UNITED STATES AIR FORCE
AIRCRAFT ACCIDENT INVESTIGATION BOARD REPORT

RQ-4B, T/N 07-2029

12th Reconnaissance Squadron
9th Reconnaissance Wing
Beale Air Force Base, California

LOCATION: NEAR LONE PINE, CALIFORNIA

DATE OF ACCIDENT: 21 JUNE 2017

BOARD PRESIDENT: COLONEL JEREMY L. THIEL

Conducted IAW Air Force Instruction 51-503

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

OFFICE OF THE DEPUTY COMMANDER
205 DODD BOULEVARD SUITE 203
JOINT BASE LANGLEY-EUSTIS VA 23665-2788

SEP 19 2018

ACTION OF THE CONVENING AUTHORITY

The report of the Accident Investigation Board, conducted under the provisions of AFI 51-503, that investigated the 21 June 2017 mishap near Lone Pine, California, involving an RQ-4B, T/N 07-2029, assigned to the 12th Reconnissance Squadron, complies with applicable regulatory and statutory guidance and on that basis it is approved.

CHRISTOPHER P. WEGGEMAN
Lieutenant General, USAF
Deputy Commander

EXECUTIVE SUMMARY
UNITED STATES AIR FORCE
AIRCRAFT ACCIDENT INVESTIGATION

RQ-4B, T/N 07-2029
NEAR LONE PINE, CALIFORNIA
21 JUNE 2017

On 21 June 2017, at approximately 1310 local (L) time, a RQ-4B Global Hawk, tail number (T/N) 07-2029, began breaking up mid-air near Lone Pine, California, approximately 49 minutes after takeoff, while conducting a ferry flight from Edwards Air Force Base (AFB), California, to Beale AFB, California. The mishap remotely piloted aircraft (MRPA) was assigned to the 9th Reconnaissance Wing, Beale AFB. The mishap aircrew (MC) were contractors for the Northrop Grumman Corporation. The MC included a mishap mission commander (MMC), a mishap pilot (MP1) who controlled the MRPA at the time of the mishap, and a Hawkeye pilot (H2) who conducted the preflight inspection. MMC and MP1 remotely operated the MRPA from a Mission Control Element (MCE1) out of Palmdale, California. H2 conducted the pre-flight inspection at Edwards AFB. An Air Force aircrew operating from a Beale AFB MCE (MCE2) monitored the mishap flight. The mishap did not result in any injuries or damage to private property. However, the debris field included portions of the Inyo National Forest. No significant hazards or wilderness impacts to the Forest were identified. The MRPA, valued at $79 million, was destroyed.

On 16 June 2017, the MRPA arrived at Edwards AFB from Beale AFB for a right-wing composite repair. Personnel from 9th Maintenance Squadron completed the repair without complications on 17 June 2017, in accordance with an engineering disposition. On 21 June 2017, maintenance and aircrew personnel conducted a pre-flight inspection at Edwards AFB. After completing the inspection, the MRPA took off at 1221L. Shortly after takeoff, the MRPA's Kearfott KN-4074E navigators (KNA and KNB) were disabled in accordance with standard procedure. The MRPA climbed and flew to planned waypoints uneventfully. At approximately 1309L, one of the two enabled Litton LN-100G navigators (LNA and LNB)--specifically LNA--began producing erroneous navigational data. Failing to detect LNA's erroneous data, the MRPA rolled to a nearly inverted position and entered a dive that resulted in an excessive airspeed. The MRPA subsequently exceeded its structural limitations and was unable to recover. The MRPA broke up during flight and crashed in an unpopulated and rugged area between Lone Pine, California, and Mount Whitney, California.

The Accident Investigation Board (AIB) President found, by a preponderance of evidence, that the causes of the mishap were that the MRPA's LNA produced erroneous navigational data and the MRPA's navigation system did not detect the erroneous navigational data. The AIB Board President also found, by a preponderance of evidence, that disabling KNA and KNB after takeoff substantially contributed to the mishap.

SUMMARY OF FACTS AND STATEMENT OF OPINION
RQ-4B, T/N 07-2029
NEAR LONE PINE, CALIFORNIA
21 JUNE 2017

TABLE OF CONTENTS

ACRONYMS AND ABBREVIATIONS iii
SUMMARY OF FACTS 1
1. AUTHORITY AND PURPOSE 1
a. Authority 1
b. Purpose 1
2. ACCIDENT SUMMARY 1
3. BACKGROUND 2
a. Air Combat Command (ACC) 2
b. 9th Reconnaissance Wing (9 RW) 2
c. 12th Reconnaissance Squadron (12 RS) 2
d. 13th Reconnaissance Squadron (13 RS) 3
e. RQ-4B – Global Hawk 3
4. SEQUENCE OF EVENTS 3
a. Mission 3
b. Planning 4
c. Preflight 4
d. Summary of Accident 4
e. Impact 6
f. Egress and Aircrew Flight Equipment (AFE) 6
g. Search and Rescue (SAR) 6
h. Recovery of Remains 6
5. MAINTENANCE 6
a. Forms Documentation 6
b. Inspections 7
c. Maintenance Procedures 7
d. Maintenance Personnel and Supervision 7
e. Fuel, Hydraulic, Oil, and Oxygen Inspection Analyses 7
f. Unscheduled Maintenance 8
6. AIRFRAME, MISSILE, OR SPACE VEHICLE SYSTEMS 8
a. Structures and Systems 8
(1) Overall Aircraft Structure 8
(2) Navigation System 8
(3) Mission Control Element (MCE) 8
b. Evaluation and Analysis 8
7. WEATHER 9
8. CREW QUALIFICATIONS 9
a. Mishap Mission Commander (MMC) 9
b. Mishap Pilot 1 (MP1) 10
c. Mishap Pilot 2 (MP2) 10

d. Mishap Pilot 3 (MP3) 10
e. Hawkeye Pilot (H2) 10
9. MEDICAL 11
a. Qualifications 11
b. Health 11
c. Lifestyle 11
d. Crew Rest and Crew Duty Time 11
10. OPERATIONS AND SUPERVISION 11
a. Operations 11
b. Supervision 11
11. HUMAN FACTORS ANALYSIS 11
12. GOVERNING DIRECTIVES AND PUBLICATIONS 12
a. Publically Available Directives and Publications Relevant to the Mishap 12
b. Other Directives and Publications Relevant to the Mishap 12
c. Known or Suspected Deviations from Directives or Publications 13
STATEMENT OF OPINION 14
1. Opinion Summary 14
2. Cause 14
3. Substantially Contributing Factors 15
4. Conclusion 15
INDEX OF TABS 16

ACRONYMS AND ABBREVIATIONS

AC(#)	Aircraft Route
ACC	Air Combat Command
ACCEL	Accelerometer Temperature
ADI	Attitude Director Indicator
AF	Air Force
AFB	Air Force Base
AFI	Air Force Instruction
AFMAN	Air Force Manual
AFMC	Air Force Material Command
AFTO	Air Force Technical Order
AFPD	Air Force Policy Directive
AIB	Accident Investigation Board
ATC	Air Traffic Control
ATO	Air Tasking Order
AME	Aviation Medical Examiner
AMU	Aircraft Maintenance Unit
AMXS	Aircraft Maintenance Squadron
BACN	Battlefield Airborne Communication Node
BLOS	Beyond Line of Sight
C	Celsius
C-(#)	Contingency
C2	Command and Control
CA	California
Capt	Captain
CAS	Calibrated Air Speed
CCB	Change Control Board
CDL	Common Data Link
CENTCOM	Central Command
CFR	Code of Federal Regulations
CO	Commanding Officer
COCOM	Combatant Command
Col	Colonel
COMM	Communication
COMSEC	Communication Security
COP	Contractor Procedures
CR	Change Request
CTF	Combined Test Facility
CTR	Contractor
DCMA	Defense Contract Management Agency
DLE	Elevator Deflection
DNIF	Duties Not Including Flying
DO	Director of Operations
DoD	Department of Defense
E(#)	Engineer
EAU	Electronic Intelligence Antennae Upgrade
ECS	Environmental Control System
EDW	Edwards
EFM	Electronic Flight Manual
ELECT	Electronics Temperature
ELT	Emergency Locator Transmitter
ER	Exceptional Release
EXT	External
F	Fahrenheit
FAA	Federal Aviation Administration
FADEC	Full Authority Digital Engine Control
FDR	Flight Data Recorder
FLCS	Flight Control System
FLT	Flight
FLTS	Flight Test Squadron
FMECA	Failure Modes Effects Criticality Analysis
FOIA	Freedom of Information Act
ft	Feet
FOD	Foreign Object Damage
g	Gravitational Force
GFR	Government Flight Representative
GH	Global Hawk
GHMD	Global Hawk Maritime Demonstration
GHOC	Global Hawk Operations Center
GM	Guidance Memorandum
GNC	Guidance, Navigation, Control
GPS	Global Positioning System
GS	General Schedule
H(#)	Hawkeye
HRS	Hours
IAW	In Accordance With
ID	Identification
IFF	Identify Friend or Foe
IMDS	Integrated Maintenance Data System
IMINT	Imagery Intelligence
IMMC	Integrated Mission Management Computer
INMARSAT	International Maritime Satellite
INSP	Inspection
IPI	In-Process Inspection
ISB	Interim Safety Board
ISR	Intelligence, Surveillance, Reconnaissance
JA	Judge Advocate
JAG	Judge Advocate General
KBAB	Beale Air Force Base
KEDW	Edwards Air Force Base
KN(A/B)	Kearfott Navigator
kts	Knots
L	Local Time
L3	Subsidiary Contractor to Northrop Grumman
lbs	Pounds
LA	Legal Advisor
LLADS	Links Logic Advisory Detailed Status SpecView
LN(A/B)	Litton Navigator
LRE	Launch and Recovery Element
Lt Col	Lieutenant Colonel
MAINT	Maintenance
Maj	Major
MAJCOM	Major Command
MBA	Master of Business Administration

MBR	Member
MC	Mishap Aircrew
MCE(#)	Mission Control Element
MFR	Memorandum for Record
mins	Minutes
MIRC	Mardem-Bey Internet Chat Relay
MTI	Moving Target Indicator
MM	Maintenance Member
MMC	Mishap Mission Commander
MOA	Memorandum of Agreement
MP(#)	Mishap Pilot
MPA	Military Personnel Appropriation
MRPA	Mishap Remotely Piloted Aircraft
MSgt	Master Sergeant
MSL	Mean Sea Level
MSN	Mission
MX(#)	Maintainer
MXS	Maintenance Squadron
NAS	National Air Space
NASA	National Aeronautics and Space Administration
NATO	North Atlantic Treaty Organization
Nav	Navigation/Navigator
NCO	Non-Commissioned Officer
NG	Northrop Grumman
NGC	Northrop Grumman Corporation
NGA	Northrop Grumman Associates
NIPR	Nonsecure Internet Protocol Router
NOTAM	Notice to Airmen
nm	Nautical Miles
NY	Normal Load Factor Axis Y
NZ	Normal Load Factor Axis Z
OG	Operations Group
OIC	Officer in Charge
Ops Sup	Operations Supervisor
ORM	Operational Risk Management
PEX	Patriot Excalibur
PFD	Pilot Flight Display
PIC	Pilot in Command
PM	Pilot Member
PR	Preflight Inspection
PSAT	Pilot Stand Alone Trainer
PST	Pacific Standard Time
pt	Point
QA	Quality Assurance
R	Red
REC	Recorder
Rev	Revised
RG	Reconnaissance Group
RPA	Remotely Piloted Aircraft
RPM	Revolutions Per Minute
RS	Reconnaissance Squadron
RTB	Return to Base
RW	Reconnaissance Wing
SATCOM	Satellite Communication
SCG	Security Classification Guide
sec	Seconds
SFS	SIB Flight Surgeon
Sgt	Sergeant
SIB	Safety Investigation Board
SIGINT	Signals Intelligence
SIPR	Secret Internet Protocol Router
SME	Subject Matter Expert
SMSgt	Senior Master Sergeant
SPM	Safety Investigation Board Pilot Member
SSgt	Staff Sergeant
TBA	Training Business Area
TCTO	Time Compliance Technical Order
TDY	Temporary Duty
T.O.	Technical Order
T/N	Tail Number
TSgt	Technical Sergeant
TT	Temperature
UAE	United Arab Emirates
UAV	Unmanned Aerial Vehicle
UAS	Unmanned Aerial System
UCLA	University of California, Los Angeles
UHF	Ultra-High Frequency
UPS	United Parcel Service
UPT	Undergraduate Pilot Training
US	United States
USAF	United States Air Force
VOIP	Voice Over Internet Protocol
VTC	Vehicle Test Controller
VVI	Vertical Velocity Indicator
WCE	Work Center Event
XTK	Cross Track Air
Z	Zulu

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

SUMMARY OF FACTS

1. AUTHORITY AND PURPOSE

a. Authority

On 14 February 2018, Major General John K. McMullen, the Air Combat Command (ACC) Deputy Commander, appointed Colonel Jeremy L. Thiel to conduct a legal investigation of the 21 June 2017 crash of an RQ-4B Global Hawk aircraft, tail number (T/N) 07-2029, near Lone Pine, California (Tab Y-3 to Y-4). The following board members were also appointed: Maintenance Member (Major); Legal Advisor (Major); Pilot Member (Captain); and Recorder (Master Sergeant) (Tab Y-3 to Y-4). The investigation was conducted at Beale Air Force Base (AFB), California, from 22 February 2018 to 27 March 2018 and in accordance with (IAW) Air Force Instruction (AFI) 51-503, *Aerospace and Ground Accident Investigations* (Tab Y-3 to Y-4). A Medical Officer (Major) and Engineer (NH-04) were also appointed as medical and navigation system subject matter experts (SMEs) to the AIB (Tab Y-5 to Y-6).

b. Purpose

IAW AFI 51-503, this accident investigation board conducted a legal investigation to inquire into all the facts and circumstances surrounding this Air Force aerospace accident; prepare a publicly releasable report; and obtain and preserve all available evidence for use in litigation, claims, disciplinary action, and adverse administrative action.

2. ACCIDENT SUMMARY

The mishap remotely piloted aircraft (MRPA) was a RQ-4B, T/N 07-2029, assigned to the 9th Reconnaissance Wing (RW), Beale AFB (Tabs P-2, Q-7, and V-16.3). The MRPA was at Edwards AFB, California, for a composite wing repair (Tab V-1.2 and V-2.2). On 21 June 2017, after completing the scheduled repairs, the MRPA took off on a ferry flight to return to Beale AFB (Tab V-16.3 to V-16.9). During the climb, at approximately 1309L, the MRPA rolled to a nearly inverted position and entered a dive (Tab DD-15). The MRPA failed to recover, broke up in flight, and crashed in an unpopulated and rugged area between Lone Pine, California, and Mount Whitney, California (Tabs Q-6, R-48, and DD-15). The mishap did not result in any injuries or damage to private property (Tab P-2). However, the debris field included portions of the Inyo National Forest (Tab DD-15). No significant remaining hazards or wilderness impacts to the Inyo National Forest were identified (Tab EE-8 to EE-9). The destroyed MRPA's loss is valued at $79 million (Tab P-2).

3. BACKGROUND

a. Air Combat Command (ACC)

ACC's primary mission is to support global implementation of national security strategy; ACC operates fighter, bomber, reconnaissance, battle-management and electronic-combat aircraft (Tab CC-3). It also provides command, control, communications and intelligence systems, and conducts global information operations (Tab CC-3).

As a force provider and Combat Air Forces lead agent, ACC organizes, trains, equips and maintains combat-ready forces for rapid deployment and employment while ensuring strategic air defense forces are ready to meet the challenges of peacetime air sovereignty and wartime air defense (Tab CC-3). Additionally, ACC develops strategy, doctrine, concepts, tactics, and procedures for air and space-power employment (Tab CC-3). The command provides conventional and information warfare forces to all unified commands to ensure air, space and information superiority for warfighters and national decision-makers (Tab CC-3). The command can also be called upon to assist national agencies with intelligence, surveillance and crisis response capabilities (Tab CC-3). ACC numbered air forces provide the air component to U.S. Central, Southern and Northern Commands, with Headquarters ACC serving as the air component to Joint Forces Commands (Tab CC-3). ACC also augments forces to U.S. European, Pacific, Africa-based and Strategic Commands (Tab CC-3).

b. 9th Reconnaissance Wing (9 RW)

The 9 RW is responsible for providing national and theater command authorities with timely, reliable, high-quality, high-altitude reconnaissance products (Tab CC-8). To accomplish this mission, the wing is equipped with the nation's fleet of U-2 and RQ-4 reconnaissance aircraft and associated support equipment (Tab CC-8). The wing also maintains a high state of readiness in its expeditionary combat support forces for potential deployment in response to theater contingencies (Tab CC-8). The 9 RW is composed of more than 4,500 personnel in four groups at Beale AFB and multiple overseas operating locations (Tab CC-8).

c. 12th Reconnaissance Squadron (12 RS)

The 12 RS mission is to expertly train, deploy and employ Airmen and assets to deliver globally integrated intelligence, surveillance, and reconnaissance (ISR) in support of warfighter needs and national objectives (Tab CC-11).

d. 13th Reconnaissance Squadron (13 RS)

The 13 RS, located at Beale AFB, is an associate reserve unit that provides theater commanders with near-real-time intelligence, surveillance, reconnaissance and target acquisition data (Tab CC-12). The squadron operates and maintains deployable, long-endurance RQ-4 Global Hawk aircraft and ground control elements to fulfill training and operational requirements generated by the Joint Chiefs of Staff in support of unified commanders and the Secretary of Defense (Tab CC-12).

e. RQ-4B – Global Hawk

The RQ-4 – Global Hawk is a high-altitude, long-endurance, remotely piloted aircraft with an integrated sensor suite that provides global all-weather, day or night ISR capability (Tab CC-14). Global Hawk's mission is to provide a broad spectrum of ISR collection capability to support joint combatant forces in worldwide peacetime, contingency and wartime operations (Tab CC-14). The Global Hawk provides persistent near-real-time coverage using imagery intelligence (IMINT), signals intelligence (SIGINT) and moving target indicator (MTI) sensors (Tab CC-14).

4. SEQUENCE OF EVENTS

a. Mission

On 16 June 2017, the MRPA arrived at Edwards AFB from Beale AFB for a right-wing composite repair (Tab V-1.3, V-1.8, and V-11.5). Personnel from 9th Maintenance Squadron (9 MXS) completed the repair without complications on 17 June 2017, IAW an engineering disposition (Tab V-1.1 to V-1.5 and V-1.8). The planned mission was a ferry flight to return the repaired MRPA from Edwards AFB to Beale AFB (Tabs K-5 and V-1.8). The Air Force Test Center (AFTC) Government Flight Representative (GFR), Edwards AFB, authorized the flight (Tab K-5). A Northrop Grumman contractor aircrew operated the MRPA from a Mission Control Element (MCE1)--a portable shelter equipped to support enroute aircraft mission functions--at Palmdale, California (Tabs K-3, R-156 to R-157, V-7.2, V-7.3 to V-7.4, and DD-4). MCE1 was not co-located with the MRPA (Tab V-7.3). A Beale AFB aircrew monitored from MCE2 (Tabs R-8, V-16.3, and DD-16). The plan called for the Northrop Grumman aircrew to transfer control of the MRPA to the Beale AFB aircrew to execute the remainder of the mission (Tab V-7.2 to V-7.3 and V-16.4).

The Northrop Grumman aircrew consisted of the mishap mission commander (MMC) and the mishap pilot in command of the MRPA at the time of the mishap (MP1) (Tab K-3). A Northrop Grumman Hawkeye pilot (H2) conducted the preflight inspection (Tab R-81 to R-82). MMC and MP1 operated from MCE1 while H2 conducted preflight operations from Edwards AFB (Tabs R-156 to R-157, V-6.2 to V-6.3, and V-7.3 to V-7.4). A second mishap pilot (MP2), 13 RS, was assigned to monitor and fly the remainder of the mission from MCE2 at Beale AFB

(Tabs G-32, R-4, and V-16.3 to V-16.4). A third mishap pilot (MP3), assigned to 12 RS, assisted MP2 with monitoring the MRPA (Tab V-5.1 to V-5.2).

b. Planning

On 21 June 2017, MMC and MP1 conducted preparation duties and briefed the mishap sortie IAW an Edwards AFB briefing guide (Tab R-54 to R-56, R-147, and R-155). The brief included mission, duties, weather, safety, and risk mitigation (Tab R-54 to R-56). Prior to commencing the mission, MP2 attended a briefing and ensured he was fit to fly (Tab R-9). A designated Operations Supervisor (OpSup) at Beale AFB verified that MP2 and MP3 were current and able to fly the mission (Tab R-9 and R-18 to R-19).

c. Preflight

On 21 June 2017, 9 RW personnel prepared the MRPA for flight and towed the aircraft to its launch location (Tab V-11.7 to V-11.8 and V-12.3). H2 accomplished a preflight walkaround of the MRPA and reviewed its maintenance documentation (Tab R-81 to R-82 and R-85 to R-87). Another Hawkeye pilot (H3) observed the walkaround and communicated to the pilots that the walkaround was complete and the forms were signed (Tab R-119 to R-120). Prior to launch, the MRPA experienced problems with its links to MCE1 and MCE2 as well as high temperature warnings (Tabs R-148 and V-11.3 to V-11.4). Both issues were resolved, and MP1 performed the launch without incident (Tabs R-148 and V-11.3 to V-11.4).

d. Summary of Accident

(Note: The AIB derived all times hereinafter by comparing internal aircraft time to the MCE2's time by using a specific command issued by MP1; all times should be considered approximate.)

The MRPA took off from Edwards AFB at 12:20:57L on 21 June 2017 (Tab AA-7). Between takeoff and approximately 13:07L, the MRPA climbed and turned to planned waypoints uneventfully (Tabs R-148 and AA-7 to AA-8). MP1 disabled the MRPA's two Kearfott KN-4074E navigators (KNA and KNB) IAW established procedures (Tabs V-8.3, V-8.5, and DD-15 to DD-16). At 13:07:02L, MP1 inputted a command for the MRPA to go to a predetermined waypoint (Tabs R-148 and AA-8). At 13:07:59L, the turn was complete (Tab AA-8).

At 13:09:30L, one of the MRPA's two enabled Litton LN-100G navigators (LNA and LNB)--specifically LNA--produced erroneous data that indicated a false left wing down roll (Tab DD-21 and DD-43). At 13:09:33L, the MRPA, having failed to detect the erroneous nature of LNA's navigational data, sent control inputs to correct the false roll data (Tab DD-43). This included keeping a full throttle, even while the MRPA was in an unusual nose low attitude (Tab DD-32). At 13:09:35L, the navigational errors continued to grow and the MRPA was in approximately 152 degrees of roll (Tab DD-21). At 13:09:42, the MRPA indicated multiple load factor faults (indications that a parameter has been exceeded) (Tab DD-20 to DD-21).

At 13:09:47L, the MRPA regained roll control but airspeed continued to increase (Tab DD-20). At 13:09:53.5L, the MRPA met or exceeded the limitations of onboard instrumentation for airspeed (Tab DD-32). Subsequently, MCE1 and MCE2 lost communication links with the

MRPA (Tab R-20 and R-148). Shortly after losing communication links, MCE1 and MCE2 received a data packet, showing the MRPA in an unusual attitude with increasing airspeed and maxed descent rate, before losing links again (Tab R-19, R-48, and R-148). At 13:10:03.9L, the MRPA experienced a sudden divergence of roll rate and lateral acceleration, indicating a structural failure (Tab DD-32 to D-33). The last recording from the MRPA's onboard systems was at 13:10:05L and indicated that the engine was still running, and the airspeed and roll rate were excessive (Tab DD-32 to D-33). The erratic flight path, ground speed and extreme rate of descent indicate that the MRPA departed controlled flight (Tabs DD-21, DD-33, and FF-28).

Table 1 depicts the correlated times between the MCEs and the MRPA's onboard systems (Tabs AA-7 to AA-8, DD-21, and DD-32 to DD-33). It also depicts the event time, starting with when the data indicates the LNA began producing erroneous data (Tab DD-21).

Local Time	MRPA Time (seconds)	Event Time	Event
13:07:02L	7856		GOTO Waypoint
13:07:59L	7913		Turn finished
13:09:30L	8003	0 Time	Navigation System incorrectly detects a left wing down roll
13:09:33L	8006	3 sec	MRPA commands itself right wing down to compensate
13:09:33.1L	8006.1	3.1 sec	One navigation component confirmed as outlier; Control Bank Error
13:09:35.5L	8008.5	5.5 sec	Navigation errors continue to grow; MRPA is in approx. 152 degrees of roll
13:09:42.3L	8015.3	12.3 sec	Structural load fault
13:09:42.5L	8015.5	12.5 sec	Control load factor fault
13:09:42.8L	8015.8	12.8 sec	Control lateral factor fault
13:09:43.16L-13:09:47L	8016.16-8020	13.6- 17 sec	Multiple right wing aileron actuator failures; inner right and left wing actuator failures
13:09:47L	8020	17 sec	Roll control regained, but airspeed still increasing
13:09:51L	8024	21 sec	Pitch oscillations begin
13:09:53.5L	8026.5	23.5 sec	Max indicatable airspeed
13:10:03L	8036	33 sec	Control load factor fault
13:10:03.9L	8036.9	33.9 sec	Sudden divergence of rates and accelerations/probable structural failure
13:10:05L	8038	35 sec	Last MRPA recording – engine still running, excessive airspeed and roll rate

Table 1 (Tabs AA-7 to AA-8, DD-21, and DD-32 to DD-33)

After losing links with the MRPA and receiving the last data packet, MMC contacted Joshua Tree Center who had no radar returns from the MRPA (Tab R-20 and R-48). Video of the mishap and photographs of the wreckage show the MRPA suffered structural failure in flight (Tabs S-4 to S-6 and FF-28 to FF-29).

Figure 1 (Tab S-5)

Figure 2 (Tab S-4)

e. Impact

Based on radar data, the MRPA remnants impacted the terrain at approximately 13:20:02L on 21 June 2017 (Tab FF-29). Portions of the wreckage field were scattered over approximately 11 nautical miles (nm) (Tab Z-3).

f. Egress and Aircrew Flight Equipment (AFE)

Not applicable.

g. Search and Rescue (SAR)

Between 27 June and 2 October 2017, approximately 14 hours of US and State government air assets were dedicated to wreckage recovery (Tab EE-10). Recovered portions of the wreckage reside at both Beale and Edwards AFBs (Tab Q-2, Q-3, and Q-11). Much of the wreckage remains in Inyo National Forest awaiting recovery (Tabs DD-15 and EE-7).

h. Recovery of Remains

Not applicable.

5. MAINTENANCE

a. Forms Documentation

Air Force Technical Order (AFTO) 781 series forms and the Integrated Maintenance Data System (IMDS) are used to document aircraft discrepancies, maintenance repair actions and flying history (Tab BB-5 and BB-7). The AIB reviewed IMDS data from 20 June 2016 to 21 June 2017, and AFTO 781 series forms from 12 January 2017 until 21 June 2017 (Tab FF-4). At the time of the mishap, the MRPA total flight time was approximately 3,610 hours (Tab D-4).

The serial number of one of the LNs recovered from the MRPA's wreckage, 500117, did not match the serial number annotated on the active Form 781B, Communication Security Equipment

Record, 500034 (Tabs D-3 and U-6). These records are supposed to be kept IAW Technical Order (T.O.) 00-20-1, *Aerospace Equipment Maintenance Inspection, Documentation, Policies and Procedures*, paragraph 5.8 (Tab BB-6). Despite the error, there is no evidence that maintenance documentation was a factor in the mishap (Tab FF-4).

All required Time Compliance Technical Orders (TCTOs) were completed at the time of the mishap or were appropriately deferred for later action (Tab U-8 to U-9). All deferred TCTOs were reviewed and determined not to be a factor (Tab FF-4).

Historical records do not reveal any recurring maintenance problems that were a factor in the mishap (Tab FF-4).

b. Inspections

Preflight inspections (PR) are a flight preparedness inspection and must be conducted prior to each flight (Tab BB-4). A PR was accomplished on the MRPA on the day prior to the mishap (Tab U-3). A production superintendent, MX3, signed an exceptional release on the day of the mishap, which certifies that an authorized individual reviewed the active aircraft forms to ensure the aircraft is safe for flight (Tabs U-3 and V-4.1 to V-4.2).

A review of required inspections was completed and all were current as of the mishap sortie (Tab D-16). There is no evidence that inspections were a factor in the mishap (Tab FF-4).

c. Maintenance Procedures

From 20-21 June 2017, multiple tasks were completed, to include preflight servicing, inspections, operational checkouts, launch and recovery operations, and ground handling--all of which were satisfactorily resolved prior to the mishap sortie (Tab D-7 to D-15). There is no evidence that maintenance procedures were a factor in the mishap (Tab FF-4).

d. Maintenance Personnel and Supervision

Personnel assigned to the 9 RW performed maintenance actions on the MRPA preceding the mishap sortie (Tab V-1.1 to V-1.2 and V-4.1 to V-4.3). A thorough review of training records and interviews with the maintenance personnel conducting this repair indicate that they had sufficient training (Tab FF-4). A review of IMDS, forms series 781, and interviews with maintenance personnel affirmed that supervision was adequate (Tab FF-4). There is no evidence that maintenance personnel and supervision were factors in this mishap (Tab FF-4).

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

Fuel, oil and hydraulic fluids were not collected from the MRPA post-mishap because they were consumed in the post-mishap fire (Tab EE-8). Post-mishap analysis of aircraft fuel from servicing fuel vehicles and a bulk fuel tank was conducted, and two of three samples collected had normal results (Tab J-2 to J-7). One sample was not within established parameters for Fatty Acid Methyl Esters Content (Tab J-6 to J-7). However, there is no evidence that the condition of fuel, hydraulic fluids or oil were a factor in the mishap (Tab FF-4).

f. Unscheduled Maintenance

The MRPA was at Edwards AFB for a composite material repair on its right wing (Tab V-1.2, V-11.4 to V-11.5 and V-12.2). No facility to make this repair was available at Beale AFB (Tab V-1.3). This repair was conducted using step-by-step instructions provided by Northrop Grumman and Air Force Life Cycle Management engineers (Tabs D-26 to D-55 and V-1.3). 9 RW maintenance personnel were ordered to temporary duty at Edwards AFB for the purpose of this repair (Tab V-1.1 to V-1.3 and V-12.2 to V-12.3). There is no evidence that unscheduled maintenance was a factor in the mishap (Tab FF-4).

6. AIRFRAME, MISSILE, OR SPACE VEHICLE SYSTEMS

a. Structures and Systems

(1) Overall Aircraft Structure

During the mishap sortie, the MRPA structurally failed in flight, with portions of the MRPA scattered along a path approximately 11 miles in length between Lone Pine and Mount Whitney, California (Tabs R-48, Q-6, Z-3, and DD-15). The navigational system components suspected of providing erroneous information were recovered and delivered to Northrop Grumman Corporation for testing (Tabs U-6 to U-8 and DD-40).

(2) Navigation System

The RQ-4 navigation system consists of four navigators, KNA, KNB, LNA and LNB, which independently report navigational data (Tab DD-16 to DD-17). All four navigators interface with the Integrated Mission Management Computer (IMMC) and the IMMC performs all navigation redundancy management (Tab DD-17). The hierarchical precedence order used to determine the selected navigator is KNA, KNB, LNA, LNB (Tab DD-17). In this configuration, if all four navigators have the same navigation quality, then KNA is the selected navigator (Tab DD-17). Flight controls are subsequently commanded by the IMMC with this navigational data (Tab DD-6 and DD-16 to DD-17).

(3) Mission Control Element (MCE)

The MCE is a portable shelter from which a flight crew remotely controls an RQ-4's ground functions, takeoff, in flight, and landing operations (Tab DD-4 to DD-5). The MCE is equipped with pilot, sensor operator (SO), quality control (QC) and communication workstations that are manned by personnel who control and/or monitor RQ-4 operations (Tab DD-4 to DD-5).

b. Evaluation and Analysis

Data recovered indicated how all four navigators were performing during the mishap sortie (Tab DD-32 and DD-35). Three navigators were operating normally (Tab DD-32 and DD-35). Because KNA and KNB were disabled at the time of the mishap, LNA was the "in-charge" navigator (Tab DD-18). LNA provided erroneous data, deviating from the other navigators (Tab DD-32 and DD-35). The RQ-4 is designed to detect erroneous data within the navigational

system (Tabs V-13.6, V-15.4, and DD-16 to DD-18). During the mishap sortie, the MRPA's navigation system did not detect LNA's erroneous data (Tab DD-32). Post-mishap analysis and testing of LNA, and same-type devices, were unable to determine the root cause of LNA's erroneous navigational data (Tab DD-40 to DD-41).

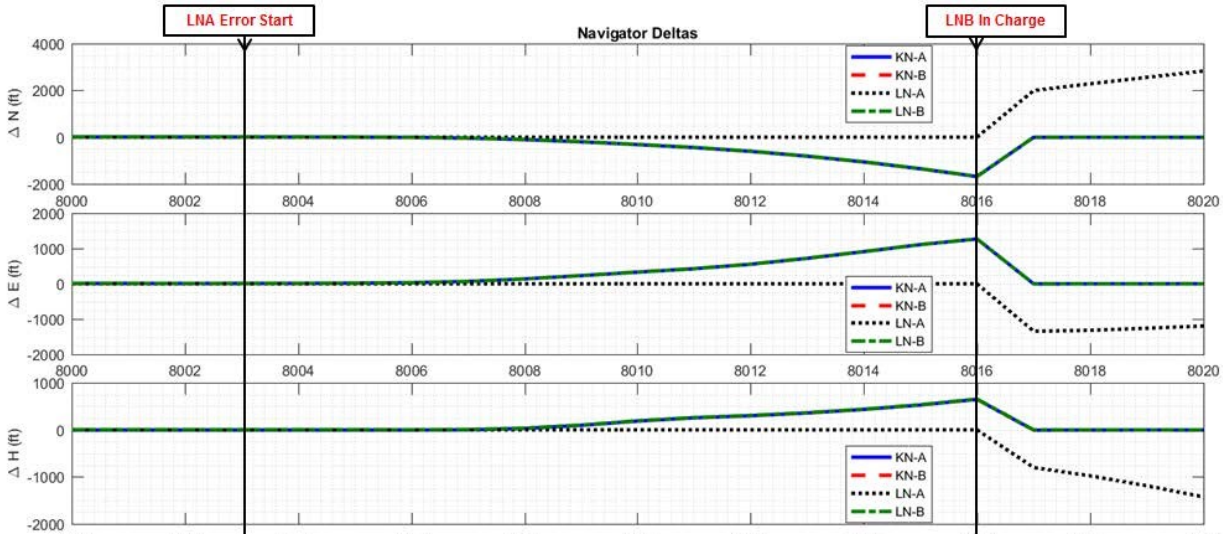

Table 2 (Tab DD-35)

7. WEATHER

The forecasted weather for the duration of the mission sortie had no forecasted upper level turbulence (Tab F-2, F-4, F-15, and F-24 to F-25). Temperatures on the ground reached as high as 102˚F/39˚C during ground operations (Tab F-6). Forecast for the departure airfield was clear sky with no visibility issues and no forecasted icing (Tab F-6). There were forecasted isolated thunderstorms along the planned route of flight with maximum tops of 36,000 ft (Tab F-29). The AIB determined that weather was not a factor (Tab FF-3).

8. CREW QUALIFICATIONS

a. Mishap Mission Commander (MMC)

MMC was a current and qualified pilot at the time of the mishap (Tab FF-3). MMC completed instructor training on 9 August 2016 (Tab G-75 to G-76). MMC's total flight time was 7426.4 hours, which includes 82.8 hours in the RQ-4 (Tabs G-25 and T-6). MMC's flight time in the RQ-4 during the 90 days before the mishap is as follows (Tab G-25 to G-26 and G-30):

	Hours	Sorties
30 days	2	1
60 days	10	2
90 days	20.5	7

b. Mishap Pilot 1 (MP1)

MP1 was a current and qualified pilot at the time of the mishap (Tab FF-3). MP1 completed RQ-4 qualification training on 18 August 2016 (Tab G-70 to G-71). MP1's total flight time as of 27 January 2016 was 5451 hours (Tab T-10). MP1's flight time in the RQ-4 during the 90 days before the mishap was as follows (Tab G-10 to G-11):

	Hours	Sorties
30 days	2	1
60 days	5.5	2
90 days	8.2	4

c. Mishap Pilot 2 (MP2)

MP2 was a current and qualified pilot at the time of the mishap (Tab FF-3). MP2 completed initial RQ-4 qualification on 14 October 2011 and Initial Instructor upgrade on 26 Nov 2012 (Tab G-78). MP2's total flight time was 3871.5 hours, which included 1183.2 hours in the RQ-4 (Tab G-38 and G-40). MP2's flight time in the RQ-4 during the 90 days before the mishap was as follows (Tab T-13 to T-14):

	Hours	Sorties
30 days	4	1
60 days	28.5	8
90 days	28.5	8

d. Mishap Pilot 3 (MP3)

MP3 was a current and qualified pilot at the time of the mishap (Tab FF-3). MP3 completed initial RQ-4 qualification on 15 June 2016 (Tab G-90). MP3's total flight time was 1216.5 hours, which included 351.3 hours in the RQ-4 (Tab G-54 to G-55). MP3's flight time during the 90 days before the mishap was as follows (Tab T-15 to T-16):

	Hours	Sorties
30 days	24	4
60 days	39.9	7
90 days	65.1	10

e. Hawkeye Pilot (H2)

H2 was a current and trained pilot (Tab FF-3). H2 completed RQ-4 pilot qualification on 3 June 2016 (Tab G-103 and G-105). Prior to the mishap sortie, H2's total flight time as of 18 January 2016 was 5222 hours (Tab T-3). Between 8 January 2015 and the date of the mishap he flew 199.9 hours in the RQ-4 (Tab G-63 to G-65). H2 did not log flight time on the mishap sortie, so the flight summary for the previous 90 days is not shown (Tab G-65 to G-66).

9. MEDICAL

a. Qualifications

There is no evidence that medical qualifications were a factor in the mishap (Tab FF-5). All aircrew except H2 were medically qualified at the time of the mishap (Tab FF-5). H2 was not medically qualified after he ingested hydrocodone on 20 June 2017 and performed aircrew duties before 24-hours had elapsed from ingestion (Tabs R-91 to R-93, BB-8, FF-3, and FF-5). Hydrocodone is not on the Official Air Force Aerospace Medicine Approved Medications list (Tabs BB-8 to BB-23 and FF-5).

b. Health

A review of the post-accident medical examination records revealed that health was not a factor in this mishap (Tab FF-5).

c. Lifestyle

After reviewing the 72-hour and 14-day histories, the AIB determined that unusual habits, behavior or stress were not factors in the mishap (Tab FF-5).

d. Crew Rest and Crew Duty Time

For both military and contract aircrews, crew rest is normally a minimum 12-hour non-duty period before the flight duty period begins (Tab BB-25 to BB-26 and BB-28). H2 was not on the flight schedule, was not medically qualified to fly, and should have been limited to duties not including flying (DNIF) (Tabs R-92 to R-93, BB-8, and FF-5). The remaining aircrew met required crew rest and duty time restrictions (Tab FF-5). There is no evidence that crew rest and crew duty time were factors in the mishap (Tab FF-5).

10. OPERATIONS AND SUPERVISION

a. Operations

There is no evidence that operation tempo was a factor in this mishap (Tab FF-3).

b. Supervision

There is no evidence that supervision was a factor in this mishap (Tab FF-3).

11. HUMAN FACTORS ANALYSIS

There is no evidence that human factors contributed to the mishap (Tab FF-6).

12. GOVERNING DIRECTIVES AND PUBLICATIONS

a. Publically Available Directives and Publications Relevant to the Mishap

(1) AFI 11-202 Volume 3, *General Flight Rules*, 10 August 2016
(2) AFI 11-2FT Volume 1, *Flight Test Aircrew Training*, 28 February 2017
(3) AFI 11-2FT Volume 3, *Flight Test Operations Procedures*, 1 March 2017
(4) AFI 11-2RQ-4 Volume 3, *RQ-4/EQ-4*, Operations Procedures, 16 April 2013
(5) AFI 10-220/DCMA INST 8210.1C, *Contractor's Flight and Ground Operations Change 1*, 5 April 2017
(6) AFPD 11-4, *Aviation Service*, 1 September 2004
(7) AFI 48-123, *Medical Examinations & Standards*, 5 Nov 2013; AFMC Supplement, 23 October 2014
(8) AFI 21-101, *Aircraft & Equipment Maintenance Management*, 21 May 2015; ACC Supplement, 19 April 2017
(9) AFI 51-503, *Aerospace and Ground Accident Investigations*, 14 April 2015; ACC Supplement, 28 January 2016
(10) AFI 91-204, *Safety Investigations and Reports*, 12 February 2014; ACC Supplement, 2 February 2016
(11) AFMAN 91-223, *Aviation Safety Investigation & Reports*, 16 May 2013; ACC Supplement, 3 April 2014
(12) T.O. 00-20-1 ACC Sup 1, *Aerospace Equipment Maintenance Inspection Documentation, Policies and Procedures*, 9 December 2016
(13) T.O. 00-20-2, *Maintenance Data Documentation*, 15 March 2016
(14) Code of Federal Regulations (CFR), Title 14, Aeronautics and Space

NOTICE: All AFIs, AFDs, and AFMANs listed above are available digitally on the Air Force Departmental Publishing Office website at: http://www.e-publishing.af.mil. All T.O.s are available on the Tinker AFB website at: http://www.tinker.af.mil/Home/Technical-Orders/. Title 14 of the CFR is available at: https://www.gpo.gov/fdsys/pkg/CFR-2004-title14-vol1/content-detail.html.

b. Other Directives and Publications Relevant to the Mishap

(1) 1Q-4(R)A-2-WA-2, Flight Manual USAF RQ-4 Block 20/30/40, Version 17.06.002 RAC 1, 2 June 2017
(2) RQ-4 SCG, RQ-4 Security Classification/Declassification Guide, 1 August 2009
(3) GH-EDW-002 Edwards COP 8210-1C Rev 5, *Edwards AFB Contractor Procedures for the RQ-4 Global Hawk System*, 11 February 2017
(4) GH-EDW-002 Interim Change 001, *Edwards AFB Contractor Procedures for the RQ-4 Global Hawk System*, 14 April 2017
(5) GH-EDW-003 Edwards COP 8210-1C Rev 5, *Edwards AFB RQ-4 Pre/Post Mishap Plan for Notification, Response, and Reporting*, 11 February 2017

(6) R-2508 Handbook, *R-2508 Complex User's Handbook*, 1 January 2017
(7) 412 OG & 69 RG Interfly Memorandum for Record (MFR), 8 March 2016
(8) NG Palmdale & 452d FLTS MOA, *Flight Operations Management Support*, 22 March 2017
(9) RQ-4 Hawkeye Candidate Requirements Waiver, AFMC Waiver, 23 February 2017
(10) RQ-4 Hawkeye Ground Chase Safety Observer MFR, 452 FLTS Waiver, 5 June 2017

c. Known or Suspected Deviations from Directives or Publications

Not applicable.

24 August 2018

JEREMY L. THIEL, Colonel, USAF
President, Accident Investigation Board

STATEMENT OF OPINION

RQ-4B, T/N 07-2029
NEAR LONE PINE, CALIFORNIA
21 JUNE 2017

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

I find, by a preponderance of evidence, that the causes of the 21 June 2017 Global Hawk--RQ-4B, tail number (T/N) 07-2029--mishap near Lone Pine, California, were that the mishap remotely piloted aircraft's (MRPA) Litton LN-100G navigator A (LNA) produced erroneous navigational data and the MRPA's navigation system did not detect the erroneous navigational data. I also find by a preponderance of evidence that disabling the MRPA's two Kearfott KN-4074E navigators (KNA and KNB) after takeoff substantially contributed to the mishap.

I developed my opinion and determined the mishap sequence of events by analyzing factual data from the MRPA, mission control element data logs, radar information, maintenance records, witness interviews, information provided by technical experts, and Air Force directives and guidance.

2. CAUSE

On 16 June 2017, the MRPA arrived at Edwards Air Force Base (AFB), California, from Beale AFB, California, for a right-wing composite material repair. On 17 June 2017, personnel assigned to the 9th Maintenance Squadron, Beale AFB, successfully completed the repair with no noted issues. After passing the preflight inspection, the MRPA took off at 1221L on 21 June 2017.

While the MRPA climbed, it flew to preplanned waypoints uneventfully. At approximately 1309L, LNA began producing erroneous navigational data. The MRPA did not detect the erroneous data, so it performed as if it was in a left wing down roll position, even though it was not. As a result, the MRPA's navigation system commanded itself into a right wing down roll that was severe enough to place it in an inverted, pitch-down position and at an excessive speed. The MRPA eventually rolled to a wings-level position, but due to its airspeed, could not recover from its inverted, pitch-down position. Consequently, the MRPA broke up in mid-air, crashing in an unpopulated and rugged area between Lone Pine, California, and Mount Whitney, California. The mishap did not cause damage to private property or persons. At no point during the catastrophic sequence of events did the MRPA's navigation system detect that the navigational data was erroneous.

3. SUBSTANTIALLY CONTRIBUTING FACTORS

The MRPA's navigation system includes four navigators. All four navigators interface with the Integrated Mission Management Computer (IMMC) and the IMMC performs all navigation redundancy management. The hierarchical precedence order used to determine the selected navigator is KNA, KNB, LNA, LNB. In this configuration, if all four navigators have the same navigation quality, then KNA is the selected navigator. Flight controls are subsequently commanded by the IMMC with this navigational data.

In this case, mishap pilot 1 (MP1) disabled KNA and KNB after takeoff in accordance with established procedures. Data recovered from KNA and KNB indicate they were operating normally at the time of the mishap. Had KNA and KNB been enabled during the mishap flight, KNA would have been the selected navigator and would have provided the MRPA accurate navigational data. Therefore, disabling KNA and KNB substantially contributed to the mishap.

4. CONCLUSION

I find, by a preponderance of evidence, that the causes of the mishap were that the MRPA's LNA produced erroneous navigational data and its navigation system did not detect the erroneous navigational data. I also find by a preponderance of evidence that disabling KNA and KNB after takeoff substantially contributed to the mishap.

24 August 2018

JEREMY L. THIEL, Colonel, USAF
President, Accident Investigation Board

INDEX OF TABS

Safety Investigator Information ..... A

Not Used ..... B

Not Used C

Maintenance Report, Records, and Data ..... D

Not Used ..... E

Weather And Environmental Records and Data ..... F

Personnel Records ..... G

Egress, Aircrew Flight Equipment, and Impact Crashworthy Analysis ..... H

Deficiency Reports I

Releasable Technical Reports and Engineering Evaluations ..... J

Mission Records and Data ..... K

Factual Parametric, Audio, and Video Data From On-Board Recorders L

Data From Ground Radar And Other Sources ..... M

Transcripts Of Voice Communications ..... N

Any Additional Substantiating Data and Reports ..... O

Damage Summaries ..... P

AIB Transfer Documents ..... Q

Releasable Witness Testimony ..... R

Releasable Photographs, Videos, Diagrams, and Animations ..... S

Personnel Records Not Included in Tab G ..... T

Maintenance Report, Records, And Data Not Included In Tab D ..... U

Witness Testimony And Statements V

Not Used ..... W

Not Used X

Legal Board Appointment Documents ..... Y

Photographs, Videos, Diagrams, and Animations Not Included In Tab S ..... Z

Flight Documents ..... AA

Applicable Regulations, Directives, and Other Government Documents ..... BB

Fact Sheets CC

Systems and Engineering Analysis ..... DD

Wreckage Recovery ..... EE

Accident Investigation Board Documents ..... FF