top seat latches of both ejection seats yielded, allowing the seats to move freely up and down the guiderails and disengaging them from the gas fittings in the aircraft (Tabs V-19.3 and DD-50). These fittings allow hot gas to flow between the seat and the aircraft in the ejection sequence (Tab DD-49). Once the fittings are disconnected, it is impossible for the seat to reattach (and thus connect with the rest of the ejection system) without human intervention (Tab DD-49 to DD-50). Intact (not fired) cartridges were located in MA1 in both the front and the rear canopy jettison systems, as well as in the front seat (Tab DD-46 to DD-47 and DD-49 to DD-50). The ballistic signal was not passed to the ISS; therefore, the rear seat was disconnected from the gas fittings prior to the handle being dislodged (Tab DD-46 to DD-47 and DD-49 to DD-50).



(Figure 14)

Second, the Powered Inertia Reel Device (PIRD) straps were not retracted prior to MIP1's being fatally injured during impact (Tabs V-19.2 and DD-52). The PIRD straps connect directly into the harness at the shoulder level to bring the pilot into the correct position for ejection (Tab DD-52). They are generally unlocked (not retracted) during flight to allow necessary movements in the cockpit (Tab V-19.2). During the ejection sequence, PIRD strap retraction is the first event that occurs after the ejection control handle is unseated, with no time delay (Tab DD-52). Forensic evidence found on the full length of the straps showed they were not retracted into the PIRD before traumatic injury occurred at impact, which indicated MIP1 did not pull the handle before his death (Tab DD-52).

The AIB determined that impact-induced forceful movement of objects in the cockpit activated the ejection control handle in the RCP, ultimately ejecting MIP1 from MA1 (Tab V-19.2). However, the AIB was unable to determine exactly what dislodged the ejection handle. After impact, the force of the ejection seat charge propelled MIP1 out of inverted aircraft through the

damaged rear canopy (Tabs C-2, V-19.4 and DD-46). When MIP1's ejection seat separated from MA1, it traveled to its final resting place (Tab DD-46)

(2) MA2 Egress

MIP2 and MSP2 were able to accomplish a ground emergency egress from MA2 without incident after coming to a stop (Tab V-5.9). Emergency personnel met them immediately (Tab X-5). The emergency egress system was not utilized, so the ejection seats were not removed for analysis (Tab DD-47).

(3) Aircrew Flight Equipment (AFE)

The MC's AFE was properly configured, performed as expected, and was not a factor in the mishap (Tab DD-78).

g. Search and Rescue

Multiple people in the ATC tower witnessed the mishap, including the Watch Supervisor who immediately initiated an emergency call on the crash phone at 1506Z stating that two T-38s were off Runway 35C, one upside down (Tab X-5). Airfield Management, Fire Department, and Medical acknowledged (Tab X-5). The Fire Department dispatched units at 1507Z, arriving on scene by 1508Z (Tab X-5). Flight medics arrived by 1515Z (Tab X-5).

First responders quickly determined both MIP1 and MSP1 sustained fatal injuries (Tab X-3). MIP2 and MSP2 were escorted to the 71st Medical Group (71 MDG) where they were evaluated and released (Tab X-5).

h. Recovery of Remains

The mishap occurred on the Vance AFB flightline, which is exclusive federal jurisdiction (Tab X-5). A physician from 71 MDG pronounced MIP1 and MSP1 dead (Tab X-3 and X-5).

An Explosive Ordinance Disposal (EOD) team from McConnell AFB, KS arrived by 1800Z to disarm MSP1's ejection seat, allowing safe recovery of remains from MA1 by the Crash and Recovery team by 2200Z (Tab X-5, X-8, X-11).

5. MAINTENANCE

The AIB found no evidence maintenance was a factor in this mishap for either mishap aircraft. The maintenance history for MA1 is below.

a. Forms Documentation

The AIB found one minor discrepancy on an Air Force Technical Order (AFTO) Form 781a for MA1 (Tab U-5). On 20 November 2019, there was a red "X" entry for a broken taxi light filament (Tab U-5). A red "X" means the aircraft is not permitted to fly until the issue is corrected unless authorized by a higher authority (Tab U-5). The light filament was replaced as required (Tab U-

5). The corrective action should have been documented with two signatures, a "corrected by" and an "inspected by," but only had a "inspected by" signature (Tab V-7.3 to V-7.4). There were no other discrepancies found in the historical forms in the previous 90 days. The taxi light filament was not a factor in the mishap.

b. Inspections

(1) Post-flight

MA1 last flew on 18 November 2019 (Tab U-7). Contractor 1 (CTR1) performed the last post-flight inspection of MA1 the same day (Tab V-10.2). He found no discrepancies (Tab V-10.2). A post-flight inspection is valid for 72 hours (Tab V-10.2).

(2) Pre-Flight

The maintenance crew chief completed a preflight inspection on 21 November 2019. (AFTO Form 781h) (Tab U-3). Contractor 7 (CTR 7) found no issues with the aircraft (Tab V-7.2). Additionally, fuel and oxygen service to the aircraft was properly documented (Tab U-4). At the time of the inspection, MA1 had 20,087.7 flight hours (Tab U-7).

c. Maintenance Procedures

Contractors with Vertex perform all T-38C maintenance at Vance AFB, adhering to Air Force guidance to conduct regular and unscheduled maintenance (Tab V-10.2). The AIB noted one procedural error that was not a factor in the mishap (Tab U-31). In February 2019, an e-mail from the 19th Air Force Logistics Directorate (19AF/LG) directed all units not to exceed 90 hours between aircraft engine washes, but Vertex was slow to implement this guidance (Tabs U-31 and V-11.3). A failure to conduct the engine washes can lead to corrosive pitting from the buildup of sulphur as fuel burns (Tab U-21). Over time, the corrosion can cause engine blades to crack (Tab U-31). The AIB determined both MA1's engines were overdue for an engine wash by 23.7 hours at the time of the mishap, but subsequent technical analysis showed the engines were free of corrosion and operating normally (Tabs U-7 and DD-34).

d. Maintenance Personnel and Supervision

There is no evidence maintenance personnel were not fully qualified and appropriately supervised.

e. Fuel, Hydraulic, Oil, and Oxygen Inspection Analyses

(1) MA1

(a) Fuel

Technical analysis determined the fuel in MA1's aft tank was normal, but debris from impact contaminated the forward fuel tank (Tab U-24). Additionally, there was an insufficient amount of fuel available for collection from the forward tank for full analysis due to tank rupture (Tab U-22).

(b) Hydraulic Fluid

Technical analysis of hydraulic fluid from MA1 was consistent with used hydraulic fluid (Tab U-16 to U-17).

(c) Engine Oil

The left engine oil test results were "inconsistent" with lubrication fluid specifications, but the AIB determined this was due to the engine ingesting significant debris during impact (Tab U-18). The right engine oil test results were consistent with specifications (Tab U-19).

(d) Liquid Oxygen

The impact damage precluded testing the liquid oxygen (U-30). There is no indication of oxygen failure.

(2) MA2

All fluids for MA2 were within standards (Tab U-20 to U-21, U-28 and U-26 to U-30).

f. Unscheduled Maintenance

After each sortie aircrew document any observed system discrepancies and pass them to maintenance personnel for corrective action (Tab V-17.2 to V-17.3). Certain discrepancies require specially qualified pilots to conduct an evaluative Operational Check Flight (OCF) or Functional Check Flight (FCF) to confirm the issue has been resolved (Tab V-17.2). In an FCF, the pilot follows a carefully prescribed profile to test the full operational envelop of aircraft performance (Tab V-17.3). In an OCF, the profile is more flexible and may be tailored to validate acceptable performance for a specific subsystem or component (Tab V-17.3). An aircraft may return to regular operational service only after successful completion of the checks conducted during these flights (Tab V-17.2).

Following a flight on 10 December 2018, aircrew documented MA1 exhibited a right-rolling tendency requiring left aileron input to maintain level flight while configured for landing with flaps fully extended (Tab U-33 to U-38). This rolling tendency required pilots to apply approximately two inches of left aileron input (roll control) to hold level flight (Tab V-17.3). Though still controllable, the aircraft was removed from the regular flight schedule pending maintenance action. The aircraft flew several OCFs and one FCF following corrective maintenance for this rolling tendency during January 2019 (Tab U-33 to U-38). The aircraft successfully completed an OCF on 15 March 2019 after maintenance personnel installed a shim to the right flap hinge that corrected the right roll tendency (Tab U-38). MA1 then returned to regular flight service. Between 15 March 2019 and the MS, MA1 flew 258 sorties and executed 554 landings (Tab U-39 to U-50). The aircraft required only minor avionics repairs and routine preventative maintenance actions during this period (Tab U-39 to U-50).

6. AIRFRAME, MISSILE, OR SPACE VEHICLE SYSTEMS

a. Structures and Systems

(1) MA1

(a) Fuselage

The fuselage remained relatively intact (Tab DD-11). The ground impact and subsequent slide destroyed the top of the fuselage (Tab DD-11). The nose section was broken, but still connected by cables, electrical connections and secondary structures (Tab DD-12). The initial impact on the ground crushed the windshield (Tab DD-12). The front canopy dislodged from the fuselage, but the rear canopy only partially dislodged (Tab DD-12). A portion of the vertical tail separated from the aircraft (Tab DD-12). MA1's right wingtip was destroyed in the collision with MA2 (Tab DD-12).

(b) Horizontal Stabilizer (Pitch)

The horizontal stabilizers did not contact the ground and were found in an 18 degree trailing edge up position, consistent with an aft stick pull (Tab DD-14). However, since MA1's engines did not immediately stop running, impact may have caused a command to that position; it may not be indicative of pilot input (Tab DD-14).

The stabilizer actuators for both the right and left side did not sustain damage (Tab DD-14 and DD-17). The right stabilizer actuator was slightly out of tolerance for TO specifications, but this is common in a used actuator (Tab DD-15). The System Program Office (SPO) at Hill AFB, Utah (UT) determined this would not have affected aircraft performance (Tab DD-15). All components of the stabilizers, to include cables and mechanical connections, were in good operational condition (Tab DD-17).

(c) Ailerons (Roll)

The aileron surfaces were near neutral and slightly sagging (Tab DD-17). This is normal when an aircraft is stationary for a period of time (Tab DD-17). The actuators were in excellent condition, having sustained no damage (Tab DD-17). Post mishap testing of the left actuator showed some evidence of leaking hydraulic fluid when subjected to pressures higher than normal operating pressure (Tab DD-18). The SPO determined this would not have affected aircraft performance. At the normal operating pressure, no leaks were detected (Tab DD-18). The right actuator passed all tests (Tab DD-18). Impact severed the interconnect cables and damaged the mechanisms in the front cockpit)Tab DD-19). All control mechanisms, control cables and interconnect cables in the rear cockpit remained intact (Tab DD-19). The aileron trim position was approximately neutral which is consistent with normal flight (Tab DD-19).

(d) Rudder (Yaw)

Impact bent the rudder actuators (Tab DD-20). All control cables, control mechanisms and rudder pedal mechanisms were intact (Tab DD-22). The actuators were still in an appropriate condition

for testing (Tab DD-21). The left actuator failed a bypass test, which looks for internal leaks (Tab DD-21). However, the SPO determined this would not have affected the functionality of the actuator (Tab DD-21). No other components of the rudder system showed signs of damage or malfunction (Tab DD-21).

(e) Speed Brakes

The speed brakes were in the retracted position (Tab DD-22). The actuators passed all testing (Tab DD-22). The left actuator had a broken retention ring, which was not the result of impact (Tab DD-23). The SPO determined this would not have affected operation of the speed brakes (Tab DD-23).

(f) Flaps

Impact did not damage the flap surfaces (Tab DD-23). The flaps were extended at 100% (full down) (Tab DD-23). The flap motors passed all functional tests (Tab DD-23). The flap operating mechanisms were intact (Tab DD-23). Additionally, the Flap-Horizontal Tail (Flap-Stab) interconnect cable was properly attached with no indications of malfunction (Tab DD-24 to DD-24).

(g) Landing Gear

The nose landing gear was extended and sustained no damage (Tab DD-24). All mechanisms passed testing (Tab DD-24). The main landing gear were also extended (Tab DD-24). The right strut (outboard gear) door sustained damage from impact with MA2, pinning it against the right main tire (Tab DD-24). The wheel-tire assembly operated normally once the door was removed (Tab DD-24). The left side did not have any damage (Tab DD-24). All the gear struts and tires remained in operational condition (Tab DD-24).

(2) MA2

MA2's left wingtip was destroyed when MA1 hit MA 2 (Tab DD-7). Additionally, MA1's right wingtip struck MA2 at the intersection of MA2's wing and fuselage, which damaged the wing root and left flap (Tab DD-8). After departing the prepared surface, the right wingtip struck a sign next to the runway, damaging the wing (Tab DD-10). MA1's right MLG tire and strut door hit MA2 first, followed by MA1's wingtip (Tab DD-8). The impact also caused paint smearing, paint transfer, and cracks in MA2's fuselage (Tab DD-8).

b. Evaluation and Analysis

(1) MA1 Controls

The SPO analyzed the aircraft damage and controls (Tab DD-4). They did not identify any malfunctions (Tab DD-24).

(2) MA1 Engines

The J85 Lead Engineer at the Air Force Life Cycle Management Center (AFLCMC), Tinker AFB, OK, analyzed the engines (Tab DD-34). The engineer concluded the engines were operating properly at the time of the mishap (Tab DD-34). Eyewitnesses confirmed seeing the engines running after MA1 came to its final resting position (Tab V-12.5 and V-15.3).

(a) Left Engine

The left engine had a total of 10,045 flight hours, with 216.8 hours since the last periodic engine inspection in July 2018 (Tab DD-29). During that inspection, maintenance personnel replaced a leaking afterburner drain valve (Tab DD-29). At the time of the mishap, two open Time Compliance Technical Order (TCTO) maintenance actions called for installing afterburner fuel manifolds and reworking the turbine case and shrouds (Tab DD-29). TCTOs mandate actions occur by a certain date; neither TCTO was overdue. Post-impact analysis showed no signs of fire or engine failure (Tab DD-30). The controls and accessories were all intact (Tab DD-31). The J85 Lead Engineer concluded the engine was most likely set to military (full, non-afterburning) power (DD-30). The engine ingested significant amounts of dirt and grass during the mishap (Tab DD-31). No other foreign object damage was evident (Tab DD-32).

(b) Right Engine

The right engine had a total operating time of 11,653.6 hours, with 430.7 hours since the last periodic inspection, and 280.9 hours since the last unscheduled maintenance (Tab DD-29). The last engine removal was in February 2019 when a broken variable exhaust nozzle (VEN), afterburner components, nozzle position transmitter and the VEN power unit were replaced (some parts multiple times) until the engine passed all testing (Tab DD-29). The engine returned to service at the end of March 2019 (Tab DD-29). The engine had one open TCTO to replace the compressor blades. The TCTO was not overdue. Post-impact analysis showed no signs of fire or engine failure (Tab DD-32). The J85 Lead Engineer concluded the engine was set to military power and the controls were intact (Tab DD-33). The right engine did not ingest as much soil and grass as the left engine (Tab DD-33 to DD-34). The engine blades had damage consistent with foreign object ingestion (Tab DD-33). The J85 Lead Engineer could not determine the source of the damage as no pieces remained in the engine that were large enough to identify (Tab DD-34). He assessed the cause to be debris from the impact (Tab DD-34).

7. WEATHER AND PHYSICAL ENVIRONMENT

a. Forecast Weather

The local Mission Execution Forecast (MEF) was issued on 21 November 2019 at 1032Z. The MEF for Vance AFB at 1500Z predicted broken ceilings from 2000 feet AGL to 5000 feet AGL, visibility greater than 7 statute miles, temperature of 8 degrees Celsius (46.4 degrees Fahrenheit), and winds from the west-northwest at 15 knots, gusting to 20 knots (Tab Q-24). The MEF called for the relatively low cloud cover to steadily lift and clear through the course of the morning (Tab Q-20). There were no adverse weather conditions forecast for the MOA (Tab Q-20).

b. Observed Weather

While the MS was airborne, cloud ceiling conditions improved as forecast, permitting the Vance AFB Supervisor of Flying (SOF) to alter the T-38 flying status from instrument recoveries-only to a visual recovery-permissible status of "Restricted Pattern – Straight-In Only" (Tab O-3). The observed weather at Vance AFB near the time of the mishap was: surface winds from the north at 16 knots, gusting to 22 knots; an overcast cloud layer between approximately 2200 feet AGL and 1600 feet AGL; 10 statute miles of visibility; temperature of 8 degrees Celsius (46.4 degrees Fahrenheit); altimeter setting of 30.07 inches of mercury; dew point of 3 degrees Celsius (37.4 degrees Fahrenheit); and dry runway surface conditions (Tabs O-10 and Q-20).

c. Space Environment

The space environment and associated weather are not applicable to this incident.

d. Operations

The MS was conducted within prescribed weather requirements and in accordance with published restrictions. The observed winds at the time of landing created a very small crosswind component from the east (right to left) (Tab DD-80). Given the speed of the formation at touchdown, the spacing between the two aircraft, and the magnitude of the crosswind component, MA2 would have had to be over 1,000 feet aft of MA1 to encounter the vortices generated by MA1's wingtips (Tabs BB-3 to BB-10 and DD-79). The two aircraft were nearly line abreast during the landing sequence. The AIB determined MA1 was not affected by MA2's wingtip vortices (Tab DD-79).

e. Pavement

There is no evidence Runway 35C pavement conditions were a factor in the MS.

During AIB interviews, Vance AFB T-38C Instructor Pilots (IPs) reported a known "bump" on the left side of Runway 35C that can be felt during takeoff roll (Tab V-1.7 and V-2.5). This minor undulation appears to be at the junction of a previously decommissioned and partially removed taxiway approximately 2200 feet from the approach end of Runway 35C (Figure 15 blue circle) (Tab W-3 and W-4). The bump is further down the runway than either aircrafts' track.

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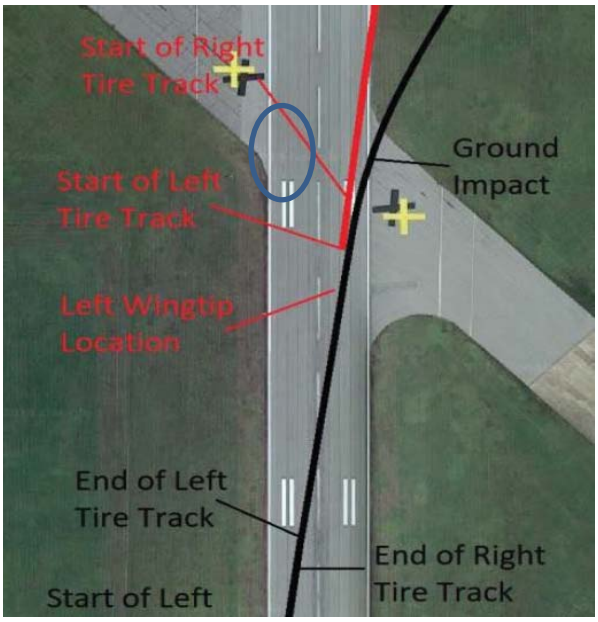
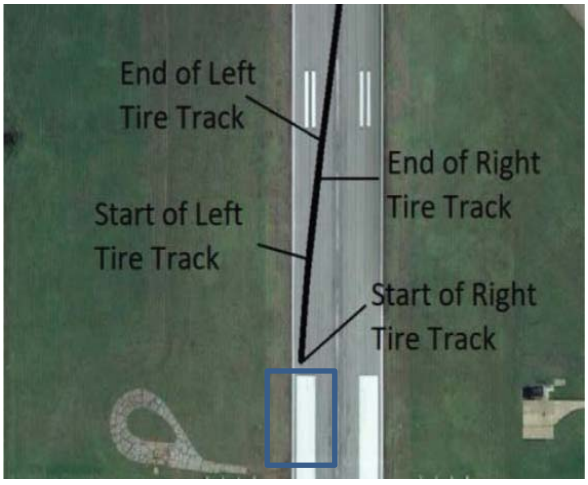


(Figure 15)

Additionally, the 71st Operations Group (71 OG) issued Flight/Crew Information File (FCIF) 19-074 on 4 December 2019 in reference to "a significant crack on Runway 35C" (Figure 16 blue rectangle) (Tabs V-9.5, W-3, and Z-14 to Z-15). Post mishap analysis of tire marks left by MA1 and MA2 showed that neither aircraft touched down until they were past the crack (Tab W-3 and W-4). Additionally, the angle of the tire marks from MA1 is inconsistent with landing in the crack (Tab W-3). Post mishap interviews and HUD review indicated Runway 35C conditions did not affect planning or execution of the MS by the MC (Tab V-1.7 and V-5.7).



(Figure 16)

8. CREW QUALIFICATIONS

a. Mishap Instructor Pilot 1

MIP1 was an Active Guard Reserve officer assigned to 5 FTS, 340 FTG, who flew fulltime with 25 FTS (Tabs T-3 and V-2.3). MIP1 was a current and qualified T-38C Instructor Pilot (Tab T-3 to T-9 and T-12 to T-13). A review of MIP1's training record revealed normal progression (Tab T-3 to T-9 and T-12 to T-13). He had nine inflight evaluations in the T-38C, all of which demonstrated desired performance and knowledge of procedures, equipment, and directives within tolerances specified (Tab T-3 to T-4). Additionally, MIP1 was a qualified functional check flight (FCF) pilot, though he did not act in such capacity on the MS (Tab T-4). MIP1 had a reputation as one of the best instructors in the unit (Tab V-2.4, V-3.6, and V-4.6).

MIP1 was current in all flight events (Tab T-12 to T-13). MIP1's total flight time in the T-38C with 984.1 hours with 736.7 hours of instructor time (Tab T-14). MIP1 was previous qualified in F-18 and F-16C aircraft and logged 3205.3 hours of total military flight time (Tab T-15).

On the day of the mishap, MIP1's recent flight time in the T-38C was as follows (Tab T-11):

	Hours	Sorties
30 days	15.0	14
60 days	36.0	35
90 days	48.8	49

MIP1's most recent flight prior to the MS was 18 November 2019 (Tab T-14). Prior to the date of the MS, MIP1's most recently accomplished a formation landing on 1 October 2019 (Tab T-13).

b. Mishap Student Pilot 1

MSP1 was assigned to 71 STUS and flew with 25 FTS (Tabs T-51, V-3.3 and V-6.2). His performance and progression during the T-6A phase of training was above average; he finished in the top one-third of his T-6A class (Tab T-291). MSP1 performed two T-6A wing formation approaches and landings (Tab T-80).

MSP1 had a stellar reputation as hard worker who put forth large amounts of effort in studying and in preparing for his sorties (Tab V-3.3, V-5.3, and V-6.3). However, several T-38C IPs noted he struggled to maintain adequate situational awareness (SA) in the dynamic environment of high performance T-38C flying (Tab V-3.3, V-3.5, and V-5.3). He tended to take his mistakes very seriously, sometimes verbally chastising himself in the cockpit (Tab V-1.4). MSP1 would let his frustration with his errors "snowball," further affecting his performance (Tab T-218, V-1.4, and V-3.3). MSP1 occasionally had trouble taking direction and applying it in flight (Tab V-13.8).

Prior to MS, MSP1 completed 55 syllabus sorties in the T-38C (Tab T-56). MSP1's training records indicated that he performed 40 sorties to a "good" or "excellent" level, four sorties to a "fair" level, seven sorties to an "unsatisfactory" level, and four ungraded sorties (Tab T-247 to T-

285). Ungraded sorties often result from incomplete training or additional sortie allocations. One unsatisfactory sortie, T5590, was MSP1's Transition Check in the T-38C, which mandated a subsequent Progress Check; he met standards (Tabs T-145 to T-148, V-4.4, and BB-60). MSP1's three sorties prior to MS each resulted in an "unsatisfactory" grade (Tab T-215 to T-220).

A combination of MSP1's three consecutive "unsatisfactory" sorties and a prior Progress Check drove an Elimination Check in accordance with the syllabus (Tabs T-147 to T-148, T-215 to T-220, and BB-60). The MS was the first of two 25 FTS Commander-directed Additional Training Sorties for MSP1 to prepare him for success in the Elimination Check (Tab V-4.5 to V-4.6). The syllabus code for the sortie was F5487 (Tab BB-58 and BB-65).

Prior to the MS, MSP1 accomplished four wing formation approaches and two wing formation landings in the T-38C (Tab T-254 and T-258). MSP1 accomplished his most recent T-38C wing formation landing on 28 October 2019 (Tab T-258). This is consistent with the number of formation landings for a student at this point in the syllabus. (Tab V-1.5 to V-1.6)

MSP1's total military flight time was 148.1 hours with 60.1 hours in the T-38C prior to the MS (Tab T-55 to T-56).

c. Mishap Instructor Pilot 2

MIP2 was assigned to 25 FTS (Tab T-32). He was a current and qualified T-38C Instructor Pilot (Tab T-34). A review of MIP2's training record revealed normal progression (Tab T-35 to T-37). MIP2 had four inflight evaluations in the T-38C, all of which demonstrated desired performance and knowledge of procedures, equipment, and directives within tolerances specified (Tab T-41).

MIP2 was current in all flight events (Tab T-33 to T-37). MIP2's total flight time in the T-38C with 679.4 hours with 492.9 hours of instructor time (Tab T-38). MIP2 was previous qualified in C-17 aircraft and logged 1882.2 hours of total military flight time (Tab T-38).

On the day of the mishap, MIP2's recent flight time in the T-38C was as follows (Tab T-33):

	Hours	Sorties
30 days	9.8	8
60 days	44.3	39
90 days	73.6	64

MIP2's most recent flight prior to the MS was 8 November 2019 (Tab T-38). Prior to the date of the MS, MIP2's most recently accomplished a formation landing on 17 October 2019 (Tab T-36). The MS was MIP2's first sortie upon return from extended leave (Tab V-5.5).

d. Mishap Student Pilot 2

MSP2 was assigned to 71 STUS and flew with 25 FTS (Tab V-6.2). He was a T-38C student pilot in the early portion of the formation category of syllabus training (Tab N-16). MSP2 was performing the MS as an authorized observation sortie outside the normal flow of the syllabus

(Tabs V-5.5 V-6.4 and BB-57). MSP2 was neither flying nor receiving instruction during the formation approach and landing (Tab BB-57).

9. MEDICAL

a. Qualifications

(1) MIP1

MIP1 completed his most recent Periodic Health Assessment (PHA) and annual Flight Physical on 15 February 2019 (Tab X-3). Vance AFB Flight Medicine issued a Medical Recommendation for Flying or Special Operational Duty (DoD Form 2992) on the same date indicating medical clearance for pilot duties (Tab X-3). A review of the Aeromedical Information Management Waiver Tracking System (AIMWTS) indicated that MIP1 required a medical waiver for one diagnosis, which was approved through February 2020 (Tab X-3). Vance AFB Flight Medicine was already in the process of renewing this waiver (Tab X-3. The AIB determined this diagnosis did not influence mishap events (Tab X-3). MIP1 was medically qualified for flying duties.

(2) MSP1

MSP1 completed his most recent PHA and annual Flight Physical on 12 December 2018 (Tab X-3). Vance AFB Flight Medicine issued a DoD Form 2992 on 14 December 2018 indicating medical clearance for pilot duties (Tab X-3). A review of AIMWTS indicated that MSP1 never required a waiver for flying duties (Tab X-3). MSP1 was medically qualified for flying duties.

(3) MIP2 and MSP2

The AIB determined the medical status of MIP2 and MSP2 was not relevant to the mishap.

b. Health

The outpatient medical and dental records (paper and electronic) were reviewed for MIP1 and MSP1 (Tab X-3). No significant health issues were identified for either member.

c. Pathology

MIP1 and MSP1 were transported to Fort Sill, OK, where an Armed Forces Medical Examiner System (AFMES) Regional Medical Examiner performed autopsies on 23 November 2019 (Tab X-3, and X-10 to X-11). The AFMES Forensic Toxicology Laboratory performed toxicology tests for alcohol, common drugs, and carbon monoxide (Tab X-3). All test results were negative (Tab X-3).

The cause of death for both pilots was blunt trauma from ground impact (Tab X-3). The manner of death was accidental (Tab X-3). Based on the pattern of injuries and force involved, death occurred for both MIP1 and MSP1 immediately upon inverted impact (Tab X-3).

d. Lifestyle

AIB interviews with coworkers indicated that MSP1 had significant personal stressors related to his performance struggles in the current phase of T-38 training (Tab V-3.6 and V-4.8). Flight and squadron leadership were aware and took appropriate steps to help MSP1 complete training (Tab V-4.5 and V-4.7). The AIB determined lifestyle was not a factor in the mishap.

e. Crew Rest and Crew Duty Time

The AETC Supplement to AFI 11-202, Volume 3, *General Flight Rules*, states crew rest is compulsory for aircrew members and is a minimum of 12 non-duty hours before the flight duty period (Tab BB-36). Crew rest is free time and includes time for meals, transportation, and rest, as well as an opportunity for at least 8 hours of interrupted sleep (Tab BB-36). The AIB determined MIP1 and MSP1 were afforded adequate crew rest in the days leading up to the mishap.

The AETC Supplement also addresses maximum flying times, including simulator time (Tab BB-37 and BB-39). For T-38s, these maximums are 6.5 hours during one flight duty period, 30 hours in 7 consecutive days, and 75 hours in 30 consecutive days. (Tab BB-39) Neither MSP1 nor MIP1 had flight time totals that approached these maximums (Tabs T-10, T-51 to T-55, BB-37, and BB-39).

	Flying Hours in current Flight Duty Period	Flying Hours per 7 Consecutive Days	Flying Hours per 30 Consecutive Days
11-202	6.5	30	75
MSP1	1	12.1	27.1 + 11.7 sim = 38.8
MIP1	1	3.3	13.8

The AIB determined crew rest and crew duty time were not factors in this mishap.

10. OPERATIONS, SUPERVISION AND FLIGHT ANALYSIS

a. Operations

25 FTS conducts Phase III fighter-bomber track (T-38C) advanced training (Tab EE-14). The training is 120 days long and is split into five units: 60 hours of ground training; 80 hours of academic training; three hours of cockpit familiarization; 29 hours of simulator training; and 119 hours of aircraft flying training (Tab BB-56). 25 FTS conducts this training in accordance with AETCI 36-2605v4, *Formal Flying Training Administration and Management*; AETC Syllabus P-V4A-A, T-38C *Specialized Undergraduate Pilot Training*; and 25 FTS Operating Instruction 11-1, *Squadron Operations* (Tabs E-2, BB-46 and BB-54).

At the time of the mishap, operations tempo for 25 FTS was slightly elevated, with a moderately aggressive schedule driven by MSP1's cohort of students being 5.23 training days behind planned program flow (Tabs V-3.18 and BB-52).

(1) MIP1

The operations tempo for MIP1 was normal, with three sorties in the week prior to the mishap and 14 sorties in the last 30 days (Tab T-10).

(2) MSP1

The operations tempo for MSP1 was elevated during the week prior to the accident (Tab T-54 to T-55 and T-68 to T-69). He flew six syllabus sorties in five days between 15 and 19 November 2019, to include cross-country sorties on Saturday and Sunday (Tab T-68 to T-69 and T-215 to T-218). He also flew with an instructor as an observer on 20 November 2019 (Tab T-69). Although MSP1 flew more frequently than he had on most prior weeks, his total flying hours remained within AETC limits (Tabs T-51 to T-55, BB-37, and BB-39). Furthermore, the AIB's review of MSP1's weekly work schedule showed significant unstructured time between flights and other events during the two weeks leading up to the mishap (Tab T-68 to T-69).

(3) MIP2

Operations tempo for MIP2 was lower than normal with eight sorties in the last 30 days (Tab T-33). MIP2's most recent flight prior to the MS was 8 November 2019 (Tab T-38). The MS was MIP2's first sortie following return from extended leave (Tab V-5.5).

(4) MSP2

MSP2 was a T-38C student pilot in the early portion of the formation phase of syllabus training (Tab N-16). MSP2 was performing the MS as an observation sortie (Tab V-5.5 and V-6.4). This observation sortie was normal and in accordance with the syllabus, but was not a required event for MSP2's program progression (Tab BB-57). MSP2 was neither flying nor receiving instruction during the formation approach and landing (Tab BB-57).

The AIB found no evidence to suggest that operations tempo or other operational conditions were factors in this mishap.

b. Supervision

The AIB determined supervision for the mishap sortie was appropriate. The on-duty Operations Supervisor properly authorized the MS, and a qualified Supervisor of Flying was on duty overseeing the flying operations for the airfield before, during and after the mishap (Tab AA-4 and AA-5). 25 FTS properly scheduled the sortie in accordance with the T-38C syllabus (Tab BB-58). MIP1, a current and qualified IP, appropriately briefed the mission and acted as the overall instructor of record for the MS; MIP2, also a current and qualified IP, served as the Pilot in Command of MA2 in formation direct support (Tab AA-3 and AA-5).

25 FTS has an active ORM Program. The members of the mishap flight completed the 25 FTS ORM checklist for the MS and the Operations Supervisor reviewed and signed the risk assessment (Tab AA-5 to AA-6). The AIB noted that one additional point should have been added to the overall risk assessment since MSP1 received a grade of "unsatisfactory" on his previous syllabus sortie (Tabs T-215 to T-220 and AA-5). Even after correcting for this error, the AIB determined

the overall risk assessment score for the mission remained "low" under the guidelines outlined by the 25 FTS ORM program (Tab AA-5).

25 FTS Operating Instruction 11-1 states students should be considered for placement on the Commander's Awareness Program (CAP) after a second consecutive flight or simulator graded below the level of "good" (Tab BB-48). MSP1 was a candidate for this program, but was not placed on CAP prior to the MS (Tab V-3.9 and V-4.7).

MSP1 received overall ratings of "unsatisfactory" on three consecutive flights prior to the MS (Tab T-215 to T-220). In this case, the Squadron Commander was not notified of MSP1's unsatisfactory sorties until the third consecutive "unsatisfactory" flight, likely because the flights occurred in quick succession during a brief period of overlapping leaves for MSP1's Flight Commander and Assistant Flight Commander (Tab V-3.10 and V-4.7). In the absence of the Flight Commander and the Assistant Flight Commander, the Squadron Scheduler notified the Squadron Commander of the third consecutive "unsatisfactory" flight (Tab V-4.7). The Commander subsequently directed the Scheduler to program two Additional Training sorties for MSP1, followed by an Elimination Check with the Commander (Tab V-3.10 and V-4.7).

The Elimination Check was a syllabus requirement driven by a combination of the MSP1's three consecutive "unsatisfactory" sorties and his previous Progress Check (Tabs T-146 to T-147, T-215 to T-220, and BB-60). Additional Training Sorties, however, are "not automatically given to every student, but are reserved for cases where the Squadron Commander determines some training irregularity or anomaly has occurred and the student has demonstrated the potential to complete" SUPT (Tab BB-59).

The Commander directed the Scheduler to have MSP1 fly the Additional Training Sorties with a seasoned Instructor Pilot (IP) (Tab V-4.5). He was not overly concerned about the issues that arose in the unsatisfactory sorties and believed MSP1 had the potential to successfully complete SUPT (Tab V-4.5). The Commander requested seasoned IPs for the additional training to ensure MSP1 received enhanced supervision and the best possible preparation for his Elimination Check (Tab V-4.5). To meet the Commander's intent, the Squadron Scheduler deliberately paired MSP1 and MIP1 for the mishap mission (Tabs V-13.4 and AA-3). MIP1 was a highly experienced aviator, widely regarded as one of the most capable and dedicated T-38 instructors at Vance AFB (Tab V-4.6). MIP1 spent approximately 1.5 hours with MSP1 the day prior to the MS preparing him for the mission (Tab V-4.8). This one-on-one engagement was over and above the requirements of the syllabus (Tab BB-59).

Though the supervisory chain did not formally place MSP1 on the CAP prior to the MS, the Squadron Commander's actions had the same net effect; MSP1 was receiving enhanced supervision from a highly qualified IP on the date of the mishap (Tab V-4.7). Furthermore, in the week leading up to the MS, MSP1 accomplished no more than two activities per day (flying or simulator); this is consistent with the recommendations of 25 FTS OI 11-1 for students on CAP (Tabs T-68 to T-69 and BB-48).

The AIB found no evidence supervision was a factor in the mishap.

c. Flight Analysis

The AIB attempted to recreate the mishap profile in the T-38C Weapons System Trainer (simulator) (Tab AA-2). The only combination of control inputs that led to a similar result was a premature aerobrake immediately after touchdown in conjunction with a right rudder input (Tab AA-2).

Additionally AIB provided the parametric data and HUD video to the Chief Test Pilot at the US Air Force Test Pilot School, Edwards AFB, CA (Tab V-22.3). During a T-38C flight conducted on 6 January 2020, the test pilot replicated the flight characteristics of MA1 during the final seconds before the collision, although at a safe altitude (Tab DD-36). The test pilot concluded the pilot flying MA1 prematurely initiated an aerobrake, causing MA1 to lift back into the air after landing (Tabs V-22.3 and DD-36). The test pilot also concluded MA1 was either airborne or so lightly planted after the aerobrake there was effectively no weight on its wheels when the pilot flying the aircraft depressed the right rudder pedal approximately halfway through its available travel, commanding approximately 15 degrees of right rudder deflection (Tab DD-37). The AIB subsequently determined this equated to approximately two inches of right rudder pedal travel. The rudder input caused MA1 to roll very slightly left, yaw to the right, then--after a delay of nearly a second--roll rapidly right (Tabs V-22.4 and DD-37). This is consistent with the known flight characteristics of an airborne T-38C flying at that airspeed and angle of attack with its gear down (Tabs V-22.4 and DD-36). The test pilot excluded other control inputs (Tab V-22.5). The test pilot concluded MIP1 likely took control of MA1 no later than when MA1 settled to the ground in a skid towards MA2 (Tab DD-38).

This characteristic is so well known that Air Education and Training Command Manual (AETCMAN) 11-251, paragraph 4.16.5 addresses Rudder Overcontrol, stating, *"When configured, the T-38's 30 degrees of available rudder is highly effective in rolling the aircraft. Although the rudder is not needed to coordinate flight, it may be useful during high AOA or asymmetric thrust situations. To prevent over control-use only small rudder inputs as required in the traffic pattern. In no case should you wait until you see aircraft response before removing rudder input in when the landing gear are extended."* (emphasis added) (Tab BB-29)

Numerous IPs stated they were aware of the dangers of using rudder in the traffic pattern and instructed their students accordingly (Tab V-16.5, V-17.5, and V-18.2). They caution students not to use rudder during normal landing operations until after the landing gear are firmly in contact with the runway (at that point, rudder is required for directional control) (Tab V-16.5, V-17.5, and V-18.2). Many IPs also stated they keep their feet close to the rudder pedals during traffic pattern operations to insure students do not input rudder, especially during the early stages of T-38C training (Tab V-1.13, V-9.5, V-13.9 and V-16.5). This would allow for the IP to quickly override the student input and take control of the aircraft in case of an inappropriate student input. IPs consistently stated, however, that incorrect application of rudder is not a common student error, particularly after the first few T-38C flights (Tab V-16.5, V-17.6, and V-18.3).

11. HUMAN FACTORS ANALYSIS

a. Introduction

As defined by AFI 91-204_Air Force Guidance Memorandum (AFGM) 2019-01, *Safety Investigation and Hazard Reporting*, a human factor is any environmental factor or psychological factor a human being experiences that contributes to or influences performance during a task (Tab BB-48). AFI 91-204_AFGM 2019-01, incorporating the most current Department of Defense Human Factors Analysis and Classification System, Version 7.0 (DoD HFACS), establishes several potential human factors for assessment during a mishap investigation (Tab BB-40).

b. PC103 Task Oversaturation & AE105 Breakdown in Visual Scan

HFACS code PC103 is a factor when the quantity of information an individual must process exceeds their mental resources in the amount of time available to process the information (Tab BB-44).

HFACS code AE105 is a factor when an individual fails to effectively execute visual scan patterns (Tab BB-41).

c. AE201 Inadequate Real-Time Risk Assessment & AE107 Delayed a Necessary Action

HFACS code AE201 is a factor when an individual fails to adequately evaluate the risks associated with a particular course of action and this faulty evaluation leads to inappropriate decision-making and subsequent unsafe situations. (Tab BB-42)

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-41).

12. GOVERNING DIRECTIVES AND PUBLICATIONS

a. Publically Available Directives and Publications Relevant to the Mishap

FAA Advisor Circular 90-236, *Aircraft Wake Turbulence*, 10 February 2014
DoD *Human Factors Analysis and Classification System*, Version 7
AFI 51-307, *Aerospace and Ground Accident Investigations*, 17 March 2019
AFI 91-204_AFGM 2019-01, *Safety Investigation and Hazzard Reporting*, 30 July 2019
AFI 11-202V3_AETCSUP, *General Flight Rules*, 30 January 2017
AETCI 36-2605, Volume 1, *Formal Flying Training Administration and Management,* 17 September 2019
AETCMAN 11-251, *T-38C Flying Fundamentals*, 4 April 2017

NOTICE: The FAA Advisory Circulars may be found at:
https://www.faa.gov/regulations_policies/advisory_circulars/ .

The DoD HFACS may be found at:
https://www.safety.af.mil/Divisions/Human-Factors-Division/HFACS/.

All Air Force and AETC 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

TO 1T-38C-1, *USAF Series T-38C Aircraft Flight Manual*, 8 March 2016, through Change 3, 5 October 2017
AETC Syllabus P-4VA-A, *T-38C Specialized Undergraduate Pilot Training*, April 2018
25 FTS Operating Instruction 11-01, *Squadron Operations*, 3 January 2017

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4 February 2020

EVAN L. PETTUS
Brigadier General, USAF
President, Accident Investigation Board

STATEMENT OF OPINION

T-38C, T/N 65-0395 and T-38C, T/N 67-4950
VANCE AIR FORCE BASE, OKLAHOMA
21 NOVEMBER 2019

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 the morning of 21 November 2019, two T-38C Talon aircraft collided during an attempted formation landing on Runway 35 Center (35C) at Vance AFB, OK.

Mishap Student Pilot 1 (MSP1) and Mishap Instructor Pilot 1 (MIP1) flew the local student formation training mission in Mishap Aircraft 1 (MA1), tail number (T/N) 65-0395. Mishap Student Pilot 2 (MSP2) and Mishap Instructor Pilot 2 (MIP2) flew in Mishap Aircraft 2 (MA2), T/N 67-4950, in direct support. Both aircraft were assigned to the 25th Flying Training Squadron (25 FTS), 71st Flying Training Wing. MIP1 was assigned to the 5th Flying Training Squadron as an Active Guard Reserve officer who flew with the 25 FTS. MIP2 was assigned to the 25 FTS. MSP1 and MSP2 were assigned to the 71st Student Squadron and flew with the 25 FTS.

Immediately after touchdown, MA1, flying in the left wing position, initiated an aerodynamic braking maneuver (aerobrake). MA1 became briefly airborne, rolled rapidly to the right, then touched down once more in nearly 30 degrees of right bank. MA1 entered a skid and crossed the runway centerline from left to right on a collision course with MA2. MA1 lifted off the runway again then struck MA2 with its right main landing gear followed by its right wing. The collision caused MA1 to roll over the top of MA2 then impact the ground in an inverted or nearly inverted attitude, fatally injuring MIP1 and MSP1. MA1 slid approximately 700 feet before coming to a stop in a grassy area roughly 300 feet east of the runway surface. Following the collision with MA1, MA2 departed the prepared surface of the runway, remained upright, travelled approximately 1,700 feet and came to a stop. MIP2 and MSP2 shut down and safely egressed their aircraft.

I find by a preponderance of the evidence the causes of the mishap were MIP1 failing to take control of MA1 as a precarious situation developed and MSP1 subsequently making an inappropriate flight control input. Additionally, I find by a preponderance of the evidence the following factor substantially contributed to the mishap: MSP1 lacked an effective visual scan during the formation approach.

2. CAUSE

Air Force Instruction 51-307, Aerospace and Ground Accident Investigations, paragraph 7.8.4, states, "A cause is an act, omission, condition, or circumstance that starts, sustains, or creates a condition permitting the mishap, without which the mishap could not have occurred. It may be an element of human, environmental, mechanical performance or a combination thereof. A given act, omission, condition, or circumstance will be a 'cause' if correcting, eliminating, or avoiding it would have prevented the mishap. *In other words, a factor is found causal if 'but for' that factor taking place, the mishap would not have occurred."*

a. MIP1 made an inaccurate real-time risk assessment during the landing sequence. As a result, he failed to take control of MA1 as a precarious situation developed.

Fellow instructors consistently stated MIP1 was one of the most capable and dedicated T-38C Instructor Pilots at Vance AFB. Some also stated he was very confident in his abilities and was therefore comfortable letting student errors progress further than many other instructors in order to maximize learning. I found no evidence, however, to indicate MIP1 ever disregarded safety of flight.

The mishap occurred during a formation landing. During the mishap sequence, MA1 crossed the overrun in stable formation with MA2, though approximately 10 feet wide (left) of optimum spacing. As MSP1 raised the nose of MA1 to match MA2's pitch through the transition to landing, the nose of MA1 blocked MIP1's forward view of the runway environment. At the same time, MA1 drifted further left, touching down with the left main gear approximately 15 feet from the runway edge on a heading 1 to 2 degrees left of runway alignment. I was unable to determine if MIP1 failed to notice the drift or if he simply elected not to intervene since MA1 remained on track to land on the prepared surface. Either way, I think MIP1 was fully aware of MA1's position and ground track by the time MA1 first touched down. In my opinion, MIP1 elected not to intervene at that time because he thought MSP1 could safely complete the landing sequence.

T-38C instructors at Vance strongly discourage the use of the rudder during normal traffic pattern operations until both main tires are firmly on the ground. Furthermore, inappropriate rudder use in the traffic pattern is not a common student error beyond the very earliest stages of the T-38C program. MSP1 was completing his 56th sortie in the T-38C. In my opinion, there would be no reason for MIP1 to expect such an error from a student with MSP1's experience during a normal landing. However, MA1's premature aerobrake and proximity to the runway edge at touchdown introduced an elevated level of risk MIP1 did not accurately assess.

Because of the delay between rudder application and noticeable aircraft response typical to a T-38 operating in this flight regime—airborne, configured and at increased angle of attack—I think MIP1 was unaware of MSP1's rudder input until after the onset of the rapid right roll. At that point, however, a collision with MA2 was inevitable. Still, in my opinion, a more accurate risk assessment would have led MIP1 to intervene in the mishap sequence by assuming control of MA1 no later than when MSP1 prematurely initiated the aerobrake, causing MA1 to begin to lift off the runway. MA1's position at that time—airborne, at low airspeed, and near the edge of the runway—left very little room for subsequent student error. Instead, however, MIP1 verbally

directed MSP1 to "go-around" as the weight left MA1's wheels. In my opinion, MIP1 did not take aircraft control until sometime after MSP1 had applied and held right rudder deflection while MA1's wheels were off the ground.

I find by a preponderance of the evidence MIP1 made an inaccurate real-time risk assessment during the landing sequence. As a result, he failed to take control of MA1 as a precarious situation developed.

b. MSP1 made an inappropriate flight control input during landing, placing MA1 on a collision course with MA2.

The mishap occurred during a formation landing. MSP1 piloted MA1 in the left wing position; MIP2 led the landing, piloting MA2. MIP2 maneuvered MA2 into a normal approach, maintained proper parameters, and touched down as planned near the center of the right (eastern) half of Runway 35 Center (35C).

MA1 was in a stable, level formation position to the left of MA2 when the two aircraft crossed the overrun to land on Runway 35C, but MA1 was approximately 10 feet wider to the left than planned. During the transition to land, MSP1 allowed MA1 to drift further towards the left edge of the runway (Tab Z-16).

MA1 touched down one second after MA2, within one knot of planned landing speed. At touchdown, MA1's left main tire was approximately 15 feet from the left edge of the runway (Figure 1). Immediately following touchdown, the preponderance of the evidence indicates MSP1 prematurely initiated an aerobrake in an effort to fall behind MA2 before MA2 began its own aerobrake. MA1 retained sufficient airspeed to lift slightly off the runway as MSP1 pulled back on the stick to raise the nose. Less than one second later, noting his close proximity to the left edge of the prepared surface, MSP1 applied right rudder to steer towards the runway centerline.

(Figure 1)

MIP1 directed a "go-around" as MA1 began to rise above the runway surface. MSP1 moved the throttles to full military power in response. MIP1 was likely not yet aware MSP1 had applied rudder.

Consistent with the flight characteristics of an airborne T-38C, the right rudder input caused MA1 to roll very slightly left, yaw to the right, then--after a delay of nearly a second--roll rapidly right. MA1 settled back to the runway on its right main wheel in approximately 30 degrees of right bank and entered a skid, quickly converging with MA2. In my opinion, a collision with MA2 was inevitable at that point.

Air Education and Training Command Manual (AETCMAN) 11-251, paragraph 4.16.5 addresses Rudder Over control, stating, *"When configured, the T-38's 30 degrees of available rudder is highly effective in rolling the aircraft. Although the rudder is not needed to coordinate flight, it may be useful during high AOA or asymmetric thrust situations. To prevent over control-use only small rudder inputs as required in the traffic pattern. In no case should you wait until you see aircraft response before removing rudder input in when the landing gear are extended."* (Emphasis added)

The preponderance of the evidence indicates MSP1 maintained the right rudder input until MA1 began rolling rapidly to the right. Because of the delay between the rudder application and noticeable aircraft response (this delay is characteristic of a T-38 operating in this flight regime: airborne, configured and at increased angle of attack), it is my opinion MIP1 was unaware of MSP1's rudder input until after the onset of the rapid right roll. I could not determine if and/or when MIP1 took control of MA1, but I find it highly likely MIP1 assumed control by the time MA1 settled to the runway on its right wheel and no later than when MA1's nose wheel touched down. MIP1 attempted to continue the go-around, leaving the throttles in full military power. He leveled the wings, arrested the skid, and aggressively pulled back on the stick in an effort to avoid a collision by overflying MA2, but lacked sufficient airspeed. MA1's right gear door made contact with MA2's left wingtip, trapping MA2's wing between MA1's right main landing gear tire and the outboard gear door. The contact caused MA1 to roll rapidly right, where its wingtip struck MA2 near the upper wing root. MA1 continued to roll to the right, passed over the top of MA2, then impacted the ground inverted with its engines in full military power. MSP1 and MIP1 were killed on impact.

I conclude by a preponderance of the evidence MSP1's right rudder input caused a roll and yaw consistent with the flight characteristics of the T-38C, and placed MA1 on a collision course with MA2.

I was unable to determine if either MIP1 or MSP1 considered initiating ejection when it became apparent collision with MA2 was imminent. Regardless, I think it worth noting their decision to continue avoidance efforts up to the moment of collision likely prevented fatal injuries to the crew of MA2.

3. SUBSTANTIALLY CONTRIBUTING FACTORS

MSP1 lacked an effective visual scan during the formation approach.

Approximately one mile from touchdown, MIP1 prompted MSP1 to tighten the formation spacing, stating, "Let's get lined up with the runway." MSP1 took proper corrective action in response, but subsequently allowed the formation spacing to widen again prior to crossing the runway overrun.

I find, by a preponderance of the evidence, MSP1 lacked an effective visual scan during the formation approach. Due to his focus on MA2, MSP1 did not adequately crosscheck his runway alignment as the formation descended below 100 feet AGL. As a result, MSP1 was unaware of MA1's further leftward drift as he raised the nose to transition to land. MSP1 did not attempt to correct that drift until after MA1 initially touched down. In my opinion, MSP1's use of right rudder as the aircraft floated back into the air after initial touchdown was a belated reaction to MA1's proximity to the left edge of the runway.

Simulator and flight test replication indicate MSP1 abruptly depressed the right rudder pedal approximately two inches (half rudder) towards the floor, commanding approximately 15 degrees of right rudder deflection. I think MSP1 was surprised to realize MA1 was so close to the left edge of the runway, leading him to attempt a hurried correction with rudder at an inappropriate time.

In my opinion, had MSP1 conducted an effective visual scan on approach, he would have made a correction to better align MA1 on the runway prior to touchdown rather than attempting to use rudder to steer MA1 just as his premature aerobrake lifted the weight from MA1's wheels. I find by a preponderance of the evidence MSP1's lack of an effective visual scan during the formation approach was a substantially contributing factor to the mishap.

4. CONCLUSION

I developed my opinion by reviewing cockpit video from both aircraft, a reconstructive animation of the mishap and engineering analyses. I also replicated the mishap sequence in a T-38 Weapon System Trainer (simulator). Finally, I consulted with a USAF Test Pilot and T-38 performance expert who subsequently replicated the circumstances leading to the mishap during a live test flight.

I find by a preponderance of the evidence the causes of the mishap were MIP1 failing to take control of MA1 as a precarious situation developed and MSP1 subsequently making an inappropriate flight control input. Finally, I find by a preponderance of the evidence the following factor substantially contributed to the mishap: MSP1 lacked an effective visual scan during the formation approach.

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4 February 2020

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Brigadier General, USAF
President, Accident Investigation Board

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