UNITED STATES AIR FORCE AIRCRAFT ACCIDENT INVESTIGATION BOARD REPORT

C-130J-30, T/N 11-5736

37TH AIRLIFT SQUADRON
86TH AIRLIFT WING
RAMSTEIN AIR BASE, GERMANY

LOCATION: RAMSTEIN AIR BASE, GERMANY

DATE OF ACCIDENT: 23 APRIL 2020

BOARD PRESIDENT:

BRIGADIER GENERAL TERRENCE L. KOUDELKA, JR.

Conducted IAW Air Force Instruction 51-307

EXECUTIVE SUMMARY
UNITED STATES AIR FORCE
AIRCRAFT ACCIDENT INVESTIGATION

C-130J-30, T/N 11-5736
RAMSTEIN AIR BASE, GERMANY
23 APRIL 2020

On 23 April 2020, at approximately 17:24:22 hours local time (L), the mishap aircraft (MA), C-130J-30, tail number (T/N) 11-5736, assigned to the 37th Airlift Squadron, 86th Airlift Wing, Ramstein Air Base (AB), Germany, conducted a routine periodic evaluation flight for Mishap Pilot 1 (MP1). The Mishap Crew (MC) flew a maximum effort (assault) landing at Ramstein AB and experienced a hard landing with a vertical acceleration load factor (g-load) exceedance value of 3.62 times the force of gravity (g) and a landing sink rate of 834 feet per minute (FPM) exceeding the mishap aircraft's maximum allowable landing limits of 540 FPM and g-load of 2.0g. Immediately upon touchdown, the MC executed a go-around and coordinated with Air Traffic Control for a visual approach, full-stop landing. The Mishap Aircraft (MA) landed safely at 17:37:23L. There were no fatalities, injuries, or damage to civilian property. The MA landing g-load exceedance resulted in significant damage to the center wing, both outer wings, left and right main landing gear assemblies, and engines, to include mounting structures. The estimated damages are $20,917,089.

The MC was scheduled to fly in a formation of three C-130J's planning to conduct two training routes. The primary training objective for the local sortie was to complete the MP1's evaluation. The MC planned to takeoff early as a single-ship, conduct a maximum effort takeoff followed by a maximum effort landing using the painted landing zone marked on the runway (requirement for MP1's evaluation), full-stop, and then rejoin the formation in order to complete the remainder of the evaluation requirements in the formation. Preflight, engine start, taxi and the Ramstein AB visual traffic pattern procedures were executed within good flying standards and were procedurally correct. The mishap occurred during the maximum effort landing.

The Accident Investigation Board President found, by a preponderance of the evidence, the cause of this mishap was MP1's early engine power reduction (power pull), beginning at 70 feet above ground level (AGL) and fully flight idle at 45 feet AGL. In addition, the board president found, by the preponderance of evidence, that MP1 and Mishap Pilot 2's failure to identify the excessive sink rate and their failure to arrest the excessive sink rate or go-around in a timely manner were substantially contributing factors that resulted in the MA exceeding the C-130J-30 g-load and sink rate landing limits.

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.

SUMMARY OF FACTS AND STATEMENT OF OPINION
C-130J / T/N 11-5736
23 April 2020

TABLE OF CONTENTS

ACRONYMS AND ABBREVIATIONS

37 AS	37th Airlift Squadron
86 AW	86th Airlift Wing
86 MXG	86th Maintenance Group
86 OG	86th Operations Group
86 OSS	86th Operations Support Squadron
AB	Air Base
AC	Aircraft Commander
ADC	Area Defense Counsel
AFI	Air Force Instruction
AFLCMC	Air Force Life Cycle Management Center
AFMAN	Air Force Manual
AFTO	Air Force Technical Order
AGL	Above Ground Level
AIB	Accident Investigation Board
AIRCAT	Automated Inspection, Repair, Corrosion, and Aircraft Tracking
AMAX	Adjusted Maximum Effort
AMC	Air Mobility Command
APU	Auxiliary Power Unit
ASIP	Aircraft Structural Integrity Program
ATC	Air Traffic Control
ATIS	Automated Terminal Information Services
BIU	Bus Interface Unit
CAP	Corrective Action Plan
CDM	Climb Dive Marker
CENTCOM	United States Central Command
CNI-MU	Communication Navigation Identification Management Unit
CONOP	Concept of Operations
CONUS	Continental United States/stateside
CVR	Cockpit Voice Recorder
DADS	Distributed Air Data System
DDWC	Desktop Debrief Workstation Computer
DFDR	Digital Flight Data Recorder
DO	Director of Ops
DTADS	Data Transfer and Diagnostic System
EFB	Electronic Flight Book
EGI	Embedded GPS/INS
EL	Electroluminescence
EP	Evaluator Pilot
FLT IDLE	Flight Idle
FPA	Flight Path Angle
FPM	Feet Per Minute
g	Force of Earth's gravity
GCAS	Ground Collision Avoidance System
GE	Germany
g-load	Vertical acceleration load factor on the airframe expressed as multiples of "g".
GPS	Global Positioning System
HUD	Heads Up Display
ID	Identification
IFF	Identification Friend or Foe
ILS	Instrument Landing System
INS	Inertial Navigation System
IP	Instructor Pilot
ISB	Interim Safety Board
KCAS	Knots Calibrated Airspeed
L	Local Time
LM	Lockheed Martin
LPS	Local Proficiency Sortie
LZ	Landing Zone
MA	Mishap Aircraft
MC	Mishap Crew
MDD	Maintenance Data Documentation
MEF	Mission Execution Forecast
MEFL	Multi-Element Formation Lead

MFD	Multi-Function Display
MMS	Maintenance Management System
MSL	Mean Sea Level
NATO	North Atlantic Treaty Organization
OPS	Operations
ORM	Operational Risk Management
OS	Operating System
PF	Pilot Flying
PFD	Primary Flight Display
PIQ	Pilot Initial Qualification
PM	Pilot Monitoring
Q3	Qualification Level 3
RAD ALT	Radar Altimeter
RMM	Removable Memory Module
RWY	Runway
SA	Situational Awareness
SIB	Safety Investigation Board
SIM	Simulator
SKE	Station Keeping Equipment
Stan Eval	Standards and Evaluations
T/N	Tail Number
TACC	Tanker Airlift Control Center
TCTO	Time Compliance Technical Order
TO	Technical Order
TOLD	Takeoff and Landing Data
TOT	Time on Target
USAFE-AFAFRICA	United States Air Forces in Europe-Air Forces Africa
USAFRICOM	United States Africa Command
USEUCOM	United States European Command
VFR	Visual Flight Rules
VVI	Vertical Velocity Indicator
WST	Weapon Systems Trainer
Z	Coordinated Universal Time (UTC)(Local -2)

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

AIB Pseudonyms

MP1	Mishap Pilot 1
MP2	Mishap Pilot 2
MP3	Mishap Pilot 3
ML	Mishap Loadmaster
MA	Mishap Aircraft
MC	Mishap Crew

SUMMARY OF FACTS

1. AUTHORITY AND PURPOSE

a. Authority

On 26 June 2020, General Jeffrey L. Harrigian, Commander, United States Air Forces in Europe-Air Forces Africa (USAFE-AFAFRICA), appointed Brigadier General (then Colonel) Terrence L. Koudelka, Jr. to conduct an aircraft accident investigation of the 23 April 2020 mishap of a C-130J aircraft at Ramstein Air Base (AB), Germany (GE) (Tab Y-2). In addition to the Board President, the convening authority appointed a Major Legal Advisor, a Captain Pilot Member, a Senior Master Sergeant Maintenance Member, a Lieutenant Colonel Medical Member, and a Master Sergeant Recorder (Tab Y-2). The investigation occurred at Ramstein AB from 15 July 2020 through 28 August 2020.

b. Purpose

In accordance with Air Force Instruction (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

On 23 April 2020, at approximately 17:24:22 hours local time (L), the mishap aircraft (MA), C-130J-30, tail number (T/N) 11-5736, assigned to the 86th Airlift Wing, Ramstein Air Base, Germany, conducted a routine periodic evaluation flight for Mishap Pilot 1 (MP1) (Tabs K-4, T-284, U-3 and U-191). Due to fuel and weight configuration, the MA's maximum landing sink rate limit was 540 feet per minute (FPM) and vertical acceleration load factor (g-load) limit was 2.0 times the force of gravity (g) (Tabs BB-77 to BB-78, J-80 to J-81, and V-8.1). The Mishap Crew (MC) flew a maximum effort (assault) landing at Ramstein AB and experienced a hard landing with a landing sink rate of 834 FPM and a g-load value of 3.62g (Tabs J-103, J-106, V-1.4, and V-1.8). The MA was recovered and landed safely at 17:37:23L (Tab J-63). There were no casualties and no injuries to the aircrew (Tab DD-4 to DD-5). The MA exceeded landing g-load and sink rate limits (Tab J-80 to J-81 and J-102) which resulted in significant damage to the center wing, both outer wings, as well as left and right main landing gear assemblies, and engines, to include mounting structures (Tab EE-4 to EE-6). The current estimated damage, pending additional aircraft inspection and analysis, is calculated at $20,917,089.04 (Tab EE-6). There was no loss or damage to non-government property (Tab O-2).

3. BACKGROUND

a. United States Air Forces in Europe – Air Forces Africa (USAFE-AFAFRICA)

USAFE-AFAFRICA, headquartered at Ramstein AB, GE, is a major command of the U.S. Air Force (Tab CC-3). It is the air component for two Department of Defense combatant commands – United States European Command (USEUCOM) and United States Africa Command (USAFRICOM) (Tab CC-3). As the air component for both USEUCOM and USAFRICOM, USAFE-AFAFRICA executes, and USAFRICOM missions with forward-based airpower and infrastructure to conduct and enable theater and global operations (Tab CC-3). USAFE-AFAFRICA directs air operations in a theater spanning three continents, covering more than 15 million square miles, containing 104 independent states, possessing more than one-fifth of the world's population, and more than a quarter of the world's gross domestic product (Tab CC-3).

b. 86th Airlift Wing (86 AW)

The 86th Airlift Wing is the host wing at Ramstein AB, GE (Tab CC-6). The Wing's mission is to generate and employ air mobility; to operate and enable air, space, and cyberspace power projection platforms; and to forge ready and resilient leaders (Tab CC-6). The Wing is comprised of seven groups responsible for operations, maintenance, mission support, civil engineering, logistics readiness, medical operations, and the 65th Air Base Group at Lajes Field, Azores (Tab CC-6). The operations group provides theater airlift, distinguished visitor transport, and aeromedical evacuation capability by maintaining readiness to deploy and employ all assets across the spectrum of air combat support missions (Tab CC-6). The maintenance group accomplishes all aspects of aircraft and equipment maintenance to fulfill the wing's airlift, contingency, and support missions (Tabs CC-6). In addition, they provide back shop maintenance and ground support equipment for the largest en route location in Air Mobility Command, while also operating Central Intermediate Repair Facilities for T-56 engines/propellers, wheels and tires, and patient oxygen bottles, supporting both EUCOM and United States Central Command (Tab CC-6). The mission support group supports the overall mission by providing security, communications, services, and personnel services (Tab CC-6). The civil engineer group supports and maintains the base's buildings and infrastructure (Tab CC-6). The logistics readiness group provides training, planning, supply, and transportation insuring wing readiness (Tab CC-7). The medical group also supports readiness through healthcare and preventive services (Tab CC-7).

c. 86th Operations Group (86 OG)

The 86 OG provides the European and African theaters with airlift and aeromedical evacuation support, to include combat ready air transportation and rapidly deployable equipment, supplies, and people (Tab CC-9). The 86 OG consists of five squadrons including one geographically separated unit (Tab CC-9). The 86 OG operates C-21A, C-37A, and C-130J aircraft (Tab CC-9). The 86 OG subordinate offices include the 76th Airlift Squadron, 86th Aeromedical Evacuation Squadron, 86th Operational Support Squadron, and 424th Air Base Squadron located at Chievres AB, Belgium (Tab CC-9).

d. 37th Airlift Squadron (37 AS)

The 37 AS is part of the 86 OG located at Ramstein AB, GE (Tab CC-9). The 37 AS provides reliable combat airlift, airdrop, and air-land support (Tab CC-10). The 37 AS provides support to three combatant commands fulfilling EUCOM-directed and AFRICOM-directed, combat support, European Defense Initiative, North Atlantic Treaty Organization (NATO), and other objectives (Tab CC-10). The squadron maintains 34 internal offices with duties spanning operations, mobility, safety, medical support, theater engagement, and executive staff (Tab CC-10). The 37 AS successfully opened new airdrop and air-land training sites within Germany and Belgium, saving valuable squadron flight training hours, increasing unit training flexibility, and further integrating with NATO allies to accomplish the EUCOM Commander's top Building Partnership Capacity objective (Tab CC-10).

e. C-130J-30 Super Hercules

The C-130J Hercules primarily performs the tactical portion of the airlift mission (Tab CC-11). The aircraft is capable of operating from rough, dirt strips, and is the prime transport for airdropping troops and equipment into hostile areas (Tab CC-11). The C-130J operates throughout the U.S. Air Force, serving with Air Mobility Command, Air Force Special Operations Command, Air Combat Command, U.S. Air Forces in Europe, Pacific Air Forces, Air National Guard, and the Air Force Reserve Command, fulfilling a wide range of operational missions in both peace and war situations (Tab CC-11). The C-130J-30 is a stretch version of the C-130J, a proven, highly reliable and affordable airlifter which adds 15 feet to the fuselage, increasing usable space (two more pallets of equipment) in the cargo compartment (Tab CC-21).

4. SEQUENCE OF EVENTS

a. Mission

The MA, known as "Herky 83", was part of a formation of three C-130J's, with a formation call sign "Herky 81" (Tabs AA-2, K-4, and L-18). The formation was planning to conduct two training routes with the MA proceeding single-ship after the first training route (Tabs AA-2 to AA-3 and V-1.4). The primary training objective for the local sortie was to complete MP1's periodic evaluation, commonly known as a "check-ride", while the rest of the formation was to complete other training not applicable to the mishap (Tabs AA-3 and R-2 to R-3). A check-ride consists of multiple types of instrument approaches and maneuvers to include simulated emergency procedures, an airdrop profile, a maximum effort profile, and formation procedures (Tab BB-43). The mishap occurred during the maximum effort landing (Tab L-26 to L-33). A maximum effort landing is a tactical landing that is flown at slower speeds to land in a shorter distance (Tab V-8.1). Maximum effort landing performance data is predicated on landing in the first 500 feet of the runway (Tab V-8.1). This was the first periodic evaluation in MP1's career (Tab V-1.4). The MC planned to takeoff as a single-ship, complete the maximum effort profile at Ramstein, AB, and shortly after rejoin the 3-ship formation (Tab V-1.4).

b. Planning

The MC arrived at the squadron between approximately 1130 to 1345L (Tab K-6). The crew individually signed the operational risk management (ORM) worksheet (Tab K-6 to K-7). The Air Force ORM worksheet is accomplished by the Aircraft Commander and includes multiple factors such as environmental, crew, mission complexity, and others that have been found to affect the risk of the mission and each factor is assessed separately to come up with an overall risk assessment for the mission (Tab V-8.1). The Aircraft Commander's (AC) risk assessment for the sortie was low and required only the AC's signature (Tab K-7). The AC is in charge of the crew and responsible for the safe accomplishment of the tasked mission (Tab V-8.2). Around 1400L, the MC received a mass briefing to include weather, Notices to Airmen, ground operations, intelligence, and the general plan for the day from the formation mission commander (Tab AA-2 and AA-6 to AA-32). The briefing audience consisted of the formation crew (Tab AA-2 and AA-8) The formation communication check (radio check) was planned for 1645L with a formation takeoff one hour later at 1745L (Tab AA-2). After the communication check and before taking off with the rest of the formation, the MC planned for a single takeoff, approach, and landing to accomplish the maximum effort profile (Tab V-1.4). The MA planned to be loaded with 32,000 pounds of fuel with no airdrop equipment or cargo in the aft section of the aircraft and to lead the formation on the first low-level training route with a lead change for the second route (Tab AA-2 to AA-3). After reviewing the hourly updated weather, to include winds, the formation planned to use Runway 26 (Tabs F-18 and V-1.5). The MC observed the wind favored Runway 08, but due to the general formation plan, the MC's familiarity with Runway 26 procedures, and being within wind limits for Runway 26 takeoffs and landings, the MC planned to use Runway 26 (Tab V-1.5).

c. Preflight

The MC arrived at the MA at approximately 1550L (Tab R-12). All preflight checks to include the walk around and maintenance forms review were normal with nothing noteworthy (Tabs R-2 to R-3). The MC consisted of the MP1 sitting in the left seat, Mishap Pilot 2 (MP2) sitting in the right seat, Mishap Pilot 3 (MP3) sitting in the third seat located between MP1 and MP2, and the Mishap Loadmaster (ML) performing flight duties aft of the flight deck (Figure 1, Tab R-29). In the C-130J, the AC may sit in the right seat and to supervise a flight pilot in the left seat for proficiency events (Tab BB-39). MP2 was the AC and MP1 was being evaluated (Tab R-29). MP3 occupied the seat located immediately aft of the center flight deck console, often referred to as the jump seat (Tabs R-20 and V.3.6). See Figure 1 below for the seating of the MP1, MP2, and MP3. In accordance with evaluation criteria, the pilot being evaluated should accomplish the maximum effort takeoff and landing from the left seat (Tab BB-43). The MC completed all ground operations in accordance with the applicable checklist, with no evidence of anything out of the ordinary (Tabs L-13 to Tab L-23 and R-3).

Figure 1: Photo of a C-130J flight deck and where the MC was seated at the time of the mishap (Tabs DD-16 and R-29)

d. Summary of Accident

At approximately 15:08 Coordinated Universal Time (Z) (17:08L), the MC taxied to Runway 26 and completed all applicable checklists and associated procedures (Tab L-21 to L-23). Information from the Automated Terminal Information Service (ATIS) reported winds with a direction of 030 degrees and a speed of 6 knots (Tab L-22). The MC assessed the winds as being well within limits for using Runway 26 (Tab V-3.5). The MC proceeded with MP1's evaluation and accomplished an adjusted maximum effort takeoff without incident (Tab L-24 to L-25). MP1 was pilot flying (PF) and the MP2 was the pilot monitoring (PM) (Tabs V-2.7, V-3.8, and L-28). The MA proceeded to local points Whiskey, Pivot, and Echo per local procedures shown in Figure 2 (Tabs BB-45 and R-4).

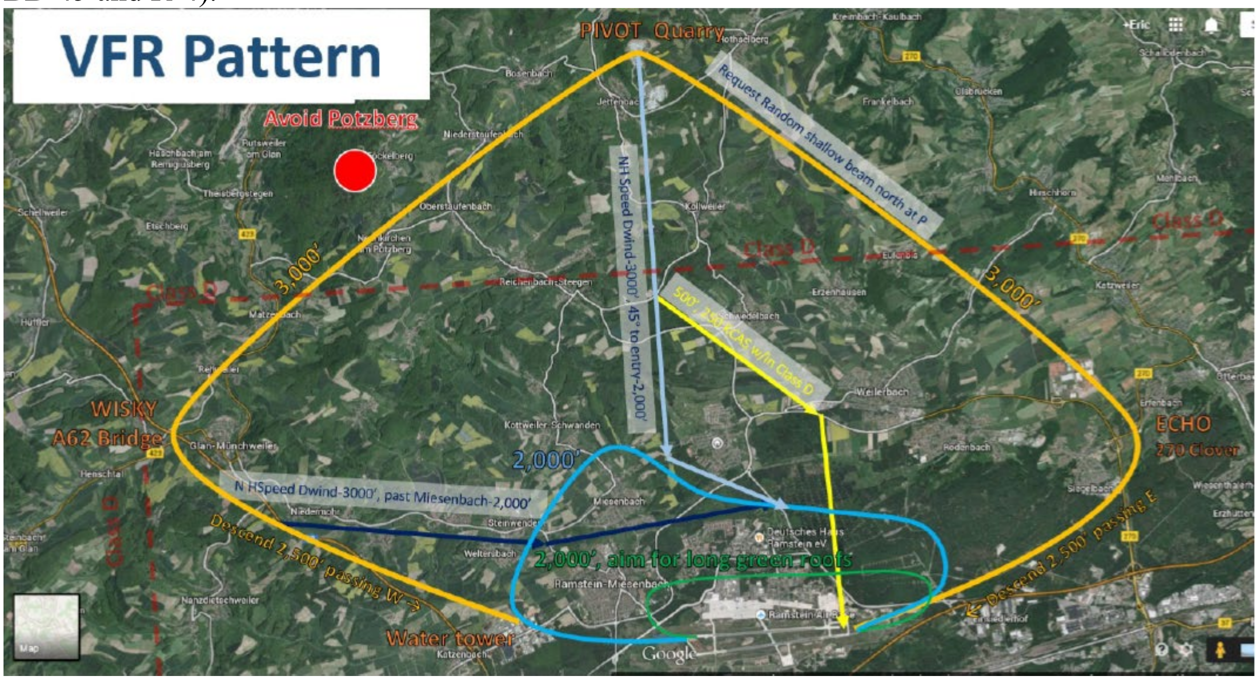

Figure 2: Ramstein VFR Pattern North Ops (Tab BB-45)

During the Visual Flight Rules (VFR) pattern, MP1 and MP2 completed necessary checklists and procedures, to include the approach brief (Tabs L-26 to L-29). During the brief, MP1 and MP2 switched roles as PF and PM to facilitate a thorough brief after which MP1 reverted to PF (Tab L-26 to L-27). At the engine start, the aircraft weighed approximately 124,260 pounds, which resulted in target max effort landing speeds of 132 knots-calibrated airspeed (KCAS) for approach, 116 KCAS for threshold (the targeted aircraft speed to maintain on short final), and 109 KCAS for touchdown (the targeted aircraft speed to land) (Tabs J-62 and R-22). At the time of the mishap, the MA weighed 123,090 (Tab J-62). During the approach brief, MP1 stated speeds 132, 116, and 109 (Tab L-27). In the brief, the MP1 briefed the go-around (apply takeoff power, climb, and retract gear and flaps (Tab V-8.1)) criteria as, “100 feet inside the zone, call me three knots fast, one knot slow, and if I’m not stable by 150, call me around”, and “if I’m not going to land in the zone please call me around as well” (Tab L-27). This brief communicates the speed and landing criteria MP1 will adhere to and if unable to, the MC will abort the approach and go-around (Tab L-27). “100 feet inside the zone” is in reference to MP1’s aim point for the aircraft (Tab L-27). MP2 acknowledged the brief and echoed, “Plus three, minus one, 100 feet, call you around” (Tab L-27).

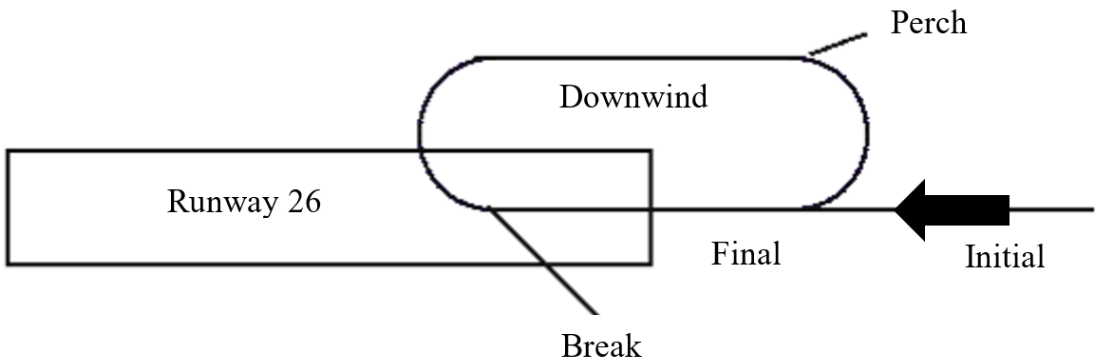

Figure 3: Standard Terminology for Overhead Approach (Tab DD-17)

The typical overhead approach execution and terminology is in Figure 3 above (Tab DD-17). The MA was approximately 200 KCAS and 2,500 feet mean sea level (MSL) at the initial point and prior to the break turn (Tab L3-15:21:49.00 to L3-15:21:50.000). At 2,500 feet MSL, approximately 1,700 feet above ground level (AGL), from the touch down point, MP1 states, "winds are direct tail" (Tab L-30 and L3-15:21:49.00 to L3-15:21:50.000). This corresponds with the Digital Flight Data Recorder (DFDR) showing a wind direction of 080-090 degrees at roughly 9 knots (Tab L3-15:21:39.500 to L3-15:21:39.625). Best wind measurements are detected in straight-and-level un-accelerated flight (Tabs V-3.6 and BB-72). From initial to the break turn, the MA was in relatively level, coordinated flight (Tab L3-15:21:39.500). The next potentially accurate wind measurements from the DFDR was just prior to the perch point and showed 045 degrees at 15 knots (Tab L3-15:23:00.500 to L3-15:23:00.625). The MA was at approximately 1,700 AGL at both the break turn and perch point (Tab L3-15:21:39.500 and L3-15:23:00.625). This AGL altitude is a few hundred feet higher than ideal (Tab V-3.7). As previously cited, there were winds that pushed the MA towards the runway (overshooting winds) (Tab L3-15:23:00.500 to L3-15:23:00.625). According to MP3, the perch point should have been executed further downwind due to the tailwind and descending from 1,700 feet AGL (Tab V3.6 to V-3.7). However, MP1 was able to descend and stabilize the MA by 150 feet AGL (Tab V-2.5).

During the right turn to final, Air Traffic Control (ATC) gave landing clearance and reported winds of 020 degrees at 8 knots, which equates to a 4 knots tailwind component and a 7 knots crosswind component (Tabs DD-15 and L-32). The "Before Landing" checklist was completed without incident and the MA was gear down and flaps 100% (Tab L-32 and L3-15:24:1.375). At 300 feet AGL, MP2 stated that the MA was still "fast" (Tabs BB-74 and L-32). At 150 feet, the MA was stable and on speed with a good aim-point for the landing zone (LZ) touchdown (Tab L-33 and L3-15:24:10.375). The MC was in accordance with the stabilized approach procedures (Tabs BB-74 to BB-75 and R-21). DFDR evidence confirms the approach callouts were made at 300 feet and at 150 feet AGL the MA was stable (Tab L3-15:23:58.375 to L3-15:24:08.375).

In order to complete a maximum effort landing within qualification standards, MP1 intended to land the MA on a painted assault LZ on Runway 26 (Tab L-27 and Tab V-8.1). According to the governing Air Force Manuals (AFMANs) for C-130J evaluation criteria, the maximum effort landing will be conducted on an actual LZ, if available (Tab BB-43). Due to the unavailability of an actual assault LZ at Ramstein AB, MP1 was to be evaluated on a painted zone 60 feet wide by 500 feet long on the runway (Tabs V-5.3 and DD-9). In accordance with the qualification standards, the MA's wheels needed to touch down within the first 500 feet of the zone for MP1 to successfully meet the evaluation criteria (Tabs BB-40 and V-8.1). At 150 feet AGL, MP1 was approximately on speed and on glide path (Tab V-2.5).

The MC was targeting a speed of 116 KCAS (Tab V-2.5). Seven seconds prior to impact, the MA was at 115 KCAS, which led to MP2 calling, "minus one on your speed" (Tabs DD-19, L-33, and L3-15:24:16.375). MP2 began that statement at 117 KCAS (Tabs DD-19 and L3-15:24:16.375). By the time, MP2 finished speaking the MA was at 120 KCAS (Tabs DD-19 and L3-15:24:17.375). The increase in airspeed correlates to a downwards pitch movement by MP1 (Tab L3-15:24:14.75 to L3-15:24:18.50). The DFDR and removable memory module (RMM) data show a pitch attitude change from 0 degrees to -2.3 degrees (Tab EE-2020-04-23T15:24:14:000Z and EE-2020-04-23T15:24:18:000Z). MP1 then began reducing power (Figure 8 and Tabs DD-19 to DD-20 and L3-15:24:18.000). The power pull was initiated at approximately 70 feet AGL (Figure 8 and Tabs DD-19 to DD-20 and L3-15:24:18.000). According to testimonies from MP2 and MP3, MP2 "shadowed" the aircraft controls with the left hand at the base of the throttles and right hand shadowing the yoke—a common technique for the PM in the C-130J community (Tabs R-8, V-2.3, V-3.3, and V6.5). The difference in the throttle angles between what is required to hold 116 KCAS and flight idle is approximately 5 degrees (Figure 4 and Tab DD-19). Prior to the power pull, the MA was at a descent rate of roughly 660 FPM, which is a normal descent rate for this stage of flight (Tab EE-2020-04-23T15:24:17:300Z). At 58 feet AGL and 3.5 seconds prior to touchdown, the engine torque had decreased approximately 76% from 70 feet AGL (Tab L3-15:24:18.125 to L3-15:24:19.125). At 45 feet AGL and 2.5 seconds prior to touchdown MP1 had reduced the throttles fully to flight idle (FLT IDLE) (Tab L3-15:24:19.125 and L3-15:24:21.125).

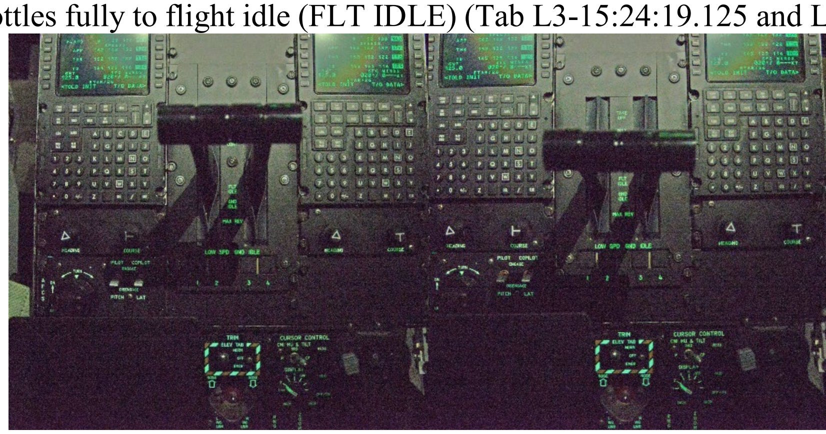

Figure 4: Throttle quadrant, Left is the required power to maintain 116 knots, and right is Flight Idle (Tab DD-19).

Since the C-130J lacks automated aural radar altimeter (RAD ALT) alerts, a common technique in the C-130J community is for the PM to callout the RAD ALT in 10 foot increments starting at 50 feet (Tabs V-4.5 and V-5.3). The RAD ALT measures altitude above the terrain presently beneath the aircraft effectively giving you precise feet above the ground (DD-18). The countdown by the PM gives the PF a verbal cue on the descent rate based on how quickly or slowly the RAD ALT is counting down—countdown cadence (Tab V-4.5). The RAD ALT readout can be seen in the heads up display (HUD) in Figure 5 (Tab DD-18).

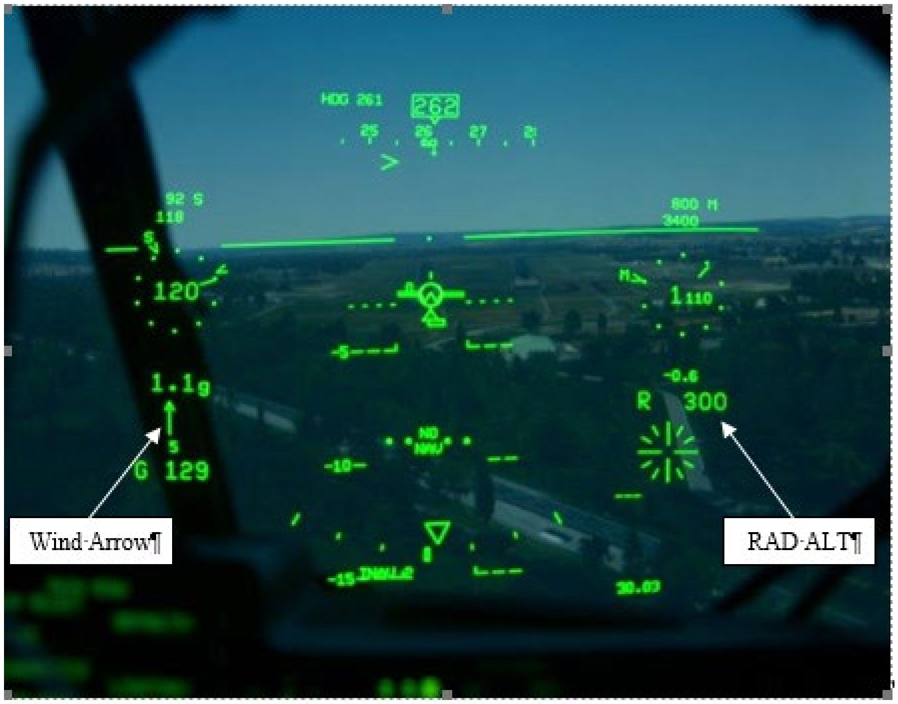

Figure 5: C-130J HUD highlighting the wind arrow and RAD ALT at 300 feet AGL (Tab DD-XX)

NOTE: For any references to Figure 7 to Figure 13, please see section "h. Simulation and Analysis" on page 11. Also note on Figure 7 to Figure 13 the painted LZ is not depicted on the runway and the RAD ALT reading is not precise (Tab DD-8).

MP2 made the 50 and 40 feet AGL calls on time (Figure 9 on page 13, Figure 10 on page 13, and Tab DD-19). At approximately 30 feet AGL, MP2 recognized the high sink rate and called, "add power" (Tab V-2.5 to V-2.6). Simultaneously as MP2 began saying "add power", MP1 was already beginning to move the throttles up (Figure 11 on page 14 and Tab DD-19). At this time, roughly 25 feet AGL, the aircraft was at a sink rate of approximately 1005 FPM or 16.75 feet per second (FPS) (Tab EE- 2020-04-23T15:24:20:800Z). Based on DFDR elevator input evidence, at approximately 30 feet AGL the MP1 began to rotate up from pitch attitude of approximately 2.3 degrees nose down (Tab L3 – 15:24:20.625). The MA began flaring (adjusting the pitch of the aircraft into a landing attitude) at 15 feet AGL as indicated by the pitch attitude change (Tab L3-15:24:20.250 to L3-15:24:22.250).

e. Impact

The MA touched down at 15:24:22.3Z (Figure 12 and Tab DD-19 and DD-22). Nearly simultaneously, as the MA touched down short of the painted LZ (yet still on the runway), MP2 called, "Go-around" (Tabs L-33 and V-3.7). The designed maximum landing sink rate is 540 FPM and the maximum g-load with flaps extended is 2.0g (Tabs BB-77 to BB 78, J-80, and V-8.1). The vertical descent rate at touchdown was approximately 834 FPM (13.9 FPS), peak instantaneous g-load of aircraft was between 3.62 to 3.81g, attitude was 3.6 degrees nose up, and at 108 KCAS (Tab J-111 and J-112). The nose gear did not come in contact with the ground throughout the mishap event (Tab J-112). Lockheed Martin (LM) Engineering estimated a g-load range of 3.62 to 3.81g (Tab J-111). The time between FLT IDLE engine power and the main landing gear impact was 2.5 to 3.5 seconds (Tabs DD-24 and L3-15:24:18.875 to L3-15:24:22.375).

f. Egress and Aircrew Flight Equipment

Egress and aircrew flight equipment were not a factor in this mishap.

g. Recovery and Post-accident Activity

After the hard landing, the MC immediately executed a go-around (Tab L-33). MP2 coordinated with ATC to land the opposite direction, Runway 08, and explained the decision with the MC citing tailwind "cut out hard" (Tab L-33). MP1 concurred saying, "Yeah, it did" (Tab L-33). The MC stated they were going to attempt another overhead approach to a maximum effort landing for Runway 08 and MP1 briefed as such (Tab L-35). MP1 and MP2 swapped PF and PM duties to facilitate the brief (Tab L-34 to L-35). Shortly after the MP2 switched back to PM duties, the MC viewed 3.8g and 3.7g peak g-load on MP1 and MP2's primary flight displays, respectively (Tab L-36 to L-37). MP2 directed the MC to land the aircraft to a full stop (Tab L-37). MP2 also directed the MP1 to a normal 100% flap landing in lieu of the maximum effort landing and MP1 concurred (Tab L-36). MP2 decided to continue with the VFR overhead for easier coordination with ATC (Tab L-37). The MC ran the checklists and procedures for the full stop landing (Tab L-36 to L-41). The MC flew the approach with 100% flaps and landed the MA (Tab L-40 to L-41). The MC taxied and parked the MA on the airfield's parking spot 1-5 (Tab L-41 to L-47).

Planning to continue with the scheduled formation mission, the MC stayed on internal aircraft power with the expectation that if the MA was not damaged and no exceedances were registered, the MC would rejoin the formation (Tab L-42). Upon parking, MP3 and ML exited the MA and visually inspected the lower fuselage (Tab R-7, R-16). ML reported on interphone to MP1 and MP2 that the MA sustained impact damage in the form of scratches on the tailskid and later noted warping of the lower fuselage skin (Tabs L-48 and R-31). The MC completed remaining checklist procedures, secured the MA, and turned the MA over to maintenance personnel (Tab L-47 to L-49).

The 86th Maintenance Group (86 MXG) personnel assigned to the MA began recovery procedures while the MC proceeded to the Maintenance Debrief Section where they reported the MA experienced a hard landing (Tabs R-18, U-44 to U-45, and V-1.8). During the debrief process, Data Transfer and Diagnostic System (DTADS) information was processed using outdated software on the Desktop Debrief Workstation Computer, which did not identify an exceedance in either g-load limit or landing sink rate (Tab J-47 to J-61, J-92, and J-102). The 86 MXG impounded the MA (Tab U-45). Between 24 April 2020 and 14 May 2020, maintenance personnel submitted eight Engineering Technical Assistance Requests to coordinate with LM engineering teams to determine MA inspection criteria in an attempt to determine the airworthiness of the MA (Tab U-146 to U-162).

On 15 May 2020, the debrief ground maintenance computer was updated and supplemental DTADS processing was completed (Tabs J-62 to J-81 and U-120). The updated DTADS data was analyzed by LM and concluded the MA center wing may have exceeded limit load and the outer wings may have reached ultimate load (Tab J-98 to J-136). This information was forwarded via email on 15 May 2020 to 86 MXG leadership and due to the LM estimate of damage in excess of $23 million the mishap was reclassified from a Class C to a Class A mishap (Tab J-3 and J-134 to J-136). At that time all maintenance actions ceased and an Interim Safety Board (ISB) was formally appointed on 21 May 2020 (Tab A-2) followed by the Safety Investigation Board (SIB) on 27 May 2020 (Tab A-3 to A-7).

h. Simulation and Analysis

(1) Animation

Figure 6: Screenshot of the mishap animation by the Mishap Analysis and Animation Facility based on information from the DFDR (Tab DD-XX)

The Air Force Safety Center, Mishap Analysis and Animation Facility created an animation of the mishap (Figure 6 to Figure 13 and Tab DD-19).

Note: the Safety Center used the DFDR to recreate the MA parameters but due to limitations of the DFDR, the RAD ALT captured and displayed in the animation only shows increments of 32 feet (Tab DD-10). The RAD ALT in the HUD would have displayed a resolution of 1 foot below 300 feet AGL (Tab V-8.1). Also, note that the animation screen shots do not accurately depict the runway as it was during the mishap (Figure 12, Figure 28, and Tab DD-8 to DD-9). For example, the painted LZ is *not* displayed on the runway (Figure 12, Figure 28, and Tab DD-9).

Figure 7: 150 feet stabilized approach call (Tab DD-20)

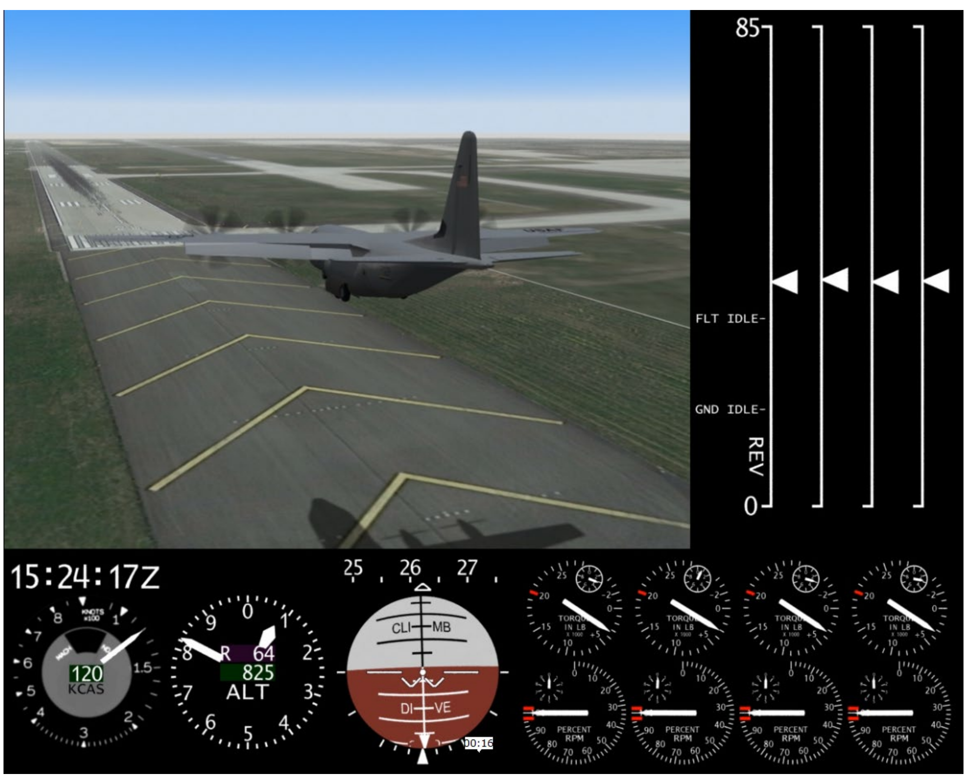

Figure 8: Beginning of power pull (Tab DD-20)

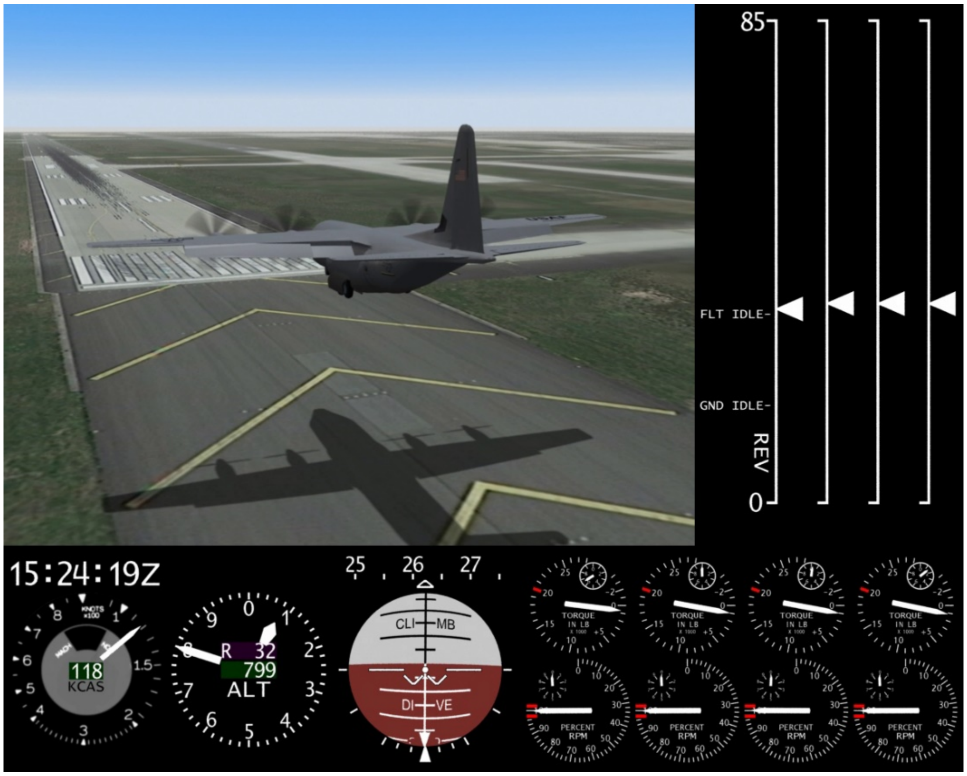

Figure 9: 50 Foot Call (Tab DD-21)

Figure 10: 40 Foot Call (Tab DD-21)

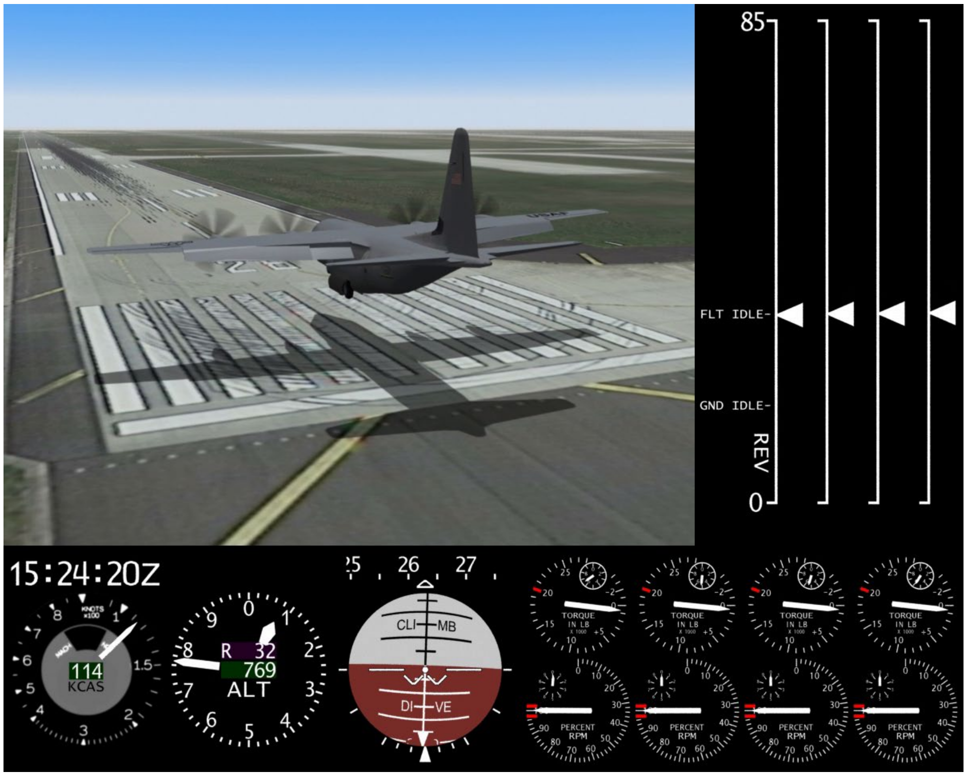

Figure 11: MP2 begins saying "Add power" and concurrent MP1 power increase (Tab DD-22)

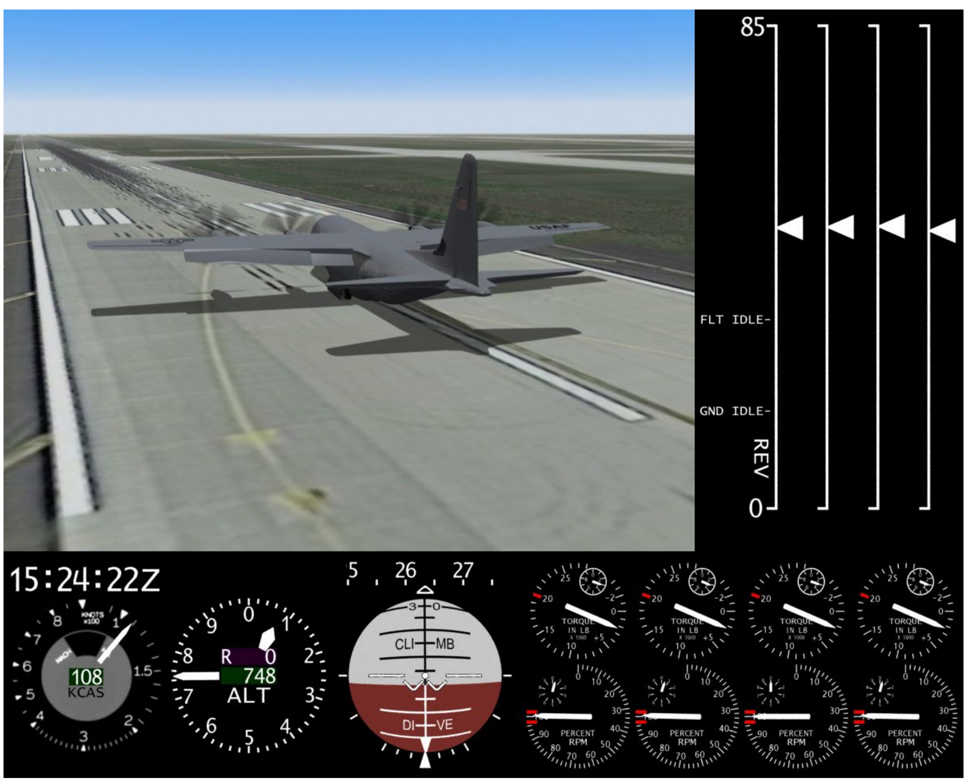

Figure 12: Touchdown and “Go-around” call by MP2 (Tab DD-22)

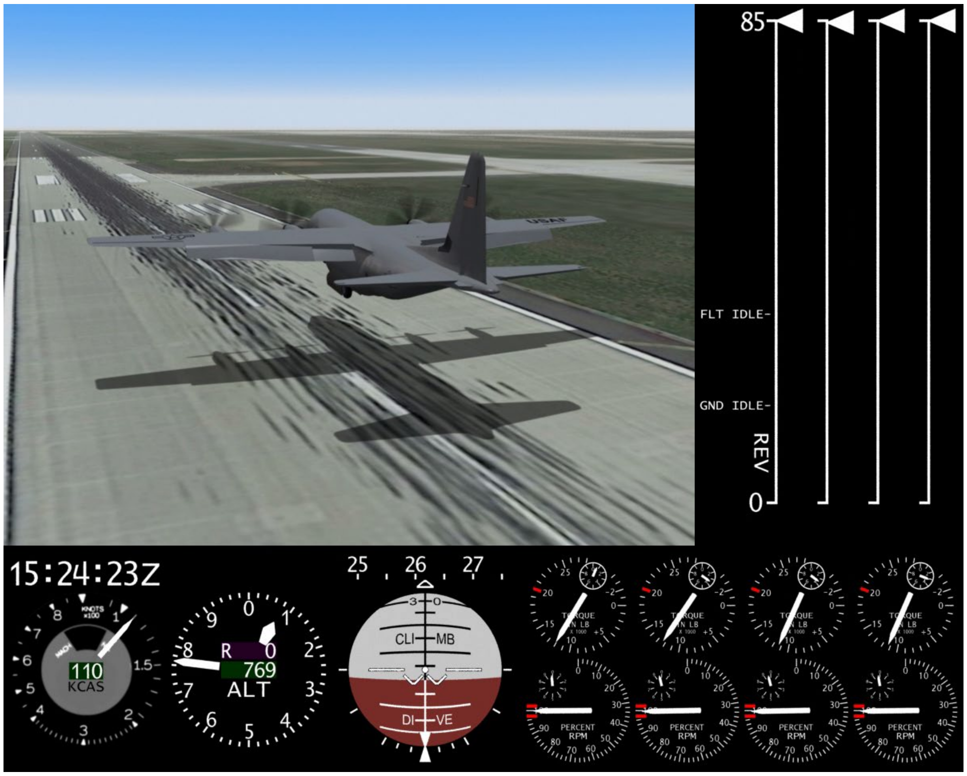

Figure 13: Go-around (Tab DD-23)

(2) Analysis of RMM Data retrieved from DTADS and cockpit voice recorder (CVR)

Note: During the investigation, the Accident Investigation Board (AIB) members discovered a DFDR limitation in that some information was only recorded at 1-second intervals or 1 hertz (Hz) (Tabs L3 and DD-19). Hz is a unit of measure defined as one cycle per second; measurements taking place at 10 Hz record 10 times per second (Tab DD-19). The RMM contained considerably more precise data points at much shorter time increments of 10 per second and 20 per second (10 and 20 Hz) (Tab EE3-2020-04-23T15:23:22:000Z to EE3-2020-04-23T15:24:28:000Z). LM supplied Figure 14 with their structural analysis (Tab J-109). LM used Figure 14 to verify the high sink rate on touchdown against what was recorded in DTADS (Tab J-108 to J-110). ALTR corresponds with RAD ALT and Nz corresponds to g-load in the vertical axis (Figure 14 and Tabs DD-24 and J-109). With the additional RMM data, the AIB was able to create plots and superimpose significant events from the CVR (See Figure 15 and Figure 16) (Tabs DD-24, EE3-2020-04-23T15:23:22:000Z to EE3-2020-04-23T15:24:28:000Z, L2-15:24:06.500 to L2-15:24:26.375, and L-33).

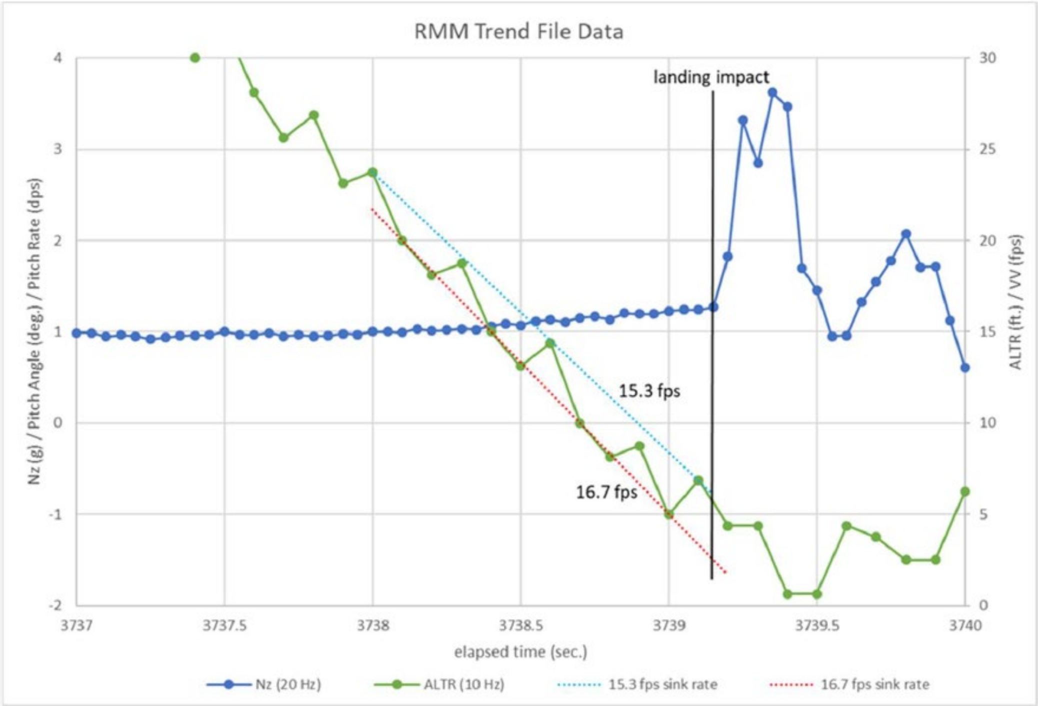

Figure 14: LM Engineering RMM trend file plot (Tab J-109)

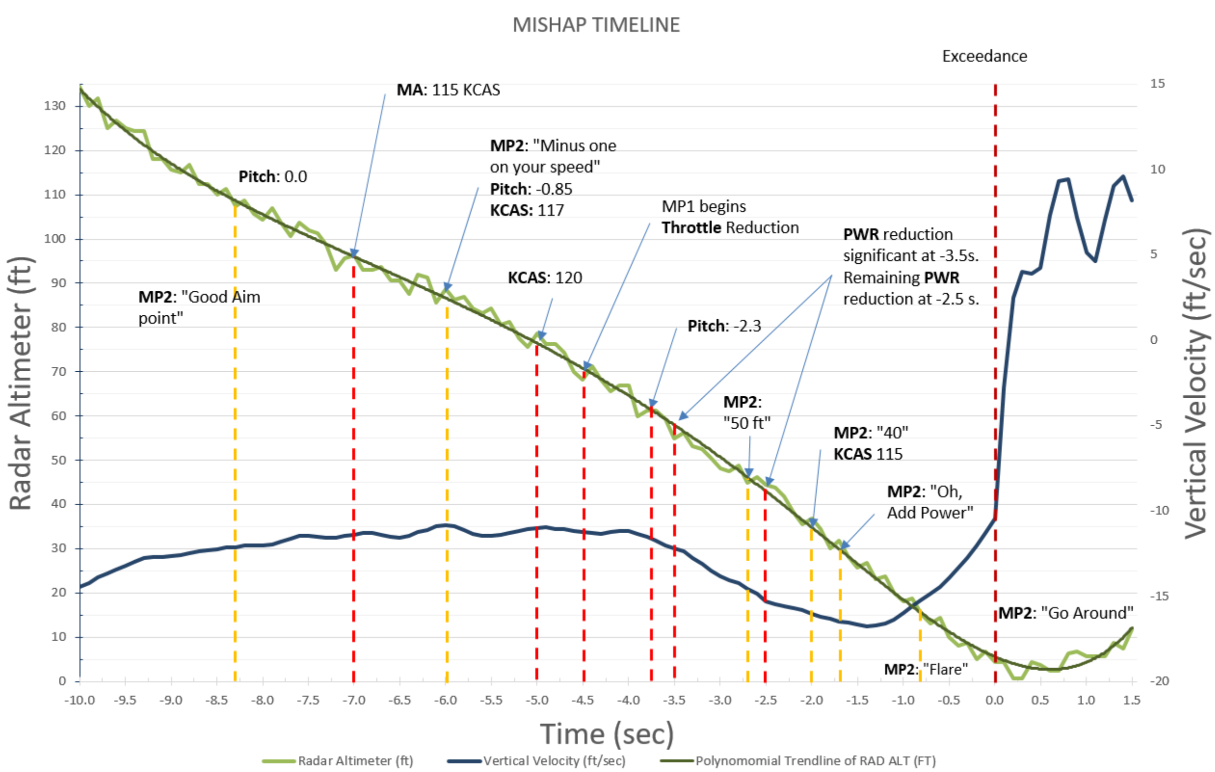

Figure 15: Mishap timeline 10 sec prior to touchdown (Tab DD-24)

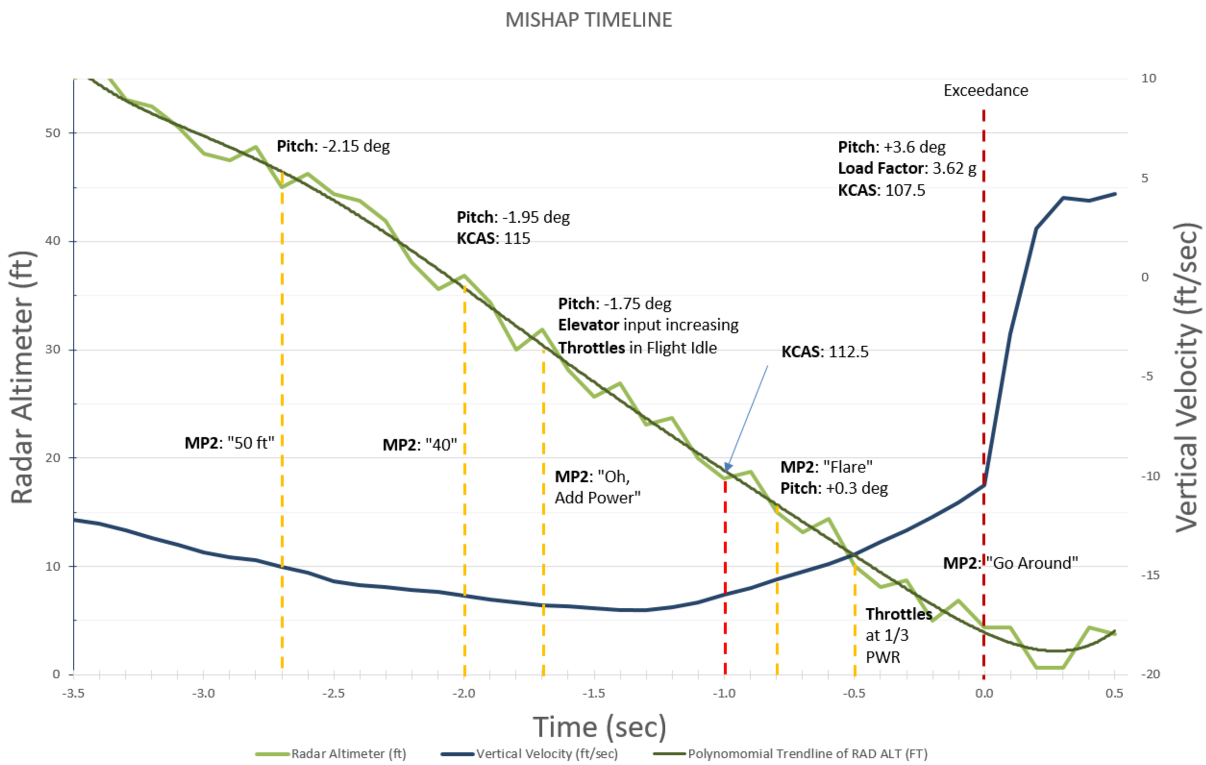

Figure 16: Mishap timeline 3.5 sec prior to touchdown (Tab DD-25)

Analysis of the mishap timeline plots show MP2's verbal calls in reference to radar altimeter, vertical velocity, and other pertinent information such as the MA's pitch attitude (Figure 15 and Figure 16 and Tab DD-25). There was a noticeable change in vertical velocity around 50 feet AGL (Figure 15, -3.5 to -2.5 and Tab DD-24). Eight seconds to the hard landing, the pitch of attitude of the aircraft began reducing from 0 degrees to -2.3 degrees (Figure 15, -8.0 and Tab DD-24). At 62 feet AGL and 4.0 seconds prior to touchdown, the MA reached -2.3 pitch attitude (Figure 15, -4.0 and Tab DD-24).

According to approaches flown in the C-130J-30 Weapon Systems Trainer (WST) (simulator) outlined in section "Testing and Analysis" on page 31, a 2.3 degree nose down pitch results in an aim point shift, which is observable in the HUD (Tab DD-6 to DD-7). This change in pitch attitude occurred right after MP2 commented, "Good aim point," (Figure 15, -8.3 and Tab DD-24). Due to the lack of HUD video, the AIB was unable to confirm where the aim point shifted (Tab V-8.1). MP2's technique, as reflected in his callouts on the CVR, for the HUD cross-check/visual scan was "aim point, airspeed, and RAD ALT" (Tab V-2.8). MP1 pitched down after MP2 announced good aim point and MP2 continued the rest of his cross-check/visual scan (Figure 15, -8.5 to -3.5 and Tab DD-24). Over 5.5 seconds transpired from the point MP2 announced "Good Aim point" and the "50 foot" RAD ALT call (Figure 15, -8.5 to -2.5 and Tab DD-24). Over 3.5 seconds transpired between MP2's airspeed call and "50 foot" RAD ALT call (Figure 15, -6.0 to -2.5 and Tab DD-24).

The MA began increasing airspeed from pitching down and reached 120 KCAS (Figure 15, -5.0 and Tab DD-24). MP1 then began to reduce the engine power at 70 feet AGL and 4.5 seconds prior to touchdown (Figure 15, -4.5 and Tab DD-24). At 58 feet AGL and 3.5 seconds prior to touchdown, the engine torque had decreased approximately 76% from 70 feet AGL (Tab L3-15:24:18.125 to L3-15:24:19.125). This power reduction corresponds with the increased sink rate (Figure 15, -3.5 and Tab DD-XX).

On a typical approach, making verbal RAD ALT callouts is a common technique and multiple experienced C-130J pilots testified to its value (Tab V-2.3, V-4.5, V-5.3, and V-6.5). The speed at which the cadence is called gives the PF an auditory indication of aircraft sink rate (Tab V-4.5). MP2's 50 and 40-foot callouts were relatively on time given the increased sink rate and factoring human error (Figure 16, -3.3 to -2.0 and Tab DD-25). The sink rate at 50 feet AGL was 13.48 feet per second (809 FPM) and increasing (Figure 15, -2.75 to -2.5 and Tab DD-24). This increasing sink rate corresponds to testimonies of a "sinking feeling" that the MC testified to (Tabs R-8 and V-2.5). The sink rate continued to increase until 25 feet AGL and peaked at 16.75 feet per second (1005 FPM) (Figure 15, -2.5 to -1.25 and Tab DD-24). At 30 feet AGL and 1.7 seconds prior to touchdown, MP1 attempted to correct the high sink rate as indicated by the increasing elevator input (Figure 16, -1.7 and Tab DD-25). Simultaneously, MP2 recognized the high sink rate and directed MP1 to add power (Tab V-2.6). MP2, who was the aircraft commander, testified that he did not take control of the MA because MP1 initiated proper go-around procedures (Tab V-2.7). Power input remained at FLT IDLE 1.5 seconds prior to touchdown, but one second later (the next recorded data point for throttles) at 0.5 seconds to touchdown, the throttles were at roughly 1/3 of full power (Tab L3-15:24:20.875 to L3-15:24:24.875). The MA was 10 feet AGL at 0.5 seconds (Figure 16, -0.5 and Tab DD-25).

Within 0.8 seconds of touchdown MP2 called "flare" at approximately 15 feet AGL (Figure 16, -0.8 and Tab DD-25). As the MA impacted the runway, MP2 announced, "Go-Around" (Figure 16, 0.0 and Tab DD-26).

i. Search and Rescue

Not applicable.

j. Recovery of Remains

Not applicable.

5. MAINTENANCE

a. Forms Documentation

The Air Force uses two primary methods to capture and maintain maintenance data for aerospace vehicles and equipment (Tabs BB-13 to BB-18). The first method of Maintenance Data Documentation (MDD) begins when the aerospace vehicle is delivered to the Air Force and fielded, and extends through the operational phase of the asset's life cycle (Tab BB-14). The objectives of the MDD process are to provide a means for collecting, storing, and retrieving base level, depot level, and contractor-type maintenance data as well as monitoring of maintenance discrepancies (Tab BB-14). Among other system, the Air Force uses a system called G081/Mobility Air Force Logistics Command & Control as a MDD Maintenance Information System (Tab BB-13 to BB-14).

The second method, the Air Force Technical Order (AFTO) 781-series forms, commonly referred to as the active aircraft record, is used as the principle real-time maintenance record (Tab BB-16). These standardized forms establish a common method within the Air Force to document aerospace vehicle maintenance actions (Tab BB-16). The common forms used on the C-130Js assigned to the 86th Airlift Wing, and the forms relevant to the MAs condition at the time of the mishap are the:

1. AFTO Form 781A, *Maintenance Discrepancy and Work Document*
2. AFTO Form 781H, *Aerospace Vehicle Flight Status and Maintenance*
3. AFTO Form 781J, *Aerospace Vehicle-Engine Flight Document*
4. AFTO Form 781K, *Aerospace Vehicle Inspection, Engine Data, Calendar Inspections, and Delayed Discrepancy Document*.

(Tabs BB-16 and U-74 to U-75). For the purpose of this report, these forms will be referred to as "the aircraft forms set", and are maintained by maintenance members assigned to 86 MXG in accordance with TO 00-20-1 (Tab BB-15 to BB-18).

Additionally, the C-130J uses DTADS. DTADS is the Maintenance Management System (MMS) designed to support on-aircraft diagnostics, software loading functions, and post-flight data retrieval processing (Tab BB-2 to BB-4).

A comprehensive review of the G081 history and aircraft forms sets from 23 January 2020 to 23 April 2020 as well as available DTADS history revealed maintenance documentation was completed in accordance with applicable directives, with minor documentation errors noted (Tabs DD-2 and U-97 to U-117). There were no overdue TCTOs, time change items, or special inspections (Tab U-57 to U-59 and U-94 to U-96). At the time this review was completed, there were no recurring maintenance issues reflected in the record (Tab U-97 to U-117). There is no evidence to suggest that forms documentation was a factor in this mishap.

b. Inspections

Maintenance on Air Force C-130Js is governed by C-130J TOs for all standard maintenance actions performed on the 14 aircraft assigned to the 86 AW (Tab BB-27). The C-130J undergoes progressive inspection requirements at intervals that build up to more extensive inspections (Tab BB-28). This inspection cycle is called a "Letter Check" (Tab BB-28). There are four letter checks: Letter A, B, C, and D (Tab BB-28). A-check inspections are accomplished in intervals of 270 days, alternating between B and C-check inspections (ex. A-B-A-C-A…) (Tab BB-28 to BB-29). A B-check inspection is more intensive than an A-check and occurs every 540 days (Tab BB-28 to BB-29). The C-check is more intensive than a B check and occurs every 1,080 days (Tab BB-28 to BB-29). A D-check is the most intensive inspection in this cycle and occurs at a designated depot facility after the first 12 years the aircraft is in service, in intervals of 2,160 days after the first D check is accomplished (Tab BB-28 to BB-29). Within the first 12 years, the C-check is completed in place of the D-check (Tab D-21). For the purpose of this report the complete 12-year cycle is represented as, "A-B-A-C-A-B-A-C-A-B-A-C-A-B-A-D" (Tab D-21). Following 12 years, the inspection cycle is as follows, "A-B-A-C-A-B-A-D" (Tab D-21). Generally, a Letter Check inspection is completed every 270 days, with increasing inspection requirements at each 270-day interval (Tab D-21). These inspections ensure the aircraft systems and structural integrity are within prescribed technical limits to ensure airworthiness of the aircraft (Tab BB-25 to BB-29).

The mishap airframe accumulated a total time of 4,624.4 hours flight time (Tab U-47). Total operating time for the engines, including the mishap flight were: 1,477.4 hours for engine #1, 4,380.9 hours for engine #2, 4,380.9 hours for engine #3, and 7,157.4 hours for engine #4 (Tab U-47). The MA was gained to the Air Force inventory on 05 December 2013, and transferred to Ramstein AB on 04 October 2017 (Tab U-76 to U-84). The most recent letter check inspection accomplished on the MA was an "A" check, completed on 06 March 2020 (Tab U-49). A review of the AFTO Form 781A set for this inspection revealed that all required maintenance was completed in accordance with prescribed directives (Tab U-3 to U-75). The MA flew 48 sorties and accrued 113 flying hours between 09 March 2020 and the 20 April 2020 mishap sortie (Tab U-118 to U-119). The MA and engines were within prescribed intervals for scheduled maintenance (Tab U-49 to U-60).

The AFTO Form 781K for the mishap flying period along with G081 records were reviewed to ensure currency of hourly/calendar inspections, TCTOs, time change items, and completion of hourly/calendar special inspections (Tab U-49 to U-60). There were no overdue special inspections, TCTOs, or time change items that would have prevented flight on the date of the mishap (Tab U-49 to U-60). Maintenance personnel completed all special inspections required per 1C-130J-6 work cards and the inspections were properly annotated on the AFTO Form 781K (Tab U-49 to U-54). There was no evidence to suggest that noncompliance with Air Force Technical Orders, TCTOs, inspections, or relevant maintenance practices was a factor in this mishap.

c. Time Compliance Technical Orders (TCTO)

TCTOs are the authorized method of directing and providing instructions for modifying military systems and end items or performing one-time inspections (Tab BB-31). TCTOs are categorized as Modification, Inspection, Commodity, Companion, Supplement, Record, or Safety (Tab BB-31). One of three priorities is assigned to each TCTO: Immediate Action, Urgent Action, or Routine Action (Tab BB-30 to BB-31). A review of the MAs historical records showed that all TCTOs had been accomplished in accordance with applicable directives (Tab U-94 to U-96).

d. Maintenance Procedures

According to active and historical records, maintenance personnel followed procedures in accordance with official technical data processes, with the exception of proper completion of TCTO 1C-130J-1048D as detailed in paragraph 5e (Tab U-97 to U-117). There is no evidence to suggest that maintenance procedures were a factor in this mishap.

e. Data Transfer and Diagnostic System (DTADS)

DTADS is the MMS designed to support on-aircraft diagnostics, software loading functions, and post-flight data retrieval processing (Tab J-13). In addition to providing the interface between the maintainer and the aircraft, DTADS supports the maintainer by providing access to troubleshooting aircraft failures, evaluating status of aircraft systems, loading/downloading of files to/from the aircraft, debriefing recorded flight/maintenance data, providing data viewers, and RMM utilities (Tab J-13). Usage data is then transferred to the Automated Inspection, Repair, Corrosion, and Aircraft Tracking (AIRCAT) system for calculating and tracking component service life (Tab J-13). The DTADS Desktop Debrief Workstation Computer post-flight report indicates exceedances experienced during the sortie analyzed (Tab J-62 to J-81).

On 30 March 2018, Lockheed Martin Engineering released a Corrective Action Plan (CAP) regarding DTADS Hard Landing Detection (Tab J-91 to J-97). The CAP noted that an investigation revealed an error in the hard landing detection algorithm in which the DTADS software required an "AND" condition for both "Maximum Sink Rate" and "Reduced Sink Rate" (Tab J-92). Maximum sink rate landing exceedance is defined as a landing sink rate greater than 9.0 feet per second (FPS) (Tab J-94). Reduced sink rate landing exceedance is greater than 5 FPS *when* the aircraft is in at heavier weights or in different fuel configurations (J-94). The CAP determination confirmed the correction to the software algorithm to an "OR" condition as either condition is sufficient to independently generate a hard landing exceedance (Tab J-92).

On 22 July 2019, Headquarters Air Mobility Command/A4QA distributed Revision 5 to Concept of Operations (CONOP) for C-130J DTADS (all variants) (Tab J-10 to J-31). This CONOP was endorsed by A4 representatives from eight Major Commands, including; Air National Guard, Air Combat Command, Air Mobility Command, Pacific Air Forces, United States Air Forces in Europe, Air Education and Training Command, Air Force Special Operations Command, and Air Force Reserve Command (Tab J-11). The purpose of this CONOP was to provide a general description of DTADS, transition to a new Operating System (OS), and provide general guidance for the proper use of the computers (Tab J-13). The CONOP also defined the DTADS Operational Environment, to ensure cyber security of stand-alone computers and reinforce maintaining the highest version of DTADS software assembly on desktop computers in accordance with applicable 1C-130J-2-00GV-00-1 series technical data (Tab J-13 to J-15). Additionally, this CONOP provided instructions for installing, updating, and running anti-virus software, as well as the latest OS software, and provided policies and procedures governing DTADS workstations (Tab J-10 to J-31).

On 28 August 2019, maintenance personnel updated the MA's DTADS software to the latest configuration under the direction and guidance of TCTO 1C-130J-1048, Supplement D, *Installation of Automatic Dependent Surveillance Broadcast (ADS-B) Out and Identification Friend or Foe (IFF) Transponder Mode 5 Group B Equipment on Selected C-130J Aircraft*, dated 07 August 2019 (Tab U-121). However, maintenance supervision failed to ensure completion of TCTO 1C-130J-1048D software updates on the Desktop Debrief Workstation Computer assigned to the Maintenance Debrief Section and it was not accomplished until after the mishap sortie (Tab U-120). This computer terminal processes data from the RMM and generates post-flight reporting upon sortie termination (Tab J-13). Subsequently, when the MA experienced the hard landing on

23 April 2020, the Desktop Debrief Workstation Computer did not recognize, and therefore did not indicate to maintenance personnel the landing exceedance experienced during the mishap sortie (Tab J-47 to J-61). The landing exceedance experienced on 23 April 2020 was solely reported by the MC (Tab R-10, R-18, and R-26). TCTO 1C-130J-1048D was accomplished on the Desktop Debrief Workstation Computer on 15 May 2020 (Tab U-120) and a subsequent assessment of the mishap sortie was conducted which reported the landing exceedance (Tab J-62).

On 21 July 2020, the AIB received an email with an attached electronic file titled, "dtads-debrief-fault-data-summary-report-20200721-0839" which originated from a C-130J Aircraft Structural Integrity Program (ASIP) Lockheed Martin Engineer (Tab U-122 to U-124). The email indicated that within the C-130J fleet, from 14 December 2011 to 26 June 2020, there were 438 historical flights uploaded to AIRCAT, that reflected the exceedance code S0520002, *Inspection Following a Hard Landing* (Tab U-123). The email listed 11 DTADS software updates distributed through TCTO (Tab U-123- to U-129). Of those 11 updates, there were known bugs that created 'nuisance exceedances' or 'fail to detect' exceedances and modifications were circulated with the last five software updates to correct detection and reporting of landing exceedances (Tab U-122 to U-129). The file contained specific information, to include Aircraft Tail Number, Aircraft Serial Number, Download Identification (ID), File Name, Debrief Type, File ID, Mission Design Series, Upload Date, Exceedance Code, and Exceedance Matches (Tab U-125 to U-129). The file listed the MA and reflected that the sink rate exceedance code (5.165 FPS with allowable limit of 5.0 FPS for the aircraft's gross weight) was recorded from a previous flight on 20 March 2014 (Tab U-127 and U-211 to U-242). The AIB found no record in the MA's historical files reflecting that the 20 March 2014 sink rate exceedance caused damage to the degree it would weaken aircraft structural components or impair the airworthiness of the MA (Tab U-76 to U-93).

On 10 August 2020, the ASIP Engineer sent updated correspondence to the AIB, reporting 442 fleet wide recorded exceedances with 19 undetected hard landings undergoing an exhaustive review (Tab U-130 to U-132, and U-137 to U-142). The email included a C-130 Maintenance Advisory, which cautions against using incompatible DTADS for a specified mission computer/operational flight program (Tab U-136). An additional attachment was a print to pdf email communication from the Air Force Life Cycle Management Center (AFLCMC) to MAJCOM/A4s in which AFLCMC equipment specialists were attempting to collect information pertinent to DTADS hardware identification in an effort to support the issuance of a Safety TCTO to report DTADS hardware and software configurations (Tab U-142 to U-144).

f. Maintenance Personnel and Supervision

All maintenance activities reviewed were normal and consistent with prescribed maintenance directives (Tab DD-2). All maintenance personnel involved in the preflight, servicing, inspecting, and launch of the MA were qualified in their duties (Tab DD-3). The Special Certification Roster and Training Business Area records were reviewed to ensure maintenance personnel were qualified for their duties as applicable (Tab DD-3). All personnel listed maintained the proper qualifications, certifications, and experience needed to maintain the MA and were considered qualified (Tab DD-3).

The AFTO Form 781H was reviewed to ensure flight preparedness of the MA on the day of the mishap (Tab U-4 to U-7). A pre-flight/post-flight inspection was accomplished on 21 April 2020 at 1430Z by qualified personnel, and a qualified supervisor reviewed the MA forms prior to flight and signed the exceptional release (Tab U-4 to U-7). There were multiple open discrepancies annotated in the mishap forms set, but none related to the mishap, and none that would have prevented flight (Tab U-20 to U-44). There is no evidence to suggest that maintenance personnel, training, or supervision were a factor in this mishap.

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

No hydraulic, or oil samples were taken from MA following the mishap, due to the extended time between the mishap and the mishap Class A determination. By the time the AIB was convened, significant maintenance had been performed on the MA that would have rendered fluid samples impossible or inconclusive as to the MA fluid state at the time of mishap (Tab U-46). There is no evidence to suggest that the hydraulic fluid or oil were factors in this mishap.

On 20 July 2020, the AIB coordinated with 86 Logistics Readiness Squadron (LRS) fuel system specialists to collect fuel samples from main tanks 1, 2, 3, and 4 (Tab U-163 to U-170). The samples were sent to the Air Force Petroleum Office Laboratory located in RAF Mildenhall (Tab U-163 to U-170). The results were returned on 30 July 2020 and showed the following (Tab U-163 to U-170):

Main Tank 1. Material meets specification requirements
Main Tank 2. Material meets specification requirements
Main Tank 3. Material meets specification requirements
Main Tank 4. Material failed specification requirements

There was one reportable deviation from the fuel sample readings of Main Tank 4 (Tab U-169 to U-170). Specifically, the Fuel System Icing Inhibitor test resulted in a failed reading for percentage of volume, but would not affect engine performance at the flight level the MA was operating (Tabs DD-27 and U-169 to U-170).

h. Unscheduled Maintenance

In the 90 days prior to the mishap, the MA experienced 12 reported unscheduled maintenance conditions (Tab U-20 to U-38 and U-97 to U-117):

1. Toilet de-serviced due to leaking service hose
2. Left hand wing: 1 each nut-plate near armpit panel broken/removed requires removal and replacement
3. Bus Interface Unit (BIU) #2 causes Terrain Collision Avoidance System fault in the #1 position (BIU's in original positions)
4. 2 each oxygen bottle dust covers in cargo broken/removed
5. Cannot illuminate electroluminescence (EL) formation lights
6. Forward EL formation light dimmer unit inoperative. Requires removal and replacement

7. Aft EL formation light dimmer unit inoperative. Requires removal and replacement
8. Right hand wingtip EL formation light shorted. Requires removal and replacement
9. Aircraft requires paint touch-ups. See paint score for details
10. Radar Warning Receiver forward right hand sector fail. Every time system started
11. #4 tank transfer pump inoperative. Requires inspection
12. Right hand main landing gear taxi light inoperative

There is no evidence to suggest any of these unscheduled maintenance actions or any aspect of the MA condition was causal to the mishap.

6. AIRFRAME, MISSILE, OR SPACE VEHICLE SYSTEMS

a. Structures and Systems

Prior to the mishap, the MA was fully mission capable with no discrepancies affecting safety of flight, and there were no indications that the pre-accident condition of the aircraft structures or systems were factors in the mishap (Tab U-3 to U-75). The MA experienced a hard landing with an over "g" (load factor) exceedance value of 3.62g (Tab J-102).

(1) Aircraft Condition

Between 23 April 2020 and 15 May 2020, multiple inspections of the MA and analysis data were conducted and determined the following aircraft structures and components exceeded design load limits upon experiencing the hard landing and required replacement (Figure 17: Identification of Major Components Requiring Replacement or Inspection and Tabs EE-4 to EE-10 and U-185 to U-189):

1. Center Wing
2. Left and right outer wings along with associated wing joint bolts
3. Left and Right Main Landing Gear (MLG) torque struts
4. Left and Right MLG shock struts (aft) along with associated swivel brackets, drag pins, tracks, and shoes
5. Propeller Gearboxes on all 4 engines
6. Propeller gearbox to power section struts on all 4 engines
7. Gearbox mounted accessory drive on all 4 engines
8. Propellers on all 4 engines
9. Spinners on all 4 engines
10. Over-speed governors on all 4 engines
11. Pitch control units on all 4 engines
12. Brush block bracket assemblies on all 4 engines
13. Auxiliary feathering pumps on all 4 engines
14. Beta tubes on all 4 engines
15. De-icing timing unit on all 4 engines

Additional inspections and analyses are required to determine airworthiness of the following (Tabs EE-3 to EE-10 and U-185 to U-189):

(1) Analyze stress on Flight Station 588 vertical beam
(2) Analyze stress on aft shelf brackets
(3) Complete analysis on Quick Engine Change (QEC) structures
(4) MLG ball screws
(5) Hard landing inspection on all 4 engines (repeat inspection requirements due after 500 engine flight hours)

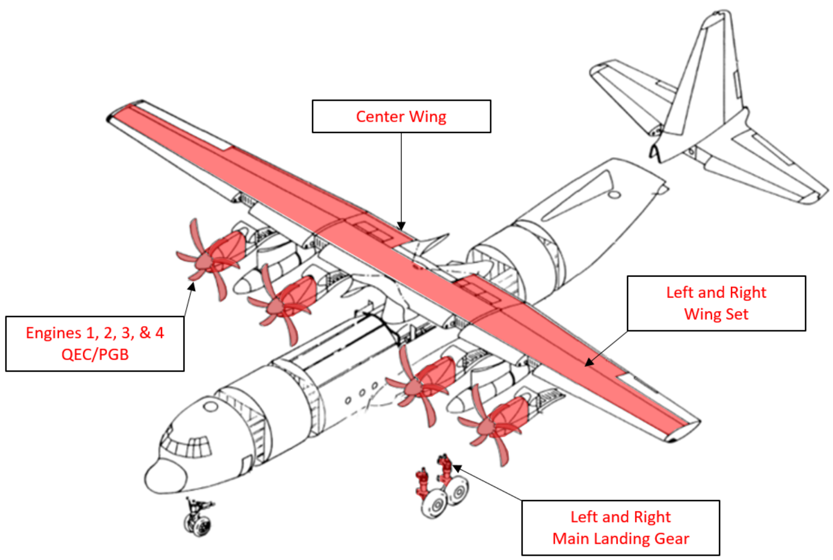

Figure 17: Identification of Major Components Requiring Replacement or Inspection (Tab J-3)

The photographs listed in Figure 17 thru Figure 26 were taken on 23 April 2020 by the 86 MXG Quality Assurance office (Tab S-3).

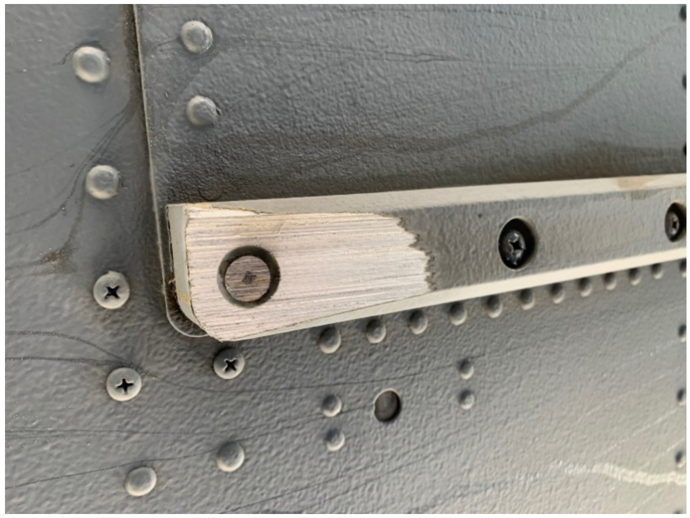

Figure 18: Right Hand Tail Skid Plate Impact Damage (Tab S-7)

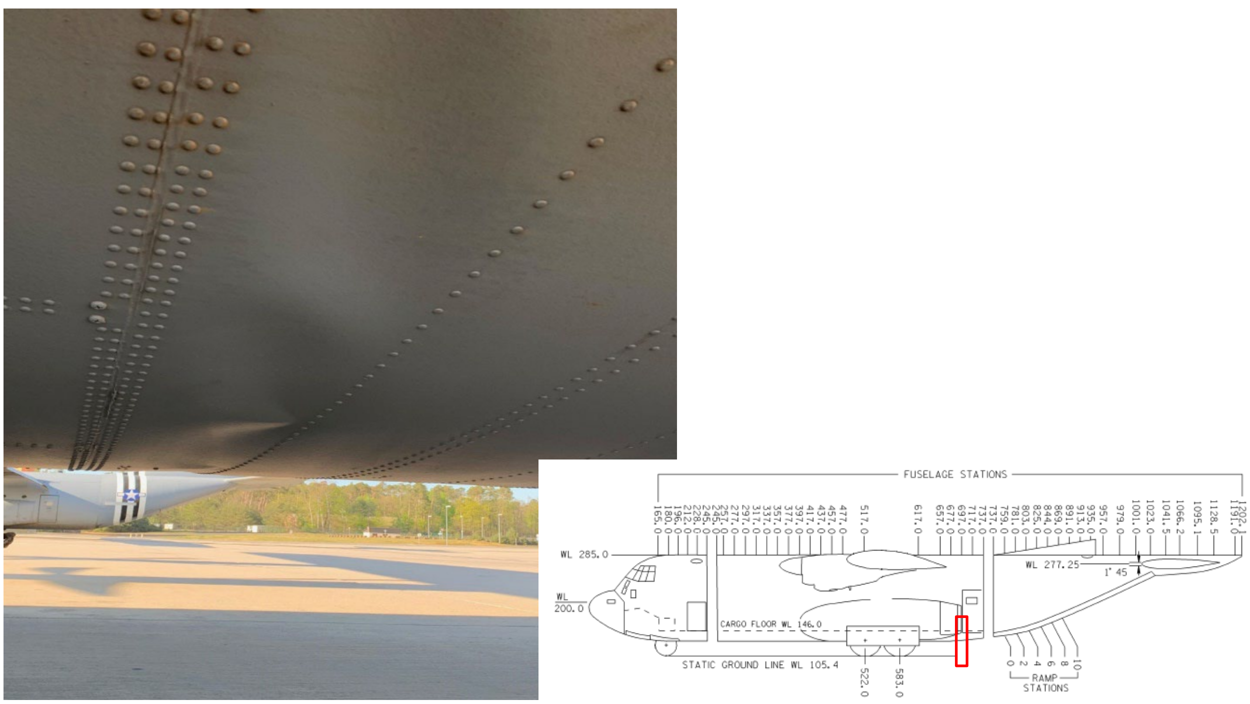

Figure 19: Lower Fuselage Buckling at FS700 (aircraft left to right perspective)(Tab S-8)

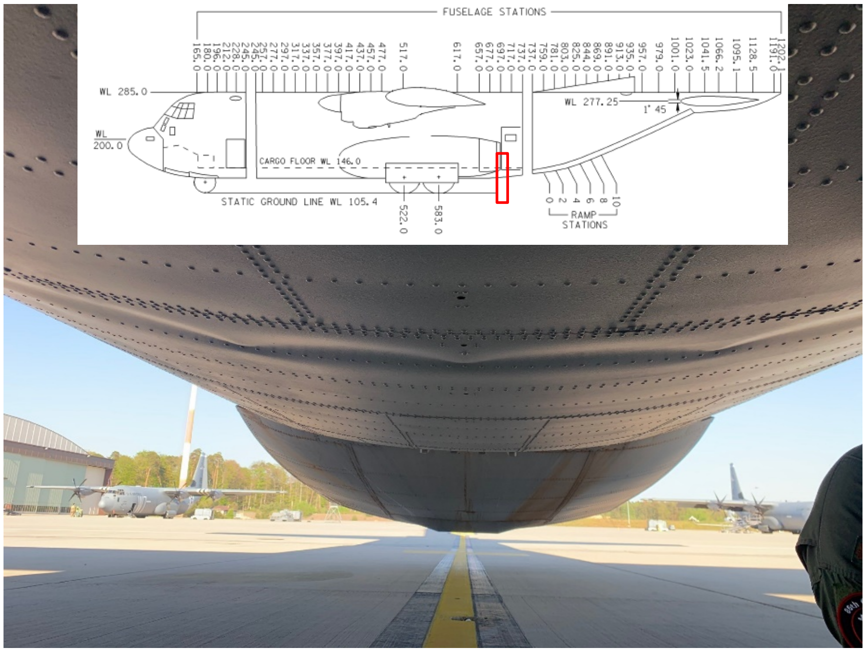

Figure 20: Lower Fuselage Buckling at FS700 (aircraft forward to aft perspective) (Tab S-9)

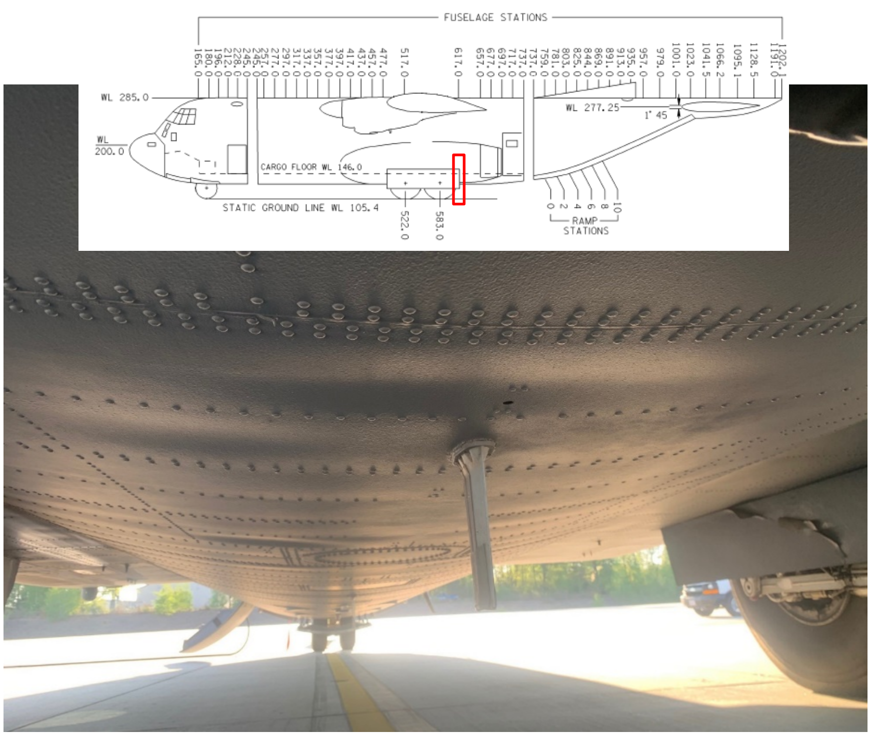

Figure 21: Lower Fuselage Buckling at FS617 (forward to aft perspective) (Tab S-10)

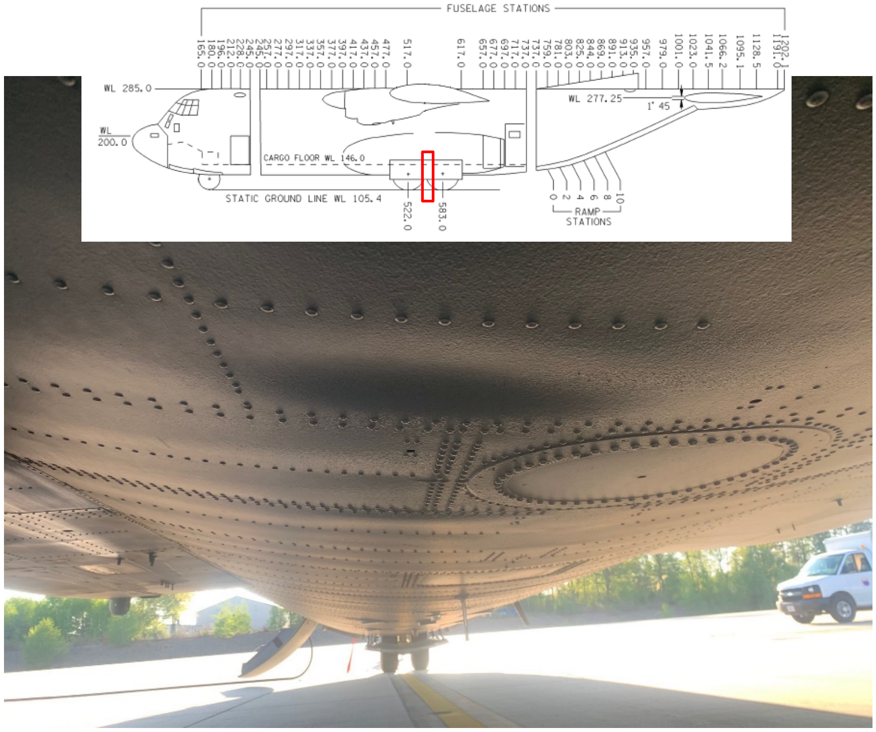

Figure 22: Lower Fuselage Buckling at FS550 (forward to aft perspective)(Tab S-11)

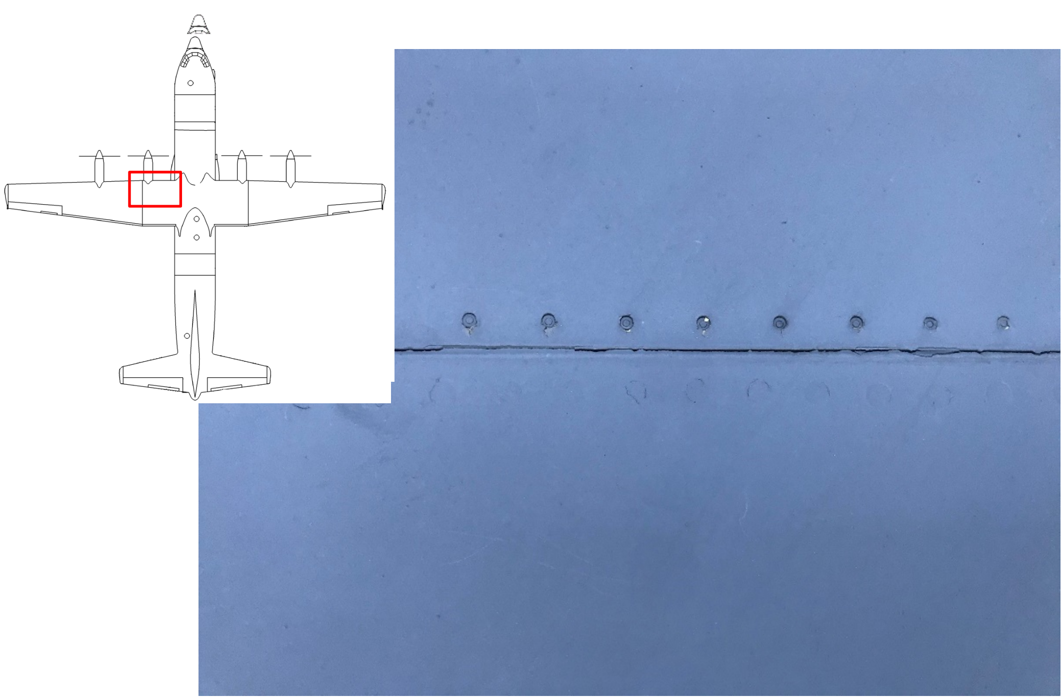

Figure 23: Left Hand Aft Wing Box at FS 617, Pulled Rivets (aircraft forward to aft perspective) (Tab S-13)

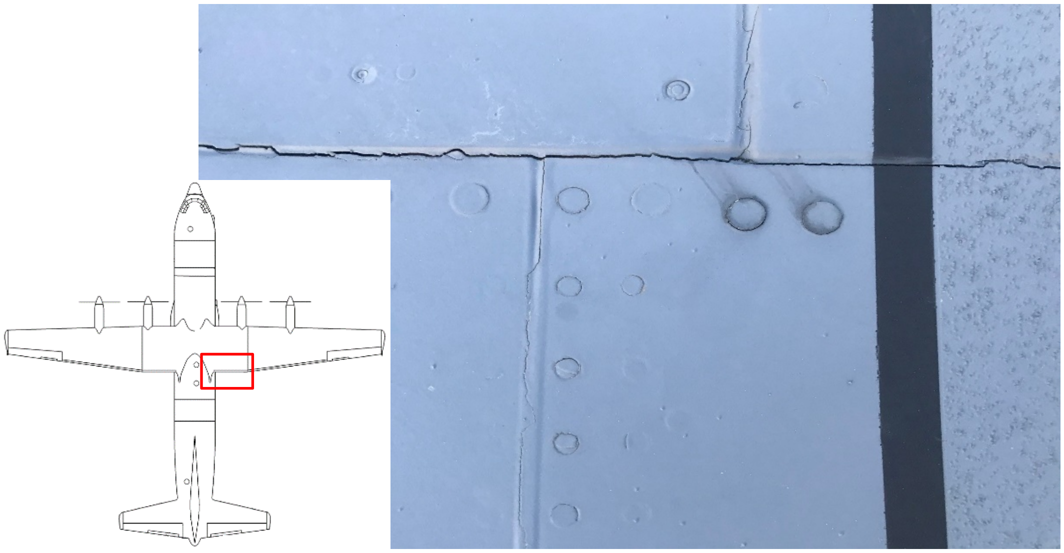

Figure 24: Right Hand Aft Wing Box at FS617, Cracked Sealant (aircraft forward to aft perspective) (Tab S-15)

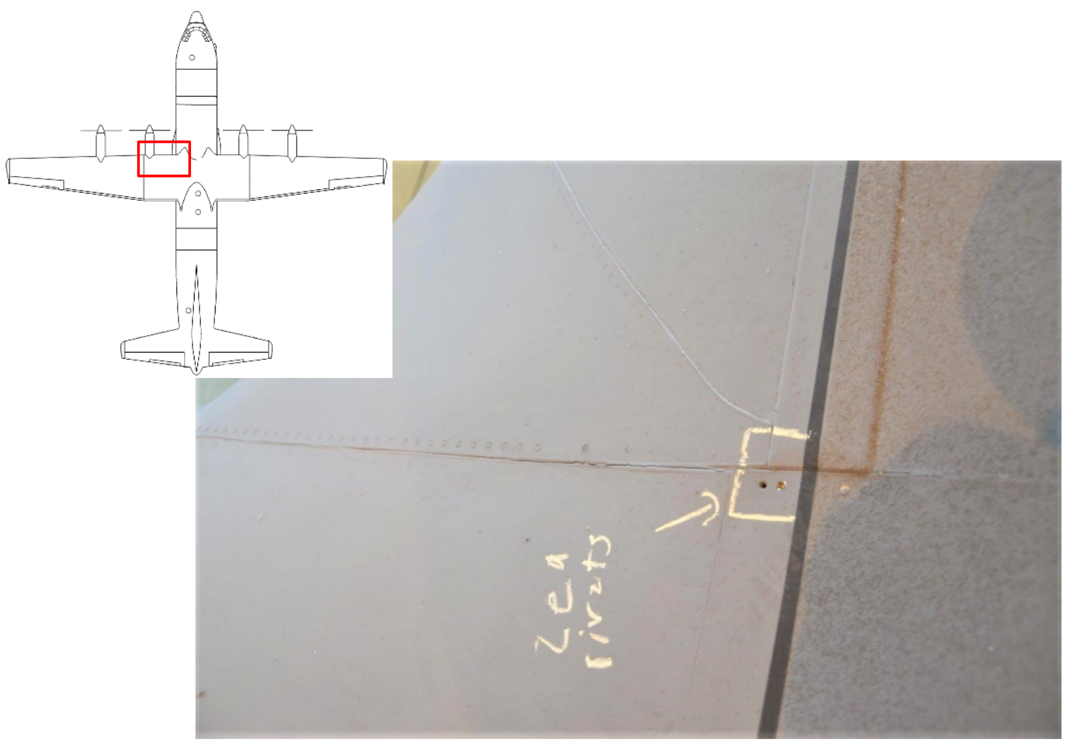

Figure 25: Left Hand Forward Wing Box at FS517, Pulled Rivets (aircraft aft to forward perspective) (Tab S-17)

Figure 26: Right Hand Forward Wing Box at FS517, Pulled Rivets (aircraft aft to forward perspective) (Tab S-18)

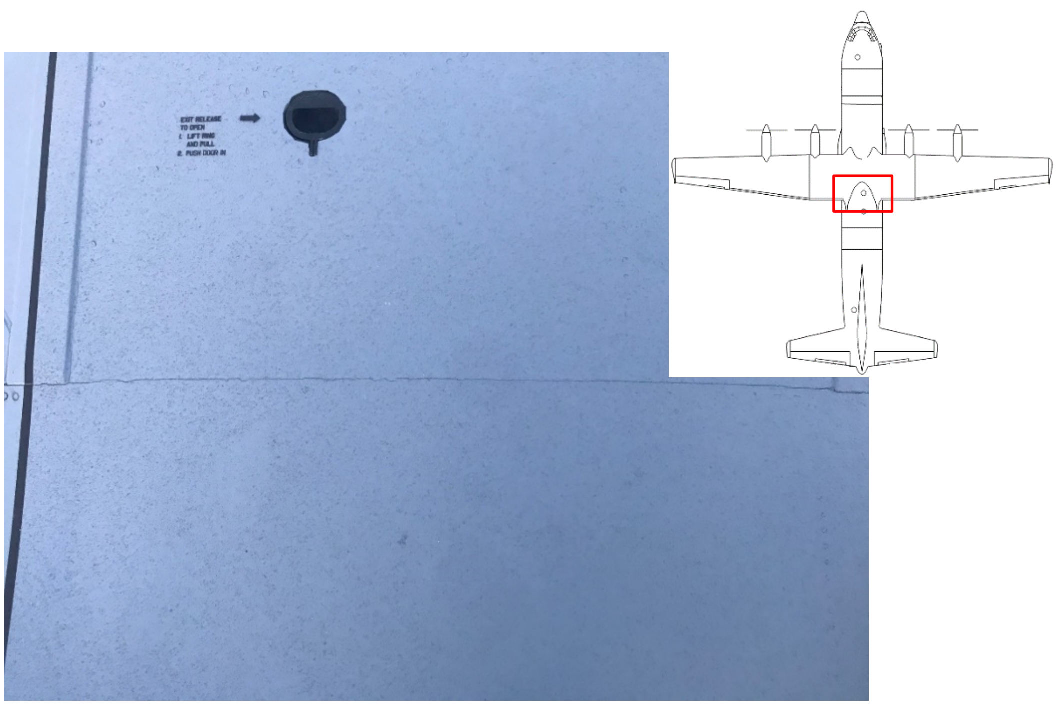

Figure 27: Aft Wing Box at FS 617, Cracked Sealant (aircraft forward to aft perspective) (Tab S-14)

b. Evaluation and Analysis

Post-mishap, the Digital Flight Data Recorder (DFDR), the CVR, and RMM data were provided to the AFSEC for analysis (Tab DD-19).

Between 23 Apr 2020 and 28 Jul 2020, LM conducted extensive hard landing internal and external loads evaluations using information from the DFDR and RMM data collected from the mishap sortie (Tabs J-98 to J-133 and U-171 to U-190). During the course of these analyses, LM concluded design load limits were reached or exceeded on multiple structural components of the MA (Tab U-171 to U-190). At the time the AIB convened, all maintenance actions had ceased, and the MA still had many visual and non-destructive inspections remaining (Tab U-162 and U-189). As such, the total extent of the damage sustained during the mishap sortie remained to be determined and the total estimated cost of repair or loss was still unknown (Tab U-188 to U-189).

c. Testing and Analysis

(1) C-130J-30 Weapon System Trainer Simulator

1. Test explanation

On 17 July 2020 and 4 April 2020, the AIB Pilot Member flew approximately 30 approaches and landings in a C-130J-30 Weapon Systems Trainer (WST) at Ramstein AB (Tab DD-6). During the tests, the AIB Pilot Member flew different landing scenarios to recreate and to help identify causal and contributing factors relevant to the mishap (Tab DD-6 to DD-8). These scenarios involved: 1) Power pull at 75 feet AGL and at flight idle at 50 feet AGL; 2) varying times to go-around; 3) gross landing weights at different extremes; and 4) wind shift from direct crosswind to tailwind (Tab DD-6). Note: The AIB pilot member flew various weights in the WST due to the fact MP1 flew an aircraft with significantly lighter weight within 48 hours of the mishap event (Tab U-191 and DD-6).

2. Landing Scenarios

The following scenarios were used during the short approach (final 300 feet AGL) to landing (Tab DD-6 to DD-8).

a. Scenario 1

Max effort landing 100% flap approach into Runway 26, at 120 KCAS, with a power pull initiated at 75 feet AGL, and gross weight of 123,100 pounds (Tab DD-6 to DD-7 and DD-15). Go-arounds were initiated at 50, 40, 30, 20, and 10 feet AGL (Tab DD-6 to DD-7). Additionally, power was added to recapture a proper sink rate and attempt to land within the landing zone at 50, 40 30, 20, and 10 feet AGL (Tab DD-6).

b. Scenario 2

Max effort landing 100% flap approach into Runway 26, at applicable speeds based on weight, with a power pull initiated at 75 feet AGL, and gross weight of 108,000 pounds (Tab DD-6).

c. Scenario 3

Max effort landing 100% flap approach into Runway 26, at applicable speeds based on weight, with a power pull initiated at 75 feet AGL, and gross weight of 150,000 pounds (Tab DD-6).

d. Scenario 4

Max effort landing 100% flap approach into Runway 26, at 116 KCAS, with an adequate power pull initiated at approximately 20 feet AGL, and gross weight of 123,100 pounds (Tab DD-6). Winds shift from 020 at 8 knots to 070 at 8 knots immediately at 30 feet (Tab DD-6).

3. Results

Scenarios similar to the mishap, to include winds, weights, and airspeed, go-around attempts at 20 and 10 feet AGL, resulted in the aircraft touching down and exceeding g landing limits (Tab DD-6 to DD-7). At 30 feet AGL, go-around and landing attempts were safely executed and within design landing limits although requiring aggressive and immediate control inputs (Tab DD-6 to DD-7). At 40 feet AGL and above, attempts to go-around and land were relatively easy to accomplish within the limits of the aircraft (Tab DD-6 to DD-7). It should be noted that in all efforts to go-around or continue (fix) the approach, a significant and immediate power increase was required (Tab DD-6 to DD-7).

Additionally, instrumentation was observed to assess what the MP1 and MP2 could see at the time of the mishap that would indicate an increasing sink rate absent throttle position (Tab DD-7). The Climb Dive Marker (CDM) is located in the center of the HUD and projects the flight path of the aircraft or aim point (Figure 28 and Tab DD-26). The energy caret is displayed just to the left of the CDM and moves vertically (Tab DD-7 and DD-26). The energy caret indicates acceleration along the flight path (Tab DD-7). When the energy caret is displayed above or below the CDM, the aircraft is accelerating or decelerating, respectively (Tab DD7). When the energy caret is displayed at the CDM, the aircraft is at zero acceleration with respect to airspeed (Tab DD-7). When duplicating the MA parameters and by monitoring the energy caret and the airspeed indicator alone, the first indication that the simulated aircraft was at a dangerous sink rate was observed at approximately 30 feet (Tab DD-7). The time elapsed between 30 feet to touchdown in the mishap was approximately 1.7 seconds (Tabs DD-7).

Analysis of the HUD in the WST revealed that in order to maintain the aim point inside the painted LZ, the pitch of the aircraft had to rise nose up considerably with a power pull initiated at 70 feet AGL (and fully FLT IDLE at 45 feet AGL) (Tab DD-7 to DD-8). The pilot member had to increase backpressure (pull up) on the yoke to maintain the aim point inside the LZ (Tab DD-7 to DD-8). Doing so caused the CDM (aim point) and pitch attitude to travel farther apart as shown in Figure 28 on page 33 (Tab DD-7 and DD-26). Figure 28 below, shows the AIB pilot member maintaining an aim point inside the painted LZ while having to pitch the simulated aircraft to roughly 2 degrees nose up (Tab DD-6 to DD-7). This indicates that a power pull initiated at 70 feet and a nose down pitch attitude would result in the MA aiming shorter and shorter (closer to the beginning of the runway) (Tab DD-7).

For lightweight scenarios at 108,000 pounds of aircraft weight, landing and approach speeds were lower and the ground speed was noticeably slower (Tab DD-7). A reduction in power at 75 feet led to a more noticeable decrease in airspeed and more time to analyze instrument cues (Tab DD-7).

For heavier weight scenarios at 150,000 pounds of aircraft weight, landing and approach speeds were higher and the ground speed was noticeably faster (Tab DD-7). A reduction in power at 75 feet led to a relatively slower decrease in airspeed while maintaining flight path angle of negative 3.0 degrees (Tab DD-7). Note that the WST cannot accurately mimic the sensory inputs such as acceleration and deceleration. In this case, the "sinking feeling" noted by the MC cannot be duplicated (Tab DD-7).

For wind shift scenarios, the aircraft was able to land in the first 500 feet of the painted zone with pilot control inputs (Tab o DD-7).

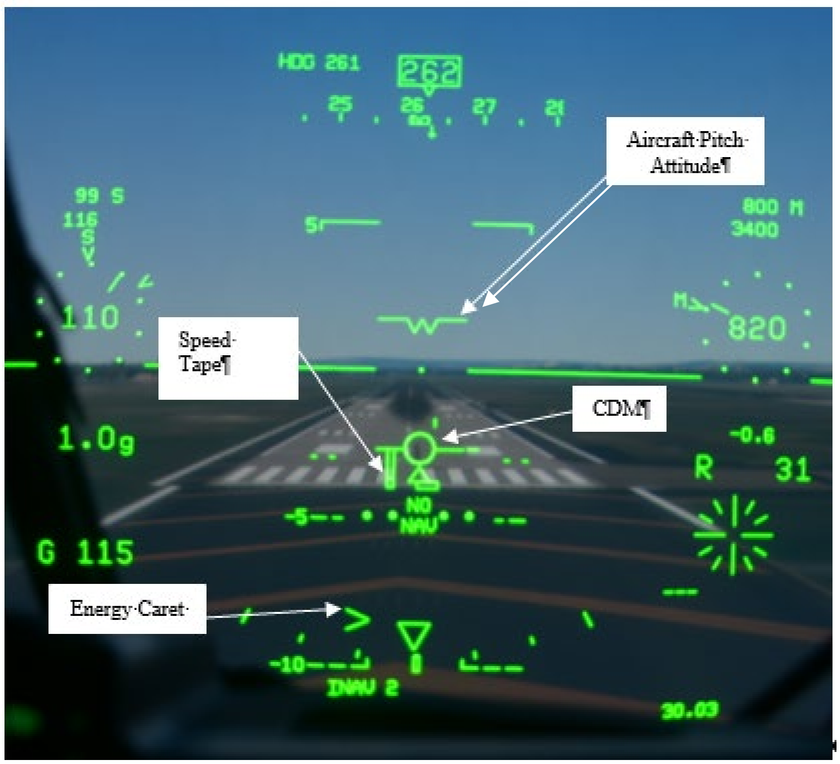

Figure 28: HUD of the WST with highlighted references at 31 feet AGL after mimicking the mishap throttle position and maintaining aim point (Tab DD-26)

d. Additional Aircraft Systems

(1) Ground Collision and Avoidance System (GCAS)

The C-130J is equipped with a Ground Collision Avoidance System (GCAS) (Tab CC-20). The GCAS is a complementary system providing visual and obstacle voice warning alerts to the crew (Tab CC-20). Provided charts show conditions in which the GCAS will alert the crew of an excessive sink rate (Tab DD-13 to DD-14). The GCAS can be set to normal or tactical mode (Tabs DD-13 to DD-14 and BB-83). Because the crew was flying a tactical approach, the correct procedure would be to set the GCAS to "tactical" which would increase the warning alert envelope from 1750 FPM to 1785 FPM (Tabs DD-13 to DD-14 and BB-83). Below 30 feet AGL, the GCAS does not provide sink rate alerts (Tab DD-13 to DD-14). At 50 feet AGL, the GCAS will alert the crew of an excessive sink rate at approximately 1785 FPM in tactical mode (Tab DD-14). The MA sink rate at 50 feet AGL was 809 FPM and continued to increase and peaked at 25 feet AGL to 1005 FPM (Figure 16 on page 17 and Tab DD-25). The MA never reached a sink rate greater than 1750 FPM, therefore, the GCAS would not have alerted the MC (Figure 15 and Tabs DD-25, L3, and L-33).

7. WEATHER

a. Forecast Weather

Weather conditions at the time of departure (1600-1800L/1500-1700Z) were forecasted to be 22º Celsius (71.6º Fahrenheit) with winds 060 degrees at 12 knots (Tab F-18). Additionally, skies were forecasted to be clear with unlimited visibility and visual meteorological conditions (Tab F-18). The forecast had no significant weather conditions (Tab F-18).

b. Observed Weather

One-minute interval automatic weather observations at the time of the mishap show at 15:23:50Z (26 seconds prior to the mishap) winds were at 010 degrees at 10 knots (Tab F-21). At 15:24:50Z (34 seconds after the mishap) winds were at 010 degrees at 9 knots (Tab F-21). The trend of the winds within 10 minutes of the mishap showed a steady state wind magnitude of 9-10 knots (Tab F-21). The direction of the wind during this 10-minute period shifted from 030 to 340 degrees (Tab F-21). The trend of the wind direction shows a potential decrease in tailwind and an increase in headwind for Runway 26 (Tab DD-8). This wind shift would be performance enhancing (Tab DD-8). Evidence shows the tailwind component during the minute prior to the mishap was between 2 and 6 knots (Tab DD-8). There was no precipitation and skies were clear with no clouds (F-22).

Just prior to takeoff, MP2 checked the ATIS (Tab L-22). ATIS is a continuous broadcast of aeronautical weather information and each ATIS update has a letter identifier (Tab DD-16). MP2 received information "Oscar" while the MA was taxing to a hold short point close to the takeoff runway (Tab L-22). Oscar reported winds 030 degrees at 6 knots from observation time 1456Z (roughly 28 minutes prior to the hard landing) (Tab L-22). MP2 stated at 15:09:07Z, "windsock is saying direct cross or almost a headwind" (Tab L-20). When ATC cleared the MA for takeoff, the tower called the winds at 030 degrees at 5 knots (Tab L-23). Approximately 12 minutes later during the right base turn (approximately 1 minute and 6 seconds prior to the mishap) the ATC tower cleared the MA to land with winds at 020 degrees at 8 knots (Tab L-32).

Post-mishap weather trended to calm winds as the day progressed with no other significant weather (Tab W-2).

c. Space Environment

Not Applicable.

d. Operations

The MC was operating within the prescribed weather requirements, flew a local VFR procedure in visual meteorological conditions, and the sortie was flown IAW AFMAN 11-202v3, *General Flight Rules*, 14 February 2019, weather requirements (Tabs K-7 and W-2).

MP1 and MP2 testified that the winds resulted in the sudden increased sink rate within 30 feet AGL of landing (Tabs V-1.7, V-2.5, R-10, and R-18). Analysis of wind data from the DFDR and the difference between the calibrated airspeed and groundspeed is below.

The wind speed and direction readout receives data from the aircraft's inertial platform and is considered inaccurate during certain pilot control inputs such as correcting for crosswind and other uncoordinated flight (Tabs V5.2 to V5.3 and DD-16). The wind data captured at 150 feet AGL was 024 degrees at 8 knots (Tab L3-15:24:12.500 to L3-15:24:12.625). The captured wind data at touchdown was 053 degrees at 7.5 knots (Tab L3-15:24:22.500 to L3-15:24:22.625). Based only on the wind data from the DFDR, the slight wind shift from 024 to 053 degrees resulted in a 2-knot tailwind increase over 11 seconds (Tab L3-15:24:12.500 to L3-15:24:12.625 and Tab L3-15:24:23.625 to L3-15:24:23.750). The effects of crosswind controls and aggressive flare (as performed in the mishap event) can reduce the accuracy of the wind data (Tabs V-5.2 and DD-15).

The ground speed at touchdown was approximately 123 knots and the calibrated airspeed was 107 knots (Tab L3-15:24:23.625 to L3-15:24:23.750). The result is an estimated 16-knot difference, and is highlighted as tailwind in an engineering report (Tab J-102). However, one to two seconds prior to touchdown, MP1 flared the MA to land (Tab L3-15:22:23.625 to L3-15:24:23.750). Variations in airflow affect the pressure sensed at the static ports of the pitot-static system, subsequently causing the airspeed indicator to read inaccurately (Tab V-3.6, V-5.2, and DD-15). The flare would have affected the airflow through the pitot-static system causing imprecise airspeed (Tab DD-15). Additionally, ground speed is a function of wind speed and true airspeed (not calibrated) (Tab DD-15). For comparison, at 100 feet AGL the difference between true airspeed and ground speed is 3 knots with no wind (Tab DD-8 and DD-15).

8. CREW QUALIFICATIONS

There is no evidence indicating crew qualifications were a factor in this mishap. There also was no evidence to indicate training deficiencies for the MC.

a. Mishap Pilot 1 (Flight Pilot in the Left Seat)

The MP1 was a current and qualified C-130J pilot (Note: there is no qualification differentiation between the C-130J and C-130J-30) (Tabs G-2 and K-6). MP1 completed Pilot Initial Qualification to become a certified Flight Pilot (Tab T-17 to T-281). MP1 had 399.1 total hours in the actual C-130J, 259.5 primary hours, 113.4 secondary hours, and 26.2 other hours (Tab T-8 to T-10). In the simulator, MP1 had a total of 174.3 hours total, 95.3 primary hours, and 79.0 secondary hours (Tab T-8 to T-10). Of the combined total of 573.4 hours, 18.7 flying hours were combat hours and 109.1 were combat support hours (Tab T-8 to T-10).

MP1's flight time for the 90 days prior to the mishap was as follows (Tab G-5):

	Hours	Sorties
Last 30 Days	58.6	25
Last 60 Days	72.4	29
Last 90 Days	133.9	51

b. Mishap Pilot 2 (Aircraft Commander in the Right Seat)

MP2 was a current and qualified instructor pilot and USAF Weapons School graduate in the C-130J (Tabs G-35 and K-6). MP2 had 1,591.0 total hours in the C-130J, 445.6 primary hours, 282.9 secondary hours, 561.3 instructor hours, and 301.2 other hours (Tab T-11 to T-15). Of the 1,591.0 total hours flown, 495.3 flying hours were combat hours and 56.6 were combat support hours (Tab T-11 to T-15).

MP2's flight time for the 90 days prior to the mishap was as follows (Tab G-36 and G-38):

	Hours	Sorties
Last 30 Days	7.5	3
Last 60 Days	27.2	11
Last 90 Days	53.2	23

c. Mishap Pilot 3 (Evaluator Pilot in Jump Seat)

MP3 was a current and qualified evaluator pilot in the C-130J (Tabs G-82 and K-6). MP3 had 1,586.6 total hours in the C-130J, 1,824.3 in Remotely Piloted Aircraft (RPA), 2,250.3 total primary hours, 239.3 secondary hours, 607.6 total instructor hours, and 130.2 evaluator hours (Tab T-4 to T-6). Of the 2,250.3 total hours flown, 418.1 flying hours were combat hours and 1827.2 were combat support hours (Tab T-4 to T-5).

MP3 flight time for the 90 days prior to the mishap is as follows (Tab T-4 to T-6):

	Hours	Sorties
Last 30 Days	9.6	7
Last 60 Days	28.0	19
Last 90 Days	53.3	33

d. Mishap Loadmaster (ML)

ML was a current and qualified loadmaster in the C-130J (Tab K-6). ML had 876.4 total hours in the C-130J, 660.4 primary hours, 5.0 secondary hours, 213.7 instructor hours, and 19.8 other hours (Tab T-2 to T-3). Additionally, ML had 1,369.2 total hours in the C-130H, 810.3 primary hours, 0.9 secondary hours, 521.8 instructor hours, and 36.2 other hours (Tab T-2 to T-3). Of the 2,245.6 total hours flown, 87.7 flying hours were combat hours and 133.2 were combat support hours (Tab T-2 to T-3).

ML's flight time for the 90 days prior to the mishap is as follows (Tab G-96 to G-97):

	Hours	Sorties
Last 30 Days	16.5	6
Last 60 Days	42.4	19
Last 90 Days	61.8	31

9. MEDICAL

a. Qualifications

Based on all available medical information, the MC appeared medically qualified for flying duties at the time of the mishap (Tab DD-5). The MC was current on their Periodic Health Assessment (Tab DD-4). Everyone had current physiological training (Tab DD-5). There is no evidence to suggest that any member of the MC had a medical condition, illness, or performance-limiting condition that would have caused or contributed to the mishap (Tab DD-5).

b. Health

Nobody was treated for injuries sustained during or after the mishap and no post-mishap medical examination records are relevant to the accident (Tab DD-4).

c. Toxicology

Toxicology tests were performed on the MC (Tab DD-4). Blood and urine were tested and all results were negative (Tab DD-5).

d. Pathology

Not applicable.

e. Lifestyle

There is no evidence to suggest lifestyle factors were a factor in the mishap (Tab DD-5).

f. Crew Rest and Crew Duty Time

AFI 11-202v3, *General Flight Rules* (10 June 2020), paragraph 3.1 states, "Crew rest is free time and includes time for meals, transportation, and rest. This time must include an opportunity for at least eight hours of uninterrupted sleep (Tab BB-69). Crew rest period cannot begin until after the completion of official duties," (Tab BB-69). The 72-hour and 14-day histories for the MP1, MP2, MP3, and ML show that each crewmember had the opportunity for at least eight hours of sleep (Tab DD-5 to DD-6). Based on the 72-hour and 14-day histories that were collected, there is no evidence to suggest inadequate crew rest was a factor in the mishap (Tab DD-5).

10. OPERATIONS AND SUPERVISION

a. Operations

Several witnesses testified that generally, the operations tempo at the 37 AS is higher than continental United States C-130J squadrons in which they previously served due to the 37 AS supporting real-world missions in USAFE and contingency operations in AFRICOM (Tab V-5.2). The MC each individually flew 25 sorties or fewer in the proceeding 30 days and no crew member flew more than 51 sorties or more than 133.9 hours in the proceeding 90 days (see section "8. CREW QUALIFICATIONS" on page 35). Of note, MP1 testified that the coronavirus restrictions had some impact on MP1's ability to fly planned training sorties (Tab V-1.3). Specifically, MP1 had two sorties planned to prepare him for the evaluation sortie, but one was cancelled due to the coronavirus restrictions (Tab V-1.3). There is no evidence that operations tempo was a factor in this mishap.

b. Supervision

The ORM process on the day of the mishap identified the risk for the mission to be in the "green" or deemed low risk (Tab K-6 to K-7). The "green" risk required only aircraft commander approval, which was MP2 (Tab K-7). The day prior, the 37 AS Commander approved the sortie based on the squadron leadership's risk assessment (Tab K-4).

11. HUMAN FACTORS ANALYSIS

The Department of Defense Human Factors Analysis and Classification System 7.0 lists potential human factors (including organizational influences, supervision, preconditions, and specific acts) that may play a role in aircraft mishaps (Tab BB-46 to BB-67). The following human factors were relevant to this mishap:

a. AE104 Overcontrolled/Undercontrolled Aircraft/Vehicle/System

Overcontrolled/Undercontrolled Aircraft/Vehicle/System is a factor when an individual responds inappropriately to conditions by either over- or undercontrolling the aircraft/vehicle/system (Tab BB-50). The error may be a result of preconditions or a temporary failure of coordination (Tab BB-50).

MP1 pitched the MA nose down and subsequently reduced power from what is required to maintain airspeed to the FLT IDLE throttle position (Figure 15 and Figure 16 and Tab DD-24 to DD-25). This occurred over the span in which the MA was between 110 feet AGL and 45 feet AGL (Figure 15 and Figure 16 and Tab DD-24 to DD-25). At 58 feet AGL and 3.5 seconds prior to touchdown, the engine torque had decreased approximately 76% from 70 feet AGL (Figure 15 and Figure 16 and Tab DD-24 to DD-25). At 45 feet, AGL MP1 had the throttles fully in FLT IDLE (Figure 15 and Figure 16 and Tab DD-24 to DD-25).

Not every landing is the same and there is variance between landings based on many factors such as weather, temperature, aircraft gross weight, pressure altitude etc. (Tab V-8.1). A baseline procedure or technique is "at about 20 feet RAD ALT above the runway reduce power and flare to land in the center of the touchdown zone" (Tab V-1.6, V-2.6, and V-4.4). If the touchdown is not within the first 500 feet (or other pre-briefed distance based on runway available) a go-around must be executed (Tabs V-8.1 and DD-15).

Over- or under-controlling can happen for a variety of reasons, one of which is how fast controls need to be applied compared to previous instances a pilot encountered (Tab DD-7 to DD-8). MP1 flew a "two-check" sortie intended to mimic and prepare for the evaluation (Tab DD-7 to DD-8. MP1 completed maximum effort landings on his "two-check" at the end of the sortie on 21 April 2020, within 48 hours of the mishap sortie (Tab V-4.7). Because MP1 flew a lighter aircraft with a headwind between 16 to 26 knots, the ground speed would have been 32% to 48% faster on the mishap approach compared to the two-check he had completed on 21 April 2020 (Tab DD-8).

In testimony, MP1 expressed concern about floating out of the LZ during the mishap landing (Tab R-8). A tailwind or light aircraft may cause the aircraft to float (Tab BB-71). The aircraft may also float if the power is left in (high) for too long (Tab BB-71). Alternatively, pulling (reducing) the power early during heavyweight landings or in headwinds can result in increased sink rates and firm touchdowns (Tab BB-71). To summarize, lighter aircraft will require a slightly earlier power pull to land whereas heavier will require leaving the power in a little longer (Tabs BB-71 and T-123 to T-124). The MA weighed 123,090 pounds at touchdown for the mishap event (Tab J-62). This is short of being considered heavyweight, but it is approximately 15,000 pounds heavier then aircraft flown by MP1 within 48 hours prior (Tabs BB-40 to BB-41 and DD-8).

The specific aerodynamics of the C-130J can also lead to undercontrolling the aircraft, specifically the propellers generate high velocity airflow over the wings, directly affecting lift (Tab V-8.1). Large power changes cause direct changes in glide path (Tab V-8.1). Any power reduction on short final, especially at heavy gross weight, will require a corresponding nose-up pitch to prevent a hard landing (Tab V-8.1).

b. AE105 Breakdown in Visual Scan

Breakdown in Visual Scan is a factor when the individual fails to effectively execute visual scan patterns (Tab BB-50).

MP2 called out, "Good aim point" at roughly 110 feet AGL and it was after the callout that MP1 began pitching downward (Figure 15, -8.3). Over 4 seconds passed between that callout and the

MA pitching down to 2.3 degrees nose down (Figure 15, -8.3 to -4.0 and Tab DD-24). Within these 4 seconds, MP1 began reducing power to FLT IDLE (Figure 15, -3.75 and Tab DD-24). Reducing power or thrust in an aircraft flying level will normally decrease airspeed; however, an aircraft pitching down would increase airspeed (Tab DD-7). Re-creation of the mishap to include power reduction and pitch in the WST revealed that in the HUD, CDM/aim point of the MA shifts down and closer to the beginning of the runway approach (short of the painted LZ) (Tab DD-7). Attempts to recreate the mishap in the WST highlighted the need for a nose up attitude to maintain a constant aim point while reducing power (Figure 28, Tab DD-7, and DD-26).

Due to the C-130J lacking automated aural RAD ALT callouts, a common technique in the C-130J community is for the PM to callout the radar altimeter in 10-foot increments starting at 50 feet AGL (Tab V-2.7, V-4.5, V-5.3, and V-6.5). Multiple experienced C-130J pilots testify to the importance of this technique (Tab V-2.7, V-4.5, V-5.3, and V-6.5). The countdown by the PM gives the PF a verbal cue on the descent rate based on how quickly or slowly the radar altimeter is counting down—the countdown cadence (Tab V-5.3). MP2 testified using a visual scan is "aim point, airspeed, and RAD ALT" (Tab V-2.8). Figure 15 and Figure 16, based off RMM and CVR data, show that the significant power reduction led to an increased sink rate. As the sink rate was increasing, MP2 began the RAD ALT calls (Figure 16, -2.7). The data also shows that 5.6 seconds passed between MP2's aim point call and 50 feet RADALT call (Figure 16, -8.3 to -2.7). Additionally, 3.3 seconds elapsed between the airspeed call and the 50 feet RAD ALT call (Figure 16, -6.0 to -2.7). The "sinking feeling" testified by the MC correlates with the increase in vertical velocity as shown in Figure 15 (Tab V-2.5). MP2 directed MP1 to add power at 30 feet AGL roughly 1.7 seconds prior to touchdown (Figure 15 and Tab DD-24).

c. AE107 Rushed or Delayed a Necessary Action

"Rushed or Delayed a Necessary Action" 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-50).

In the C-130J-30 WST, multiple go-around and landing attempts were successful at 30 feet AGL and above without over exceeding 2.0g on the aircraft; however, note that in the WST, go-arounds were immediate, aggressive, and with a drastic throttle increase (Tab DD-6 to DD-8). Due to rapid engine response and the lift generated by the propeller wash over the wings, a four engine go-around can be safely executed at any time during the approach and even after touchdown, if necessary (V-8.1)

12. GOVERNING DIRECTIVES AND PUBLICATIONS

a. Publically Available Directives and Publications Relevant to the Mishap

(1) AFI 11-202V3, *General Flight Rules* (10 August 2016 Incorporating AFGM2019-01)
(2) AFI 11-202V3, *Air Mobility Command Supplement, General Flight Rules* (14 February 2019)
(3) AFI 21-101, *Aircraft and Equipment Maintenance Management* (16 January 2020)
(4) AFI 51-307, *Aerospace and Ground Accident Investigations* (18 March 2019 Incorporating AFGM2020-01, 26 February 2020)

(5) AFI 91-204, *Safety Investigation and Hazard Reporting* (27 April 2018 Incorporating AFGM2020-01, 7 July 2020)
(6) AFMAN 11-2C-130JV1, *C-130J Aircrew Training* (10 February 2020)
(7) AFMAN 11-2C-130JV2, *C-130J Aircrew Evaluation Criteria* (4 October 2019)
(8) AFMAN 11-2C-130JV3, *C-130J Operations Procedures* (17 July 2019)
(9) AFMAN 91-223, *Aviation Safety Investigations and Reports* (14 September 2018 Incorporating AFGM2020-01, 6 August 2020)
(10) Department of Defense Human Factors Analysis and Classification System 7.0 (DoD HFACS 7.0), available at https://www.safety.af.mil/Divisions/Human-Factors-Division/HFACS/
(11) DODI 6055.07, *Mishap Notification, Investigation, Reporting and Record Keeping* (6 June 2011 Incorporating Change 1, 31 August 2018)
(12) RABI 13-204, *Airfield Operations* (15 February 2019)

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

b. Other Directives and Publications Relevant to the Mishap not Publicly Available

(1) AFTTP 3-3.C-130J, *Combat Aircraft Fundamentals C-130J,* (27 July 2018)
(2) TCTO 1C-130J-1048, *Installation of Automatic Dependent Surveillance Broadcast (ADS-B) Out and Identification Friend or Foe (IFF) Transponder Mode 5 Group B Equipment on Selected C-130J Aircraft*, 12 Feb 2019
(3) TO 00-5-15, *Air Force Time Compliance Technical Order Process*, 01 Jul 2020
(4) TO 00-20-1, *Aerospace Equipment Maintenance Inspection, Documentation, Policies, and Procedures*, 06 Sep 2019
(5) TO 00-20-2, *Maintenance Data Documentation*, 05 Sep 2019
(6) TO 1C-130J-l, *Flight Manual, USAF Series C-130J Aircraft*, 1 July 2011 w/Change 17 -1 January 2020
(7) TO 1C-130(C)J-l-l, *Flight Manual, USAF Series C-130J (Long) Aircraft*, 1 July 2011 w/Change 10 - 1 January 2020
(8) TO 1C-130J-2-45GS-00-1, *Data Transfer and Diagnostic System*, 01 Jan 2019
(9) TO 1C-130J-6S-3, *Aircraft Scheduled Inspection and Maintenance Requirements*, 10 Feb 2020
(10) TO 1C-130J-6WC-10, *Preflight/Thruflight/Combined Pre/Postflight Inspection*, 01 Jan 2020
(11) TO 1C-130J-6WC-14S-1, *A/B/C/D Check Inspection*, 20 Mar 2020
(12) 86 MXGOI 21-101, *Aircraft and Equipment Maintenance Management*, 01 Jan 2019
(13) 86 OGOI 10-101, *Ramstein AB In Flight Guide,* (1 October 2019 Incorporating Change TRF20-07 30 March 2020)

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13 January 2021

TERRENCE L. KOUDELKA, JR.
Brigadier General, USAF
President, Accident Investigation Board

STATEMENT OF OPINION

C-130J / T/N 11-5736
Ramstein AB, GE
23 April 2020

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

1. OPINION SUMMARY

This Accident Investigation Board (AIB) was conducted IAW Air Force Instruction 51-307.

On 23 April 2020, at approximately 17:24:22 hours local time (L), the mishap aircraft (MA), C-130J-30, tail number (T/N) 11-5736, assigned to the 37th Airlift Squadron, 86th Airlift Wing, Ramstein Air Base (AB), Germany, conducted a routine periodic evaluation flight for Mishap Pilot 1. The Mishap Crew (MC) flew a maximum effort (assault) landing at Ramstein AB and experienced a hard landing with a vertical acceleration load factor (g-load) exceedance value of 3.62 times the force of gravity (g) and a landing sink rate of 834 feet per minute (FPM). Immediately upon touchdown, the MC executed a go-around and coordinated with Air Traffic Control (ATC) for a visual approach, full-stop landing. The Mishap Aircraft (MA) landed safely at 17:37:23L. Due to the weight and fuel configuration, the MA's *maximum* allowable landing limits were 540 FPM sink rate and a g-load of 2.0g. There were no fatalities, injuries, or damage to civilian property. The MA landing g-load exceedance resulted in significant damage to the center wing, both outer wings, left and right main landing gear assemblies, and engines, to include mounting structures. The resulting damage is estimated at $20,917,089.

The MC consisted of Mishap Pilot 1 (MP1), the Flight Pilot, sitting in the left seat and Mishap Pilot 2 (MP2), the Aircraft Commander and Instructor Pilot, sitting in the right seat. Mishap Pilot 3 (MP3), the Evaluator Pilot was sitting in the third seat located between MP1 and MP2. The Mishap Loadmaster (ML) was performing flight duties aft of the flight deck, in the cargo compartment. At the time of the mishap, all members of the MC were current and qualified to perform flying duties.

The MC was scheduled to fly in a formation of three C-130J's planning to conduct two training routes. The primary training objective for the local sortie was to complete the MP1's evaluation. The MC planned to takeoff early as a single-ship, conduct a maximum effort takeoff followed by a maximum effort landing using the painted landing zone (LZ) marked on the runway (requirement for MP1's evaluation), a full-stop, and then rejoin the formation in order to complete the remainder of the evaluation requirements in the formation. Preflight, engine start, taxi and the Ramstein AB visual traffic pattern procedures were executed within good flying standards and were procedurally correct. The mishap occurred during the maximum effort landing.

The prevailing weather for the airfield was clear sky, unlimited visibility, and winds 060 degrees at 12 knots. The primary runway at the time of the mishap was Runway 08. However, given the familiarity with Runway 26 procedures, ease of formation rejoin, and the airfield's windsock showing a crosswind to a headwind relative to Runway 26, the MC elected to use Runway 26 versus the active Runway 08. When the Ramstein ATC tower cleared the MA for takeoff, the winds were reported as 030 degrees at 5 knots. Approximately 12 minutes later during the turn to final approach, tower cleared the MA to land with winds 020 degrees at 8 knots. One-minute interval automatic weather observations at the time of the mishap show winds were at 010 degrees at 10 knots.

The MA weighed 123,898 pounds resulting in maximum effort 100% threshold speeds of 116 knots calibrated airspeed (KCAS) and 109 KCAS touchdown speed. On short final for Runway 26 and at 150 feet above ground level (AGL), MP2 called "good speed, stable" and the aircraft was in fact stable. At 110 feet AGL, MP2 called "good aim point," then at 90 feel AGL "minus one on your speed." MP1 began to pitch down causing the MA airspeed to increase to 120 KCAS. At approximately 70 to 75 feet AGL, MP1 began to reduce the MA throttles/power to the flight idle (FLT IDLE) position (throttles set to the lowest in-flight setting and propellers producing minimum thrust). By 45 feet AGL the MA was fully at FLT IDLE power. MP2 monitored the AGL altitudes and announced the altitudes at 50 and then 40 feet. At 30-foot AGL, MP2 detected the rapid sink rate through visual and vestibular senses and instructed MP1 to "add power." MP1 increased throttles between 25 and 10 feet AGL. The MA main landing gear touched down on the runway at 3.62g and 834 FPM sink rate, exceeding the C-130J-30 landing design load limits of 2.0g and 540 FPM. The nose gear did not touch the runway. MA attitude was 3.6 degrees nose up, and touchdown speed was 108 KCAS. The time elapse from FLT IDLE engine power to the main landing gear impacting the ground was 3.5 seconds. Simultaneously with landing impact, MP2 called "go-around", MP1 pushed the throttles fully forward to takeoff power, and the MC executed standard go-around procedures.

After the hard landing, the MC coordinated with Ramstein tower to execute a normal landing on Runway 08, believing a tailwind resulted in the high sink rate. During the visual pattern, the MC confirmed 3.7 to 3.8g on their primary flight displays. The MC landed and returned to parking in order to have maintenance inspect the MA and make a decision whether to continue the formation mission or not. The approach and landing on Runway 08 were uneventful. Upon parking, the MC visually identified MA damage in the form of scrapes on the tailskid and buckling of the lower fuselage skin.

I find by the preponderance of evidence, the cause of the mishap was MP1's early engine power reduction (power pull), beginning at 70 feet AGL and fully FLT IDLE at 45 feet AGL, resulting in the excessive sink rate and exceeding the C-130J-30 g-load and sink rate landing limits. Additionally, I find by a preponderance of evidence that each of the following factors substantially contributed to the mishap: MP1 and MP2's failure to identify the excessive sink rate and their failure to arrest the excessive sink rate or go-around in a timely manner.

I developed my opinion by analyzing available flight data, the mishap animation, witness testimony, engineering analysis, Air Force directives and guidance, the data from the MA's

Removable Memory Module (RMM), Data Transfer and Diagnostic Systems (DTADS), Digital Flight Data Recorder (DFDR), and Cockpit Voice Recorder (CVR). Additionally, the AIB's pilot member used the C-130J-30 Weapon Systems Trainer (WST) simulator to recreate the mishap as well as fly multiple scenarios with various winds, gross weights, and maximum effort approach & landing speeds. While a Heads Up Display (HUD) video recording would have been useful in this investigation, the C-130J does not have that capability.

2. CAUSE

I find by a preponderance of evidence, the cause of the mishap was MP1's early engine power reduction (power pull), beginning at 70 feet AGL and fully FLT IDLE at 45 feet AGL. For a maximum effort landing, the start of the power pull should have occurred at approximately 20 feet AGL in conjunction with the flare in order to land in the center of the runway touchdown zone. Due to the aerodynamics of the C-130J, a reduction in power will exacerbate the sink rate due to the fact the C-130J propellers generate high velocity airflow over the wings, directly affecting lift.

On final approach at 150 feet AGL, the MA was stable in accordance with published guidance, at the calculated threshold speed of 116 KCAS, and had an adequate descent rate and flight path in order to land within the LZ markings on Runway 26. At 110 feet AGL, the MA had a good aim point, as announced by MP2. Shortly after, MP1 began slightly pitching down and the MA began increasing airspeed, reaching 120 KCAS. With the MA four knots fast and concerned with floating out of the LZ, MP1 then began the early power reduction at 70 feet AGL (4.5 seconds prior to touchdown). By 58 feet AGL (3.5 seconds prior to touchdown), the engine torque had decreased approximately 76% from 70 feet AGL and at 45 feet AGL the engines were fully FLT IDLE. The sink rate at 50 feet AGL was 810 FPM and peaked to 1005 FPM by 25 feet AGL. According to the DFDR, at 10 feet AGL (0.5 seconds prior to touchdown), MP1 did add power as directed by MP2; however, it was insufficient, resulting in the g-load exceedance (hard landing). The MA main landing gear impact was on the runway, but short of the painted LZ. The MA nose gear did not touchdown.

3. SUBSTANTIALLY CONTRIBUTING FACTORS

Two interrelated factors substantially contributed to this mishap, they are:

a. MP1 and MP2 Failure to Identify Excessive Sink Rate

The MP1 and MP2 failed to identify the MA excessive sink rate. Evidence illustrates that MP1 and MP2 had minimal, but an adequate amount of time and indications to identify the sink rate and make a go-around or arrest the sink rate between 50 feet AGL (3.0 seconds prior to touchdown) and 30 feet AGL (1.7 seconds prior to touchdown). At 110 feet AGL, MP2 observed the MP1's landing aim point (as indicated by the Climb Dive Marker (CDM)) and MP2 called "good aim point". DFDR evidence shows that MP1 began to pull the throttles to the FLT IDLE position at 70 feet AGL. The MA was descending at a normal 660 FPM on a 3.0-degree glide path—within typical approach parameters. The lack of HUD video evidence makes it difficult to identify exactly where MP1's aim point was when the MA began to pitch down between 85 to 65 feet AGL;

however, the early power pull in conjunction with a negative 2.3 degree pitch would cause the aim point to shift to the front and out of the LZ. From 70 to 50 feet AGL the sink rate increased to 810 FPM. At 30 feet AGL the sink rate was over 900 FPM and peaked to 1005 FPM at 25 feet AGL. MP1 began to flare at approximately 30 feet AGL and started adding power from 25 to 10 feet AGL (approximately one-third full power at 10 feet AGL). MC testimony, as well as the CVR and animation analyses, provided evidence that the excessive sink rate was not identified by MP2 until 30 feet AGL when the instantaneous sink rate was 980 FPM—1.7 seconds later the MA touched down at 834 FPM. The MC had 2.5 seconds from the engines at fully FLT IDLE to the MA's main landing gear touchdown on the runway at 834 FPM and short of the painted LZ markings. While the mishap approach transpired quickly, there was sufficient time, cues, and instrumentation available to MP1 and MP2 to identify and arrest the sink rate early enough to land within parameters or execute a go-around. The MC testimony confirmed MP2 did "shadow" both the throttles and yoke; however, since MP2 did not identify the excessive sink rate until 30 feet AGL, and with only 1.6 seconds to react, taking the controls at that altitude may have induced more errors in MP1's aircraft control.

The sensory cues (visual and vestibular sinking feeling/ground rush), the aim point (indicated by the HUD CDM) shifting closer to the front of the runway, and the rate of decrease in AGL altitude were available directly to MP1 and MP2 in order to identify the rapid sink rate prior to impact. The MC testified that the MA sink was felt from 50 to 30 feet AGL. Per testimony, MP2's visual scan/HUD crosscheck was "aim point, airspeed, RAD ALT." Because the C-130J lacks automated radar altimeter (RAD ALT) aural advisories, beginning at the 50 foot AGL callout, MP2's visual scan likely shifted and became focused mostly on the RAD ALT, failing to recognize the CDM/aim point shift. Likewise, MP1's breakdown in visual scan was a result of focus on maintaining threshold airspeed and failure to identify the CDM/aim point shift associated with the rapid sink rate. With the downward pitch attitude during the final five seconds to touchdown, the MA airspeed did not decrease significantly; therefore, the airspeed indicator alone would not have been an adequate indication of MP1's early power pull.

Note that MP3's crew position was the seat located between MP1 and MP2, immediately aft of the center flight deck console, commonly referred to as the "jump seat." This crew position on the C-130J-30 has no aircraft controls or instrumentation and typically is occupied by any extra crewmember to include Loadmasters. In this seat, the only cues and situational awareness tools on an approach are visual and/or vestibular senses, as well as viewing/referencing the Communication, Navigation, and Identification Unit on the center console and the Multi-Function Displays (MFDs) located on the main instrument panel. The MFDs can be difficult to view based on angle and distance from the seating position. Importantly, this position cannot view the pilot's HUD indications. ML was seated in the aft cargo compartment without access to instrumentation or controls at the time of the mishap. Both MP3 and ML testified that they felt the sink rate increase at approximately 50 to 30 feet AGL. While either MP3 or ML could have called the go-around, it is not reasonable to expect they would in this mishap based on the minimal reaction time and the limitations of their MA seating positions.

b. MP1 and MP2 Failure to Arrest Excessive Sink Rate Prior to Touchdown or Go-around in a Timely Manner Once Sink Rate Was Identified

Evidence supports that the MP1 and MP2 delayed the necessary actions to arrest the high sink rate or execute a go-around once the high sink rate was identified. By 30 feet AGL, MP2 should have immediately directed the go-around rather than an "add power" call to MP1 based on the CDM/aim point shift and corresponding sink rate. With the MA in FLT IDLE power and at an over 900 FPM sink rate, a significant power increase no lower than 30 feet AGL was required in order to safely touchdown within limits or execute go-around procedures. In the C-130J-30 Weapon Systems Trainer (WST), attempts by the board pilot member to arrest the sink rate and land within parameters and/or go-around were successful at 30 feet AGL and above. Note that in the WST the go-around or landing attempt with a high sink rate was anticipated by the pilot member and therefore the action was immediate with a drastic and aggressive throttle increase. Below 30 feet AGL, the aircraft exceeded g-load and sink rate limits regardless of throttle and control inputs.

At 30 feet AGL (1.7 seconds prior to touchdown), MP1 attempted to correct the high sink rate as indicated by an increasing elevator input, but without the necessary power increase. Simultaneously, MP2 identified the high sink rate (through vestibular/visual sensory "sinking" feeling and not the aim point shift) and directed MP1 to add power. Evidence verifies that the MA remained at FLT IDLE at 25 feet AGL (1.5 seconds prior to touchdown). By 25 feet AGL, in FLT IDLE, the sink rate peaked at 16.75 feet per second or 1005 FPM; at 10 feet AGL (0.5 seconds prior to touchdown), MP1 had the throttles only set at approximately 1/3 of full power—untimely and inadequate to decrease the sink rate to C-130J limits. MP1 testified concern about adding too much power and floating out of the LZ or having to go-around, which likely resulted in the delayed and insufficient power increase. Immediately upon impact with the runway, MP2 called/directed the go-around—unquestionably too late to prevent the mishap.

4. OTHER ITEMS FOR DISCUSSION

The board considered several factors as possibly contributing to the mishap. What follows is a brief explanation of other items the board considered, but these factors were not classified as substantially contributing factors to this mishap.

a. Minimal Local Training at Ramstein AB

The 37 AS operations tempo, supporting both United States Air Forces in Europe and Air Forces Africa missions, leaves less time and opportunities dedicated to local area training, which is particularly important for less experienced aircrew. Several 37 AS witnesses testified that dedicated training sorties have lower priority than operational missions, resulting in fewer training sorties. The lack of local training sorties, combined with local area restrictions, make it difficult to practice critical combat airlift skills, to include maximum effort takeoffs, approaches, and landings. Experienced instructor pilot (IP) and evaluator pilot (EP) witnesses, with assignments at other C-130J units, testified that the operational tempo supporting contingency operations is greater at the 37 AS than their previous squadrons. In addition, airspace restrictions in Germany were highlighted as a significant limitation in conducting tactical mission flight training as compared to stateside C-130J units.

b. Lack of Local LZ

Several witnesses testified that the lack of a local landing zone (LZ) on Ramstein AB is a significant limitation to training and proficiency on maximum effort takeoffs and landings. Ramstein AB Runway 26/08 is 10,497 feet long 148 feet wide with painted, simulated LZs on both ends of the runway. The painted LZ on both approach ends of these runways are 60 feet wide by 500 feet long to simulate a LZ. Witness testimony by senior IP's and EP's remarked that the use of the painted zones does not provide realistic training for assault landings and takeoffs. The nearest real-world LZs are located an average of 45 minutes to 1 hour of cruise flight away. The transition time to and from the remote LZs reduces the amount of time available for practicing critical phases of flight such as maximum effort takeoffs, approaches, and landings. Additionally, weather conditions, fuel load/cargo weight, and scheduled training profiles can limit LZ training time at geographically remote locations other than Ramstein AB.

c. DTADS Software Limitation

On 30 March 2018, Lockheed Martin Engineering released a Corrective Action Plan (CAP) regarding DTADS Hard Landing Detection. The CAP noted that an investigation revealed an error in the hard landing detection algorithm in which the DTADS software required an "AND" condition for both "Maximum Sink Rate" and "Reduced Sink Rate." A maximum sink rate landing exceedance is defined as a landing sink rate greater than 9.0 feet per second (FPS). A reduced sink rate landing exceedance is greater than 5 FPS *when* the aircraft is in a non-optimal operating weight area or in secondary fuel management. The CAP confirmed the correction to the software algorithm to an "OR" condition, as either condition is sufficient to independently generate a hard landing exceedance. Subsequently, under TCTO 1C-130J-1048, Supplement D, the aircraft DTADS software was updated to the latest version on 28 August 2019; however, 86 MXG personnel failed to update the Desktop Debrief Workstation Computer (DDWC), which computes and generates post-flight reporting. The DDWC did not receive the software update until 15 May 2020. The detection of the MA landing exceedance (hard landing) during the maintenance debrief process was solely dependent upon the MC reporting it. Failure to update the DDWC is not a substantially contributing factor to this mishap; however, early detection of landing exceedances experienced by the MA would enable proper application of aircraft operating restrictions and would have started the safety and AIB processes in a more timely manner.

Evidence showed that the MA did experience one previous sink rate exceedance of 5.165 FPS (309.9 FPM) with an allowable limit of 5.0 FPS (300 FPM) for the aircraft's gross weight on 20 March 2014, which was not captured by the maintenance personnel due to the software limitation. In addition, there were no g-load exceedances captured by DTADS prior to the mishap sortie; therefore, with only one previous minor sink rate exceedance and no previous g-load exceedance, there is no evidence to support any unidentified exceedances caused damage to the degree it would weaken aircraft structural components or contributed to the damages of the MA.

d. Weather Not Listed as Substantially Contributing Factor

The board thoroughly discussed potential weather impact after the MC testimonies referenced a possible wind shift and subsequent tailwind at 30 to 50 feet AGL on the mishap landing; however, the board did not find evidence of a significant wind shift to a tailwind that would have substantially contributed to the mishap. Evidence indicates that the winds were no greater than 6 knots on the tail of the MA. A tailwind could cause an aircraft to land long past the LZ and/or cause an increased decent rate without proper energy management (pitch/throttle control); however, wind speeds recorded the day of the mishap were no greater than 7 knots and well within limits for the C-130J. Analyzing a 10-minute window at the time of the mishap reveals that the winds were performance enhancing, shifting from tailwind to a headwind. Furthermore, several profiles in the C-130J-30 WST were flown with worst-case winds, to include a sudden shift in winds resulting in a loss of 4 knots of airspeed in which the pilot member was able to compensate for the shift. Forecast, observed, and recorded weather for the day of the mishap did not significantly impact a safe maximum effort approach and landing to Runway 26. Additionally, to summarize the testimony by the on-duty weather officer, weather was good with nothing indicating gusty or drastically shifting winds; therefore, the board concluded that the weather did not substantially contribute to the mishap.

5. CONCLUSION

I find by a preponderance of evidence, the cause of the mishap was MP1's early engine power reduction (power pull), beginning at 70 feet AGL and fully FLT IDLE at 45 feet AGL. In addition, I find, by the preponderance of evidence, that MP1 and MP2's failure to identify the excessive sink rate and their failure to arrest the excessive sink rate or go-around in a timely manner were substantially contributing factors that resulted in the MA exceeding the C-130J-30 g-load and sink rate landing limits.

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INDEX OF TABS