Steep Climb and Uncontrolled Descent During Takeoff
National Air Cargo, Inc., dba National Airlines
Boeing 747 400 BCF, N949CA
Bagram, Afghanistan
April 29, 2013

Accident Report

NTSB/AAR-15/01
PB2015-104951

National Transportation Safety Board

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National
Transportation
Safety Board

490 L'Enfant Plaza, S.W.
Washington, D.C. 20594

National Transportation Safety Board. 2015. ***Steep Climb and Uncontrolled Descent During Takeoff National Air Cargo, Inc., dba National Airlines, Boeing 747 400 BCF, N949CA, Bagram, Afghanistan, April 29, 2013*. Publication Type NTSB/AAR-15/01. Washington, DC.**

Abstract: This report discusses the April 29, 2013, accident involving a Boeing 747-400 BCF, N949CA, operated by National Air Cargo, Inc., dba National Airlines, which crashed shortly after takeoff from Bagram Air Base, Bagram, Afghanistan. All seven crewmembers—the captain, first officer, loadmaster, augmented captain and first officer, and two mechanics—died, and the airplane was destroyed from impact forces and postcrash fire. Safety issues relate to National Airlines' deficient procedures for restraining special cargo loads; inadequate Federal Aviation Administration (FAA) guidance for operators for restraining special cargo loads; the lack of FAA certification for cargo handling personnel and, thus, a lack of standardized procedures, training, and duty hour limitations and rest requirements for personnel who perform the safety-critical functions of loading and securing cargo; inadequate training and guidance for FAA inspectors who have oversight responsibilities for air carrier cargo handling operations; and the ability to defer nonresourced FAA surveillance items without limitation. Safety recommendations are addressed to the FAA.

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Abbreviations

AC	advisory circular
ACAT	acquisition categories
AMC	Air Mobility Command
APB	aft pressure bulkhead
ASAP	aviation safety action program
ATC	air traffic control
ATOS	air transportation oversight system
BS	body station
CBT	computer-based training
CFR	*Code of Federal Regulations*
CFT	cargo focus team
CG	center of gravity
CVR	cockpit voice recorder
DoD	Department of Defense
FAA	Federal Aviation Administration
FCOM	flight crew operating manual
FDR	flight data recorder
FLM	front line manager
FOQA	flight operations quality assurance
FSDO	flight standards district office
Hg	inches of mercury
IATA	International Air Transport Association
JCAT	Joint Combat Assessment Team

LOSA	line operations safety audit
M-ATV	MRAP all-terrain vehicles
MoTCA	Ministry of Transportation and Civil Aviation
MOU	memorandum of understanding
MRAP	mine-resistant ambush-protected
NAC	National Air Cargo
NACA	National Air Carrier Association
NPG	National Work Program Guidelines
NTSB	National Transportation Safety Board
PA	performance assessment
PAI	principal avionics inspector
PCU	power control units
PIC	pilot-in-command
P-items	planned surveillance work activity items
PMI	principal maintenance inspector
POI	principal operations inspector
PTRS	program tracking and reporting system
R-items	required surveillance work activity items
RNA	resources not available
SAFO	safety alert for operators
SAT	safety action team
SIC	second-in-command
SMS	safety management system
SOP	standard operating procedure
STC	supplemental type certificate

TRC tall rigid cargo

UAE United Arab Emirates

ULD unit load devices

Executive Summary

On April 29, 2013, about 1527 local time, a Boeing 747-400 BCF, N949CA, operated by National Air Cargo, Inc., dba National Airlines, crashed shortly after takeoff from Bagram Air Base, Bagram, Afghanistan. All seven crewmembers—the captain, first officer, loadmaster, augmented captain and first officer, and two mechanics—died, and the airplane was destroyed from impact forces and postcrash fire. The 14 *Code of Federal Regulations* Part 121 supplemental cargo flight, which was operated under a multimodal contract with the US Transportation Command, was destined for Dubai World Central - Al Maktoum International Airport, Dubai, United Arab Emirates.

The airplane's cargo included five mine-resistant ambush-protected (MRAP) vehicles secured onto pallets and shoring. Two vehicles were 12-ton MRAP all-terrain vehicles (M-ATVs) and three were 18-ton Cougars. The cargo represented the first time that National Airlines had attempted to transport five MRAP vehicles. These vehicles were considered a special cargo load because they could not be placed in unit load devices (ULDs) and restrained in the airplane using the locking capabilities of the airplane's main deck cargo handling system. Instead, the vehicles were secured to centerline-loaded floating pallets and restrained to the airplane's main deck using tie-down straps. During takeoff, the airplane immediately climbed steeply then descended in a manner consistent with an aerodynamic stall. The National Transportation Safety Board's (NTSB) investigation found strong evidence that at least one of the MRAP vehicles (the rear M-ATV) moved aft into the tail section of the airplane, damaging hydraulic systems and horizontal stabilizer components such that it was impossible for the flight crew to regain pitch control of the airplane.

The likely reason for the aft movement of the cargo was that it was not properly restrained. National Airlines' procedures in its cargo operations manual not only omitted required, safety-critical restraint information from the airplane manufacturer (Boeing) and the manufacturer of the main deck cargo handling system (Telair, which held a supplemental type certificate [STC] for the system) but also contained incorrect and unsafe methods for restraining cargo that cannot be contained in ULDs. The procedures did not correctly specify which components in the cargo system (such as available seat tracks) were available for use as tie-down attach points, did not define individual tie-down allowable loads, and did not describe the effect of measured strap angle on the capability of the attach fittings.

In addition to National Airlines' deficient procedures for restraining special cargo loads, the NTSB found several additional areas of safety concern:

- Current Federal Aviation Administration (FAA) guidance for operators for restraining special cargo loads is inadequate. FAA Advisory Circular 120-85 contains guidance that conflicts with the safety requirements for using procedures based only on airplane manufacturer, STC-holder, or other FAA-approved data.
- Cargo handling personnel are not FAA-certificated; thus, there are no standardized procedures, training, and duty hour limitations and rest requirements for personnel

who perform the safety-critical functions of loading and securing cargo. The accident loadmaster did not have adequate procedures for securing the special cargo load, and his training was provided by National Airlines, which had developed the inadequate procedures. He had also been on continuous duty for about 21 hours at the time of the accident.

- FAA inspectors who have oversight responsibilities for air carrier cargo handling operations do not have adequate training and guidance to ensure appropriate oversight of operators that transport special cargo loads. The inspectors assigned to National Airlines were unaware of the airline's deficient procedures. After the accident, the FAA initiated extensive and ongoing action, including improving inspector training, developing inspector job aids, and establishing a permanent cargo focus team to provide inspectors with direct technical validation of operator cargo procedures, documents, and support for technical decisions related to cargo.
- Nonresourced FAA surveillance items can be deferred without limitation. FAA inspectors were unable to perform any en route inspections of National Airlines' operations overseas because of State Department restrictions on inspector travel into Afghanistan. However, current FAA policy specifies no alternative inspector activities that could help mitigate risks for an operator until the surveillance tasks can be completed.

The NTSB determines that the probable cause of this accident was National Airlines' inadequate procedures for restraining special cargo loads, which resulted in the loadmaster's improper restraint of the cargo, which moved aft and damaged hydraulic systems Nos. 1 and 2 and horizontal stabilizer drive mechanism components, rendering the airplane uncontrollable. Contributing to the accident was the FAA's inadequate oversight of National Airlines' handling of special cargo loads.

After the accident, the FAA, National Airlines, and the National Air Carrier Association (NACA) took numerous actions to enhance safety both at National Airlines and across the cargo industry.[1] Many of these actions are ongoing and directly address operator procedures for, FAA oversight of, and industry knowledge about the proper restraint and aircraft limitation considerations for securing heavy vehicle special cargo loads. Boeing also revised some of its manuals and publications and participated in NACA outreach efforts.

In addition, as a result of this accident investigation, the NTSB issues six safety recommendations to the FAA. These safety recommendations address FAA guidance for operators that handle special cargo loads; certification, training, and duty hour limitations for personnel responsible for the loading, restraint, and documentation of special cargo loads on transport-category airplanes; and FAA inspector training, oversight, and surveillance responsibilities.

[1] NACA is comprised of 16 air carriers that provide nonscheduled and scheduled passenger and cargo services, including services that support the US military. NACA members are National Airlines, Air Transport International, Allegiant Air, Atlas Air, Eastern Air Lines, Everts Air Cargo, Kalitta Air, Lynden Air Cargo, Miami Air International, Northern Air Cargo, Omni Air International, Southern Air, Spirit Airlines, Sun Country Airlines, USA Jet Airlines, and Western Global Airlines.

1. Factual Information

1.1 History of Flight

On April 29, 2013, about 1527 local time, a Boeing 747-400 BCF, N949CA, operated by National Air Cargo, Inc., dba National Airlines, crashed shortly after takeoff from Bagram Air Base, Bagram, Afghanistan.[2] All seven crewmembers—the captain, first officer, loadmaster,[3] augmented captain and first officer, and two mechanics—died, and the airplane was destroyed from impact forces and postcrash fire.[4] The 14 *Code of Federal Regulations* (CFR) Part 121 supplemental cargo flight was destined for Dubai World Central - Al Maktoum International Airport, Dubai, United Arab Emirates (UAE).

Before the accident flight, the airplane had arrived at Bagram about 1353 after an approximate 1.7-hour flight from Camp Bastion, Afghanistan.[5] According to the load manifest, before the airplane left Camp Bastion, ground personnel from National Air Cargo (NAC) loaded its main deck with about 207,500 lbs of cargo. The cargo included five mine-resistant ambush-protected (MRAP [pronounced *EM-rap*]) vehicles that NAC personnel had secured onto pallets and shoring. Two vehicles were 12-ton MRAP all-terrain vehicles (M-ATVs [pronounced *MAT-vee*]) and three were 18-ton Cougars. One M-ATV was positioned forward of the three Cougars, and the other M-ATV was positioned at the rear (see figures 1, 2, and 3).

[2] National Air Cargo, Inc., dba National Airlines, was one of two subsidiaries of National Air Cargo Holdings; National Air Cargo was the other. See section 1.10 for more information. The investigation was originally led by the Afghanistan Ministry of Transportation and Civil Aviation (MoTCA), which appointed an investigator-in-charge. The National Transportation Safety Board (NTSB) assigned a US accredited representative under the provisions of International Civil Aviation Organization Annex 13, representing the State of Manufacture and Operator, to assist in the investigation. In October 2014, the MoTCA delegated the investigation to the NTSB.

[3] The position of loadmaster is not defined by the Federal Aviation Administration, but the term is commonly used in the cargo industry. According to National Airlines, a loadmaster is responsible for performing airplane weight and balance calculations, inspecting cargo and pallets, and ensuring that items are secured properly with the provided restraints or supplemental restraints. See section 1.10.1 for more information.

[4] The augmented flight crew (the four pilots together were known as a "heavy crew") and the sleeping quarters on board the airplane enabled National Airlines to schedule a 30-hour duty day for the pilots, as specified in 14 CFR 121.523.

[5] The flight from Camp Bastion was originally planned with Dubai as its destination, but the airline could not obtain an overflight permit for Pakistan. Dispatchers instead planned for the flight to fly from Camp Bastion to Bagram and then continue to Dubai.

Photograph courtesy of NAC.

Figure 1. Photograph of one of two M-ATVs (secured by chains to its respective pallet) during loading onto the accident airplane via a side door aft of the left wing.

Photograph courtesy of Sarah Lipfird

Figure 2. Photograph of one of three Cougars (secured by chains to its respective double-pallet platform) during loading onto the accident airplane via a side door aft of the left wing.

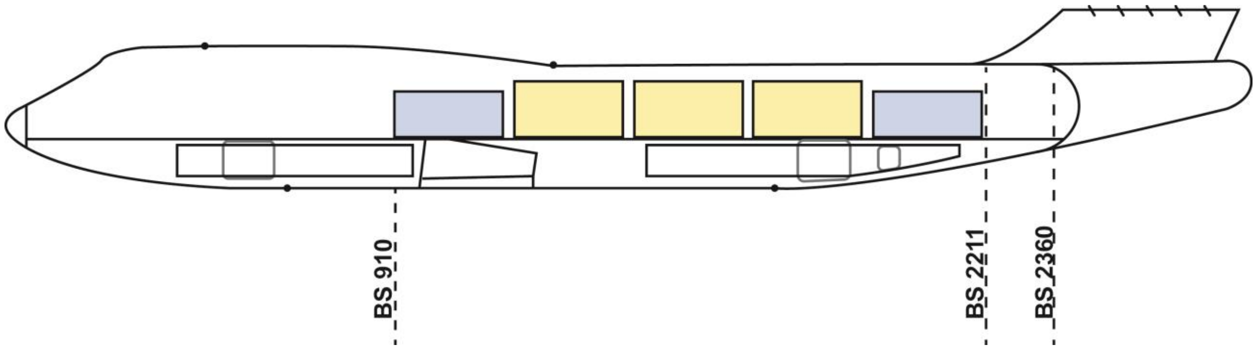


Figure 3. Diagram showing the loaded positions of the two M-ATVs (blue) and three Cougars (yellow) with respect to select airplane body station (BS) locations.

Note: All of the vehicles were loaded facing forward. All depicted locations are approximate. The back of the rear M-ATV was located about BS 2211, and the front of the forward M-ATV was about BS 910. BS 2360 corresponds with the location of the airplane's aft pressure bulkhead.[6]

All of the vehicle/pallet units were loaded into the center of the airplane's main deck as centerline-loaded pallets. According to the NAC loaders at Camp Bastion, the pallets were loaded about 3 to 4 inches apart, and no main deck floor locks were used on any of the vehicle/pallet units; each vehicle was restrained to the airplane's main deck with 5,000-lb-rated straps.[7] According to the NAC loaders, the loadmaster (a National Airlines employee) told them to use 24 tie-down straps to secure each M-ATV and 26 straps to secure each Cougar. The NAC operations specialist said that, before the airplane left Camp Bastion, he walked the main deck with the loadmaster to inspect the securing of the cargo. He said that he did not see the pilots inspect the load.

The flight from Camp Bastion to Bagram was the first experience that the captain, first officer, and loadmaster had with heavy vehicle special cargo at National Airlines and was the first time that the airline had ever transported any Cougars. After the airplane arrived at Bagram, it remained parked on the ramp for about 1.5 hours and was refueled but took on no additional cargo. An NAC ground crew met the airplane during refueling but did not enter the airplane. NAC personnel spoke only with the loadmaster at the entrance of the main deck door.

According to the cockpit voice recorder (CVR) transcript, while the airplane was parked on the ramp, crewmembers discussed that some cargo had moved, some tie-down straps had become loose, and one strap had broken sometime during the flight from Camp Bastion to Bagram.[8] About 1428, the first officer brought it to the captain's attention that "one of

[6] On this airplane, the BS numbers correspond with the body arm, which is a true measure in inches from the reference datum 90 inches forward of the airplane's nose.

[7] The floor locks were not designed to secure the centerline-loaded pallets, which were considered a special cargo load. For more information about centerline-loaded pallets and special cargo loads, see section 1.3.1.

[8] The quoted comments are excerpted from the CVR transcript and may contain editorial revisions, such as punctuation, capitalization, and ellipses to denote words omitted for brevity. Parentheses in the quoted material indicate a questionable word insertion, as indicated in the CVR transcript. The CVR transcript is available in the public docket for this accident and is attached as an appendix to this report. The flight data recorder data for the flight from Camp Bastion to Bagram showed some perturbations in the recorded flight parameters, particularly

those…straps is busted," and they discussed a "knot." The first officer described that there were "a bunch" of straps to keep the cargo from moving forward and "a bunch" to keep it from moving backward and stated that "all the ones that were keeping 'em from movin' backwards were all…loose." The augmented captain made some joking statements, and, about 1429, the captain stated, "I hope…rather than just replacing that strap, I hope he's beefing the straps up more." The first officer stated, "he's cinching them all down." About 15 minutes later, the loadmaster joined the conversation. The captain asked, "how far did it move?" The loadmaster responded that "they just moved a couple inches." The captain commented, "that's scary" and "without a lock (for those big heavy things/anything) man, I don't like that." The captain then stated, "I saw that, I was like…I never heard of such a thing." He later stated, "those things are so…heavy you'd think, though, that they probably wouldn't hardly move no matter what." The loadmaster replied, "They always move….Everything moves. If it's not strapped." The transcript contained no further discussion about the straps or cargo.

About 1515, the air traffic control (ATC) ground controller cleared the flight to taxi to runway 3. According to interviews with ATC personnel, the airplane taxied out normally. The CVR transcript showed a division of duties consistent with the first officer acting as pilot flying and the captain acting as the pilot monitoring. At 1525:47, the first officer acknowledged the flight's takeoff clearance. The CVR captured a sound similar to engines increasing speed, and, at 1526:38, the captain said "rotate," followed 6 seconds later by "positive climb." At 1526:45, the first officer said, "gear up," and the recording ended 2 seconds later (about 30 seconds before the airplane crashed).[9] ATC personnel in the control tower east of runway 3 stated that the airplane's rotation appeared normal, and the rotation occurred near the taxiway C intersection (see figure 4).

during the airplane's descent, but there were no unusually excessive G loads. The vertical acceleration values ranged from 0.6 G to 1.4 G, and the maximum longitudinal deceleration value was -0.3 G, which occurred during landing.

[9] Both the CVR and the flight data recorder (FDR) stopped recording shortly after the airplane rotated. Under normal operations, both recorders (each of which is powered by a separate electrical bus) capture data when electrical power is supplied to the unit (typically an entire flight from airplane startup to power-down). More information about the CVR and FDR is provided in section 1.6. Analysis of the cessation of the recordings is discussed in section 2.2.2.

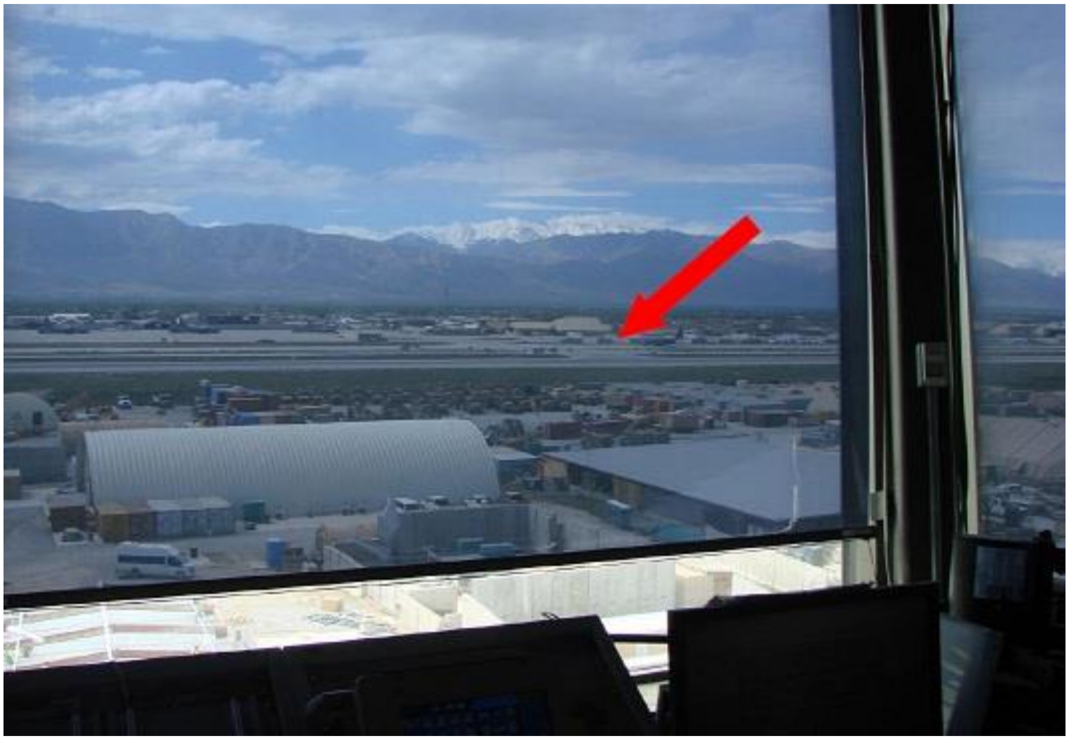


Figure 4. Photograph showing the view from the Bagram control tower looking west toward runway 3.

Note: The accident airplane departed to the north (from left to right). The red arrow indicates the location of the taxiway C intersection, near where the airplane reportedly rotated.

A dashboard camera from a moving ground vehicle captured video images of the airplane after rotation that showed it in a steep climb with a high pitch attitude before it reached its highest point and entered a roll to the right.[10] At the time of the airplane's right roll, the camera captured audio similar to engine thrust noise. The images showed that the airplane then began a rapid descent as it rolled back to the left then struck the ground in a nose-down and nearly wings-level attitude. One witness who saw the airplane from the east side of the airport reported seeing "a stream" of white "smoke" with "small puffs" trailing behind the airplane before it stopped climbing. ATC personnel did not see any smoke.

The airplane struck the ground about 590 ft northeast of the departure end of runway 3. A sweep of the runway after the accident found pieces of debris on runway 3 in the area of taxiway C that included small pieces of airplane fuselage skin, a segment of hydraulic return tubing, a piece of the E8 rack (which provides a shelf for the airplane's CVR and flight data recorder [FDR] inside the back of the airplane), and part of a M-ATV antenna assembly. These debris pieces are discussed further in section 1.7. Other pieces of debris were found along the length of the runway (see figure 5).

[10] Images from the dashboard camera and two security cameras were also used in a study that determined the airplane's landing gear configuration during the flight. See section 1.9.1 for more information.

Figure 5. Overview image of runway 3 with locations of parts debris and the main wreckage noted.

Note: The yellow arrow depicts north. The airplane departed from left to right.

1.2 Personnel Information

1.2.1 Captain

The captain, age 34, held an airline transport pilot certificate for multiengine land airplanes with type ratings for the Boeing 747-400 series and DC-8 airplanes (circling approach only in visual meteorological conditions for both types). His first-class airman medical certificate was issued May 24, 2012, with the limitation of "must wear corrective lenses." He also held a flight instructor certificate for airplane single-engine land and instrument airplane, and a commercial pilot certificate for airplane single-engine, multiengine, and instrument airplane. According to National Airlines, the captain had about 6,000 hours total flying time, which included about 4,700 hours pilot-in-command (PIC) time, of which about 440 hours were Boeing 747-400 PIC time. The captain had flown 14 hours within the preceding 24 hours and had flown 74 hours within the preceding 30 days. The captain had no previous experience with MRAP vehicle cargo at National Airlines before the flight from Camp Bastion to Bagram and the accident flight.

The captain was hired by National Airlines on June 3, 2004. He had been flying the Boeing 747-400 since June 22, 2012, after previously serving as captain on the DC-8. The captain's most recent PIC line check was August 10, 2012, and his most recent proficiency check was July 22, 2012. The National Airlines check airman who gave the captain his most recent proficiency check described him as well prepared, dedicated, and excellent in his training.

A review of Federal Aviation Administration (FAA) records for the captain found no previous accident, incident, or enforcement actions, and a search of the National Driver Registry found no history of driver license revocation or suspension.

The day before the accident, the captain was scheduled to operate as part of a "heavy crew" of two captains and two first officers flying three segments for a total duty of 25 hours 4 minutes with a total block time of 14 hours 11 minutes. The captain had been on duty for about 21 hours at the time of the accident, having completed the first two flight segments for a total block time of 10 hours 41 minutes. The flight segments, which were revised, consisted of a flight from Chateauroux, France, to Camp Bastion then continuing to Bagram with the final leg (the accident flight) to Dubai.

1.2.2 First Officer

The first officer, age 33, held a commercial pilot certificate for multiengine land airplanes with second-in-command (SIC) privileges for the Boeing 747-400 series and DC-8 airplanes (circling approach only in visual meteorological conditions for both types). His first-class airman medical certificate was issued March 23, 2013, with no limitations. He also held a flight instructor certificate for airplane single-engine land, multiengine land, and instrument airplane; ground instructor certificates for advanced and instrument; an airframe and powerplant mechanic certificate; and a flight engineer certificate for turbojet-powered aircraft. According to National Airlines, the first officer had about 1,100 hours total flying time, which included about 451 hours PIC time and 209 hours SIC time in the Boeing 747-400. The first officer had flown 14 hours within the preceding 24 hours and had flown 71 hours within the preceding 30 days. The first officer had no previous experience with MRAP vehicle cargo at National Airlines before the flight from Camp Bastion to Bagram and the accident flight.

The first officer was hired by National Airlines on February 23, 2009. He had been flying as a first officer on the Boeing 747-400 since July 20, 2012, after previously serving as a first officer on the DC-8. The first officer's most recent line check was April 13, 2013, and his most recent proficiency check was October 10, 2012. The National Airlines check airman who gave the first officer his initial Boeing 747-400 simulator training described the first officer as very well prepared. Two National Airlines captains who had flown with the first officer stated that his monitoring skills were great and that he had good flying skills for his low pilot time.

A review of FAA records for the first officer found no previous accident, incident, or enforcement actions, and a search of the National Driver Registry found no history of driver license revocation or suspension.

The first officer had the same schedule as the captain from the day before the accident up to the accident.

1.2.3 Loadmaster

The loadmaster, age 36, was hired by National Airlines on November 22, 2010. He previously worked as a ground handling supervisor/trainer for CP Deliveries from 2004 until

November 2010. He had no previous experience at National Airlines with MRAP vehicle cargo before the flight from Camp Bastion to Bagram and the subsequent accident flight.

According to company records, the loadmaster's most recent recurrent line evaluation was performed by a National Airlines check loadmaster on the accident airplane on December 16, 2012, on flight segments between stops at Riga, Latvia; McGuire Air Force Base in New Jersey; and Ramstein Air Base in Germany.[11] The evaluation included tie-down restraint criteria and calculations, shoring (load-spreading) criteria and computations, and cargo conveyance/restraint systems operation. The loadmaster's overall performance was graded as satisfactory.

The loadmaster's most recent training was a 1-day training session on May 8, 2012, for the Boeing 747-400 computerized weight and balance system. Between January 5 and 9, 2012, the loadmaster attended Boeing 747-400 cargo training that included a review of a cargo handling DVD from Telair (the manufacturer of the airplane's main deck cargo handling system), Boeing 747-400 aircraft familiarization, and Boeing 747-400 weight and balance training. He attended a 3-day loadmaster recurrent training course between December 1 and 3, 2011, and initial training from December 6 to 14, 2010. (Section 1.10.3 provides more information about National Airlines' loadmaster training.)

The loadmaster had the same schedule as the flight crew from the day before the accident up to the accident.

1.3 Airplane Information

1.3.1 General Configuration and Cargo Handling Equipment

The Boeing 747-400 BCF, known as a Boeing Converted Freighter, was a Boeing 747-400-series passenger airplane that had been modified in accordance with FAA-approved Boeing Service Bulletin 747-00-2004 to operate in a freighter configuration. The airplane was equipped with crew rest facilities and a Telair main deck cargo handling system as specified in supplemental type certificate (STC) ST00459LA5.

The Telair cargo restraint equipment included pallet locks, side guide restraints, centerline guide restraints, and retractable and fixed-end stops. All cargo restraining equipment was installed in seat tracks or floor fittings or within other cargo components. Caster trays in the floor had a 4-inch channel that housed 1.25-inch roller bearings, each of which was in a 4-inch, circular housing. The restraining system was designed to lock unit load devices (ULDs) in place to prevent forward, aft, vertical, or lateral movement (see figure 6).[12] Generally, cargo loaded in an approved ULD can be secured using the cargo handling system's locking hardware and does not require the use of tie-down straps.

[11] There are no FAA requirements for loadmaster evaluations. The line evaluations were developed by National Airlines and conducted periodically to assess the performance of the loadmasters.

[12] A ULD is a container used to load luggage, freight, and mail on wide-body aircraft and specific narrow-body aircraft. ULDs enable cargo to be placed into standard-size units to facilitate rapid loading onto and unloading from aircraft with compatible handling and restraint systems that interface directly with the ULD.

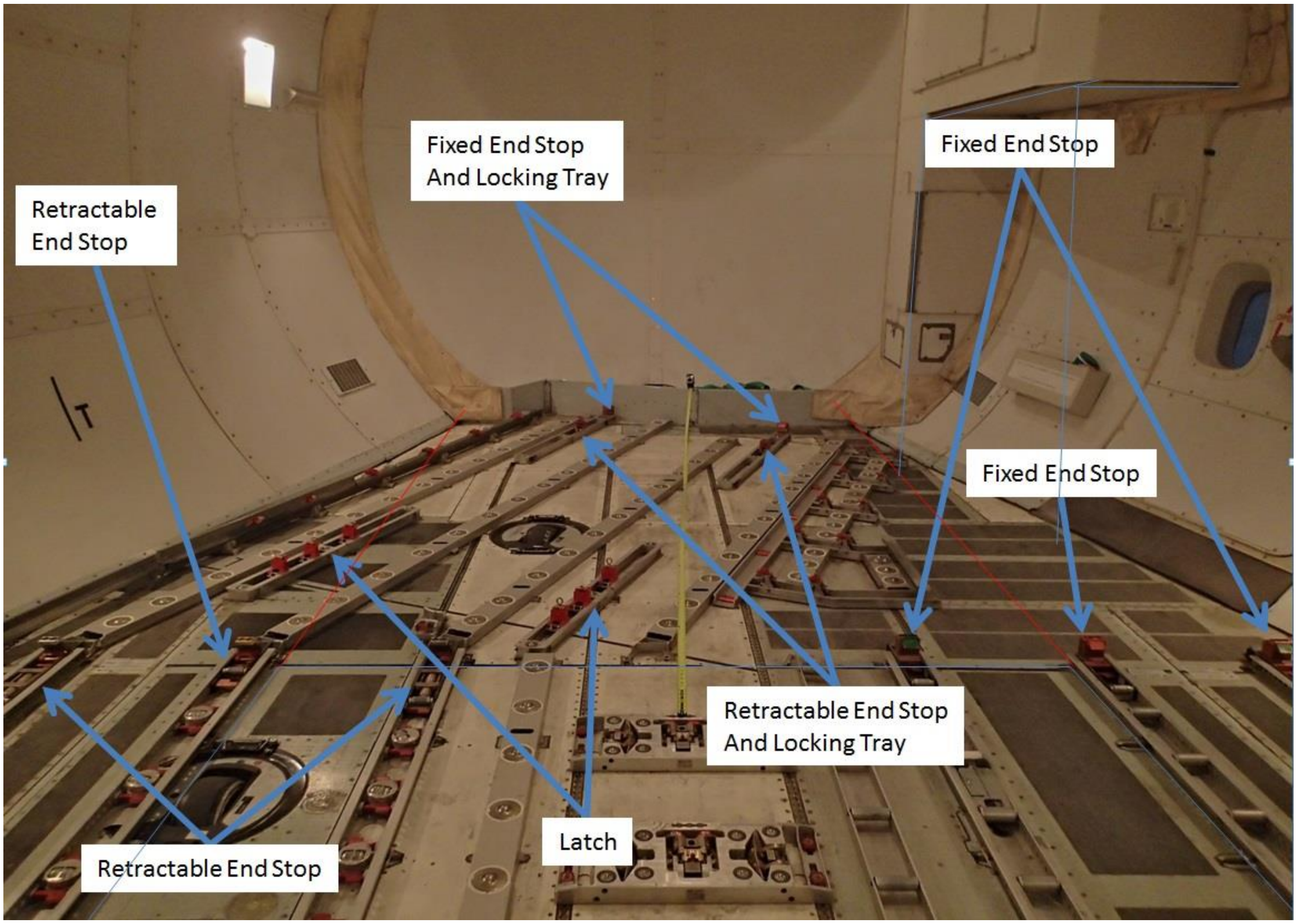


Figure 6. Photograph of a section of main deck flooring in the back of an exemplar airplane, looking aft.

Note: The locations of various fixed and retractable end stops and latches of the cargo handling system are noted with blue arrows. Note: The CVR and FDR shelf is in the upper right corner of the picture.

The accident flight's MRAP vehicle cargo (which was secured to G-code pallets and centerline-loaded) was considered a heavy vehicle special cargo load because its size precluded use of ULD containers capable of locking into the airplane's cargo handling system.13 Such cargo instead required special handling or restraint devices such as approved tie-down straps secured to approved locations in the main cargo deck floor (see figure 7).

[13] G code refers to pallet size. The pallets were 238.5 inches long and 96 inches wide.

Photograph courtesy of Telair

Photograph courtesy of FedEx

Figure 7. Photographs of other operators' airplanes showing an exemplar special cargo load (left) secured to floor structures using straps and an exemplar ULD (right) secured by integrated locking devices.

National Airlines' weight and balance calculations for the accident flight recorded that the cargo weight was 207,497 lbs, the airplane's takeoff weight was 675,296 lbs, and the airplane's takeoff center of gravity (CG) was 30.4%. Published limitations for the airplane indicated that the maximum takeoff weight was 870,000 lbs, and the takeoff CG range limits were 15.5% to 33%.

National Airlines maintained the airplane under a continuous airworthiness maintenance program authorization, and the airline retained pertinent aircraft, engine, and component records using both manual and electronic methods. At the time of the accident, the airplane had accumulated 76,940 hours and 10,813 cycles. A review of maintenance records for the airplane found no anomalies in the available documentation.

1.3.2 Hydraulic Systems and Flight Controls

The Boeing 747-400 BCF airplane has four functionally independent hydraulic systems that operate at 3,000 psi. Hydraulic power is used to actuate various flight control systems (elevator control, rudder control, ailerons, and horizontal stabilizer actuator) except leading edge flaps. Hydraulic power is also used to extend and retract the airplane's landing gear. In the event of a hydraulic system failure, some flight controls (including elevators and ailerons) associated with the failed system will move to their float position based on airplane configuration and atmospheric conditions. Landing gear associated with a failed system will not function as commanded.

The main components for each hydraulic system are located in the nacelle area above and aft of each engine. Each hydraulic system also has components in the airplane's empennage, aft of the aft pressure bulkhead (APB), to power flight control systems in the back of the airplane (for example, the elevators and horizontal stabilizer). Tubing for supply and return for each system runs longitudinally below or near the main cargo deck floor and through the APB to reach the components in the back of the airplane.

Pitch attitude of the airplane is controlled by the elevators and the variable incidence horizontal stabilizer. The elevator control system is operated manually by movement of the control columns, which actuate the power control units (PCUs) located in the horizontal stabilizer. The control columns are connected to the elevator PCUs by a series of cables, pulleys, and torque tubes that run from the flight deck, along the top of the fuselage, and to the elevators. The PCUs are powered by the hydraulic systems. The left outboard elevator is powered by hydraulic system No. 1, the left inboard elevator is powered by systems Nos. 1 and 2, the right inboard elevator is powered by systems Nos. 3 and 4, and the right outboard elevator is powered by system No. 4.

1.4 Meteorological Information

According to airport weather observations at Bagram, about 1525, wind was from 020° at 7 knots, few clouds at 4,000 ft, a broken ceiling of cumulonimbus clouds at 8,000 ft and broken clouds at 15,000 ft, temperature 18° C, dew point 6° C, and altimeter 29.94 inches of mercury (Hg). The remarks noted a peak wind from 060° at 26 knots at 1435, a wind shift at 1457, and distant lightning and cumulonimbus clouds to the northwest.

The weather observation for 1528 indicated wind from 350° at 11 knots gusting to 17 knots, few clouds at 5,000 ft, a broken ceiling of cumulonimbus clouds at 8,000 ft and a broken ceiling at 15,000 ft, temperature 14° C, dew point 5° C, and altimeter 29.93 Hg. The remarks noted distant lightning to the northwest.

1.5 Airport Information

Located near the city of Bagram in the Parwan Province of Afghanistan, Bagram Airfield is the largest US military base in Afghanistan. The field elevation is 4,895 ft above mean sea level, and runway 3/21, its only runway, is 11,819 ft long and 151 ft wide.

1.6 Flight Recorders

1.6.1 Flight Data Recorder

The airplane was equipped with a Honeywell 4700 solid-state FDR mounted in the airplane's aft equipment area. The FDR is dependent on power logic to start and stop recording and is powered from alternating current Bus 3.

The FDR's crash-survivable memory unit was found separated from the chassis, and other damage was evident. Removal of the internal memory board from the damaged unit enabled a successful download of its recorded contents, which included more than 25 hours of more than 600 data parameters, capturing the accident flight (up to the point at which the recording stopped) and flights that preceded it, including the flight from Camp Bastion to

Bagram. Data for the accident flight began at power-up at 1511:23. The data showed the airplane configured for a flaps-10 takeoff with a recorded stabilizer setting of about -0.85° (3.85 units).

The data captured that, at 1525:25, N_1 for all four engines began to increase. The engines reached full power at 1526:11, and the recording ended about 34 seconds later, a few seconds after the airplane lifted off. For the duration of the recording, there were no autopilot cautions or warnings and no master cautions. Also, at the time the recording ended, the data indicated that all landing gear were down and locked, and hydraulic systems Nos. 1, 2, 3, and 4 showed pressure indications of about 3,000 psi with no low pressure warnings.

1.6.2 Cockpit Voice Recorder

The airplane was equipped with a Honeywell 980-6022 CVR capable of recording and retaining 2 hours of audio information. The unit is powered by alternating current Bus 1. The CVR showed evidence of minor thermal damage and soot. The internal circuit cards and memory chips were found undamaged. The recording contained 2 hours of audio information. For the CVR transcript, the timing of events was correlated to corresponding events that the FDR captured to establish a common time base for the two recorders. The CVR recording also ended a few seconds after the airplane lifted off. The CVR group did not identify any sounds for further examination by sound spectrum or waveform analysis.

1.7 Wreckage and Impact Information

1.7.1 Debris Found on Runway

The debris found on runway 3 in the area of taxiway C included two small pieces of blue-and-white painted airplane fuselage skin, a segment of white-painted hydraulic return tubing, a section of the E8 rack support stanchion (colored green), a reinforcement bracket (for a hydraulic line pass-through a fuselage frame), and part of a M-ATV antenna assembly.

The investigation determined that the tubing was part of hydraulic system No. 2; its installed location in the airplane was aft of the APB on the lower left side of the airplane and above the main deck floor. The installed location of the E8 rack was forward of the APB on the left side of the airplane, aft of the L5 door. The installed location of the hydraulic pass-through bracket was BS 2377. The loaded location of the rear M-ATV was between BS 1973 and 2211.

1.7.2 Main Wreckage

1.7.2.1 General

The main wreckage was spread about 394 ft along a heading of 75°. The airplane forward of about BS 2060 was highly fragmented and consumed by fire. Each of the four engines sustained damage from impact and postcrash fire. Each engine was fragmented, and components attached to or inside each engine were found separated, burned, or crushed. The rotating components of each engine exhibited damage typical of rotation and thrust generation at impact.

1.7.2.2 Aft Pressure Bulkhead Sections and Other Interior Components

The APB, the installed location for which was in the back of the airplane (aft of the cargo) at BS 2360, was found in five main sections, labeled APB-1 through -5 by investigators. Sections APB-3, -4, and -5 were found attached to corresponding fuselage structures and skin panels. Sections APB-1 and -2 were not connected to any fuselage structure. Sections APB-2 and -5 were found under the horizontal stabilizer. Figure 8 shows where each APB section was found at the accident site.

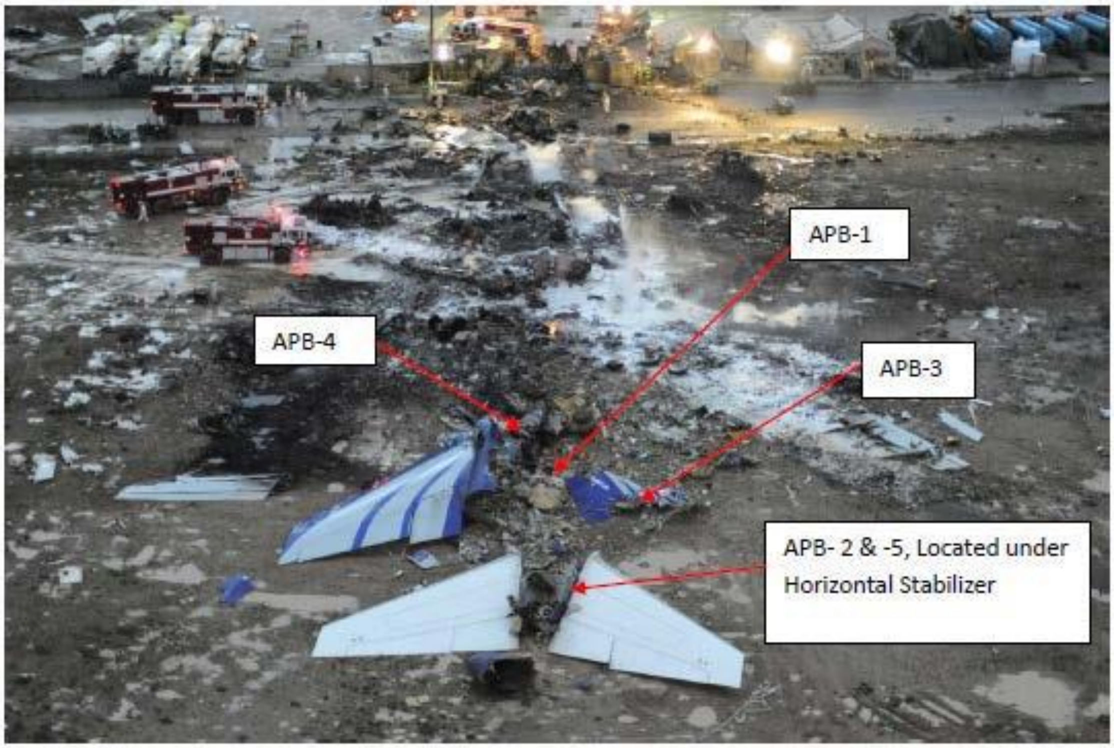


Figure 8. Photograph showing where five sections of the APB were found at the accident site.

Note: The view is from the tail of the airplane looking forward.

Figure 9 shows the relative installed location of each APB section using a photograph of an intact APB (without the liner), looking aft, as well as the locations where hydraulic system tubing, wire bundles, control cables, and static lines pass through the APB. (The installed location of the liner is on the forward face of the APB.)

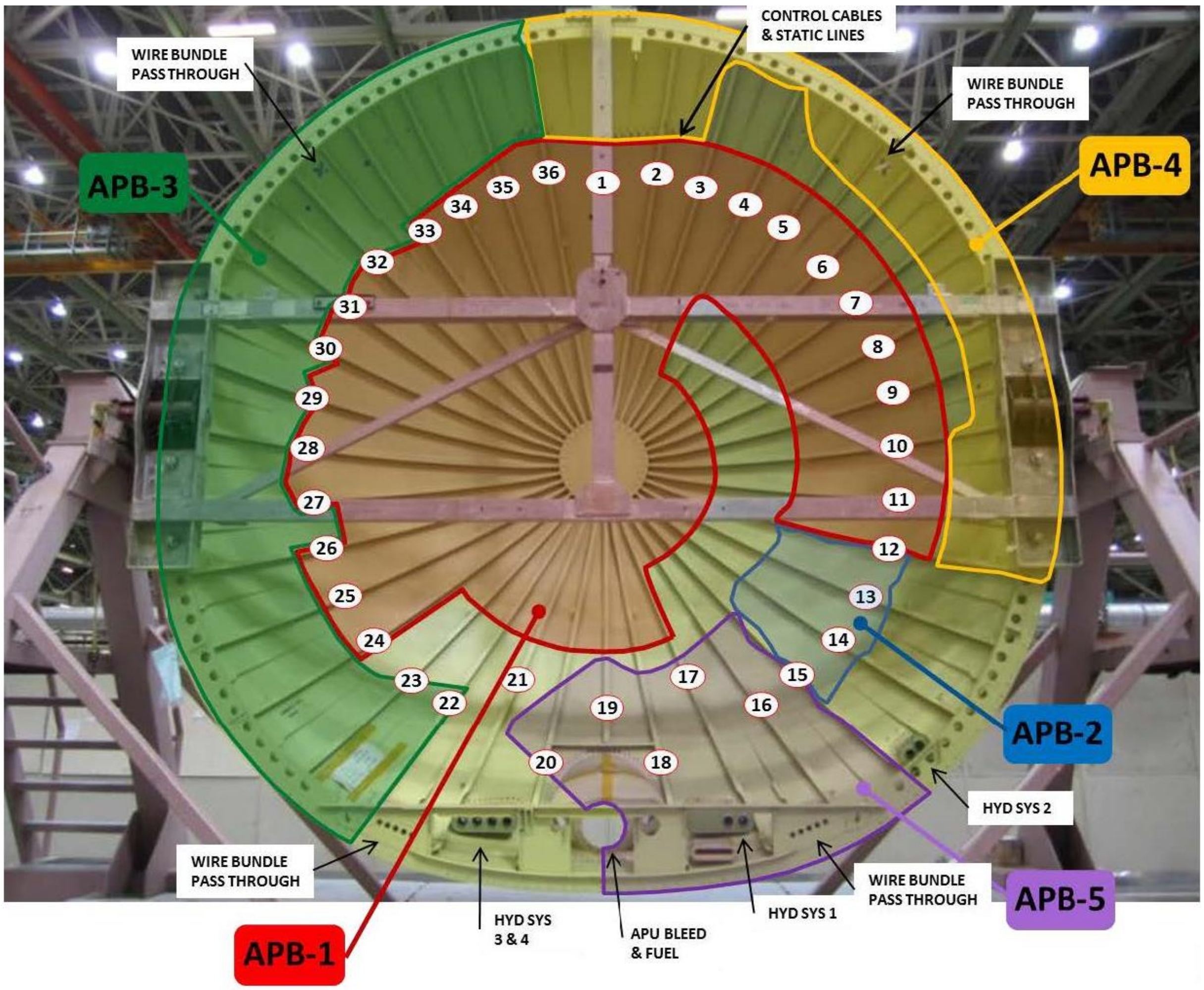


Figure 9. Photograph of an intact APB, looking aft, superimposed with color-shaded and labeled areas showing the installed location of each of the APB sections.

Note: The pass-through locations for various components are labeled. The radial numbers were used to identify the respective structures in the wreckage.

The upper left quarter panel of the APB liner showed a black mark from a 44-inch-diameter tire from a M-ATV. The installed location of this APB liner upper left quarter panel is immediately aft of and adjacent to the E8 rack. The tire imprint was consistent with a tire being parallel to the APB and the tire center located 81.5 inches above the main deck cargo floor (see figure 10).

Figure 10. Photograph of M-ATV tire mark on the upper left quarter panel of the APB liner.

Other sections of main deck interior panels (including panels from the ceiling and the E8 rack) located forward of the APB had tire marks. Black tire marks were also found on airplane structure aft of the APB location at BS 2360; these included tire marks on the green dorsal fairing support structure located just forward of BS 2412. The E8 rack, which included the CVR and FDR, showed impact damage. The FDR chassis, which was painted orange, showed puncture damage on one side.

1.7.2.3 Elevator Components

The elevator torque tube, elevator autopilot actuators, and connecting flight control cables were contained in the section of wreckage that included the vertical stabilizer and rudder. The aft elevator torque tube (common aft elevator quadrant) was bent, and the push rod attach bearings were damaged. The three autopilot servos and the elevator feel computer input rods were attached to the torque tube. The torque tube push rods were connected to the tube and were severed near the horizontal stabilizer bulkheads on each side. The tube could be manipulated through its assumed full range of travel. Continuity of each of the four elevator cables from the aft elevator torque tube forward to the bulkhead at BS 2412 was confirmed. None of the four elevator PCUs appeared damaged, and no foreign objects were observed in the PCU access areas. Functional testing of each PCU at the manufacturer’s facility revealed that none exhibited a functional failure or jam condition.[14]

1.7.2.4 Horizontal Stabilizer and Trim Mechanism

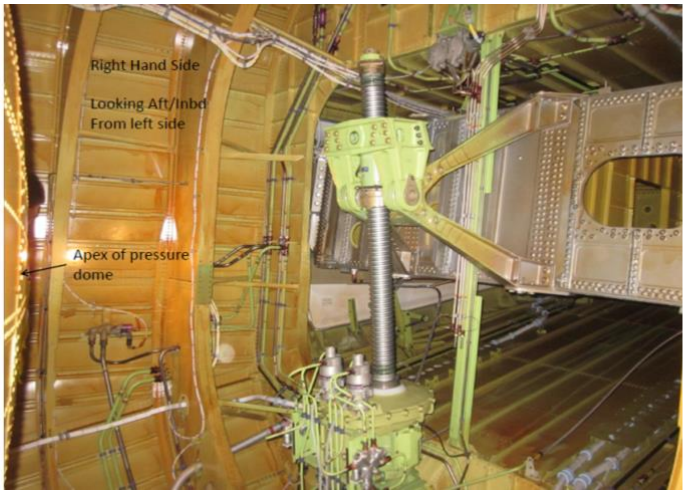
The horizontal stabilizer structure was found inverted in the aft section of the airplane wreckage, clear of the area of postimpact fire, and aft of the vertical stabilizer. Insulation from

[14] Some test reference faults related to tolerances, rig limits, and other conditions were noted for some units.

the APB was found at the stabilizer actuator. (The APB and insulation were installed forward of the stabilizer actuator.) The horizontal stabilizer jackscrew (also known as the ballscrew) was severed on its lower end about 1.5 inches above the drive assembly. A crack about 4 inches long extended longitudinally from the jackscrew's fractured end toward the upper gimbal support structure. The jackscrew drive assembly was aft of its installed location and was embedded in the lower horizontal stabilizer structure (see figure 11). The hydraulic drive motors were broken away from their housing and dislodged but were connected to brackets and tubing. The length of exposed jackscrew threads from the upper stop to the end of the threads was about 9.56 inches.

The horizontal stabilizer trim drive assembly, associated attachment hardware, and components were recovered from the accident site for examination. The origin of the fracture that separated the jackscrew into two pieces was on the forward side, and the longitudinal crack was on the aft side. The jackscrew showed an aft bend. The location of the jackscrew separation corresponded with an installed location of about 2 ft above the airplane's floor surface. The measured jackscrew nut travel was consistent with the recorded takeoff stabilizer position of about -1°.

One of the legs of the upper gimbal support structure that attaches the horizontal stabilizer jackscrew to the forward side of the stabilizer structure was distorted and fractured. The yoke of upper gimbal support structure was gouged and showed material smearing on the forward surface. The installed location of yoke upper gimbal support structure is about 8 ft above the main cargo deck floor.



Images courtesy of Boeing

Figure 11. Photographs (left) showing the accident airplane's jackscrew and horizontal stabilizer in the wreckage and (right) showing an exemplar jackscrew in its installed position aft of the APB and forward of the horizontal stabilizer.

Note: The wreckage photograph has been rotated so that the top of the horizontal stabilizer (which was inverted on the ground) appears at the top of the image.

1.7.2.5 Landing Gear Components

A segment of the nose landing gear upper cylinder was identified in the wreckage. Both wing landing gear actuators (one for each wing landing gear assembly) were fire-damaged and found positioned against their respective attachment structures. The retract actuators for each appeared extended. For the wing landing gear actuator, extension corresponds with a gear-up position. The body landing gear retract actuators (one for each body landing gear assembly) were fragmented, and both actuator pistons were detached from the cylinders. One actuator showed 5.5 inches of exposed shaft, measured to the center of the attached linkage. For the body landing gear actuator, extension corresponds with a gear-down position.

1.7.3 Rear M-ATV

The M-ATV that was loaded in the back of the airplane was found in the wreckage in the area not consumed by fire; this area included other structure from the empennage, including the horizontal stabilizer and the vertical stabilizer (see figure 12).

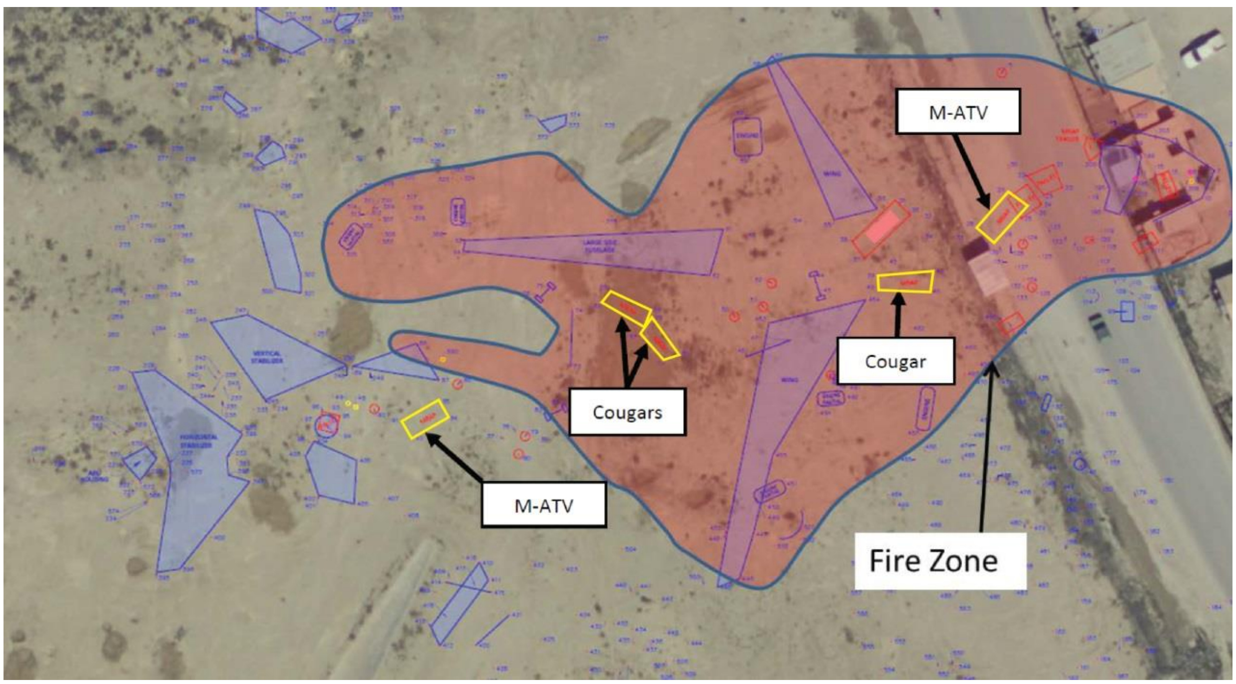


Figure 12. Overview of the accident debris field showing the respective locations of the MRAP vehicles and fire zone.

Pieces of airplane main deck interior panels were found inside the rear M-ATV, and the vehicle was missing its antenna assembly (which had been located on its rear, upper left corner). Sections of the APB's interior lining material from the right side of the airplane were found impinged in the right side of the M-ATV, such that the lining material was trapped in and pinched by the collapsed M-ATV structure.

The M-ATV's spare tire, as installed, is mounted on the back of the vehicle on the upper right side, parallel to the rear bumper. For a M-ATV shored and secured on a pallet, the bottom of the spare tire is about 59.5 inches above the floor (making its center about 81.5 inches above the floor). The rear M-ATV's spare tire was found positioned forward of and at a 90° angle to its installed position (see figure 13), which shows the spare tire as found in the wreckage and an inset diagram depicting the spare tire's installed position.

Figure 13. Photograph of the left side of the rear M-ATV as found in the wreckage and an inset diagram showing the installed position.

An orange transfer mark was noted on the back of the M-ATV on the antenna mounting structure on the upper left side (the location of the orange transfer mark was about 104 inches from the ground on an intact M-ATV). A comparative analysis of the orange transfer mark, which was performed using an infrared microspectrophotometer, determined that the spectrum of the transfer mark on the M-ATV was similar to other spectra of paints, indicating that the transfer was likely paint. A comparison of the transfer mark with a paint sample from the FDR chassis found that the spectra shared three similar peak patterns; however, the origin of the orange paint transfer could not be determined by spectral analysis.

A portion of a G-code pallet was found in a crater adjacent to the vertical stabilizer. Red-colored, linear transfer marks were present on the bottom of the pallet. The red-colored, linear transfer marks, which were about 4 inches wide and extended several feet, also showed material smearing and a directional change. Two 1.25-inch-diameter circular indentations (each circumscribed by a 4-inch circular mark) about 28 inches apart were present along the marks. One end of the pallet was curled under itself. The fixed-end stop and the retractable end stop were fractured.

Several dozen separated sections of tie-down straps were recovered from areas of the airplane aft of the loaded location of the rear M-ATV. Four of the strap segments were found attached to seat tracks, one of which was identified as a seat track location between BS 1920 and 1940. Laboratory examinations of segments of tie-down straps were performed using a digital zoom microscope and infrared spectrometry. Strap types and color varied, but all were polyester-based and exhibited some photodegradation. All of the strap segments displayed filament damage characteristics consistent with overstress pulling or tearing (one exception was a strap segment in which melting precluded determination of the failure mode). Some of the overstress failures also featured angled tears consistent with contact with a sharp object.

1.8 Medical and Pathological Information

The Armed Forces Medical Examiner performed autopsies on the seven crewmembers. The cause of death for each crewmember was listed as "multiple injuries." Toxicology results for all crewmembers were negative for ethanol and drugs, with the exceptions that traces of an allergy medication were detected in specimens from the augmented captain and traces of a cold medication were detected in specimens from one mechanic.

1.9 Tests and Research

1.9.1 Image Study: Landing Gear and Nose Gear Door Positions

Video image recordings from three sources were examined. These included a dashboard camera from a moving ground vehicle on Perimeter Road near the runway 21 threshold; a security camera mounted near the northeast end of the airfield; and a security camera mounted near the northwest perimeter of the airfield. The recordings from the dashboard camera and from the security camera near the northeast end of the airfield provided information about the configurations of the airplane's individual landing gear assemblies and that of the nose gear door. Landing gear and nose landing gear door configurations can provide information related to the functional status of the airplane's hydraulic systems.

The airplane's landing gear includes two sets of wing landing gear (left side and right side), which are located under the wings and are powered by hydraulic system No. 4; two sets of body landing gear (left side and right side), which are located under the fuselage and are powered by hydraulic system No. 1; and a nose landing gear assembly, which is powered by hydraulic system No. 1 (see figure 14). During normal operations, one of the first events in the landing-gear-retraction sequence (when the flight crew uses the gear lever in the cockpit to command the retraction of the landing gear) is the opening of the nose landing gear and body landing gear doors to allow the nose landing gear to retract into the airplane.

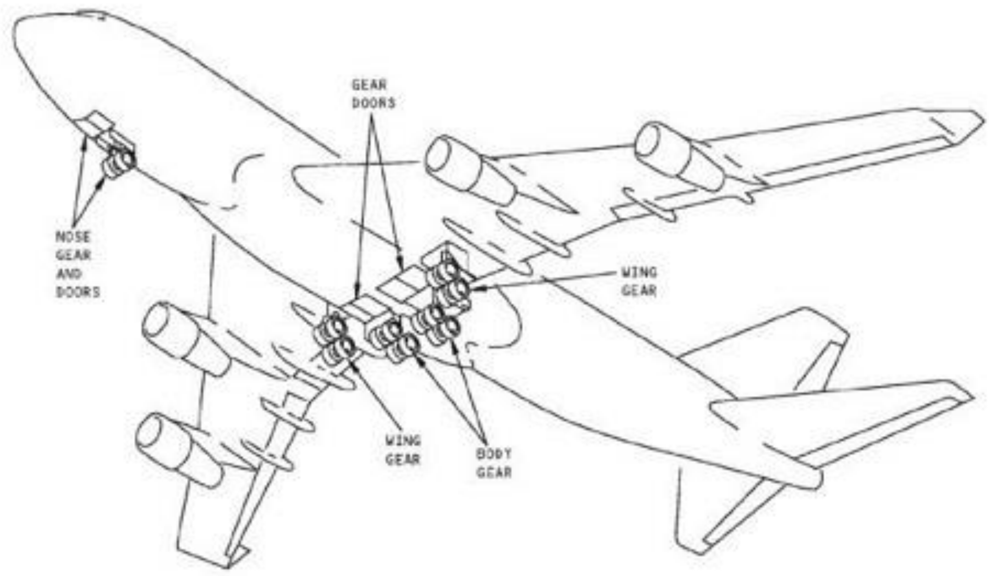


Figure 14. Diagram showing the respective locations of the nose, wing, and body landing gear on a Boeing 747-400 BCF.

The image study used Autodesk Softimage 2013 to compare the image data to a three-dimensional model of the airplane. The study found that, during the portions of the flight captured by one or more cameras, the airplane's left wing landing gear was not visible, consistent with it being in the retracted position. The right body landing gear, left body landing gear, and nose landing gear were visible (captured by one or more cameras), consistent with them being in the extended position. The study also found that the nose landing gear door was visibly protruding, consistent with the fully open position (see figure 15).

Figure 15. Still image from a security video of the accident airplane with a superimposed three-dimensional model airplane. (The model has all landing gear extended.)

Note: Red arrows indicate which of the accident airplane's landing gear appear to be missing when compared to the model (consistent with the retracted position) and which appear to be aligned (consistent with the extended position).

Due to image quality, camera distance from the airplane, and/or the orientation of the airplane to the camera, none of the three camera sources provided information that could be used to determine airplane control surface movements. None of the videos showed any evidence of smoke, fire, or explosion occurring before the airplane's ground impact.

1.9.2 Airplane Performance Study

FDR data showed that, during the accident flight's takeoff roll, the airplane's rotation was initiated with nose-up control column input, and the airplane rotated to a normal takeoff pitch attitude. Analysis of ground track data calculated that the airplane was about 4,700 ft beyond the runway threshold (just past taxiway E) at the time the flight crew initiated the rotation, and the airplane was about 6,400 ft beyond the threshold when liftoff occurred. The airplane was about 6,860 ft beyond the runway threshold (just before taxiway C) when the valid FDR data ended a few seconds after the airplane lifted off. The final recorded data showed the airplane at 33 ft radio altitude and about 171 knots indicated airspeed. The airplane was pitched up about 13° and banked right about 4°. Elevator deflections were around 5° to 6° trailing-edge up. A comparison of pertinent parameters for the accident flight's takeoff roll and rotation with those of the airplane's previous takeoff from Camp Bastion found that the FDR data for both takeoff rolls and rotations matched closely and appeared to be normal.

In the absence of FDR data for the remainder of the accident flight, simulation analyses were performed to determine possible scenarios that could have produced the observed motions of the accident airplane, which were characterized by an extremely high pitch attitude during climb followed by a motion consistent with an aerodynamic stall. The simulation analyses considered FDR and CVR data for the takeoff roll and liftoff, video image recordings of the accident flight, physical evidence from the accident site and wreckage, reported weather information, and a calculated wind profile.[15]

The simulation used a calculated gross takeoff weight of 685,000 lbs and a calculated initial CG position of 31.7%, which considered the best available information for the cargo loading and fuel.[16] The simulation also assumed an airplane configuration consistent with the accident airplane near its last valid FDR data point, including a trimmed pitch attitude of 16.2°. The study found that, with this baseline configuration, the simulated airplane's performance matched the accident airplane's FDR data closely up until the final 3 seconds of FDR data, during which time the simulation deviated from the FDR data in pitch, longitudinal acceleration, and radio altitude. That is, the accident airplane's final 3 seconds of FDR data showed that it exhibited a steeper nose-up pitch attitude and reached a higher radio altitude than the baseline simulated airplane.

The simulations examined numerous scenarios, each of which included an aft CG shift (involving the aft movement of one to all five MRAP vehicles) followed by an immediate full nose-down command input on the control column in response to the simulated airplane's rapid pitch up. The scenarios also assessed the combined effects of an aft CG shift with various hydraulic system statuses, such as fully operational; system No. 1 failed; systems Nos. 1 and 2 failed; or systems Nos. 1, 2, and 3 failed. Hydraulic system failures adversely affect the functionality of the flight controls associated with each failed system (such as elevators and/or ailerons), and these effects were accounted for in the simulations. Some simulated scenarios also considered horizontal stabilizer issues, as described below.

1.9.2.1 Scenarios Involving Aft Movement of Single MRAP Vehicle

The study evaluated potential outcomes if the rear M-ATV moved aft from its loaded location to the location of the stabilizer jackscrew, resulting in a shift of the calculated CG from 31.7% (all MRAP vehicles in place) to 34.9%. Applying the CG shift to the simulated airplane produced results that better matched the accident airplane's final FDR data for pitch attitude, longitudinal acceleration, and radio altitude than the baseline simulation that assumed no CG shift.

The study found that, with the aft movement of only the rear M-ATV, the simulated airplane remained controllable even when failures of hydraulic systems Nos. 1 and 2 or failures

[15] The analyses, which were performed by Boeing at the request of the NTSB, used a Boeing 747-400 desktop simulation capable of using the accident airplane's FDR data to drive the simulation control positions and/or mathematical pilot models to produce the desired airplane state or flightpath. The Boeing Flight Simulations and FDR Data Analysis report is available in the public docket for this accident.

[16] This weight value, which is higher than the flight crew's calculated takeoff weight of 675,296 lbs, accounts for the weight of the pallets and tie-down straps used to restrain the MRAP vehicles.

of hydraulic systems Nos. 1, 2, and 3 were applied. In both cases, the simulated airplane could be returned to a level pitch attitude within 6 seconds without stalling. Thus, another source of nose-up pitch would be required for the simulated airplane to replicate the pitch attitude of the accident airplane.

One such source of nose-up pitch considered in the study was a loss of horizontal stabilizer functionality, such as what could result if the horizontal stabilizer's jackscrew actuator and surrounding structure were struck and damaged by an impact from the rear M-ATV. Assuming such damage, two loss-of-functionality scenarios were considered: the horizontal stabilizer moves leading-edge down (from its set takeoff position) and becomes fixed in the new position, or the stabilizer floats and rotates freely to different positions (rather than remaining in its set takeoff position).

The study determined that a range of fixed leading-edge-down stabilizer positions could result in the inability of the available flight control surfaces to counter the airplane's nose-up pitching moment. In one such scenario, when an aft movement of only the rear M-ATV and the failure of hydraulic systems Nos. 1 and 2 were assumed, the study determined that a shift of the horizontal stabilizer from the set takeoff position of 4 units to at least a position of 9 units (which produced a 5° leading-edge-down position of the stabilizer) resulted in an inability of the available flight control surfaces to counter the nose-up pitching moment. Study calculations determined that, for a 5° deflection of the horizontal stabilizer's leading edge, the corresponding displacement at the stabilizer's root correlated approximately with the displacement of the fractured stabilizer jackscrew and surrounding structure as found in the wreckage.

For the freely floating stabilizer scenario, the study determined that the simulated airplane's stabilizer would move to a leading-edge-down (airplane nose-up) condition under its own weight and air loads. However, when elevator deflection occurred (such as commanded by the flight crew), the floating stabilizer would react to the loads imposed by the elevator deflection and move in a direction opposite that of the elevators in response. Thus, the application of airplane-nose-down elevator control inputs (which would result in trailing-edge-down movement of the elevators) would contribute to the leading-edge-down movement of a freely floating stabilizer. That is, in an airplane with a freely floating stabilizer, any crew-commanded nose-down inputs on the control column would worsen the airplane's pitch-up condition.

1.9.2.2 Scenarios Involving Aft Movement of Multiple MRAP Vehicles

Scenarios that considered the effect of the aft movement of up to five MRAP vehicles assumed that the rear M-ATV moved aft to the location of the stabilizer jackscrew and that each remaining MRAP vehicle moved aft to occupy the available space. For the scenarios in which all hydraulic systems were assumed fully functional, the study found that the simulated airplane remained pitch-controllable when up to five MRAP vehicles shifted aft, resulting in calculated CG shift from 31.7% (all MRAP vehicles in place) to at most 56% (all five MRAP vehicles shifted aft); for each CG configuration, the simulated airplane could be returned to a level pitch attitude in less than 5 seconds.

The study also evaluated the effects of various hydraulic system failures with each CG-shift scenario, including failures of hydraulic system No.1, systems Nos. 1 and 2, or systems Nos. 1, 2, and 3. The study found four scenarios in which the simulated airplane exhibited a rapid pitch up leading to an aerodynamic stall that could not be countered with control inputs. These cases represented scenarios in which either four or five MRAP vehicles shifted aft and either hydraulic systems Nos. 1 and 2 or hydraulic systems Nos. 1, 2, and 3 were failed. All of these cases closely replicated the pitch-up attitude that the accident airplane exhibited in the videos. These scenarios assumed no anomalies with the horizontal stabilizer's position.

1.9.3 Loading Studies for Tall Rigid Cargo Requirements

M-ATVs (which are about 102 inches tall) and Cougars (which are about 129 inches tall) are considered tall rigid cargo (TRC), which is defined as cargo that is taller than 96 inches and will not break apart or conform to the contour of the airplane when subjected to 9 Gs forward during an emergency landing event. TRC is subject to restrictions and safeguards designed to prevent the TRC from impacting the upper deck passenger compartment in the event of an emergency landing. These restrictions were described in both the Boeing and Telair weight and balance manuals, each of which specified the most-forward location where TRC could be loaded and stated that the TRC must either be restrained to a 9 G-forward condition or be placed aft of sufficient frangible cargo that can arrest its movement without penetrating or damaging the barrier net.

After the accident, both Boeing and Telair performed studies to determine if it was possible to transport centerline-loaded MRAP vehicles on pallets in compliance with the TRC requirements. In its study, Boeing determined that one centerline-loaded M-ATV on a G-code floating pallet could be transported in accordance with the guidelines in the Boeing and Telair weight and balance manuals. The study determined that, to meet the TRC requirement, the M-ATV must be positioned no farther forward than BS 1281, secured by 60 5,000-lb-rated tie-down straps, and be positioned aft of a specified quantity of frangible cargo in ULDs (see figure 16).

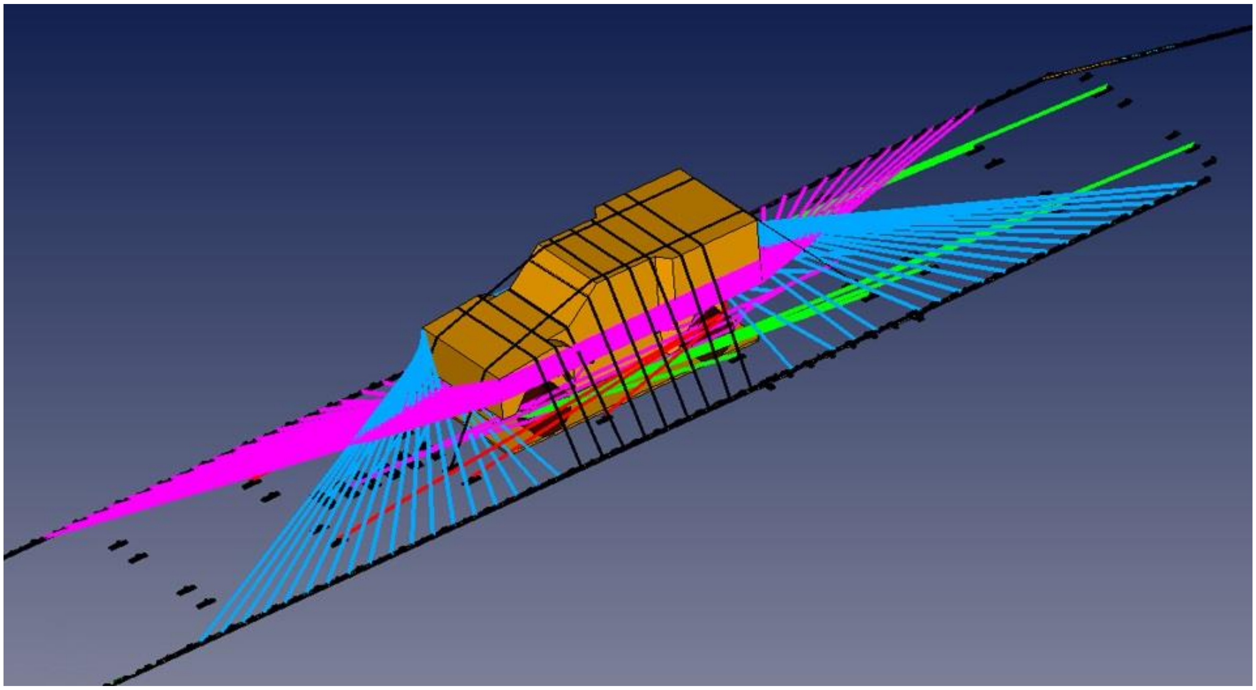


Figure 16. This line drawing provides an exemplar configuration showing how about 60 straps could secure a M-ATV to approved floor structures.

The study found that no centerline-loaded Cougars on G-code floating pallets could be secured and transported in the airplane in accordance with the weight and balance manual because the vehicle would have to be positioned aft of BS 1480 and would exceed the structural strength limitations of the main deck cargo floor in that area.

In its study, Telair determined that no centerline-loaded MRAP vehicles on G-code floating pallets could be transported in the airplane in accordance with the guidelines in the Telair weight and balance manual because the available number of tie-down points would be insufficient to restrain it. The Telair study result differed from the Boeing study result based on Telair's interpretation that there can be no space between the TRC and the ULDs containing frangible cargo, which must be loaded "directly forward" of it.[17] A lack of space between the TRC and the frangible cargo would restrict access to tie-down points forward of the TRC.

1.9.4 Explosives Examinations

On-scene wreckage examination found no evidence of explosion, explosive residue, or preimpact fire. The Joint Combat Assessment Team (JCAT) assessments of the debris field found no visual signs of weapons effects on any portion of the airplane.[18] Two JCAT assessors

[17] When Telair drafted its weight and balance manual in 2005, it used Boeing's B747-400F weight and balance manual, which, at the time, contained the phrase "directly forward." Boeing subsequently revised the manual such that the phrase "directly forward" no longer appears. Telair did not make a similar revision to its manual.

[18] The JCAT investigates aircraft battle damage and shoot-downs to determine the threat weapon system(s) used in an attack and the enemy tactics, techniques, and procedures employed. Additionally, JCAT cooperates with the acquisition and test community and the Defense Systems Information Analysis Center to share lessons learned and archive combat damage data. The JCAT employs military forensic specialists who conduct on-scene

heard the accident airplane's engines during takeoff and observed its steep pitch attitude and subsequent descent. Neither JCAT assessor observed any fire, smoke, or sooting during the airplane's flight, and neither observed any visual or acoustic signatures of weapons employment. The two JCAT assessors traveled to the accident site and found no indications of weapons effects during their initial on-scene assessment or during their analysis of airplane debris found on the runway. At the request of the NTSB, the JCAT conducted a second detailed physical examination of the wreckage and found no damage consistent with weapons effects. The JCAT's examination of internal airplane cargo hardware components, including straps, attach points, chains, and pallets, found no evidence of weapons effects. The JCAT's consideration and analysis of the wreckage evidence, weapon engagement zones for various classes of weapons, witness statements, and videos led to the final JCAT assessment that "there was absolutely no evidence that any sort of weapon was employed against [the airplane] at any time prior to, during, or after the event."[19]

Chemical analysis performed by the US military on a piece of airplane skin and part of a hydraulic line found no evidence of explosive residue. No observations of hostile fire near the airport at the time of the accident were reported.

1.10 Organizational and Management Information

1.10.1 General

National Air Cargo Holdings was the holding group for two subsidiaries: National Air Cargo, Inc., dba National Airlines, which was based in Orlando, Florida; and NAC, which was based in Dubai, UAE. National Airlines operated under 14 CFR Part 121 and contracted load planning services from NAC, the cargo handling vendor. NAC accepted customer orders for cargo transport, including the weight of the load to be carried; coordinated with National Airlines for the load's transportation; and supplied cargo loaders who performed load planning and pallet build-up services. The accident flight was operated as part of the International Security Assistance Force, outlined in United Nations Security Council resolution 1386. National Airlines operated under a multimodal contract with the US Transportation Command to transport military equipment.

At the time of the accident, National Airlines had three Boeing 747-400 cargo airplanes and one Boeing 757 passenger airplane on its certificate. All of the Boeing 747-400 operations were conducted overseas in support of Department of Defense (DoD) contract missions. According to FAA records, the airline had a total of 230 employees, including 43 captains, 35 first officers, 13 check airmen, and 21 flight attendants. Pilots were typically scheduled for 20 days on and 10 days off and were subject to the flight time and duty day limitations specified in the National Airlines general operations manual and 14 CFR 121.523. According to the chief loadmaster, National Airlines employed 13 loadmasters and three check loadmasters.

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assessments of incidents and aircraft damage to determine the extent and impact of weapons effects on both military and civilian aircraft of interest to military commanders. For events in which weapons employment is initially uncertain, the JCAT conducts an investigation in parallel with any ongoing aircraft mishap investigation until weapons effects can be ruled out as a cause of the event.

[19] The JCAT assessment is in the public docket for this accident.

The National Airlines director of operations was responsible for airline operations and for the quality of the National Airlines weight and balance program. He had the authority to establish and modify the policies, procedures, instructions, and information for the National Airlines weight and balance program process. The director of operations was also responsible for the quality of the flight operations training manual and had the authority to establish and modify that program. At the time of the accident, National Airlines had a system chief pilot and two fleet managers (for the Boeing 757 and Boeing 747-400). Line check airmen reported to the system chief pilot through each fleet manager. Airline personnel indicated that, based on the organizational chart, the loadmasters and loading supervisors ultimately answered to the director of operations.

The director of training had been in that position since May 2012. He stated that his duties at National Airlines included regulatory compliance and effectiveness training for pilots, flight followers, dispatchers, and flight attendants. He was not responsible for loadmaster training. He had three full-time staff, six or seven additional pilots in the Boeing 757 and Boeing 747 (each of whom were simulator instructors and check airmen), and flight-follower instructors. National Airlines had 10 dispatchers, all of whom held dispatcher certificates. National Airlines conducted Boeing 747 simulator training at other operators' facilities in Ypsilanti, Michigan, and Denver, Colorado, and conducted Boeing 757 training in Miami, Florida. National Airlines provided its own instructors and check airmen and used the FAA when type ratings were needed.

The National Airlines chief loadmaster had held that position since he was hired by the airline in October 2010 and was responsible for 13 loadmasters and 3 check loadmasters. According to the National Airlines weight and balance manual, the chief loadmaster was responsible for the hiring, training, scheduling and management of loadmasters at National Airlines. (The training program is described in section 1.10.3.) The chief loadmaster stated that loadmasters were responsible for performing weight and balance calculations of the airplane during the preplanning stages of the flight in accordance with manufacturer limitations. Loadmaster duties included inspecting cargo and pallets to ensure adherence to airworthiness requirements, ensuring strap and pallet limits were not exceeded, and ensuring that items were secured properly with the provided restraints or supplemental restraints. Loadmasters filled out the weight and balance documents, inspected and properly loaded hazardous materials, and were required to notify the captain of the locations of hazardous materials or dangerous goods. Loadmasters at National Airlines also served as ground security coordinators.

The positions of loadmaster, load supervisor, check loadmaster, and chief loadmaster are not FAA-certificated positions and are not defined by regulations. The National Airlines cargo operations manual referenced both load supervisor and loadmaster positions but did not define them. In practice, a load supervisor holds the same responsibilities as a loadmaster but is based at a station and does not travel; a loadmaster is a load supervisor who travels with the flight crew, typically to handle loading situations at airports where the airline does not have an operations base. The FAA principal operations inspector (POI) for National Airlines stated that the airline used the term "check loadmaster" to identify personnel who monitor and evaluate the loadmasters.

According to the FAA, the term load supervisor (or loadmaster) could “describe the person who has the duty of supervising the loading of aircraft and preparing the load manifest forms as specified in 14 CFR 121.655.” The FAA indicated that a load supervisor (or loadmaster) is not considered “other operational personnel” as specified in 14 CFR 121.400, which specifies training requirements for such personnel.

1.10.2 Decisions, Actions, and Guidance Related to Accident Flight Cargo

1.10.2.1 Acceptance of Heavy Vehicle Special Cargo Load

On April 26, 2013, the NAC load planning department in Dubai contacted the National Airlines chief loadmaster via e-mail to advise that NAC was planning to load five MRAP vehicles on the National Airlines flight from Camp Bastion to Dubai on April 29, 2013. The e-mail indicated that three of the vehicles weighed between 41,450 lbs and 41,900 lbs (including pallets and shoring) and that two weighed about 26,450 lbs. The e-mail stated, “Please let us know any additional precaution we need to take before confirming the load.” The National Airlines chief loadmaster responded the same day with an e-mail that stated, “That shouldn’t be a problem. We just need to make sure we have enough ballast in the front to prevent the aircraft from tipping and for weight and balance.”

The National Airlines director of safety, security, and compliance said that a risk analysis was never done on the carriage of heavy vehicle special cargo loads on centerline-loaded floating pallets. He said that he was not involved in the decision to begin carrying such cargo, and the safety department was not asked to provide input. The National Airlines chief loadmaster stated that NAC gave the airline the freight and the NAC decided what loads to accept. The loadmaster described the operator’s role as, “you call, we haul.”

According to interviews, National Airlines had previously transported Stryker vehicles, which were similar to the M-ATVs (Strykers weighed about 12 to 13 tons); one pilot stated that the airline had previously transported at least three Strykers at one time. The airline had never before transported a Cougar, and NAC personnel had no previous experience loading one. According to National Airlines records, of the accident crew, only one mechanic and the augmented first officer had previous experience operating a Boeing 747-400 with MRAP vehicle cargo at National Airlines.

National Airlines company policies and procedures regarding cargo operations were incorporated in the National Airlines cargo operations manual (dated September 25, 2012), which was an FAA-accepted manual. The cargo operations manual contained the checklists and procedures that the loadmasters used. According to the National Airlines chief loadmaster, the information contained in the manual was to “ensure the loadmaster would make a safe and informed decision.”

The cargo operations manual, section 1.8.3, “Load Supervisor,” page 1-7, stated, in part, the following:

For the purpose of this manual, the title Load Supervisor can be interchanged with Plane Side Representative, Experienced Cargo Handling Personnel, Loadmaster, Mechanic, or Flight Engineer. The Loading Supervisor is responsible for:

- Reviewing the location of any missing restraint (Beartrap, side lock etc.) and advising maintenance for any corrections
- Confirm[ing] load and proper ULD contour.
- Confirm[ing] proper tie down.

1.10.2.2 Pallet Build-Up, Shoring, and Loading of MRAP Vehicles

On April 27, 2013, the NAC load planning department in Dubai sent the NAC cargo loaders at Camp Bastion photos of examples of shoring to use for the MRAP vehicles. Shoring was used to spread the weight of each vehicle over a larger area on the pallet. For the accident cargo, NAC ground personnel loaded each M-ATV onto a single pallet, placed wood shoring beneath the vehicle, and secured each M-ATV to its respective pallet with chains attached to the vehicle's axles and structures on the front, rear, and sides. For each Cougar, the specialist built a double-pallet platform comprised of one pallet on top of another pallet with a sheet of plywood in between. Cargo tie-down straps attached the two pallets together. The NAC ground personnel loaded each Cougar onto each double pallet and placed wood shoring beneath the vehicle. Each Cougar was secured to the top pallet with chains around the vehicle's axles and to the bottom pallet with chains attached to structures on the vehicle's front, rear, and sides. NAC ground personnel deflated each vehicle's tires to allow the vehicle to rest on the shoring.

The NAC operations specialist who was in charge of the pallet build-up for the accident flight load said that he did not have a standard operating procedure (SOP) for any particular load, there was no specific manual that he followed when building the pallets, and he did not know the load capacity of a pallet. He said that the only manual he had for reference in Camp Bastion was a dangerous goods manual. NAC staff did not have a copy of the National Airlines cargo operations manual in Camp Bastion and did not have a computer to view any manuals online. The NAC vice president of ground operations Middle East said there was no SOP for loading of a Cougar, and no demonstration was performed to teach NAC loaders how to load these types of MRAP vehicles.

The National Airlines chief loadmaster did not know what guidance NAC had sent its loaders for the pallet build-up or loading of the MRAP vehicles. He said that the National Airlines cargo operations manual did not address double pallets or how they should be built. He also said that the cargo operations manual had a section that gave guidelines on shoring, but the National Airlines loadmaster would determine the amount of shoring based on his experience. He said that the airline's policy was for the loadmasters to use their judgment on proper shoring.

The National Airlines cargo operations manual contained a cargo vendor prequalification form, which included the following vendor checklist items:

- Does the vendor have in their possession a current copy of the National Airlines Cargo Operations Manual?
- Does the vendor have procedures for the handling of special or oversized loads?
- The cargo operations manual, chapter 3, "Cargo Loading and Unloading Procedures," page 3-1, stated, in part, the following:

> All cargo operations personnel involved with the loading of an aircraft are required to use the procedures, instructions, and information outlined in this manual. Checklists and forms contained in this manual and the General Operations Manual must be used to control the loading of an airplane. Information provided to the [PIC] must be accurate so the maximum allowable weight of the aircraft is not exceeded.

The National Airlines weight and balance manual, chapter 2, "Loading Information," page 2-1, stated, in part, the following:

> Given that it is common practice for an air carrier to carry cargo loads that vendors have built up or loaded, an air carrier should have a program that ensures vendors perform cargo buildup and loading in accordance with the air carrier's procedures. Under such a program, an air carrier should have procedures to:
>
> 1. Train vendor employees, train a vendor employee to train other vendor employees (train-the-trainer method), or accept the vendor's training program and procedures provided they meet or exceed the standards established in the air carrier training program and procedures.
>
> 2. Designate a trained, qualified, and authorized person to oversee the vendor services to ensure the vendor performs the services in accordance with the air carrier procedures.
>
> 3. Audit vendors for compliance with air carrier procedures and training programs under the National Airlines IEP [internal evaluation program].

Regarding floating pallets, the National Airlines cargo operations manual, chapter 6, "Special Loads," page 6-2, stated, in part, the following:

> Floating pallets are defined as pallets which are oriented in the aircraft in such a manner that the forward and aft pallet end restraint fittings and side rails will not all engage the pallet to restrain it, and it might not be possible to place all pallet end restraint fittings in proximity of the floating pallet in the locked position.

The National Airlines cargo operations manual, chapter 6, "Special Loads," page 6-3, stated, in part, the following:

> In all floating pallet installations, the Loading Supervisors shall ensure and certify that all pallet end restraint fittings that are not beneath the floating pallet assembly

> or blocked by the floating pallet are in the locked position prior to closure of the main cargo door on departure.

The National Airlines cargo operations manual, chapter 6, "Special Loads," page 6-11, stated, in part, the following:

> Shoring is used to spread highly concentrated loads over a greater base area than that occupied by the cargo alone. Use of shoring permits carrying a load with a higher concentration than would be normally allowed.…Cargo exceeding the rated floor bearing capacity of a ULD or aircraft will require shoring to distribute the load over a greater area. Shoring used for weight distribution may be ordinary planking laid beneath the cargo, or it may be composed of plywood sheets.

The National Airlines weight and balance manual, chapter 2, "Loading Information," page 2-1, stated, in part, the following:

> The National Airlines Load Supervisor (Loadmaster) or qualified representative is responsible for the acceptance of all cargo planeside, and that all ULDs and pallets are properly identified and tagged in accordance with the Cargo Operations Manual requirements. The load supervisor is also responsible for verifying the aircraft is loaded and cargo weights checked for accuracy in accordance with the loading manifest…. This verification is essential to ensure weight and balance calculations previously performed by National Airlines OCC [Operations Control Center] are valid.

1.10.2.3 Tie-Down of Accident Flight's Cargo

As directed by the loadmaster, NAC personnel used 24 straps to secure each M-ATV and 26 straps to secure each Cougar to the main deck of the airplane. The NAC load planning department in Dubai did not provide the NAC loaders at Camp Bastion with tie-down or strapping instructions for securing the MRAP vehicles on the main deck of the Boeing 747-400. National Airlines did not provide the accident loadmaster any special tie-down instructions or strapping plans for securing the MRAP vehicles on the main deck of the accident airplane.

The National Airlines chief loadmaster developed the airline's procedures and guidance for tie-down strap calculations. The chief loadmaster said that he extracted charts from both the Boeing and Telair manuals and inserted them into the cargo operations manual. According to the chief loadmaster, large MRAP vehicles were no different than other cargo on floating pallets regarding how they should be strapped down in the airplane. The chief loadmaster said that, in his 17 years as a loadmaster, about 95% of the straps he saw to secure floating pallets were to the seat tracks and not to the side rails.

At the time of the accident, National Airlines followed no restrictions on tie-down points on the seat tracks of the main deck of the Boeing 747-400 other than the cargo operations manual specification that the attachment points must be separated by 20 inches or more. The National Airlines procedures that the chief loadmaster developed assumed that all of the straps were installed at 30° angles relative to both the airplane centerline and the airplane floor. The procedures also assumed that all of the floor attachment points were capable of reacting 3,750 lbs in all three directions (forward/aft, lateral, and vertical) simultaneously.

During the investigation, the chief loadmaster demonstrated the calculations a loadmaster would perform to determine how many straps to use on a M-ATV. For a 27,566-lb M-ATV, he used the following load factors to calculate the required number of straps: 1.5 G forward, 1.5 G aft, 1.5 G lateral, and 2.2 G vertical. Each strap had an allowable load of 5,000 lbs, and the chief loadmaster incorporated a safety factor of 75% in the strap calculations, reducing the strap allowable load to 3,750 lbs. Using the National Airlines procedures, he calculated that 12 straps each were required to restrain a M-ATV in the forward and aft directions. Per the cargo operations manual, each of these straps (12 forward and 12 aft), was considered to be able to react 3,750 lbs each for a total of 45,000 lbs in the forward, aft, and lateral directions, and all 24 straps could be used in the vertical direction for a total of 90,000 lbs.

The chief loadmaster's calculations also assumed that an infinite number of tie-down points existed on the MRAP vehicles. Later during the investigation, the chief loadmaster revised his calculations using higher vehicle weights (for both M-ATVs and Cougars) and revised load factors of 2.0 G lateral and 2.5 G vertical. Using the National Airlines guidance, the chief loadmaster's revised calculations concluded that 32 straps would be needed to restrain each of the two M-ATVs, 44 straps to restrain one Cougar, and 46 straps to restrain each of the other Cougars. The revised calculations again assumed that all of the straps were installed at 30° angles to both the airplane centerline and the airplane floor and that the floor attachments were all capable of reacting 3,750 lbs in all directions simultaneously.

Part 121 operators are required to operate their aircraft in accordance with the manufacturer's and the STC holder's approved weight and balance and loading control manuals.[20] The Boeing and Telair manuals defined individual tie-down allowable loads for single and double stud fittings inserted into the cargo system side rails, end stops, center guides, pallet lock tie-down rings, and the available seat tracks. Per the Boeing weight and balance manual, the most any seat track attachment can react is 2,769 lbs.

The Boeing and Telair manuals also stated that each tie-down fitting may only be used to react load in one direction (forward, aft, side, or vertical). These manuals defined allowable loads that can be applied to the attach fittings in terms of 0°, 30°, 60°, and 90° increments when measured relative to both the airplane centerline and airplane floor. The Boeing and Telair manuals stated that these loads vary in magnitude from an allowable load of 0 lbs up to 5,000 lbs. The full capability of the attach fittings varies depending on the measured strap angle and the location of the attach fitting on the airplane.

The National Airlines cargo operations manual, chapter 6, "Special Loads," page 6-11, stated, in part, the following:

[20] Title 14 CFR Part 121.141 states that a certificate holder must keep a current approved airplane flight manual for each airplane that it operates, and 14 CFR 91.9 requires that all operators comply with the limitations contained in the manual. Weight and balance limitations (which are established by the airplane's manufacturer/type certificate holder as amended by an STC holder, if applicable) must be contained in the approved manual per 14 CFR 25.1583(c).

> Cargo must be restrained so it will not shift because of loads resulting from dynamic forces encountered during takeoff, flight, and landing. The restraint must be adequate for the greatest load that may result. These loads are expressed in terms of cargo-weight times the applicable load factor. If a cargo unit is subjected to a load equal to 1.5 times its weight, it must be restrained for a load factor of 1.5 to prevent it from shifting.

The National Airlines cargo operations manual, chapter 6, "Special Loads," page 6-2, stated, in part, the following:

> Prior to loading Oversize BIG [outsized] and/or OHG [overhanging] items, ensure that there is sufficient and suitable tie-down positions available, and if necessary, raise the load above the pallet surface to gain access to, or make more tie-downs available.[21]

According to the NAC operations specialist who loaded the Camp Bastion load on the accident airplane, NAC had a "ULD department" that was responsible for the inventory of straps and chains and for inspecting the chains and straps used on board National Airlines flights.[22] The NAC vice president of ground operations Middle East said that the ULD department coordinated strap and chain inventory. There was no specific training for that position and no quality assurance program for the straps. He also stated that they had not needed to replace any strap inventory, and there was no training for the ULD inspector to determine when a strap was no longer safe. He said the airline provided the guidelines for the type of strap or chains required, using International Air Transport Association (IATA) standards.[23]

The National Airlines cargo operations manual, section 6.0, "Pallet Tiedown," page 2-25, stated, in part, the following:

> Cargo straps must be checked prior to their use for excessive wear or cuts, working hardware may be deformed but must be operable, if an expiration date is shown it must not exceed that date.

The National Airlines cargo operations manual, section 1.1, "Load Manifest," page 3-2, stated that, during the pallet inspection process before loading, the loadmaster or qualified individual must inspect the pallet, nets, and straps for airworthiness and ensure that the ULD pallet tag includes the required information, including the ULD weight. According to the chief loadmaster, loadmasters used a "loadmaster report" to log discrepancies, but, at the time of the

[21] BIG items are those that are loaded on two or more pallets or that, due to size or weight, require special handling or equipment for loading or offloading. OHG items are those that are loaded on one or more pallets and overhang into positions other than those on which they are loaded.

[22] According to the principal maintenance inspector, he had never heard of a "ULD group" that inspected cargo straps.

[23] IATA is a trade association representing about 250 airlines to support various aviation activities and help formulate industry policy on critical aviation issues. Among its goals are helping airlines operate safely, providing professional support for industry stakeholders, and advocating for the interests of airlines worldwide regarding regulatory issues.

accident, there was no requirement for the loadmaster to complete the loadmaster report every flight leg.

1.10.2.4 Flight Crew Responsibilities and Guidance Regarding Cargo

There was no specific checklist item in the National Airlines flight crew operating manual (FCOM) to verify the cargo load and security of the load on the main deck of the Boeing 747-400 before flight. According to the National Airlines Boeing 747-400 check airman who provided training to both accident pilots, there was no specific training or guidance provided to National Airlines pilots for operations conducted with MRAP vehicles loaded on the main deck of the Boeing 747-400. He said that there was no specific guidance for pilots on how to check the cargo during a walk around but that it was discussed as a technique during operating experience. The check airman said that pilots at National Airlines were not evaluated on the contents of the cargo operations manual. He stated that "the loadmasters have their job…there is very little interaction" between pilots and loadmasters. A Boeing 747-400 first officer stated that pilots at National Airlines "relied on the loadmasters 100% to make sure the load was done and secured properly."

Weight limits for the accident airplane were found in the National Airlines FCOM limitations section, and the final product of the weight and balance loading process was a completed load manifest. It ensured that the airplane was loaded in such a way that any weight restriction had not been or would not be exceeded and that the CG was and would remain within its envelope for the entire flight.

The National Airlines weight and balance manual, section 8.8, "Load Manifest," page 1-11, stated, in part, the following:

> The Captain, Loadmaster, or other qualified personnel who have been properly trained, may be delegated the authority for performing the weight and balance Computation for each flight. The Captain is responsible for ensuring that the aircraft does not exceed any performance limited weight or center of gravity limits. The Captain has final responsibility.

1.10.3 Training Programs

1.10.3.1 Pilot and Dispatcher Training

Pilots at National Airlines were trained in the simulator to recover from unusual attitudes (including nose-high unusual attitudes) based on the guidance outlined in the National Airlines Boeing 747-400 FCOM. According to the Boeing 747 check airman who provided simulator training to the accident captain, in his experience, none of the National Airlines pilots he trained ever had a problem with upset recovery.

The director of training and standards stated that he was not aware of any specialized pilot training or procedural changes regarding floating pallet centerline cargo, MRAP vehicles, or Cougars. There was no module included in the National Airlines flight operations training manual for pilots to review a cargo load.

According to the National Airlines Boeing 747-400 check airman who provided Boeing 747-400 training to both accident pilots, pilots received a half day of training with the head loadmaster during initial training and also had a computer-based training (CBT) module on cargo loading and safety with an embedded video. Another National Airlines Boeing 747-400 captain stated that he did not recall attending training with any of the loadmasters and was not trained on their procedures but did receive a CBT module on general cargo strap and tie-down conditions. Several National Airlines pilots stated that they received no special training on the transport of large military vehicles.

1.10.3.2 Loadmaster Training

According to the National Airlines weight and balance manual, the chief loadmaster was responsible for hiring, training, scheduling, and management of loadmasters at National Airlines. The chief loadmaster also wrote the policies, procedures, and training for loadmasters and was responsible for evaluating loadmasters and check loadmasters. According to the chief loadmaster, he wrote the loadmaster training course using content from various other companies that he "cut and paste from a lot of other manuals." He also was responsible for training ground operations vendors like NAC on National Airlines' procedures. Loadmasters did not train with the pilots or the cargo loaders from NAC, who were responsible for pallet build-up and loading of the airplanes.

Loadmaster training requirements are not defined by the FAA. The National Airlines cargo operations manual listed general training modules of learning. National Airlines provided the National Transportation Safety Board (NTSB) with separate outlines for initial and recurrent loadmaster training as part of the accident loadmaster's training file. The training times listed below were derived from the accident loadmaster's training file and not from any approved or accepted National Airlines manual.

According to the loadmaster's training file, the National Airlines loadmaster initial training was a 68-hour course that consisted of the following subjects:

Dangerous Goods Training	24 hours
Departmental Policies and Procedures	4 hours
Flight and Cargo Documentation	3 hours
Ground Operations	8 hours
757 Emergency Equipment Training	2 hours
757 Door Training	
757 Ditching	

Ground Security Coordinator Training	4 hours
Passenger Operations Security (2 hours)	
Cargo Operations Security (2 hours)	
Aircraft Familiarization and Weight and Balance	
DC-8	2 hours
Boeing 757	4 hours
Boeing 747-400 (includes Telair DVD)	12 hours
Crew Resource Management Training	2 hours
Human Resources Orientation	3 hours
Total Time	68 hours

According to the loadmaster's training file, the National Airlines loadmaster recurrent training was a 24-hour course that covered the same subject areas as the initial training.

FAA Advisory Circular (AC) 120-85 provides guidance for the training of loaders and load supervisors. For cargo handling system training topics, AC 120-85 suggests the following:

a. Loading procedures and their effect on airplane performance consequences;

b. Potential hazards to flight caused by improper loading;

c. Airplane cargo handling system procedures and serviceability, including accounting for damaged or missing restraint devices; and

d. The purpose and use of various restraint systems authorized for each airplane type the air carrier operates.

Regarding identifying individuals who need training, AC 120-85 suggests the following:

> An air carrier should have procedures to properly identify those individuals who need training. An air carrier should provide training to its own loading personnel as well as vendor loading personnel.

1.10.4 Safety Programs

The National Airlines director of safety is responsible for safety management system (SMS) implementation, aviation safety action program (ASAP) oversight, flight operations quality assurance (FOQA) flight data analysis, and had joint responsibility for the security program with the director of security.[24] He was also a liaison to the DoD for its safety program.

[24] On January 8, 2015, the FAA published a final rule to require most commercial airlines to develop and implement an SMS by 2018. 80 *Federal Register* 1308. According to the FAA, "SMS is the formal, top-down, organization-wide approach to managing safety risk and assuring the effectiveness of safety risk controls. SMS gives airlines a set of business processes and management tools to examine data gathered from everyday operations, isolate trends that may be precursors to incidents or accidents, take steps to mitigate the risk, and verify the effectiveness of the program. SMS requires compliance with technical standards but also promotes a safety culture

The National Airlines safety department consisted of the director, a safety assurance manager, and a flight safety analyst. According to the director of safety, National Airlines had not conducted any line operations safety audit (LOSA) of their operations.[25] At the time of the accident, the FAA had just completed a safety action team (SAT) audit allowed under the air transportation oversight system (ATOS) for risk mitigation. According to the National Airlines director of safety, following the 2011 SAT audit, it was recommended that the airline conduct a LOSA of its operations, but the company opted not to do one.

National Airlines had an ASAP program for the pilots and an online irregularity reporting system. Pilots could also download a copy of the reporting form from the company intranet, send an e-mail to the safety department, or call a hotline and leave a recorded message. The director of safety stated that he had not received any ASAP reports concerning cargo loading issues or load shifts.

According to the FAA principal maintenance inspector (PMI), National Airlines also used a web-based access tool for data collection and analysis. The PMI indicated that mechanics were a part of the ASAP program, and, other than simply going directly to management, there was not another program for a mechanic to disclose a safety issue. The director of safety said the loadmasters did not have an ASAP program at National Airlines, mainly because "they were not certificated," and it was not clear how to fit them in with the FAA because the program provided certificate protection. According to the chief loadmaster, National Airlines loadmasters could file "safety reports" on the company intranet that were then sent to the National Airlines safety department. He said that he had never had a report about a load shift from a loadmaster.

1.10.5 FAA Oversight

1.10.5.1 General

At the time of the accident, National Airlines' certificate was managed by the East Michigan Flight Standards District Office (FSDO) located in Belleville, Michigan.[26] Oversight of the National Airlines certificate was the responsibility of the POI, PMI, and principal avionics inspector (PAI).

The POI characterized National Airlines' safety culture as "satisfactory." The PMI characterized his communications with the airline as "open" with management, the director of

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to improve the overall performance of the organization. It uses four key components – safety policy, safety risk management, safety assurance, and safety promotion." According to AC 120-66B, "Aviation Safety Action Program (ASAP)," the objective of ASAP is to encourage air carrier and repair station employees to voluntarily report safety information that may be critical to identifying potential precursors to accidents. The FAA has determined that identifying these precursors is essential to further reducing the already low accident rate. Under an ASAP, safety issues are resolved through corrective action rather than through punishment or discipline. An ASAP provides for the collection, analysis, and retention of the safety data that is obtained. ASAP safety data, much of which would otherwise be unobtainable, is used to develop corrective actions for identified safety concerns and to educate the appropriate parties to prevent a recurrence of the same type of safety event. According to the FAA, FOQA is a voluntary safety program designed to improve aviation safety through the proactive use of flight recorded data.

[25] For more information about LOSA, see AC 120-90, "Line Operations Safety Audit."

[26] FAA oversight of National Airlines' certificate was moved to the South Florida Certificate Management Office during the summer of 2013.

maintenance, and the director of quality control. The PMI said that National Airlines had a "good compliance attitude" and that the director of operations was open to communications, would come to the FAA with questions, and worked well with FAA inspectors.

According to the POI, the FAA used ATOS for its oversight guidance.[27] The POI described ATOS as "primarily an inclusive closed loop system of surveillance and evaluation and certification of a Part 121 operator. It included evaluation of new programs and certification, doing surveillance and oversight, and a risk management system to mitigate risks at an operator for items identified as high risk."

The POI said that his responsibilities included oversight of the operations of the air carrier, including all operational aspects of National Airlines' training, operation of the aircraft, and "basically complete oversight on the operations side." The POI, PMI, and PAI met quarterly to talk about the risk assessments associated with the airline. Each inspector answered to the front line manager (FLM). The frequency of visits to National Airlines was driven by ATOS surveillance requirements.

1.10.5.2 Oversight Responsibility for Loadmasters

In response to an NTSB inquiry, the FAA indicated that it did not delineate oversight responsibility specifically to the POI or the PMI for supervising duties related to the loading of aircraft. The FAA stated that both operations and airworthiness inspectors, who possess various degrees and types of expertise and experience, had oversight responsibility.

When asked if he had oversight of loadmasters, the POI said that "it fell under both specialties, but there was no guidance in [FAA Order 8900.1]." The PMI also said that the ATOS contained no guidance that addressed loadmasters. The POI considered loadmasters as "an extension of the captain, being given the authority to load the airplane together and loading of hazmat." The PMI said that loadmasters were considered part of operations and that he "had nothing to do with the Cargo Operations Manual at National [Airlines]." The National Airlines chief loadmaster said that loadmasters "straddle a line" between PMI and POI responsibility for oversight because part of a loadmaster's work was with the loading system, which is part of the PMI's responsibility, and part of their work was with operations, which is part of the POI's responsibility. The POI said that the review of loadmasters was based on other carriers' best practices because there was no guidance for the oversight of loadmasters and that the lack of guidance "was part of the problem."

[27] According to FAA Order 8900.1, volume 10, chapter 1, section 1, "Air Transportation Oversight System Doctrine," ATOS is based on the explicit policy of the FAA that states that "The FAA will pursue a regulatory policy, which recognizes the obligation of the air carrier to maintain the highest possible degree of safety." ATOS implements FAA policy by providing safety controls (that is, regulations and their application) of business organizations and individuals that fall under FAA regulations. Under ATOS, the FAA's primary responsibilities are (1) to verify that an air carrier is capable of operating safely and complies with the regulations and standards prescribed by the administrator before issuing an air carrier operating certificate and before approving or accepting air carrier programs; (2) to reverify that an air carrier continues to meet regulatory requirements when environmental changes occur by conducting periodic reviews; and (3) to continually validate the performance of an air carrier's approved and accepted programs for the purpose of continued operational safety.

According to the POI, the cargo operations manual was an FAA-accepted manual. The POI stated that accepted manuals “generally had to do with policies and procedures not specific to the [operations specifications].” He said he found that the National Airlines cargo operations manual referenced both the Boeing and Telair manuals. According to the POI, the appropriate principal inspector generally handled the acceptance process for manuals, using FAA Order 8900.1, volume 3, section 2, “Approval and Acceptance of Manuals and Checklists,” as a guide. The order also contains guidance for the POI’s role in the review process and for resolving any discrepancies found in any of the manual material.

There are no duty time or rest requirements for loadmasters. The POI said that National Airlines had a fatigue risk management program that included flight crews, but, to his knowledge, the loadmasters were not included. He said that National Airlines told him that the loadmasters were scheduled with the flight crew. The POI did not know that loadmasters were being scheduled up to 30 hours. He said that loadmasters could get rest in the airplane in the bunk rooms, but he believed they typically did not use them.

The POI said that he wanted to see loadmaster training at National Airlines, but “there was no loadmaster training guidance or [FAA Order 8900.1] guidance.” The POI had contacted another Part 121 cargo operator to get an idea of how it trained its loadmasters and had worked with the chief loadmaster to develop checklists so that the loadmasters had some sort of guidance.

1.10.5.3 En Route Inspections and Direct Surveillance

According to the POI, the FAA had attempted to conduct en route inspections of National Airlines flights into and out of Afghanistan but could not because of the State Department’s restrictions. According to the FAA, the agency did not typically clear its ATOS en route inspections through the State Department but did so for en route inspections on National Airlines flights into Afghanistan because the trips involved travel into a war zone. Following a request by the POI to perform an en route inspection on National Airlines in Afghanistan, the State Department advised the FAA that there was a travel restriction for all government personnel to Afghanistan. The State Department told the FAA that FAA inspector travel to Afghanistan was not recommended, “given the deteriorating security situation there.” Travel into Afghanistan would have to entail “extenuating circumstances” and involve “full State Department security (armored vehicles travel, etc.) in country, which is now problematic and costly” for travel at the airports that the FAA requested.

For the FAA to accomplish flight crew line checks and observations, National Airlines flew a Boeing 747-400 to the United States when needed for that purpose. Once the airplane was in the United States, the crews flew it to two or three destinations, rotating pilots, while the FAA performed line checks for new captains and 2-year observations of check airmen. These check flights were flown without cargo on board.

Under ATOS, cargo loading equipment and continuous analysis surveillance are high-criticality items and, as such, are scheduled for evaluation every 6 months.[28] The PMI said that, to his knowledge, ATOS addresses cargo loading equipment but not securing cargo. A ramp inspection on National Airlines was performed once in Dubai for the Boeing 747-400 in September 2012. The PMI said that the FAA had tried "a half dozen times" to do ramp inspections on a National Airlines Boeing 747-400 but that, each time, the airplane was not available due to trip changes or cancellations.

Both the PMI and POI observed cargo equipment movement in Dubai, but the airline loaded only general items and military items, and the inspectors looked at loads to see if there was anything obviously wrong with them. The PMI said that he never had an opportunity to observe the tie-down straps or centerline-loaded pallets; all the loads he saw were secured to the side rails. Neither the PMI nor the POI had observed any build-ups, and the PMI stated "that was the POI's responsibility." The PMI said that he had attempted to go to Dubai since the September 2012 ramp check but was told that the FAA did not have the funding. The PMI said that he was able to observe the loading process on a more regular basis with the DC-8s when they were coming through the airport in Ypsilanti, Michigan. Postaccident, the POI said that he would not know whether loadmasters were performing their duties in Afghanistan in accordance with the cargo operations manual.

According to the FAA, there had not been any attempts to conduct surveillance on the National Airlines cargo or flight operations in Dubai since September 2012. A review of FAA program tracking and reporting system (PTRS) data for National Airlines revealed no record of any surveillance event for an en route cockpit inspection of a Boeing 747-400.[29] The POI said that the FAA could not require an operator to provide an airplane to conduct an en route inspection because the FAA could not impose cost on an operator.

Surveillance items that the POI and PMI did not accomplish in accordance with ATOS guidance were listed as "nonresourced." Those nonresourced items would roll over into the next month, when the POI and PMI would again try to accomplish them. Although the ATOS would show nonresourced items that were carried over, neither the POI nor the PMI knew how long those items could continue not being accomplished, and neither knew if there was a threshold of how many nonresourced items could be accumulated before the operation had to be observed. The PMI said that items like cargo loading surveillance that they could not accomplish would be indicated in the inspectors' acquisition categories (ACAT).[30] The PMI said the FLM did not have to respond to nonresourced items but would acknowledge the increased risk level noted in ACAT

[28] ATOS uses time-based performance assessments (PA) to confirm that an air carrier's operating systems produce intended results, including mitigation or control of hazards and associated risks. PAs are intended to detect latent, systemic failures that may occur due to subtle environmental changes. PA schedules are adjustable based on known risks or safety priorities. Depending on the element's criticality, assessments are automatically scheduled to occur every 6 months (high criticality), 1 year (medium criticality), or 3 years (low criticality). The normal planning process includes developing a risk-based data collection plan.

[29] The PTRS is a comprehensive information management and analysis system that provides FAA inspectors the means for recoding, storing, retrieving, and analyzing data collected as they perform their various job functions. The PTRS enables FAA personnel to plan work programs, prioritize activities and specific job tasks, and to analyze the safety and compliance status of various elements of the air transportation industry.

[30] The ACAT is inspectors' basis for doing risk assessments for operators they oversee; items not accomplished would elevate the risk for further assessment.

and such acknowledgement would be placed in the comment field. There was no specific threshold when the risk indications were elevated, and, according to the POI and PMI, they would keep increasing the risk assessment even though they were not accomplishing the surveillance.

In response to an NTSB question regarding how many nonresourced items of a particular element are allowed and how long nonresourced items are allowed to accumulate before the FAA takes additional action, the FAA stated that, when resources are insufficient to perform all of the planned action items, the POI and PMI must make a determination based on risk about where resources should be allocated. The FAA's response did not specify how many nonresourced items are allowed or how long they can accumulate, but it noted that FAA Notice 8900.261, "Resources Not Available for ATOS and National Work Program Guidelines Surveillance," provides direction and guidance for FLMs when a shortfall in resources affected the risk-based surveillance plan.31 The notice is intended to reinforce ATOS policy for resources not available (RNA) and revise National Work Program Guidelines (NPG) to establish cancellation procedures for planned surveillance work activity items (P-items) and required surveillance work activity items (R-items) that are not performed due to RNA.[32] The notice states that "current ATOS policy requires the use of RNA to identify surveillance activities that are not accomplished and current NPG policy requires the cancellation of R-items if resources are not available." The order states that open R-items and P-items identified for cancellation would remain open each quarter until resources were provided to accomplish the surveillance or closed when the FAA Flight Standards National Field Office provided authorization to cancel the R-item or P-item at the end of the fiscal year.

1.10.5.4 Risk Management Process

FAA Order 8900.1, volume 10, chapter 3, section 1, "Risk Management Process," provides guidance for FAA inspectors to oversee and evaluate the disposition of any hazard identified by any certificate management team member that a principal inspector or certification project manager decides is sufficiently significant to justify analysis and tracking. The order states that systemic hazards are often good candidates for this process. According to the order, the process has five major steps that include hazard identification (identifying hazards and consequences), risk analysis (analyzing hazards and identifying risks), risk assessment (consolidating and prioritizing risks), decision-making (developing an action plan), and validation of control (evaluating results for further action).

National Airlines did not inform (and it was not required to inform) the FAA that the airline was carrying large, heavy military vehicles centerline-loaded on floating pallets in the Boeing 747-400 or that the airline was carrying multiple MRAP vehicles. The FAA learned that National Airlines was transporting MRAP cargo in early 2013, only when, according to the POI, "someone in the [FSDO] office said [some operators]…were hauling them." The FAA did not conduct a risk analysis when it discovered that National Airlines was hauling heavy military

[31] Notice 8900.261 amended Order 8900.1, chapter 2, section 3, "Design and Performance Assessment Resource Management," paragraph 10-150.

[32] The NPG is described in FAA Order 1800.56O.

vehicles because, according to the POI, "the manual seemed sufficient," and "if they were following their manual, there should not be an issue."

The POI said that he was not aware that National Airlines was strapping the heavy vehicles to the seat tracks until after the accident, when he saw pictures of the strapping. The FAA was not aware of any risk analysis done by National Airlines for the carriage of 18-ton military vehicles, like the Cougar. The PMI said that it was out of his area of expertise to determine whether the carriage of those vehicles would constitute a change in the operations requiring a risk analysis to be conducted; however, in his opinion, "it would need to be addressed."

At the time of the accident, the FAA had just completed a SAT allowed under ATOS for risk mitigation. A National Aviation Safety Inspection Program had also run an assessment, and, according to the PMI, the primary problem with National Airlines that was identified was that "they were having problems training and hiring loadmasters."[33]

1.11 Additional Information

1.11.1 Cargo Movement Incident with Horizontal Stabilizer Component Damage

On February 2, 2008, a Boeing 747-200 freighter operated by Atlas Air experienced an aft movement of cargo during takeoff rotation in Lome, Togo, Africa. The cargo, an oil well drill shaft, moved aft, broke through its wooden container, created an 8-inch diameter hole in the APB, and became lodged in the tail section of the airplane. The flight crew climbed the airplane to cruise altitude but had difficulties maintaining airplane pressurization. The flight crew returned the airplane to the departure airport and landed it safely. Examination of the airplane found that the horizontal stabilizer jackscrew support beam was also bent.

1.11.2 Previously Issued Safety Recommendations

1.11.2.1 Training for Cargo Handling Personnel

On August 7, 1997, a Douglas DC-8-61 cargo airplane operated by Fine Airlines Inc. (Fine Air) crashed after takeoff in Miami, Florida; all four persons on board and a motorist on the ground died. The airplane had been misloaded such that it had an aft CG and incorrect stabilizer trim setting, which resulted in an extreme pitch up at rotation. Because of the incorrect stabilizer trim setting, the pilots could not gain control of the airplane before it struck the ground. The NTSB determined that a contributing factor to the accident was "the failure of the [FAA] to adequately monitor Fine Air's operational control responsibilities for cargo loading and the failure of the FAA to ensure that known cargo-related deficiencies were corrected at Fine Air." (NTSB 1998)

[33] Personnel from the DoD commercial airlift division conducted a biennial survey of the National Air Cargo Group, Inc., from March 26 to 29, 2012. According to the survey results, National Air Cargo, Inc., met the DoD commercial air transportation quality and safety requirements for continued participation in the DoD Air Transportation Program.

During the investigation, the NTSB expressed concern that other cargo operators may have the same deficiencies that Fine Air had in its cargo loading and handling training programs and noted that FAA inspectors did not have the appropriate guidance material to evaluate training programs in cargo handling operations. As a result of the investigation, the NTSB issued multiple safety recommendations to the FAA addressing issues related to the training of cargo handling personnel and FAA oversight of cargo airlines.

To ensure that the problems found at Fine Air did not affect other cargo carriers, Safety Recommendation A-98-45 asked the FAA to do the following:

> Conduct an audit of all…Part 121 supplemental cargo operators to ensure that proper weight and balance documents are being used, that the forms are based on manufacturer's data or other approved data applicable to the airplane being operated, and that FAA principal inspectors confirm that the data are entered correctly on the forms.

In a July 20, 2000, letter, the FAA reported that it had reviewed more than 4,000 records of Part 121 supplemental cargo operators during a special emphasis audit initiated in 1998 and that, when any records were found to be inadequate, they were corrected. On May 18, 2004, the NTSB stated that this audit satisfied the intent of the recommendation to ensure that the correct documents were being used properly, and Safety Recommendation A-98-45 was classified "Closed—Acceptable Action."

In the report on the Fine Air accident, the NTSB concluded that formal training was necessary to ensure that cargo handling personnel receive standardized instruction on safety-critical aspects of the loading process. As a result, Safety Recommendation A-98-47 asked the FAA to do the following:

> Require training for cargo handling personnel and develop advisory material for carriers operating under…Part 121 and principal operations inspectors that addresses curriculum content that includes but is not limited to, weight and balance, cargo handling, cargo restraint, and hazards of misloading and require all operators to provide initial and recurrent training for cargo handling personnel consistent with this guidance.

In its first response, on October 1, 1998, the FAA indicated that it was evaluating whether 14 CFR 121.400, which required that each certificate holder establish and maintain a training program for "other operations personnel," could be interpreted to include cargo handlers and if training could be mandated for cargo handlers. While this determination was being made, the FAA accomplished the following:

- Published AC 120-85, "Air Cargo Operations," which contained guidance for cargo handlers and a recommended training syllabus.
- Published AC 120-27E, "Aircraft Weight and Balance Control," which addressed weight and balance procedures, cargo handling systems, unit load device maintenance, weight scales, cargo restraints, loading/unloading, supervision, and training.

- Developed FAA course 21059, "Air Cargo Operations Inspectors," which addressed certification, FAA oversight, cargo basics, air cargo basics, various cargo equipment, maintenance needed, and all topics covered in AC 120-85. This course is part of the indoctrination training required of FAA aviation safety inspectors in their first 18 months after being hired and is also available for industry representatives.

On October 1, 2012, the FAA indicated that, based on its review of 14 CFR 121.400, it had determined that cargo handlers were not considered "other operations personnel"; thus, the FAA could not mandate specific training for them. The FAA noted, however, that 14 CFR 121.135 required an operator to develop a manual that must include instructions and information necessary to allow personnel to perform their duties to the highest degree of safety and must contain methods and procedures for maintaining the aircraft weight and CG within approved limits. The FAA stated that, as such, when an operator placed requirements for training cargo handlers in its manual, Part 121 required compliance with cargo handler training programs. This training included loading of aircraft, distribution of cargo and passengers, and loading checklists to verify the correct loading, in addition to weight and balance calculations.

Based on the FAA's development of the ACs and the training course, combined with the existing provisions in 14 CFR 121.135, the NTSB classified Safety Recommendation A-98-47 "Closed—Acceptable Action" on December 18, 2012.

1.11.2.2 FAA Oversight of DoD Contract Operations Overseas

On November 27, 2004, a Construcciones Aeronauticas Sociedad Anonima C-212-CC (CASA 212) twin-engine, turboprop airplane, registered to Aviation Worldwide Services, LLC, and operated by Presidential Airways, Inc., of Melbourne, Florida, collided with mountains in the vicinity of the Bamiyan Valley, near Bamiyan, Afghanistan. All six people on board died. Presidential Airways operated the flight under Part 135 under an Air Mobility Command (AMC) contract with the DoD. The flight had departed from Bagram Air Base. The NTSB determined that the probable cause of the accident was, in part, the captain's inappropriate decision to fly a nonstandard route. Contributing factors to the accident included "the lack of in-country oversight by the FAA and the DoD of the operator." (NTSB 2006)

The investigation found that, in addition to FAA requirements, Presidential Airways, under contract to AMC, was required to adhere to the provisions of 32 CFR Part 861, which requires operators to comply with contract provisions, including demonstrating effective flight-following capability. However, in the case of the CASA 212 accident, the operator did not perform effective flight following for the accident flight. According to 32 CFR 861.4, the DoD is required to approve and monitor contract operators to ensure compliance with contract provisions. The regulations are intended to "complement rather than replace the [FAA] criteria applicable to the carrier." In the accident report, the NTSB noted that it was "concerned that the unique risks and oversight challenges presented by operations in remote overseas locations have not been adequately addressed for civilian contractors that provide air transportation services to the U.S. military."

As a result, the NTSB issued multiple safety recommendations, including Safety Recommendation A-06-77, which asked that the FAA coordinate with the DoD to do the following:

> Ensure [that] oversight, including periodic en route inspections, is provided at all contractor bases of operation for civilian contractors that provide aviation transportation to the U.S. military overseas under 14 [CFR] Part 121 or Part 135.

In response to Safety Recommendation A-06-77, the FAA stated that it was not FAA practice to send inspectors into areas of military hostilities to conduct en route inspections because the risk to FAA personnel could not be justified as necessary. However, the FAA performed a broad review with the DoD of issues related to safety oversight of aircraft operations under contract to DoD. The FAA and DoD reviewed the memorandum of understanding (MOU) regarding oversight of civilian contractors in Afghanistan, and the DoD determined that the current MOU appropriately addressed information sharing. Both agencies agreed to enhance their mutual communications and to brief each other on a continuous basis regarding oversight efforts of DoD operations in austere locations. As a result, Safety Recommendation A-06-77 was classified "Closed—Acceptable Action" on January 11, 2008.

1.11.3 Postaccident Safety Actions

1.11.3.1 Federal Aviation Administration

Immediately after the accident, the FAA established a team of inspectors to review the weight and balance programs for National Airlines and five other supplemental cargo operators with a focus on restraint procedures for cargo that is unable to be loaded via ULDs or bulk compartments. Based on information obtained during the review and the accident investigation, on May 17, 2013, the FAA issued Safety Alert for Operators (SAFO) 13005, which advises cargo operators of the potential safety impact of carrying and restraining heavy vehicle special cargo loads. The purpose is to reemphasize current policy and guidance concerning weight and balance control procedures, cargo loading procedures, loading schedules, and loading instructions. SAFO 13005 notes the following:

> The air carrier must have procedures to ensure that employees and vendors are properly trained in the process, the loading is properly completed, and that cargo restraints and loading devices meet the requirements of the approved program. …Heavy vehicle special cargo loads, due to the non-standard and irregular nature of the cargo itself, require careful consideration of the limitations of the aircraft and the characteristics of the cargo to ensure safe operation of the aircraft. There are often overlapping limitations on the basic airframe and floor; cargo loading system attachment limitations; shoring requirements; strap material; and orientation in the forward/aft, lateral, and vertical direction. All of these limitations must be considered before defining a safe restraint configuration for special cargo.

SAFO 13005 provides several suggestions, including advising operators to "use at least a qualified loadmaster and trained staff member to ensure loading and restraint processes are in accordance with your approved weight and balance program."[34] The SAFO reiterates guidance that an air carrier's procedures for restraining cargo should be "based on airplane manufacturer, STC, or other FAA-approved data."

In June 2013, the FAA established a permanent cargo focus team (CFT) to provide a permanent technical support organization for FAA inspectors who oversee air cargo operations. Specifically, the CFT is intended to provide direct technical validation of operator cargo procedures, documents, and support for technical decisions related to cargo. According to the FAA, the CFT also developed a strategic action plan to address certification, operations, and airworthiness issues with the intent of providing clearer, more precise guidance on cargo loading procedures; offering operators improved practices and safer procedures to aid in their decision-making processes concerning cargo operations; and enhancing coordination and outreach efforts with internal and external stakeholders to establish safer cargo operations.

On August 20, 2013, the FAA issued SAFO 13008, which recommends tie-down procedures for restraining special cargo loads. SAFO 13008 suggests that operators review their weight and balance manual and cargo loading documents to ensure adherence to the manufacturers' FAA-approved weight and balance manual or STC supplement and to "verify that over-simplified procedure substitutions are not used…for securing special cargo load." SAFO 13008 states the following:

> The method of determining the number of straps required to secure a load by dividing the payload weight by a reduced strap allowable is not recommended. This method does not reflect the strength, or lack of, the actual vehicle or airplane attach point.

The FAA issued Notice 8900.262, "Review of Weight and Balance Control Programs Including Special Cargo Operations," effective May 6, 2014, that informs FAA inspectors about the support functions that the CFT provided and advises them to review weight and balance control programs, including special cargo operations. The notice advises inspectors of the following:

> The CFT will be required to review air cargo operations manuals and weight and balance manuals to provide concurrence for approval of those documents to [principal inspectors]. For consistency of application, all non-routine issues related to cargo operations must be discussed with the CFT. Special cargo, for the purpose of this notice, is non-standard and irregular in nature, and may require special handling or restraint using restraint devices other than a…ULD.

The notice also provides guidance for PMIs and POIs to track review activities in the PTRS. The notice indicates that the principal inspectors should send the appropriate manuals to the CFT for review and recommendation for approval, including weight and balance control program manuals, supporting documentation such as source documents and deviations, and an operator's personnel training programs associated with weight and balance, load manifest, and

[34] As discussed previously in section 1.10.1, the position of loadmaster is not an FAA-certificated position, and neither the position nor its qualifications are defined by the FAA.

cargo loading to include special cargo and cargo restraint. The notice estimates that a complete review would take about 45 days.

The FAA reported that, as of May 28, 2015, the CFT had completed thorough reviews of the weight and balance control programs and manuals of six air carriers (including National Airlines) and that the CFT worked with the FAA certificate management offices of these carriers to correct identified deficiencies in some air carrier procedures in the areas of cargo restraint; determining methods for securing special cargo loads; and communication among air carriers, contractors, freight forwarders, and the DoD. The CFT initiated reviews of the weight and balance control programs and manuals of three more Part 121 air carriers and developed a schedule to complete such reviews for 83 air carriers, to be performed in a sequence determined by risk assessment. Other safety action that the FAA reported in its May 28, 2015, letter included the following:

- Issued Information for Operators 13012 on November 21, 2013, to inform Boeing 747 operators about revisions that Boeing made to its weight and balance manuals for the Boeing 747-8F, -400F, and 400BCF series airplanes. The revisions, which the FAA approved, include updated tie-down requirements and seat-track capabilities.
- Continued outreach efforts and stakeholder initiatives for cargo operations at various industry meetings (discussed in section 1.11.3.4) and supported a voluntary “safety stand down” with the US military regarding the use of contract carriers to transport heavy vehicles.
- Revised some of the content of the FAA air cargo training course provided to new inspectors.
- Developed weight and balance program job aids for FAA inspectors regarding an operator’s load control and cargo loading training.

The FAA also informed the NTSB about a number of activities that the CFT anticipated to complete by the end of 2015. These included plans to revise AC 120-85 and FAA Inspector Handbook 8900.1 to improve guidance in the areas of training, special cargo, restraint, operator’s evaluation system for weight and balance control, freight staging, checklists, and job aids. The FAA is also drafting a notice to provide guidance for FAA principal inspectors on the process of accepting and/or approving changes to cargo manuals for Part 91K, 121, 125, and 135 operators.

The FAA also planned to continue to revise the FAA air cargo operations training course and develop a new training course to emphasize the enhanced guidance in the revised AC once it is issued. The FAA also stated in its May 28, 2015, letter that it was developing an exemplar operations specifications document for cargo operations and was initiating a study to research duty day/hour limitations and human factors for load supervisors and flight mechanics. The FAA stated that the study will “attempt to explore the feasibility of creating an airman certificate requirement for load supervisors and flight mechanics, and also the feasibility of creating a certificate of demonstrated proficiency for load supervisors and flight mechanics.”

1.11.3.2 National Airlines

After the accident, National Airlines reviewed and revised its cargo operations manual to incorporate restraint information from both the Boeing and Telair weight and balance and load control manual to include the following information (among other items): approved tie-down points and their limitations; restraint values for straps connected to seat tracks and other floor components; Boeing and Telair strap value chart differences; a worksheet for use in determining total restraint value per direction; requirements pertaining to TRC and determining forward limits; and information about approved ULDs and cargo loading ground operations. The airline also created guidance for clearly identifying seat track usage in accordance with Boeing's weight and balance manual and marked the seat tracks on the main cargo deck with either a red or green painted stripe to indicate whether it is an acceptable location to attach load-bearing straps. The airline developed guidance to address ULD and strap airworthiness, serviceability, and procedures for the acceptance of ULDs planeside, including the cargo loading systems and the ULD airworthiness requirements.

National Airlines also created a special loads team to evaluate loads, including preplanning tie-down, shoring, and special handling equipment; produced training material for crews to identify possible problems with cargo loaded on the aircraft; and worked with NACA and Boeing's working groups to standardize the cargo industry with respect to aircraft manufacturer guidelines. Several of National Airlines' loadmasters attended formal training at the Boeing performance engineering course, and the airline plans to send four loadmasters to three courses. The airline also defined when audits and training are required. According to the National Airlines chief loadmaster, since the accident, loadmasters are required to complete a "loadmaster report" for every flight leg so that the airline can spot trends in the operations.

1.11.3.3 Boeing

At the time of this report, Boeing had initiated enhancements to the Boeing 747-400 BCF and other Boeing 747 freighter model weight and balance manuals to increase the number of seat tracks available for tie-down and anticipated that the revisions would be completed by the end of summer 2015. Boeing increased the number of weight and balance training classes it offered beginning in fall 2013 to meet an increased demand by operators. Boeing also supported NACA meetings that were held in 2013 and 2014 to address to transporting ultra-large cargo.

1.11.3.4 Cargo Industry

Following the accident, the National Air Carrier Association (NACA) initiated safety action intended to educate industry operators about the importance of proper restraint and aircraft limitation considerations for securing heavy vehicle special cargo loads.[35] These efforts included assisting the FAA with the CFT and developing the SAFOs, assisting the FAA with its planned

[35] NACA is comprised of 16 air carriers that provide nonscheduled and scheduled passenger and cargo services, including services that support the US military. NACA members are National Airlines, Air Transport International, Allegiant Air, Atlas Air, Eastern Air Lines, Everts Air Cargo, Kalitta Air, Lynden Air Cargo, Miami Air International, Northern Air Cargo, Omni Air International, Southern Air, Spirit Airlines, Sun Country Airlines, USA Jet Airlines, and Western Global Airlines.

revisions to AC 120-85, and working with the FAA and Boeing to develop industry best practices. NACA held Boeing 747 Special Cargo Load Meetings on June 26, 2013, and November 13, 2013, and hosted other activities in 2014, in which the FAA and/or Boeing participated. In addition, IATA conducted two forums that addressed special cargo load safety on February 23, 2014, and October 22, 2014, in which the FAA participated. Both NACA's and IATA's activities related to best practices for special cargo loads are ongoing.

2. Analysis

2.1 Acceptance of Special Cargo Load and Previous Flight

The cargo that was loaded on board the accident airplane represented the first time that National Airlines had attempted to transport five MRAP vehicles. These vehicles, which were secured to pallets, were considered a special cargo load because they could not be restrained in the airplane using the locking capabilities of the airplane's main deck cargo handling system. The airline's safety department was not involved in the decision to begin carrying heavy vehicle special cargo loads. When interviewed by investigators, the National Airlines chief loadmaster described the operator's role as "you call, we haul" and stated that approval of the cargo was up to NAC, the cargo handling vendor that gave National Airlines the freight.

Although the airplane could accommodate the weight of the proposed cargo within its weight and balance envelope, the MRAP vehicles were considered TRC and, therefore, were subject to specific restraint requirements designed to protect the upper deck passenger compartment in the event of an emergency landing. However, when personnel from the NAC load planning department contacted the chief loadmaster to inquire whether precautions should be taken before confirming the cargo load of two M-ATVs and three Cougars, the chief loadmaster's response noted only weight and balance considerations. The National Airlines cargo operations manual, which was developed by the chief loadmaster, did not contain all of the required information from the Boeing and Telair weight and balance manuals and loading control documents. The NTSB concludes that, had the National Airlines chief loadmaster consulted the required manufacturers' weight and balance manuals, he could have determined that the intended load of five vehicles could not be properly secured in the airplane in accordance with the TRC safety requirements; at most, only one M-ATV could be transported.

However, the cargo was accepted, and the loadmaster ensured that it was loaded within the weight and balance envelope for the airplane. Under the supervision of the loadmaster, NAC personnel secured and shored the vehicles onto centerline-loaded floating pallets and restrained the cargo in the airplane with tie-down straps. The airplane successfully completed one flight with the cargo from Camp Bastion to Bagram (the flight that preceded the accident flight); however, discussions between flight crewmembers and the loadmaster that the CVR captured indicated that at least some of the cargo had moved, one strap had broken, and other straps had become loose during that flight. The FDR data for that flight indicated that no unusually excessive G loads were encountered.

Before the airplane departed on the accident flight, the flight crew discussed that the loadmaster was taking action to re-secure the cargo. The first officer mentioned that the loadmaster was "cinching them all down," and the captain said that he hoped that the loadmaster was adding more straps. Although some of the discussion was conducted in a joking manner, the comments indicated that the flight crewmembers were concerned that the cargo had moved and that they relied on the loadmaster to know how to correct the problem and ensure the safe restraint of the cargo. The NTSB concludes that, although the flight crewmembers and the loadmaster were aware that the cargo moved during the previous flight, they did not recognize that this indicated a serious problem with the cargo restraint methods.

2.2 Accident Sequence

2.2.1 Loss of Pitch Control

During the airplane's takeoff roll and rotation, its performance and motions were initially normal when compared with both FDR data from its previous takeoff and a baseline simulation that assumed an airplane with a similar load and configuration. Although the entire flight lasted about 30 seconds from liftoff to the time of impact, the airplane's FDR and CVR both stopped recording data within a few seconds after liftoff. The final 3 seconds of the airplane's FDR data, which ended when the airplane had climbed to about 33 ft, showed that the accident takeoff had begun to diverge from both the previous takeoff and the baseline simulation, climbing more steeply. Recorded video footage captured the airplane in a steep climb with a high pitch attitude before it reached its highest point, entered a roll to the right, then rapidly descended and struck the ground in a nose-down and nearly wings-level attitude. The airplane's steep pitch attitude and subsequent departure from controlled flight were consistent with an aerodynamic stall.

2.2.2 Evidence of Aft Movement of the Rear M-ATV

Debris found on the runway starting near the airplane's point of rotation included fragments of airplane skin, tubing from hydraulic system No. 2, fragments of the E8 rack, and part of a M-ATV antenna; all of the airplane debris came from structures that had been located aft of the loaded location of the rear M-ATV, and the installed location of the M-ATV's antenna was its rear, upper left corner. This runway debris evidence strongly suggests that, about the time of the airplane's rotation, the rear M-ATV moved aft, struck the E8 rack (which provides a shelf for the CVR and FDR), penetrated the APB, and damaged hydraulic system No. 2, the tubing for which passes through the APB on the airplane's lower left side. Given that fragments of hydraulic system No. 2 were found on the runway (and the other evidence of hydraulic system damage described below), it is likely that the puffs of white "smoke" that one witness reported seeing was misting hydraulic fluid.

Additional evidence found in the main wreckage further supports this scenario. Damage to the rear M-ATV's upper left side, including an orange paint transfer that appeared visually consistent with the orange paint on the FDR chassis, and the location of the paint on the M-ATV corresponded with the height of the mounted location of the FDR chassis on the E8 rack. A M-ATV tire imprint was found on a large, separated section of the APB. The lower left side of the APB near the main cargo deck floor was separated into at least three smaller sections (two were identified), and these smaller separated sections of the APB corresponded with areas where the tubing for hydraulic systems Nos. 1 and 2 pass through. (Although preimpact damage to hydraulic system No. 1 could not be determined from the wreckage evidence, information from the image study provided information about the status of the system, which is analyzed in section 2.2.3.) Sections of the APB's interior lining material from the right side of the airplane were found impinged in the M-ATV structure, consistent with the lining material having been in contact with the M-ATV structure at the time of the airplane's ground impact; that is, the damage was consistent with the M-ATV structure becoming crushed around the liner material during the ground impact sequence. All of this evidence suggests that the rear M-ATV moved aft through the APB before the airplane struck the ground. In addition, damage on the underside of the M-ATV's pallet, damage to the aft floor locks, and the premature cessation of the CVR and FDR (which are powered by separate alternating current buses and stopped recording almost simultaneously) further support the scenario that the rear M-ATV moved aft shortly after the airplane's rotation.

Damage observed on the horizontal stabilizer jackscrew assembly and support structure and the presence of tire marks on structure aft of the APB provide further evidence that the rear M-ATV moved aft until it struck these components (see figure 17). Also, the displacement of the M-ATV's tire 90° from its original position and the presence of tire marks on the green dorsal fairing support structure for the vertical stabilizer are consistent with the M-ATV having been located aft of its original loaded location when the airplane struck the ground; that is, the tire displacement and the tire mark evidence is consistent with the M-ATV having been positioned beneath the vertical stabilizer at the time of the airplane's ground impact, and the vertical stabilizer collapsed down onto the rear portion of the M-ATV at ground impact.

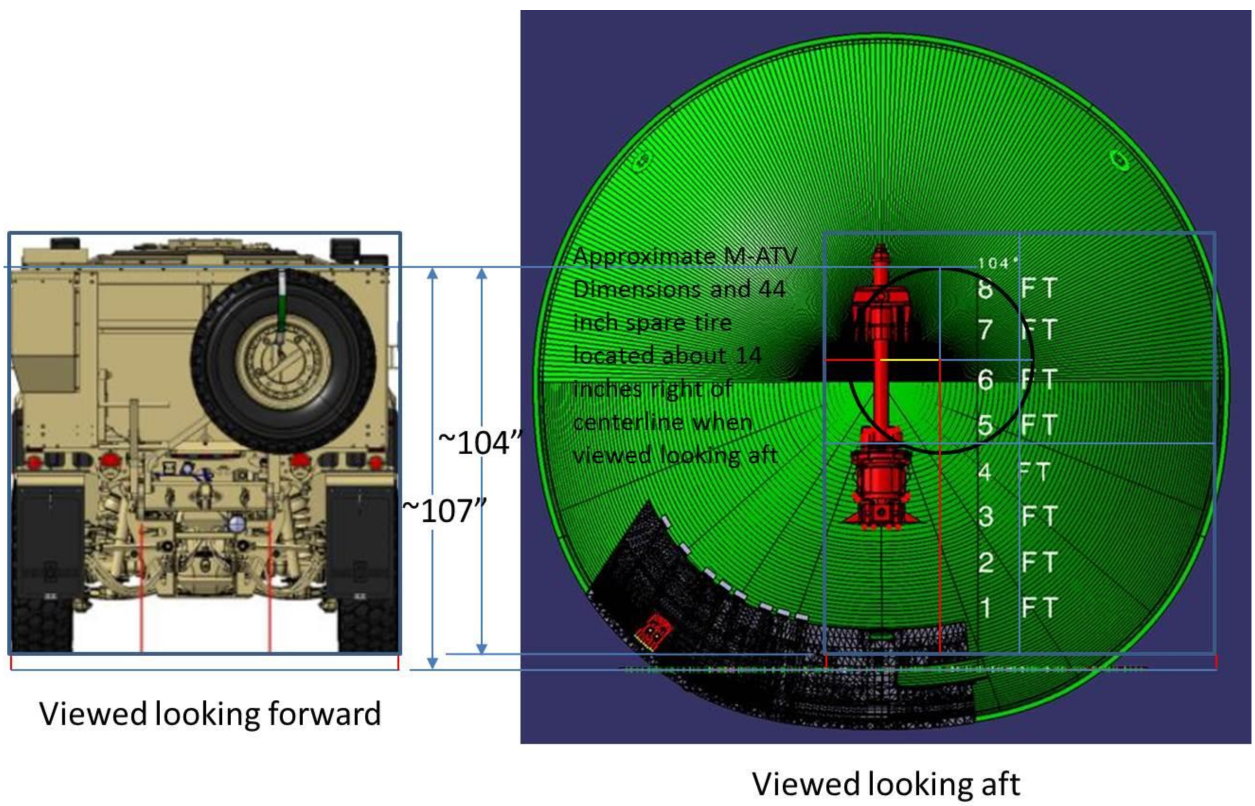

Figure 17. Illustration showing how the dimensions of the M-ATV align with the APB and jackscrew structures. On the image at right, the jackscrew components are shown in red, and the location of the tire imprint found on the APB is depicted with a black circle.

2.2.3 Simulation Results

In the absence of FDR data, simulations were performed to determine possible scenarios that could have produced the observed motions of the accident airplane. Scenarios that considered the effect of the aft movement of one or more MRAP vehicles found that the simulated airplane remained pitch-controllable when up to all five MRAP vehicles moved aft, resulting in a calculated CG shift from within weight and balance at 31.7% (all MRAP vehicles in place) to an aft CG of at most 56% (all five moved aft). For each CG configuration, including the most extreme aft CG condition, the simulated airplane could be returned to a level pitch attitude in less than 5 seconds; thus, a CG shift alone cannot explain the loss of control of the airplane.

Based on the wreckage evidence and evidence from the image study, scenarios that were considered the most plausible included aft movement of at least the rear M-ATV, failures of at least hydraulic systems Nos. 1 and 2, and the effects of a damaged horizontal stabilizer's jackscrew actuator and surrounding structure (due to collision from the M-ATV).[36] In one study scenario, when an aft movement of the rear M-ATV and the failure of hydraulic systems Nos. 1 and 2 (or Nos. 1, 2, and 3) were assumed, a shift of the horizontal stabilizer from the set takeoff position to a 5° leading-edge-down position resulted in an inability of the available flight control surfaces to counter the resulting nose-up pitching moment. Study calculations determined that, for a 5° deflection of the horizontal stabilizer's leading edge, the corresponding displacement at the stabilizer's root corresponded approximately with the displacement of the fractured stabilizer jackscrew and surrounding structure as found on the accident airplane. Therefore, the NTSB concludes that the airplane's loss of pitch control was the result of the improper restraint of the rear M-ATV, which allowed it to move aft through the APB and damage hydraulic systems Nos. 1 and 2 and horizontal stabilizer drive mechanism components to the extent that it was not possible for the flight crew to regain pitch control of the airplane.

2.2.4 Explosives Examinations

The NTSB and JCAT examinations of the airplane wreckage (including components from inside the airplane) and review of witness statements (including two JCAT assessors who saw and heard the accident airplane during its climb and descent), video images, and other information did not reveal any evidence that explosives were used against the airplane. The JCAT analysis also considered local weapon engagement zones for various classes of weapons. The JCAT, which consists of military forensic specialists on weapons effects, concluded that "there was absolutely no evidence that any sort of weapon was employed against [the airplane] at

[36] The image study showed that, during the accident flight, the airplane's nose landing gear and body landing gear were extended, the nose landing gear doors were open, and the wing landing gear was retracted. Further, the configurations of the main landing gear actuators were consistent with the body landing gear being in the down position and the wing landing gear being in the up position. Although the FDR did not capture any landing gear command or transition before the data ended, the first officer said "gear up" just before the CVR and FDR recordings ended; thus, it is likely that the gear lever was soon after moved to the "up" position to command that the landing gear be retracted. The successful retraction of the wing landing gear provides evidence that hydraulic system No. 4 was functional. The opening of the nose landing gear doors is among the first events in the gear retraction sequence; however, the doors opened, but the nose landing gear remained extended. This provides evidence that hydraulic system No. 1 became compromised very shortly after gear retraction was commanded. The functional status of hydraulic system No. 3 was not determined.

any time prior to, during, or after the event." In addition, chemical analysis performed by the US military on pieces of wreckage found no evidence of explosive residue. Further, the CVR group identified no anomalous sound or noise on the CVR recording that was consistent with an explosive event. Therefore, the NTSB concludes that there is no evidence that an explosive device or hostile acts were factors in this accident.

2.3 National Airlines

2.3.1 Incorrect Procedures and Training for Restraining Special Cargo Loads

Before takeoff from Camp Bastion (the flight that preceded the accident flight), the National Airlines loadmaster directed NAC personnel to use 24 straps to secure each of the two M-ATVs and 26 straps to secure each of the three Cougars. This configuration was not in compliance with National Airlines' procedures (which would have indicated the use of 32 straps for each M-ATV and 46 for each Cougar); however, National Airlines' procedures did not incorporate the required safety-critical cargo-securing information from the airplane and the cargo handling system manufacturers' manuals.

National Airlines' procedures omitted the required information from the Boeing and Telair weight and balance manuals regarding cargo restraining methods outlined and instead contained incorrect restraining methods for special cargo loads. For example, the cargo operations manual, which contained guidance for the loadmasters, did not define the individual tie-down allowable loads for the various components in the cargo system such as the available seat tracks; did not specify that each tie-down attachment point may be used to react load in only one direction; and did not consider that the full capability of the attach fittings varied depending on the measured strap angle. Therefore, the NTSB concludes that, although the loadmaster did not follow National Airlines' procedures for securing the special cargo load, the procedures were deficient to the extent that, if followed, they could not have enabled him to properly load and restrain a special cargo load in accordance with the manufacturer and STC holder requirements.

The chief loadmaster developed National Airlines' procedures without any coordination with the flight operations or safety personnel and developed the loadmaster training without any involvement from the director of training. He stated that he developed the content for the loadmaster training course by referencing materials from various other companies and cutting and pasting from "a lot of other manuals." Although the loadmaster's training file indicated that he received initial and recurrent training, the course content list did not include special cargo loads. Also, the effectiveness of the training is highly questionable because it would have been based on the airline's incorrect procedures. Therefore, the NTSB concludes that, although National Airlines provided the accident loadmaster with initial and recurrent training, this training was deficient to the extent that it could not have provided him the knowledge and skills necessary to properly load and restrain a special cargo load in accordance with the manufacturer and STC holder requirements.

After the accident, on May 17, 2013, the FAA issued SAFO 13005, which reiterates guidance that an air carrier's procedures for restraining cargo should be "based on airplane manufacturer, STC, or other FAA-approved data." SAFO 13005 also states that special cargo loads, due to the nonstandard and irregular nature of the cargo itself, require careful consideration of the aircraft limitations and the cargo characteristics when determining a safe restraint configuration. The FAA also issued SAFO 13008, which advises operators to verify that "over-simplified procedure substitutions" are not used for securing special cargo load. The SAFO specifically references a method similar to that which National Airlines used in which the number of straps required to secure the load was determined by dividing the payload weight by a reduced strap allowable and in which the strength of the actual airplane attach point (and cargo attach points) were not considered.

However, a review of cargo handling guidance provided in AC 120-85 revealed that it contains information that conflicts with the requirements for operators to use FAA-approved data. Although the AC does contain guidance that advises operators to have procedures to restrain cargo in accordance with FAA-approved data, chapter 201(a)(4) states that an air carrier must also "have procedures in its manual for the use of miscellaneous restraint devices in cases that may not be specified by the applicable manufacturer weight and balance manual, approved STC supplement, or other FAA-approved data." The NTSB is concerned that such guidance allows operators to introduce incorrect procedural substitutions like those used by National Airlines, particularly for special cargo loads.[37] Therefore, the NTSB recommends that the FAA revise the guidance material in AC 120-85, chapter 201(a)(4), to specify that an operator should seek FAA-approved data for any planned method for restraining a special cargo load for which approved procedures do not already exist, and remove the language in the AC that states that procedures other than those based on FAA-approved data can be used.

SAFO 13005 also advised cargo operators to "use at least a qualified loadmaster" and ensure that employees and vendors are properly trained, loading is properly completed, and cargo restraints and loading devices meet the requirements of the operator's FAA-approved program. Although the NTSB agrees with the intent of this guidance, the NTSB notes that, currently, the FAA does not define the position of "loadmaster" and has not established training requirements that would set qualification standards for cargo handling personnel. Although AC 120-85 provided some guidance for training, operators are not required to adhere to the AC's recommendations.

As a result of its investigation of the August 7, 1997, accident involving a Fine Air cargo flight, the NTSB concluded that formal training was necessary to ensure that cargo handling personnel receive standardized instruction on safety-critical aspects of the loading process. In response to Safety Recommendation A-98-47, on October 1, 2012, the FAA indicated that it could not mandate training for cargo loaders but that it believed that the provisions of 14 CFR 121.135, which required an operator to develop a manual that includes the instructions and information necessary for personnel to perform their duties to the highest degree of safety, adequately addressed the issue of required training for cargo loaders. However, as the circumstances of the National Airlines accident show, the FAA's actions in response to Safety Recommendation A-98-47 did not ensure that operators' procedures and training for its cargo handling personnel were adequate to ensure the proper evaluation and restraint of special cargo loads.

[37] As noted in section 1.11.3, after the accident, the FAA worked with National Airlines to review and correct the airline's manuals.

FAA-certificated positions, like pilots, dispatchers, and mechanics, are subject to specific requirements for initial and recurrent training and experience. These requirements help ensure that these personnel have the knowledge, skills, training, and proficiency to perform their duties in the interest of safety. A loadmaster is not an FAA-certificated position, and, as such, there are no FAA requirements for the procedures and training programs for personnel who oversee cargo loading plans and implementation of those plans. (In contrast, the US military recognizes the position of loadmaster as a required crewmember, and military loadmasters receive extensive required training and evaluations to become qualified for the position.) Also, unlike flight crewmembers, cargo handling personnel are not subject to duty time limitations or rest requirements. Because the procedures and training for the accident loadmaster were so deficient, there is no evidence to suggest that enhanced rest opportunities for the loadmaster could have prevented the accident; however, the investigation found that loadmasters were being scheduled for long duty days without the same rest opportunities that were provided to the flight crews with whom they traveled.

The NTSB is concerned that the lack of duty time limitations or rest requirements for cargo handling personnel could leave these personnel vulnerable to the performance-degrading effects of fatigue. The FAA has noted that special cargo loads, due to the nonstandard and irregular nature of the cargo itself, require careful consideration of the aircraft limitations and the cargo characteristics to ensure safe operation of the aircraft. Overlapping limitations on the basic airframe and floor; cargo loading system attachment limitations; shoring requirements; strap material; and orientation in the forward/aft, lateral, and vertical direction must all be considered before a safe restraint configuration for special cargo can be defined. Thus, cargo handling personnel who evaluate and restrain special loads perform a skilled and critical safety function. Although a captain is ultimately responsible for the cargo load, pilots are not trained on how to safely load and restrain cargo and rely almost exclusively on the cargo handlers to ensure the safety and security of the cargo load.

The NTSB concludes that the certification of personnel responsible for ensuring the proper loading, restraint, and documentation of special cargo loads, including requirements for their procedures, training, and duty time and hour limitations, would help ensure that these personnel properly perform their safety-critical duties. In a May 28, 2015, letter to the NTSB, the FAA stated that it had initiated a study to explore the feasibility of creating an airman certificate requirement and a certificate of demonstrated proficiency for load supervisors and that it will research duty day and hour limitations and human factors for load supervisors. The NTSB is encouraged by the FAA's research in these areas and believes that the circumstances of this accident and the previous cargo flight accident involving Fine Air support the need for a level of safety for cargo handling personnel consistent with that of other personnel who perform safety-critical functions. Also, the NTSB has long believed that the FAA should include cargo handling functions among the safety-sensitive duties listed in Part 121, Appendixes I and J.[38] Therefore,

[38] Appendixes I and J to Part 121 contain the FAA's standards for antidrug and alcohol misuse prevention programs for personnel who perform safety-sensitive functions. On August 18, 2003, the NTSB issued Safety Recommendation A-03-36, which asked the FAA to "modify the list of safety-sensitive functions described in…Part 121, Appendixes I and J, to include all personnel with direct access to the airplane and a direct role in the handling of the flight, including cargo handlers, load planners, and ramp supervisors." Safety Recommendation A-03-36 is classified, "Open—Unacceptable Response" due to the FAA's delays in completing the recommended action.

the NTSB recommends that the FAA create a certification for personnel responsible for the loading, restraint, and documentation of special cargo loads on transport-category airplanes, and ensure that the certification includes procedures; training; and duty hour limitations and rest requirements consistent with other safety-sensitive, certificated positions.

2.3.2 Inadequate Procedures and Training for Verifying Pallet Build-Up

All cargo operations personnel involved in aircraft loading for National Airlines are required to use the procedures and instructions contained in the cargo operations manual and the forms and checklists in both the cargo operations manual and the general operations manual. The cargo operations manual stated that the airline must verify that vendors have a current copy of the manual and procedures for handling special or oversized loads; however, NAC personnel did not have a copy of the manual or access to an electronic copy. In addition, the NAC operations specialist who was in charge of the pallet build-up was provided no training and no specific procedures or manual to reference when building the pallets for the accident load and did not know the load capacity of a pallet. National Airlines' chief loadmaster, who was responsible for training ground operations vendors on National Airlines' procedures, did not know what guidance NAC had sent its loaders for the pallet build-up or loading of the MRAP vehicles.

Similarly, although the loadmaster was responsible for inspecting pallets and ensuring that the pallet limits were not exceeded, the cargo operations manual did not address double pallets (like those used for the Cougars) or how they should be built. Loadmasters were not provided additional guidance on how to shore or load MRAP vehicles, and loadmasters were expected to use their judgment on proper shoring based on their experience. However, neither the accident loadmaster nor anyone else at National Airlines had any experience transporting a Cougar.

The correct build-up of pallets and shoring, and the securing of heavy special cargo loads to these platforms, are important functions for the overall restraint of the cargo and for ensuring that it does not exceed the structural limitations of the airplane's floor. The NTSB's investigation could not determine if any pallet build-up or shoring problems contributed to the movement of the cargo; however, the NTSB is concerned that National Airlines did not have any procedures or training in place for its loadmaster and its cargo handling vendor to ensure that these functions were performed correctly. This issue, combined with the previously described problems with the airlines' procedures and training for its own cargo handling personnel, highlights deficiencies with the FAA's oversight of the operator.

2.4 Federal Aviation Administration Oversight

2.4.1 Inadequate Review of National Airlines' Procedures

As previously mentioned, National Airlines' cargo operations manual not only omitted critical information from the Boeing and Telair manuals about properly restraining special cargo loads but also contained information that conflicted with the manufacturers' FAA-approved information. Although the POI learned in early 2013 that National Airlines was carrying heavy loads on pallets, no FAA risk analysis was performed. The POI stated that "the manual seemed sufficient," and "if they were following their manual, there should not be an issue." However, as previously mentioned, the cargo operations manual was deficient.

FAA Order 8900.1, volume 3, section 2, "Approval and Acceptance of Manuals and Checklists," contains direction and guidance for POIs when approving or accepting an operator's manuals and checklists and describes the POI's role in the review process and for resolving any discrepancies in both approved and accepted manuals. The NTSB concludes that the FAA did not provide adequate oversight to ensure that the National Airlines cargo operations manual reflected the correct information and guidance from the airplane and cargo handling system manufacturers that specified how to safely secure the cargo.

After the accident, the FAA's CFT completed reviews of the cargo loading manuals for National Airlines and five other air carriers and worked with the air carriers to correct identified procedural deficiencies (for some of the carriers) in the areas of cargo restraint and determining methods for securing special loads. As previously discussed, the FAA also issued SAFO 13008, which suggests that operators review their weight and balance manual and cargo loading documents to ensure adherence to the manufacturers' FAA-approved weight and balance manual or STC supplement and to verify that over-simplified procedure substitutions are not used for securing a special cargo load. The SAFO specifically advises against using the method of determining the number of straps required to secure a load by dividing the payload weight by a reduced strap allowable.

At the time of this report, the FAA's CFT had initiated reviews of the weight and balance control programs for three more air carriers; however, it had identified 83 air carriers whose programs it intended review, to be performed in a sequence determined by risk assessment. Although the NTSB is strongly encouraged by the FAA's cargo safety enhancement efforts since the accident, the NTSB is concerned that the problem of incorrect restraint procedures is not unique to National Airlines and that the FAA has completed reviews on only a small percentage of cargo air carriers in the 2 years since the accident. Therefore, the NTSB recommends that the FAA add a special emphasis item to FAA Order 1800.56O, "National Flight Standards Work Program Guidelines," for inspectors of Part 121 cargo operators to review their manuals to ensure that the procedures, documents, and support in the areas of cargo loading, cargo restraint, and methods for securing cargo on transport-category airplanes are based on relevant FAA-approved data, with particular emphasis on restraint procedures for special cargo that is unable to be loaded via ULDs or bulk compartments.

2.4.2 Unclear Inspector Responsibility for Cargo Handling Personnel

The FAA stated that both operations and airworthiness inspectors had oversight responsibility for the duties related to the loading of aircraft. However, FAA Order 8900.1 outlines no specific guidance for either the POI or the PMI related to the duties or procedures of cargo handling personnel. The POI for National Airlines based his review of loadmasters on other carriers' best practices, and the PMI considered loadmasters as part of operations. The POI considered loadmasters as "an extension of the captain, being given the authority to load the airplane together."

The NTSB is concerned that the FAA divides the oversight of the safety-critical duties of cargo handling personnel between the authority of the POI and PMI with no clear guidance as to how each inspector should provide oversight of these personnel and their procedures. The NTSB concludes that the lack of clear guidance regarding FAA inspector responsibility for the oversight of cargo handling personnel resulted in minimal oversight of these areas at National Airlines and enabled the persistence of critical safety deficiencies. Although the FAA has indicated that it is revising the inspector handbook to enhance FAA guidance that addresses cargo operations, the FAA has not specified whether these revisions will clearly define responsibilities for POIs and/or PMIs regarding special cargo loads. Therefore, the NTSB recommends that the FAA include specific guidance in the FAA inspector handbook that defines responsibilities for principal inspectors for the oversight of an operator's loading, restraint, and documentation of special cargo loads.

Also, although the newly formed CFT now provides technical support to assist principal inspectors with the oversight of air cargo operations, the NTSB is concerned that field personnel lack technical expertise regarding cargo handling procedures and restraint, particularly for special cargo loads. The FAA's planned revisions to the FAA's air cargo operations training course to enhance course content for special cargo and restraint have not yet been completed, and inspectors must rely on the CFT to perform manual reviews. Therefore, the NTSB recommends that the FAA provide initial and recurrent training for all principal inspectors who have oversight responsibilities for air carrier cargo handling operations that specifically addresses operator cargo procedures, documents, restraint, and support for technical decisions related to special cargo loads.

2.4.3 Lack of En Route Inspections and Direct Surveillance

Under FAA Order 8900.1, the FAA is required to perform cockpit en route inspections on National Airlines' operations. However, the POI had attempted to conduct en route inspections of National Airlines' Boeing 747-400 flights but could not because of the State Department restrictions on inspector travel into Afghanistan. Similarly, the PMI could not provide direct surveillance of mechanics overseas. As a result, FAA inspectors had never performed any en route cockpit inspections of National Airlines' Boeing 747-400 cargo flight operations and had not performed a ramp inspection since 2012 in Dubai.

The FAA considers en route inspections as one of its most effective methods of accomplishing air transportation surveillance objectives and responsibilities, and the evaluation of airman duties and flight deck procedures is a high criticality item scheduled to be performed every 6 months. Such inspections provide FAA inspectors the opportunity to observe how personnel apply procedures and to ask questions of those personnel. When inspectors cannot accomplish the inspections due to resource shortfalls or other restrictions, the items are carried over into the next month. According to the POI and PMI for National Airlines, when they could not accomplish the surveillance, they would note the elevated risk for further assessment. However, FAA Notice 8900.261 references no limitations on the number of times that these nonresourced surveillance items can be deferred; instead, nonresourced items may be canceled.

The NTSB previously investigated a fatal accident in 2004 involving a US operator conducting operations in Afghanistan under a DoD contract. As a result of that investigation, the

NTSB issued multiple safety recommendations, including Safety Recommendation A-06-77, which asked the FAA to coordinate with the DoD to ensure that oversight, including periodic en route inspections, is provided at all bases of operation for civilian contractors that provide aviation transportation to the DoD overseas under Part 121 or Part 135. The NTSB notes that any contract compliance evaluations conducted by DoD personnel are intended to complement, not replace, the FAA oversight responsibility that applies to the operator. In response to Safety Recommendation A-06-77, the FAA stated that it was initiating a broad review with the DoD of issues related to safety oversight of aircraft operations under contract to the DoD. The FAA and DoD reviewed the MOU regarding oversight of civilian contractors in Afghanistan, and both agencies agreed to enhance their mutual communications and to brief each other on a continuous basis regarding oversight efforts of DoD operations in austere locations. As a result, Safety Recommendation A-06-77 was classified "Closed—Acceptable Action" on January 11, 2008.

The NTSB is concerned that, despite these previous assurances from the FAA that it had made improvements to its oversight process for DoD contract operations, its oversight of National Airlines' Boeing 747-400 operations was inadequate to detect critical deficiencies in the operator's cargo handling procedures. The NTSB recognizes the unique oversight challenges presented by operators that provide air transportation services to support DoD contracts in locations subject to State Department restrictions on inspector travel; however, for operations that have been subject to the repeated deferral of surveillance tasks, risks that might otherwise be detected can persist or increase. Therefore, the NTSB concludes that, when circumstances such as FAA inspector travel restrictions or resource shortfalls result in the repeated deferral of required surveillance tasks, an alternative method of risk reduction could help mitigate risks until the surveillance tasks can be completed. For example, when FAA inspectors first learned that National Airlines was transporting heavy cargo on pallets, they could have conducted a risk analysis at the operator's US base of operations, which could have detected (and ultimately led to the correction of) the airline's incorrect procedures for restraining such loads. Therefore, the NTSB recommends that the FAA implement temporary risk-reduction methods any time that required surveillance items for Part 121 and 135 operators are deferred, and establish appropriate limitations on surveillance deferrals.

3. Conclusions

3.1 Findings

1. Had the National Airlines chief loadmaster consulted the required manufacturers' weight and balance manuals, he could have determined that the intended load of five vehicles could not be properly secured in the airplane in accordance with the tall rigid cargo safety requirements; at most, only one mine-resistant ambush-protected all-terrain vehicle could be transported.

2. Although the flight crewmembers and the loadmaster were aware that the cargo moved during the previous flight, they did not recognize that this indicated a serious problem with the cargo restraint methods.

3. The airplane's loss of pitch control was the result of the improper restraint of the rear mine-resistant ambush-protected all-terrain vehicle, which allowed it to move aft through the aft pressure bulkhead and damage hydraulic systems Nos. 1 and 2 and horizontal stabilizer drive mechanism components to the extent that it was not possible for the flight crew to regain pitch control of the airplane.

4. There is no evidence that an explosive device or hostile acts were factors in this accident.

5. Although the loadmaster did not follow National Airlines' procedures for securing the special cargo load, the procedures were deficient to the extent that, if followed, they could not have enabled him to properly load and restrain a special cargo load in accordance with the manufacturer and supplemental type certificate holder requirements.

6. Although National Airlines provided the accident loadmaster with initial and recurrent training, this training was deficient to the extent that it could not have provided him the knowledge and skills necessary to properly load and restrain a special cargo load in accordance with the manufacturer and supplemental type certificate holder requirements.

7. The certification of personnel responsible for ensuring the proper loading, restraint, and documentation of special cargo loads, including requirements for their procedures, training, and duty time and hour limitations, would help ensure that these personnel properly perform their safety-critical duties.

8. The Federal Aviation Administration did not provide adequate oversight to ensure that the National Airlines cargo operations manual reflected the correct information and guidance from the airplane and cargo handling system manufacturers that specified how to safely secure the cargo.

9. The lack of clear guidance regarding Federal Aviation Administration inspector responsibility for the oversight of cargo handling personnel resulted in minimal oversight of these areas at National Airlines and enabled the persistence of critical safety deficiencies.

10. When circumstances such as Federal Aviation Administration inspector travel restrictions or resource shortfalls result in the repeated deferral of required surveillance tasks, an alternative method of risk reduction could help mitigate risks until the surveillance tasks can be completed.

3.2 Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was National Airlines' inadequate procedures for restraining special cargo loads, which resulted in the loadmaster's improper restraint of the cargo, which moved aft and damaged hydraulic systems Nos. 1 and 2 and horizontal stabilizer drive mechanism components, rendering the airplane uncontrollable. Contributing to the accident was the Federal Aviation Administration's inadequate oversight of National Airlines' handling of special cargo loads.

4. Recommendations

To the Federal Aviation Administration:

Revise the guidance material in Advisory Circular (AC) 120-85, "Air Cargo Operations," chapter 201(a)(4), to specify that an operator should seek Federal Aviation Administration (FAA)-approved data for any planned method for restraining a special cargo load for which approved procedures do not already exist, and remove the language in the AC that states that procedures other than those based on FAA-approved data can be used. (A-15-13)

Create a certification for personnel responsible for the loading, restraint, and documentation of special cargo loads on transport-category airplanes, and ensure that the certification includes procedures; training; and duty hour limitations and rest requirements consistent with other safety-sensitive, certificated positions. (A-15-14)

Add a special emphasis item to Federal Aviation Administration (FAA) Order 1800.56O, "National Flight Standards Work Program Guidelines," for inspectors of 14 *Code of Federal Regulations* Part 121 cargo operators to review their manuals to ensure that the procedures, documents, and support in the areas of cargo loading, cargo restraint, and methods for securing cargo on transport-category airplanes are based on relevant FAA-approved data, with particular emphasis on restraint procedures for special cargo that is unable to be loaded via unit loading devices or bulk compartments. (A-15-15)

Include specific guidance in the Federal Aviation Administration inspector handbook that defines responsibilities for principal inspectors for the oversight of an operator's loading, restraint, and documentation of special cargo loads. (A-15-16)

Provide initial and recurrent training for all principal inspectors who have oversight responsibilities for air carrier cargo handling operations that specifically addresses operator cargo procedures, documents, restraint, and support for technical decisions related to special cargo loads. (A-15-17)

Implement temporary risk-reduction methods any time that required surveillance items for 14 *Code of Federal Regulations* Part 121 and 135 operators are deferred, and establish appropriate limitations on surveillance deferrals. (A-15-18)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

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Adopted: July 14, 2015

References

NTSB (National Transportation Safety Board). 2006. "Aviation Accident Briefs." *NTSB Case Number IAD05FA023.* Washington, DC: NTSB.http://www.ntsb.gov/_layouts/ntsb.aviation/Results.aspx?queryId=be138f46-1d9b-4dfa-b7fe-b4683d117dff (accessed June 9, 2015)

—. 1998. *Uncontrolled Impact with Terrain, Fine Airlines Flight 101, Douglas DC-8-61, N27UA, Miami, Florida, August 7, 1997*. NTSB/AAR-98/02. Washington, DC: NTSB.

5. Appendix

Cockpit Voice Recorder Transcript

Transcript of a Honeywell model 980-6022 solid-state cockpit voice recorder, serial number 9713 (CSMU assembly), which was installed on a National Airlines Boeing 747-400 (N949CA), which crashed during takeoff from Bagram Air Base, Afghanistan on April 29, 2013.

LEGEND

CAM	Cockpit area microphone voice or sound source
HOT	Flight crew audio panel voice or sound source
RDO	Radio transmissions from N949CA
GND	Radio transmission from the Bagram ground controller
TWR	Radio transmission from the Bagram airport tower controller
AWS	Aural Warning System

For CAM, HOT and RDO comments:

-1	Voice identified as the Captain
-2	Voice identified as the First Officer
-3	Voice identified as the Additional Crew Member (second Captain)
-4	Voice identified as the Loadmaster
-5	Voice identified as the Mechanic
@	Third party name
-?	Voice unidentified
*****	Unintelligible word
#	Expletive
( )	Questionable insertion
[ ]	Editorial insertion

Note 1: Times are expressed in UTC.

Note 2: Generally, only radio transmissions to and from the accident aircraft were transcribed.

Note 3: Words shown with excess vowels, letters, or drawn out syllables are a phonetic representation of the words as spoken.

Note 4: A non-pertinent word, where noted, refers to a word not directly related to the operation, control or condition of the aircraft.

CVR Quality Rating Scale

The levels of recording quality are characterized by the following traits of the cockpit voice recorder information:

Excellent Quality Virtually all of the crew conversations could be accurately and easily understood. The transcript that was developed may indicate only one or two words that were not intelligible. Any loss in the transcript is usually attributed to simultaneous cockpit/radio transmissions that obscure each other.

Good Quality Most of the crew conversations could be accurately and easily understood. The transcript that was developed may indicate several words or phrases that were not intelligible. Any loss in the transcript can be attributed to minor technical deficiencies or momentary dropouts in the recording system or to a large number of simultaneous cockpit/radio transmissions that obscure each other.

Fair Quality The majority of the crew conversations were intelligible. The transcript that was developed may indicate passages where conversations were unintelligible or fragmented. This type of recording is usually caused by cockpit noise that obscures portions of the voice signals or by a minor electrical or mechanical failure of the CVR system that distorts or obscures the audio information.

Poor Quality Extraordinary means had to be used to make some of the crew conversations intelligible. The transcript that was developed may indicate fragmented phrases and conversations and may indicate extensive passages where conversations were missing or unintelligible. This type of recording is usually caused by a combination of a high cockpit noise level with a low voice signal (poor signal-to-noise ratio) or by a mechanical or electrical failure of the CVR system that severely distorts or obscures the audio information.

Unusable Crew conversations may be discerned, but neither ordinary nor extraordinary means made it possible to develop a meaningful transcript of the conversations. This type of recording is usually caused by an almost total mechanical or electrical failure of the CVR system.

TIME and SOURCE	INTRA-COCKPIT COMMUNICATION CONTENT	TIME and SOURCE	AIR-GROUND COMMUNICATION
08:51:09 [start of recording]			
09:57:23 [Start of Transcript]			
09:57:33 **CAM-2**	there's your trouble Brad.		
09:57:35 **CAM-1**	what is it?		
09:57:37 **CAM-1**	what the # was that from?		
09:57:39 **CAM-2**	one of those # straps is busted.		
09:57:42 **CAM-3**	* * tire.		
09:57:44 **CAM-1**	no no, I know that... * no I know, but....		
09:57:45 **CAM-2**	give you one guess what was right there.		
09:57:49 **CAM-1**	what was right where?		
09:57:49 **CAM-2**	right here.		
09:57:50 **CAM-1**	a knot?		
09:57:51 **CAM-2**	uh huh.		
09:57:52 **CAM-1**	that was the one right at the door?		

TIME and SOURCE	INTRA-COCKPIT COMMUNICATION CONTENT	TIME and SOURCE	AIR-GROUND COMMUNICATION
09:57:54 **CAM-2**	no... this was at.... * *.		
09:57:56 **CAM-1**	so you (go on/goin) puttin more straps (on #)?		
09:57:59 **CAM-2**	(well) it just shifted (apparently/barely).		
09:58:01 **CAM-3**	there was a bunch of them first... that first (truck).		
09:58:02 **CAM-1**	did it move? .... # moved?		
09:58:04 **CAM-2**	yes. just tightened up on the straps.		
09:58:06 **CAM-2**	the truck?		
09:58:06 **CAM-3**	* like.... tightened those straps up uh, quite a bit, on the first one.		
09:58:13 **CAM-2**	you know how that...well you go look at the.... went and looked at them now... all the ones * they had a bunch like this, to keep them from movin backwards...a bunch like this * * movin forward? all the ones that were keepin em from movin backwards were all # loose.		
09:58:28 **CAM-3**	what the # do you think's gonna happen when you # slam it on the runway and slam on the # brakes and don't use reverse... [said in a joking manner]		
09:58:35 **CAM-1**	[sound of laughter]		

TIME and SOURCE	INTRA-COCKPIT COMMUNICATION CONTENT	TIME and SOURCE	AIR-GROUND COMMUNICATION
09:58:36 **CAM-2**	there ain't nothin you coulda done about that.		
09:58:37 **CAM-3**	* * I'm putting it on the # # board I'm gettin off this plane, I'm scared. [said in a joking manner]		
09:58:43 **CAM-?**	* *.		
09:58:46 **CAM-1**	thow that out man, that's evidence. * @ [the loadmaster] don't want that hangin around either.		
09:58:50 **CAM-?**	no.		
09:58:53 **CAM-1**	I hope instead of * rather than just replacing that (strap) I hope he's beefing the straps up more.		
09:58:59 **CAM-?**	just on that one spot.		
09:59:00 **CAM-2**	yeah.		
09:59:02 **CAM-?**	all the rest of them are fine.		
09:59:06 **CAM-2**	he's cinching them all down.		
10:14:49 **CAM**	[break in transcript]		
10:14:57 **CAM-1**	what's up, dude?		
10:15:01 **CAM-2**	did you throw that other strap away?		

TIME and SOURCE	INTRA-COCKPIT COMMUNICATION CONTENT	TIME and SOURCE	AIR-GROUND COMMUNICATION
10:15:04 **CAM-1**	what did you - did you put a couple more on?		
10:15:11 **CAM-1**	how far did it move.... a couple of inches?		
10:15:13 **CAM-4**	yeah, they just moved a couple inches... cause you know, its nylon ya know, so.		
10:15:20 **CAM-2**	(you throw some) numbers (in here)?		
10:15:21 **CAM-1**	that’s scare-... that's # scary-		
10:15:24 **CAM-1**	without a lock (for those big heavy things / ** anything) man I don't like that.		
10:15:27 **CAM-1**	I saw that, I was like #, I never heard of such a thing.		
10:15:30 **CAM-?**	* I'd be kinda interested ta ... wish I could put a camera down there and watch it.....		
10:15:36 **CAM-2**	(you'd probably) # yourself.		
10:15:37 **CAM-1**	right.		
10:15:37 **CAM-?**	see what they do.		
10:15:39 **CAM-1**	those things are so # heavy you'd think though that they probably wouldn't hardly move no matter what.		

TIME and SOURCE	INTRA-COCKPIT COMMUNICATION CONTENT	TIME and SOURCE	AIR-GROUND COMMUNICATION
10:15:42 **CAM-4**	they always move.... everything moves. If it's not strapped -		
10:15:46 **CAM-1**	no no - I-		
10:15:48 **CAM-4**	it'll roll on them things [makes a 'motorized' sound]		
10:15:51 **CAM-1**	[sound of laughter]		
10:16:12 **CAM**	[break in transcript]		
10:16:17 **CAM-2**	ready to put some numbers in there?		
10:16:17 **CAM-1**	yeah go ahead.		
10:16:19 **CAM-2**	alright.... zero fuel weight is...... two fifty nine two		
10:16:29 **CAM-1**	three oh seven three.		
10:16:32 **CAM-2**	three oh seven two.		
10:16:34 **CAM-1**	full T/O		
10:16:36 **CAM-2**	full T/O, full climb.		
10:16:37 **CAM-1**	one oh nine point three?		
10:16:39 **CAM-2**	and that is.... one oh nine three. checks.		

TIME and SOURCE	INTRA-COCKPIT COMMUNICATION CONTENT	TIME and SOURCE	AIR-GROUND COMMUNICATION
10:16:44 **CAM-1**	flaps..... ten.		
10:16:47 **CAM-2**	flaps ten.		
10:16:49 **CAM-1**	(thousand feet for acceleration?)		
10:16:53 **CAM-2**	yes sir.		
10:17:01 **CAM-1**	fuel?		
10:17:05 **CAM-2**	is..... thirty decimal four		
10:17:08 **CAM-1**	three point eight?		
10:17:10 **CAM-2**	three point seven, checks. [break in transcript]		
		10:28:47 **ATIS**	…tower information victor 09:55 observation wind one zero zero at one seven, gust three zero. Sky condition eight thousand five hundred scattered, ceiling one four thousand broken, two zero thousand broken. Temperature one seven dewpoint six, altimeter two niner niner two. Runway three in use expect visual approach. * advisories taxiway charlie alpha closed. weather warnings moderate thunderstorms, high winds greater than or equal to thirty five less than forty five knots. hail greater than or equal to one quarter less than one half inch. weather watch * potential * five, weather advisories crosswinds observed greater than or equal to twenty knots. * *.

TIME and SOURCE	INTRA-COCKPIT COMMUNICATION CONTENT	TIME and SOURCE	AIR-GROUND COMMUNICATION
		10:28:48 **RDO-2**	"Yes sir ISAF [international security assistance force.....] nine five alpha quebec....."
10:41:21 **CAM**	[break in transcript]		
10:41:21 **HOT-1**	ok. starting four and three [engines 4 and 3]		
10:41:23 **CAM**	[sound similar to power interruption]		
10:44:49 **CAM**	[break in transcript]		
		10:44:52 **RDO-2**	Bagram ground ISAF nine five alpha quebec is ready to taxi.
		10:44:56 **GND**	nine five alpha quebec, taxi to runway three via juliet golf one, when able say civilian call sign.
10:45:01 **HOT-1**	* one F I think.		
		10:45:04 **RDO-2**	ok understand uh runway three via golf uh juliet and golf one and uh, repeat the rest for -
10:45:09 **HOT-1**	civilian callsign.		
		10:45:10 **RDO-2**	oh. civilian callsign is november charlie romeo five-one zero two.
10:45:13 **HOT-1**	one zero-		
		10:45:17 **GND**	copy NCR one zero two

TIME and SOURCE	INTRA-COCKPIT COMMUNICATION CONTENT	TIME and SOURCE	AIR-GROUND COMMUNICATION
10:45:21 **CAM-2**	I only knew that -		
		10:45:21 **GND**	five alpha quebec, I have your clearance, advise when ready to copy.
10:45:24 **HOT-1**	yeah let's do it.		
		10:45:25 **RDO-2**	ready to copy, for nine five alpha quebec.
		10:45:32 **GND**	nine five alpha quebec, cleared direct SIBLO via diverse vectors. on departure fly runway heading until thee DME then turn left heading two one zero. climb and maintain two eight zero, squawk zero four seven three, departure frequency one two four point eight.
10:45:47 **HOT-1**	got all that?		
		10:45:48 **RDO-2**	ok understand cleared to diverse vectors to SIBLO on takeoff runway heading to three DME, then right turn two one zero up to flight level two eight zero, squawk zero four seven three, on one two four decimal eight for departure ISAF nine five alpha quebec.
		10:46:07 **GND**	nine five alpha quebec that's a left turn two one zero, readback is correct, contact tower when ready.
		10:46:13 **RDO-2**	kay left turn two one zero, for ISAF nine five alpha quebec.

TIME and SOURCE	INTRA-COCKPIT COMMUNICATION CONTENT	TIME and SOURCE	AIR-GROUND COMMUNICATION
10:46:17 **CAM-1**	gotta setup somethin for your DME.		
10:46:25 **HOT-1**	could just do, off uh....what can we put there-		
10:46:30 **HOT-2**	I could do uh.... the airport.		
		10:46:36 **GND**	ISAF nine five alpha quebec give way to the C-17 off your right he's taxiing juliet golf one.
10:46:40 **CAM-1**	let him go first.		
		10:46:40 **RDO-2**	roger we'll let him go first, for uh nine five alpha quebec.
10:46:56 **CAM-1**	works for me.		
10:47:02 **HOT-1**	kay.		
10:47:03 **HOT-2**	that one’s right here in the middle.		
10:47:06 **CAM-?**	IBAG * *.		
		10:47:16 **GND**	break ISAF nine five alpha quebec continue to follow the C-17.
10:47:19 **HOT-1**	roger.		
		10:47:20 **RDO-2**	keep following the C-17 for nine five alpha quebec.

TIME and SOURCE	INTRA-COCKPIT COMMUNICATION CONTENT	TIME and SOURCE	AIR-GROUND COMMUNICATION
10:47:26 **HOT-1**	those lights out?		
10:47:29 **HOT-1**	[sound of laughter]		
10:47:29 **CAM-3**	(sleepin) * *.		
10:47:31 **HOT-2**	okay, turnoff lights are on.		
10:47:38 **HOT-1**	all right, three hours, Tim.		
10:47:39 **CAM-5**	good.		
10:48:17 **HOT-2**	all right. for our takeoff departure review, be uh...I got one six seven, V1 one forty, runway heading is zero two seven up to flight level two eight zero, TOGA TOGA, VNAV, uh when I get up to three DME, have you put me on uh runway heading... actually before that, I'll have you- * right autopilot on command.		
10:48:39 **HOT-1**	yeah * *.		
10:48:40 **HOT-1**	ok.		
10:48:41 **HOT-2**	and then I'll do a left turn to two one zero, up to two eight zero. T/O, full T/O one oh eight one.		
10:48:55 **HOT-2**	I think it's good.		
10:48:59 **HOT-1**	kay uh, let's go before takeoff checklist, to the line.		

TIME and SOURCE	INTRA-COCKPIT COMMUNICATION CONTENT	TIME and SOURCE	AIR-GROUND COMMUNICATION
10:49:02 **HOT-2**	before takeoff checklist....... flaps?		
10:49:05 **HOT-1**	ten (planned), ten checked.		
10:49:07 **HOT-2**	flight controls?		
10:49:09 **CAM-1**	check(ed).		
10:49:12 **HOT-2**	takeoff departure review is complete, before takeoff checklist is complete to the line.		
10:49:23 **HOT-2**	it’s like- this air is just billowing outta here.		
10:49:26 **HOT-1**	yeah what's that, what's-		
10:49:31 **HOT-2**	you got some windshield air on over there?		
10:49:33 **HOT-1**	I ain’t got # on, man.		
10:49:39 **HOT-1**	mine are all off.		
10:49:53 **HOT-1**	how do we look on that wing, everything look clear?		
10:49:55 **HOT-2**	everything’s great.		
10:49:56 **CAM-3**	@ [another company Captain] BBM'd, said what’s up with the brake temps in Bagram.		

TIME and SOURCE	INTRA-COCKPIT COMMUNICATION CONTENT	TIME and SOURCE	AIR-GROUND COMMUNICATION
10:49:60 **HOT-1**	[sound of chuckle] all normal.		
10:50:06 **HOT-2**	said they're all zeros.		
10:50:07 **HOT-1**	yeah. * what the # yer talking about.		
10:50:010 **CAM-3**	* #.		
10:50:11 **HOT-1**	did you actually talk to him?		
10:50:12 **CAM-3**	no *. I don't talk to that # anymore.		
10:50:13 **HOT-1**	[sound of laughter]		
10:50:15 **HOT-1**	holding at the line?		
10:50:16 **HOT-2**	holding at the line, sir.		
10:50:18 **HOT-1**	ok you can go to tower.... set me up for departure... twenty four eight.		
10:50:24 **CAM-3**	is @ [the second F/O] there? I haven't seen him. I hope he's in the bunk.		
10:50:26 **HOT-2**	yeah that'd be better if he was.		
10:50:29 **HOT-1**	he didn't get off.		
10:50:31 **HOT-2**	no.		

TIME and SOURCE	INTRA-COCKPIT COMMUNICATION CONTENT	TIME and SOURCE	AIR-GROUND COMMUNICATION
10:50:39 **CAM-3**	yeah, he's in there. * *.		
10:50:43 **HOT-1**	* # do a nose over, and put him through the ceiling.		
10:50:47 **HOT-2**	yeah uh. him and those uh- those uh-		
10:50:52 **HOT-1**	all right we'll be ready my man-		
10:50:53 **CAM-2**	-MRAPs [mine resistant ambush protection vehicles]		
		10:51:01 **RDO-2**	tower ISAF nine five alpha quebec we'll be- is ready golf one, for departure runway three.
		10:51:15 **TWR**	ISAF nine five alpha quebec, Bagram tower. roger, hold short.
		10:51:18 **RDO-2**	hold short runway three ISAF nine five alpha quebec.
10:51:53 **CAM-2**	* * we're waitin for that guy.		
10:51:59 **HOT-1**	we all happy with that?		
10:52:00 **HOT-2**	yeah, I'm good.		
10:52:07 **HOT-2**	it’s been uh - an hour and a half.		
10:52:10 **HOT-1**	what's that?		

TIME and SOURCE	INTRA-COCKPIT COMMUNICATION CONTENT	TIME and SOURCE	AIR-GROUND COMMUNICATION
10:52:11 **HOT-2**	it's been an hour and a half.		
10:52:15 **CAM-3**	* sixteen off.		
10:52:16 **HOT-1**	yeah. we're gonna-we're gonna beat it by about a half-by about a half hour. we're gonna need it.		
10:52:24 **HOT-2**	half an hour or half a minute, its all the same.		
10:52:27 **HOT-1**	that's right. we earned it. as far as I'm concerned man. I don't think - min rest, I'd be dead tomorrow man.		
10:52:34 **HOT-2**	yeah. I think I think I would have to agree with that sentiment.		
10:52:39 **CAM-3**	I'm dead right now.		
10:52:41 **HOT-1**	so do you even tell crew scheduling -er do you just-		
10:52:46 **HOT-1**	I mean.		
10:52:47 **CAM-3**	see what they say * call em in the van on the way to the hotel.		
10:52:51 **HOT-2**	what the hell's this guy doin?		
10:52:53 **CAM-3**	see if they catch it.		

TIME and SOURCE	INTRA-COCKPIT COMMUNICATION CONTENT	TIME and SOURCE	AIR-GROUND COMMUNICATION
10:52:57 **HOT-1**	maybe-		
10:52:57 **CAM-3**	you guys aren't leavin until seven Z anyways, so.		
10:52:57 **CAM-3**	* might have to delay about a half hour.		
10:53:04 **HOT-2**	S turns...		
10:53:05 **HOT-1**	yeah it ain't a huge delay.		
10:53:10 **HOT-1**	yeah, he like overshot that, big time.		
10:53:12 **HOT-1**	or-		
10:53:14 **HOT-2**	maybe he was just-		
10:53:18 **CAM-3**	I need a one in seven.		
10:53:20 **HOT-2**	zero four zero at one zero. [in response to a wind check provided by the TWR for a landing aircraft]... is that what he just said?		
10:53:23 **HOT-1**	yeah.		
10:53:24 **HOT-2**	do you see a windsock out there?		
10:53:28 **HOT-1**	no, I don't... what did he say?		
10:53:30 **HOT-2**	zero four zero at one zero.		

TIME and SOURCE	INTRA-COCKPIT COMMUNICATION CONTENT	TIME and SOURCE	AIR-GROUND COMMUNICATION
10:53:32 **HOT-1**	that's good. right down the runway.		
10:53:33 **HOT-2**	yeah.		
10:53:40 **HOT-2**	I'm not gonna go and-		
10:53:41 **HOT-1**	hang on.		
10:53:43 **HOT-?**	(yeah).		
10:53:44 **HOT-2**	I'm not gonna go barreling down the runway with...		
10:53:49 **HOT-1**	ah *.		
10:53:49 **HOT-2**	two units of [sound of chuckle] trim in.		
10:54:00 **HOT-?**	[sound of chuckle]		
10:54:00 **HOT-2**	tryin to # buzz all these people on the road, or what.		
10:54:06 **HOT-1**	some kinda tactical thing goin on here or-		
10:54:09 **HOT-2**	I'm gonna put it on top of that *.		
10:54:14 **HOT-2**	bet you can't get off at the first turnoff.		
10:54:15 **HOT-1**	* * oh you know what, I'm sitting low, that's the problem.		

TIME and SOURCE	INTRA-COCKPIT COMMUNICATION CONTENT	TIME and SOURCE	AIR-GROUND COMMUNICATION
		10:54:20 **TWR**	ISAF nine five alpha quebec runway three, full length, lineup and wait.
		10:54:25 **RDO-2**	lineup and wait runway three, ISAF nine five alpha quebec.
10:54:28 **HOT-1**	final items.		
10:54:29 **CAM**	[sound of several clicks]		
10:54:35 **HOT-1**	runway three is verified.		
10:54:37 **HOT-1**	clear left.		
10:54:38 **HOT-2**	prepare for departure.		
10:54:41 **HOT-2**	kay.... cabin's notified. autothrottles are armed. I'm in weather, you're in terrain, selected.		
10:54:48 **HOT-2**	transponder TA/RA.		
10:54:52 **CAM-2**	runway three.		
10:54:53 **CAM-1**	verified.		
10:54:55 **HOT-2**	verified runway three. before takeoff checklist complete.		
10:55:03 **HOT-1**	lineup and wait.		

TIME and SOURCE	INTRA-COCKPIT COMMUNICATION CONTENT	TIME and SOURCE	AIR-GROUND COMMUNICATION
10:55:04 **HOT-2**	lineup and wait.		
10:55:10 **HOT-2**	tryin to make life exciting for all those guys there, I guess.		
		10:55:33 **TWR**	ISAF nine five alpha quebec runway three full length, wind estimated zero one zero at one one gusting one-[transmission interrupted]
10:55:44 **HOT-1**	cleared for takeoff.		
10:55:45 **HOT-2**	clear for takeoff runway three.		
		10:55:47 **RDO-2**	clear for takeoff runway three, ISAF nine five alpha quebec.
10:55:52 **HOT-1**	got it.		
10:56:03 **HOT-2**	stable.		
10:56:05 **HOT-2**	thrust REF.		
10:56:07 **CAM**	[sound similar to engines increasing speed]		
10:56:15 **HOT-1**	zero one zero.		
10:56:19 **HOT-2**	hold.		
10:56:21 **HOT-1**	eighty knots, thrust set.		

TIME and SOURCE	INTRA-COCKPIT COMMUNICATION CONTENT	TIME and SOURCE	AIR-GROUND COMMUNICATION
10:56:22 **HOT-2**	checks.		
10:56:34 **HOT-1**	V1.		
10:56:35 **AWS**	V1. [from the Aural Voice Annunciation system]		
10:56:38 **HOT-1**	rotate.		
10:56:44 **HOT-1**	positive climb.		
10:56:45 **HOT-2**	gear up.		
10:56:46 **HOT-1**	keep on that (wing/weight/wait).		
10:56:47 **CAM**	[End of Recording, End of Transcript]		