Bus: 800-344-7930
Fax: 541-955-9205

CARSON HELICOPTERS INC.

828 Brookside Blvd.
Grants Pass, OR 97526

Submission of Carson Helicopters, Inc. to the National Transportation Safety Board Regarding the Accident Involving

N612AZ

At Weaverville, California

August 5, 2008

In accordance with 49 C.F.R. § 831.14, Carson Helicopters, Inc. respectfully submit their proposed findings to be drawn from the evidence produced during the course of the investigation, proposed probable cause, and proposed safety recommendations to the National Transportation Safety Board.

Communication with respect to this Submission may be addressed to

Andy Mills, General Manager
Carson Helicopters, Inc.
828 Brookside Boulevard
Grants Pass, Oregon 97526
(800) 344-7930

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ACRONYMS/DEFINITIONS

Airworthiness Report	NTSB Airworthiness Group Chairman's Factual Report, dated September 10, 2009, Docket No. 426650
C	Celsius
Carson	Carson Helicopters, Inc.
Columbia Helicopters	Columbia Helicopters, Inc.
CVR	Cockpit Voice Recorder
F	Fahrenheit
FAA	Federal Aviation Administration
FCU	Fuel Control Unit (specifically the JFC26 fuel control unit installed on S-61 helicopters)
Forest Service	U.S. Forest Service
GE	General Electric Company
GPS	Global Positioning System
HOGE	Hover Out of Ground Effect
Hover Study	NTSB Hover Study, dated September 11, 2009, Docket No. 426604
IHOG	Interagency Helicopter Operations Guide
Materials Lab Report	NTSB Materials Laboratory Factual Report No. 08-121, Docket No. 430172, as revised
Meteorological Report	NTSB Meteorological Factual Reports, dated June 15, 2009 and November 25, 2009, Docket Nos. 421099 and 430552, respectively
Nf	Torque Output
Ng	Gas Generator Speed
Nr	Main Rotor RPM

NTSB	National Transportation Safety Board
Operations Report	NTSB Operations Factual Report, dated September 15, 2009, Docket No. 426753
PIC	Pilot-in-Command
PRV	Pressure Regulating Valve
RAWS	Remote Automated Weather Station
RPM	Rotations Per Minute
SIC	Second-in-Command
Sikorsky	Sikorsky Aircraft Corporation
Sound Spectrum Study	NTSB Sound Spectrum Study CVR, dated May 21, 2009, Docket No. 419427
SRD	Service Revealed Difficulty
T5	Turbine Temperature

INTRODUCTION

There appear to be two competing theories of the cause of the crash of N612AZ. One is a theory settled on by the NTSB operations group early in the investigation. Under this theory, the helicopter was too heavy for the conditions – high altitude and warm temperatures – so there was insufficient power available from the engines to complete the takeoff. The other is a theory that Carson, after months of painstaking investigation, believes is compelled by the evidence. Under this second theory, during the takeoff, one of the engines malfunctioned as a result of an FCU failure, causing a loss of power to that engine, which then resulted in a reduction of power to the main rotor system causing it to lose RPM and lift capacity.

Carson disagrees with the theory that the helicopter was too heavy for the conditions. The records of the actual weighings of the helicopter submitted in connection with the company's contract bid to the Forest Service did contain errors. But a careful reconstruction of the aircraft's weight documents, and comparison of those weights to the documented weights of identical sister aircraft, demonstrate that the weight of N612AZ, exclusive of fuel, passengers, and cargo, was at least 400 to 500 lbs. less than that theorized by the NTSB operations group. If the correct weight and environmental conditions are used to calculate the helicopter's performance capability, the results show that N612AZ had more than sufficient performance capability to take off, hover, and fly under the conditions existing at the time of the accident. Moreover, the two successful previous takeoffs by N612AZ from H-44 earlier that evening had similar or less favorable performance margins than did the unsuccessful third takeoff.

Carson has closely examined the temperature and wind information used in the performance analysis done in the NTSB investigation and found several inconsistencies and flaws in that data. In addition to its analysis of the investigation information, Carson had a flight test performed by independent parties using an S-61 helicopter similarly equipped to N612AZ and flown under similar environmental conditions. That demonstration proved that the helicopter will take off, hover, and fly under the conditions stated in the performance studies done in the NTSB investigation, flawed as they may be.

The FCU malfunction leading to engine power loss theory is well supported by the evidence. The initial teardown of the engines revealed severe heat damage to the turbine wheel sections of the engine, and the NTSB's own Preliminary Report states that the helicopter lost power to the main rotor system. During this investigation, both of the helicopter's FCUs were inspected and found to have contamination in critical areas that have been documented to cause malfunctions leading to engine power loss. This evidence of FCU contamination, combined with the damage to the engine turbine wheels and the observation that the engine torque gauge showed a 30% reduction in power from the number 2 engine, is a compelling indication that an engine power failure actually caused the crash.

Congress entrusted the NTSB with the mission of investigating accidents and issuing "safety recommendations aimed at preventing future accidents."[1] The NTSB justifiably, and quite rightly, takes pride in the success it has achieved in having the overwhelming majority of its transportation safety improvement recommendations adopted – more than 82% of the time, according to the NTSB's current Strategic Plan.[2] The NTSB attributes this success to its "reputation for impartiality and thoroughness."[3] For that reason, the NTSB has as its mission to communicate the lessons learned from its "careful, competent and independent investigation" of accidents to prevent future loss of life and personal injury.[4] The NTSB has committed itself to accomplishing that mission by the "masterful execution of function" and "by the creation of a self-critical learning culture" within the Board.[5]

Carson regrets to say that the operations group assigned to investigate the crash of N612AZ did not always advance these worthy NTSB goals, and did not further the NTSB's laudable and important mission. Despite Carson's disappointment and dismay in this regard, Carson makes this Submission with optimism that the Members of the Board will remain faithful to their statutory mandate and live up to the NTSB's mission. Carson wants to do everything it can to make sure that the loss of engine power that caused the N612AZ to crash is corrected, so that a similar loss of engine power will never again result in the loss of a single life or injure another person.

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[1] About the NTSB; History and Mission, http://www.ntsb.gov/abt_ntsb/history.htm.

[2] NTSB "Strategic Plan 2006-2010" (December 16, 2005) at 4.

[3] Id.

[4] Id. at 5.

[5] Id.

I. EXECUTIVE SUMMARY

Carson begins by accepting responsibility and making no excuses for its mistakes. Carson acknowledges that after the accident it learned that there were anomalies and irregularities in the weight documents maintained for N612AZ, and in the performance charts in Carson's, and presumably the accident aircraft's, flight manuals. Although the reason for this incorrect information could not be determined by Carson, the factual information developed during the course of the investigation has demonstrated that neither the incorrect weight documents, nor the mislabeled performance charts (and the actual aircraft weight at the time of the accident), was a cause of, or a contributing factor to, the crash of N612AZ. The only impact these anomalies and irregularities had was to make it difficult to determine the weight of the aircraft at the time of the accident with 100% certainty. N612AZ did not crash because of them, nor did they lead to the deaths and injuries of the victims, whose lives, pain, and suffering Carson will never forget.

Only Carson and its employees have been harmed by the anomalies and irregularities. In addition to causing a tremendous blow to Carson's 50 years reputation for excellence and integrity in helicopter technology and operations, these irregularities and anomalies have led to the loss of many good jobs held by fine people otherwise uninvolved with the accident or these anomalies and irregularities. Many of the anomalies and irregularities appear to have originated from documents created or assembled by Steve Metheny, Carson's Vice President of Operations. Carson subsequently fired him. In response to these anomalies and irregularities, Carson has modified its operations and procedures, including, but not limited to, improving internal controls over the weighing process, to minimize the chance of such anomalies and irregularities occurring in the future.

In this submission Carson sets forth three factual findings and two recommendations:

FACTUAL FINDING:	**Power loss caused N612AZ to crash**

Based on the information developed during the course of the investigation, including the CVR data, eyewitness observations, and the accident wreckage itself, it is evident that the N612AZ experienced a partial loss of power during the transition from a stationary hover to forward flight that resulted in a significant "settling with power" situation that resulted in an uncontrolled descent and ground impact. This conclusion finds additional support in the environmental conditions at the time of the accident (wind velocity/direction and temperature at the departure point) and the known power output of the aircraft's engines under normal operating conditions. Under normal operating conditions, N612AZ should have had more than enough power to successfully complete its final flight, even if the aircraft weighed as much as the NTSB operations group claims it did. The fact that N612AZ should have had more than ample power to successfully complete its final mission, but did not, leads to a simple, but pivotal conclusion: the crash of N612AZ was caused by a failure of the aircraft's engines to deliver the power they should have to the main rotor.

The results of an independently conducted and witnessed flight performance evaluation test Carson commissioned of an S-61 helicopter cement this conclusion.[6] The test aircraft had equipment similar to N612AZ's, and flew under conditions similar to those at the time of the accident. The results of that test confirm that the only way to induce flight characteristics similar to those experienced by N612AZ immediately prior to the crash was for the test aircraft to reduce power to one of the aircraft's engines.

It is clear that a power loss caused N612AZ to crash. Carson believes that the primary cause of the crash of N612AZ was the failure of the aircraft's engines to deliver the full rated power during the departure. This in turn resulted in an uncontrolled descent from a low altitude that did not afford the flight crew sufficient time to perform a successful autorotation.

<u>**FACTUAL FINDING:**</u>	**Fuel control unit contamination caused the N612AZ power loss**

N612AZ had FCU-related engine power issues during the months leading up to the accident, and the FCUs recovered from the accident wreckage contained significant amounts of contamination. Despite its lack of any subpoena powers or other legal investigative authority, Carson managed to identify numerous S-61 mishaps, ranging from recoverable power lapses to full blown crashes, which occurred in the years before and after the N612AZ accident. For example, the Transportation Safety Board of Canada determined that similar contamination caused engine power loss that resulted in an S-61 crash in 2002. Such contamination also has caused or contributed to numerous other instances of S-61 power loss.

<u>**FACTUAL FINDING:**</u>	**GE, Columbia Helicopters, and Sikorsky all knew of the danger of contaminated FCUs for years, yet took no action**

GE manufactured the engine used in the S-61 model aircraft, including the N612AZ. Columbia Helicopters overhauled N612AZ's engines and the FCUs. Sikorsky manufactured the S-61 itself. All three companies have known of the hazard presented by contamination in FCUs since at least 2002. GE and Columbia Helicopters specifically discussed this danger in their official engine and maintenance manuals. In addition, in early 2010, Sikorsky took steps to address this danger on an emergency basis by directing that all operators of the S-61 replace preexisting 40 micron fuel filters with new 10 micron filters.

What is even more disturbing is that, as Carson has recently learned, GE, Sikorsky, and Columbia Helicopters have privately and actively discussed the significant danger posed by contamination in FCUs and the fact that engine power loss had been associated with such contamination on numerous occasions since at least 2002. These discussions have gone on behind closed doors, outside of the view of the helicopter operating community, the flying public, and, most critically, the NTSB itself. Despite their superior knowledge, and their

[6] Carson invited the operations group to establish a flight test protocol and participate in the flight test of an exemplar helicopter at various weights, but the operations group declined to participate in any flight test activities.

position as the sole manufacturer or service provider for N612AZ, until Sikorsky stepped forward earlier this year, GE, Columbia Helicopters, and Sikorsky had done absolutely nothing to protect the helicopter operating community or the flying public from the safety threat posed by contamination in FCUs.

<u>RECOMMENDATION</u>:	**The NTSB should fully investigate the safety-of-flight issue posed by FCU contamination**

Carson has uncovered internal documents and correspondence that prove that – years before the accident – GE, Columbia Helicopters, and Sikorsky each knew of the hazard created by contamination of FCUs. Each of them could have taken steps to prevent this hazard or, at least, warn the helicopter operating community or the flying public about it. GE, Columbia Helicopters, and Sikorsky instead chose to do nothing.

In addition to being the root cause of the crash of N612AZ, contamination in the FCUs installed in other S-61 model aircraft has been linked to numerous other aviation mishaps. It is, therefore, a general safety-of-flight concern with ramifications that go well beyond the scope of this accident investigation. Until Sikorsky finally got around to taking some action in January 2010, years after the contamination hazard surfaced, none of the entities historically responsible for manufacturing the parts for, or overhauling, the S-61 took any steps to mitigate this known hazard and to ensure that the helicopter operator community and the flying public at large were aware of the threat posed by contamination in FCUs. Accordingly, the NTSB should fully investigate the safety-of-flight issue posed by FCU contamination.

Because this issue has yet to be thoroughly investigated and GE, Columbia Helicopters, and Sikorsky's preexisting knowledge of the hazard of FCU contamination has yet to be brought to light, the factual record of the NTSB investigation is incomplete. Moreover, the danger to aviation safety and the potential for another accident resulting from a contaminated FCU will remain a serious hazard until this issue is properly addressed and the risk has been mitigated. Therefore, the NTSB should recommend that GE and Columbia Helicopters take corrective action similar to the action Sikorsky took in January 2010. It is further recommended that the NTSB request the FAA to issue an Airworthiness Directive requiring the reduced micron fuel filters to mitigate the potential for contamination in the FCU.

<u>RECOMMENDATION</u>:	**The NTSB should put in place concrete, mandatory procedures to safeguard against errors in investigations**

Carson has reviewed the methods and practices that the NTSB requires its investigators to follow (including those in the NTSB Aviation Accident Investigations Manual) during the course of an aviation accident investigation. It became apparent during the course of this investigation that the operations group has focused its attention on, and developed theories regarding the cause of the accident that are predicated solely on, the irregularities and anomalies in the weight documents and performance charts associated with N612AZ. It is unfortunate that the operations group has shaped their investigation and factual findings to support their conclusion that the crash is a result of these issues, while selectively dismissing factual evidence that negates its theory or supports other logical explanations for the accident. This is particularly evident in the continued disregard of factual information and/or the lack of thorough development of additional factual information, as it relates to a loss of engine power due to contaminated FCUs.

It is disconcerting to say the least that the Investigator-In-Charge chose not to take the initiative or provide leadership to the supporting NTSB staff and party representatives for developing pertinent information to identify the cause(s) of the accident, and to make recommendations that will mitigate or eliminate the potential for a future accident. Further, it became evident in the early stages of the investigation that the operations group had chosen to follow an analytical path designed to minimize the importance of serious errors which have been identified and brought to the attention of senior NTSB management, and which have been permitted to continue without correction. These actions have served to shape the investigation and prevent it from being the thorough, methodical, and transparent process, conducted with the open assistance of all parties, on which the NTSB rightly prides itself.

Carson believes the NTSB should review its policies and procedures to ensure that its investigators conduct themselves, and the investigations which they run, in as thorough and methodical a manner as possible. The goal should be for all facts, conditions, and circumstances to be developed and analyzed, all theories considered, and the proper conclusions identified while simultaneously maintaining the highest level of professionalism and transparency.

II. FACTUAL FINDING: POWER LOSS CAUSED N612AZ TO CRASH

A. The Facts

At approximately 1940[7] on August 5, 2008, N612AZ, a Sikorsky S-61 helicopter owned by Carson, took off from H-44, a helibase located in remote, mountainous terrain at approximately 5,945 ft. elevation near Weaverville, California. Approximately 1.5 minutes into this flight, during the transition from a hover to forward flight, N612AZ was unable to maintain altitude and aircraft control and the helicopter descended to the ground. Carson employee and PIC Roark D. Schwanenberg, and Shawn Blazer, Scott Charlson, Edrik Gomez, Matthew Hammer, James N. Ramage, Caleb Renno, and Bryan Rich were killed. Carson employee and SIC William H. Coultas, and Michael Brown, Jonathan Frohreich, and Richard Schroeder, Jr., were injured.[8] Mr. Ramage, a Forest Service pilot inspector, was on board the aircraft serving as a self-appointed helicopter flight manager. Messrs. Blazer, Brown, Charlson, Frohreich, Gomez, Hammer, Renno, Rich, and Schroeder were all private firefighters under contract to the Forest Service. The accident flight was N612AZ's third flight that day into and out of H-44, the staging area that was located near the accident site; the first two flights, which had occurred only a short time before, had been uneventful.

The CVR sheds light on N612AZ's final minutes. At H-44 at 1935, while the aircraft was still on the ground, a Forest Service helitack crewmember is heard informing the pilots that their payload for the next flight would be 2,355 lbs. The SIC is heard on the CVR noting that the maximum payload for the aircraft, assuming an outside air temperature of 32° C, was 2,552 lbs., or approximately 200 lbs. more than the aircraft would be required to carry. The SIC further stated that because the temperature read from the cockpit temperature gauge is 12 to 13° cooler, i.e., 19 to 20° C, the aircraft would be able to perform its mission.

The aircraft began to lift off at approximately 1940 and ascended vertically to a normal hover, 60-70 ft. above ground level with the full load.[9] The aircraft then nosed over into translational flight. In a later pilot interview, the SIC stated that, at this point, after the expected dip of the aircraft nose associated with the transition to forward flight, he recalled a second, sharp dip of the nose of the aircraft, which was not normal. He could also hear the rotor starting to slow down.

The SIC can be heard on the CVR telling the PIC that the rotor is starting to droop,[10] then saying the main rotor RPM is at 100%. Right after that, both the PIC and the SIC begin yelling with alarm and the SIC can be heard repeatedly asking the aircraft to "just fly." It is almost certain that both pilots had their heads in the bubble windows at this time and were trying to navigate the aircraft over and through the trees. During this period, the rotor is quickly and

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[7] Unless otherwise noted, all times stated in this Submission are Pacific Daylight Time (PDT).

[8] Everyone on the aircraft besides the PIC and the SIC was a qualified non-crewmember.

[9] The aircraft had to hover that high in order to clear the trees almost directly in the departure path.

[10] "Droop" is a term used to describe the reduction of main rotor RPM.

steadily losing main rotor RPM at a rapid rate (this can be heard on the CVR). Before the aircraft crashes, the main rotor RPM has drooped below approximately 92% and is trending downward. At that point, the CVR plot ends.

B. The Finding From The Facts

The facts demonstrate that N612AZ crashed because of a loss of full engine power. The CVR evidence showing the rapid decrease in main rotor RPM, even while the gas generator speeds were at topping, indicates the main rotor is not getting full power. The aircraft had already demonstrated enough power to come to a hover. The second dip of the nose of the helicopter and rapid loss of main rotor RPM are not consistent with an aircraft that is too heavy, but instead indicate a loss of engine power.

The fact that these events show a loss of engine power is backed up by the only torque gauge recovered from the wreckage. This intact and uncompromised torque gauge showed a 30% lower torque reading on the number 2 engine than on the number 1 engine when power was lost to the aircraft panel. The CVR and physical evidence showing the role power loss played in the crash of the aircraft has been confirmed by the independently conducted and witnessed flight test commissioned by Carson.

Had they functioned properly, N612AZ's engines should have had more than ample power for the aircraft to successfully transition to forward flight after coming to a hover, and to complete the accident flight. That the aircraft did not successfully transition to forward flight after coming to a hover confirms that the aircraft's engines were not delivering the power they should have. It also confirms that, while there are anomalies and irregularities in the weight documents for N612AZ and in the performance charts in the aircraft's flight manual, these anomalies and irregularities were not the cause of the crash.

C. The Evidence Supporting The Finding

1. The Forest Service, not Carson, had operational control of N612AZ at the time of the accident

At the time of the crash, N612AZ was under contract to the Forest Service, and as such, was a public aircraft under the operational control of the Forest Service.[11] That meant that while the PIC may have retained ultimate responsibility for the safe operation of the aircraft, the Forest Service controlled (i) flight dispatch and scheduling; (ii) formulation of flight plans; (iii) determination of aircraft crew and cargo; and (iv) the conduct of safety briefings.[12]

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[11] See Carson's contract with the Forest Service, [Public Docket No. 430589]; FAA Advisory Circular 00-1.1 [Exhibit 1].

[12] Carson maintained the aircraft to FAA Part 135 standards as a condition of its contract with the Forest Service, and the pilots and crew were Part 135 certified. However, as a public use aircraft under Forest Service operational control, N612AZ did not fly according to Carson's FAA Part 135 Operation Specifications.

The Forest Service's operational control not only gave the Forest Service management control of the actual flight operations, but also responsibility for determining, constructing, and managing H-44, the helispot into which N612AZ would be required to fly. According to the IHOG[13] [excerpts at Exhibit 2], a helispot is a landing site used on a recurring basis to transport personnel and/or cargo. IHOG at 15-1. The IHOG required the H-44 helispot to be constructed to provide "for approaches and departures in several directions." IHOG at 8-12.

At helispots like H-44 that are located on ridge tops, it is the Forest Service's duty to clear brush and trees below the level of the landing area, because "[j]umbled brush and limbs" can "dissipate the ground-effect cushion" created by a helicopter's rotor blades. IHOG at 8-9. If that happens, it causes an abrupt transition to out-of-ground-effect flight as the aircraft compensates for the loss of power. IHOG at 8-9. If a helispot "cannot be built to safe standards, or negative environmental impacts cannot be mitigated," it "should not be considered a landing site." IHOG at 8-2.

2. The Forest Service's failure to exercise proper operational control over N612AZ was a factor

The Forest Service did not live up to its responsibility to make sure H-44 was in a safe condition for both normal and emergency flight operations. The IHOG required at least two approach and departure paths, but H-44 had only one. Moreover, the departure from H-44 required a vertical liftoff to clear the 50 ft. trees in the immediate path, even though the IHOG requires that to be avoided if possible. IHOG at 8-12.

Following the crash, the Forest Service had a team cut down an additional 45 trees on the departure path and around the helispot in order to accommodate helicopters smaller than N612AZ that were used during the accident rescue and recovery efforts. The Forest Service would not have had to do that if the pre-accident tree and brush clearance had complied with the IHOG.[14] The Forest Service's choice of H-44 as a helispot and its construction and preparation of H-44 contributed to the crash.

In addition, because the Forest Service operational control supersedes that helicopter operator's Operations Specifications, the Forest Service conducts the safety briefings and mission planning. This also meant that Carson did not adhere to restrictive Category A (single engine) flight parameters for transporting personnel since the Forest Service does not utilize Category A requirements in its planning. Moreover, Carson was also transporting hazardous materials onboard the aircraft for the Forest Service, which is allowed during public use flights and is part of the mission requirements for the Forest Service, but is not allowed under FAA Part 135 Operations Specifications.

[13] The IHOG is published through the National Interagency Fire Center, the Forest Service, and certain Bureaus and Offices within the U.S. Department of the Interior. The IHOG is policy for helicopter operations for all participating agencies, including the Forest Service.

[14] The IHOG at 9-13, also required the Forest Service to have a crash-rescue kit and an evacuation kit at H-44, but neither was onsite. This Forest Service failure may have hampered

3. Pilot experience was not a factor

The Carson pilots had substantial experience flying S-61 aircraft and flying for Carson. PIC Schwanenberg was first trained as a helicopter pilot by the U.S. Army in 1973. He obtained his commercial pilot's license in 1979 and was type rated in the S-61 in 1993. At the time of the accident, Mr. Schwanenberg had approximately 34 years experience flying various models of helicopters, had accumulated more than 20,000 hours of flight time, and had more than 8,000 hours flying the S-61. He was also a registered Part 135 pilot with substantial experience piloting helicopters in passenger carrying missions. In addition, Mr. Schwanenberg had civilian passenger transport experience, including transport of passengers for offshore work under IFR (Instrument Flight Rules) conditions, and was one of the few pilots at Columbia Helicopters (a prior employer) to be rated for passenger hauling Part 135 operations in the Chinook heavylift helicopter.

SIC Coultas is also a former U.S. Army helicopter pilot. He received his initial training in 1991 and his commercial pilot's license in 1992. Mr. Coultas obtained a visual flight rules rating in the S-61 in 2005. At the time of the accident, Mr. Coultas had accumulated 3,000 flight hours with 1,100 hours in S-61 aircraft. Both pilots were Part 135 rated for passenger operations, and both had prior experience flying passenger transport flights in the military.

In short, both Mr. Schwanenberg and Mr. Coultas had the skills and experience to successfully pilot N612AZ on the firefighting missions assigned to the aircraft by the Forest Service.

4. N612AZ experienced no problems during its earlier two flights from H-44

Within the two hours prior to the accident flight, N612AZ made two successful flights out of H-44. The Forest Service had concerns about the potential for high altitude lightning and therefore the mission that day was to ferry approximately 45 contract firefighters to a lower altitude base.[15]

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the ability of the victims of the crash to get out of the aircraft, and certainly did hamper post-crash rescue efforts.

Moreover, the safety briefing given by Forest Service helitack crewmembers to the firefighters prior to the flight took place outside of the aircraft. It therefore may not have included a demonstration of how to use the type and model of safety belts the Forest Service required to be installed on the aircraft. Such a demonstration was crucial because the required safety belts are of a substantially different design than standard aviation passenger safety belts and therefore were likely unfamiliar to the firefighters. Forest Service maintenance inspectors specifically required Carson to install the type of rotary seatbelts that N612AZ was using prior to the commencement of the aviation firefighting contracts.

[15] Forest Service Pilot Inspector Ramage's participation was not required to perform this mission. He accompanied N612AZ to conduct a flight evaluation of the PIC and then, at his own initiative, stayed aboard as a safety crewmember.

N612AZ's first flight into H-44 the day of the accident revealed that the helispot had problems. N612AZ's first attempt to land had to be aborted because of brownout visibility conditions caused by dust and dirt particles being blown into the air by the aircraft's rotor downwash. Only after other helicopters performed water drop dust abatement could N612AZ safely and successfully land on a rock outcrop about 100 ft. from the original landing spot chosen by the Forest Service.

Before their first departure from H-44, the PIC and the SIC discussed whether the aircraft would have sufficient power to complete the vertical takeoff necessary, given the way the Forest Service had configured the helispot. The pilots agreed that N612AZ would have sufficient power. N612AZ then successfully took off at approximately 1814, and successfully completed its first transport flight of the day. Although N612AZ was lighter on its initial flight out of H-44 than on the accident flight, the temperature was considerably warmer. The warmer temperature meant that the actual operating performance margin of the aircraft on its initial takeoff out of H-44 was <u>less</u> than on the accident takeoff. The aircraft, however, was still in full compliance with all appropriate operating procedures and limitations. N612AZ returned to H-44 for its second flight and departed at approximately 1843. The SIC told the PIC that power was good during this flight.[16] In light of their prior successfully completed missions, the pilots of N612AZ had no reason to believe that the aircraft would not successfully take off and complete its third planned flight out of H-44 later that day.

5. Given the aircraft's weight and the meteorological conditions at the accident scene, N612AZ should have had sufficient performance to successfully complete its final flight

Aircraft performance is not simply a function of the aircraft's engines. Temperature, wind speed, and wind direction are all very important variables that must be taken into account in determining the performance of any helicopter. Power output varies significantly based on increases or decreases in temperature. While a headwind can help lift a helicopter aloft, thereby causing the aircraft to perform better than anticipated, a tailwind can have the opposite effect. Aircraft weight (the weight of the empty airframe, plus installed components or equipment plus fuel, crew, and payload) is important because the engine power must be able to carry that weight to successfully accomplish the mission.

The facts clearly show that N612AZ should have had sufficient engine power to successfully complete the accident mission. Using the most reliable weight documents that exist for the aircraft, see sections II.C.5.a and V.B.1 below, N612AZ most likely weighed no more than 18,588 lbs.[17] Given an outside air temperature of approximately 20° C, the aircraft's

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[16] After successfully completing the second flight, N612AZ returned to the Shasta Trinity helibase for refueling. The mechanic who inspected the aircraft during refueling observed that ash covered both engine intakes. He removed ash which had accumulated on the main rotor blades.

[17] This amount consists of the most likely empty weight for the aircraft at the time of the crash, 13,432 lbs., plus 5,156 lbs., the weight of the crew, fuel, cargo, and qualified non-crewmembers on the aircraft at the time.

engines had capacity to lift 19,338 lbs., a positive margin of at least 750 lbs. Even if the operations group's disputed, excessive weight for the aircraft is used (413 lbs. more, or 19,001 lbs.), there still is a positive performance margin of at least 330 lbs. When the presence of a 5 knot headwind is factored in, this performance margin increases to at least 900 lbs. using the most likely weight for the aircraft. The fact that N612AZ should have had more than ample power to successfully take off, but did not, compels the conclusion that the crash of N612AZ was caused by a failure of the aircraft's engines to deliver the power they should have.

a. Aircraft weight

Carson acknowledges that after the accident it learned that there were anomalies and irregularities in the weight documents maintained for N612AZ. Carson also acknowledges that such a weight document was erroneously used in the bid documents associated with Carson's Forest Service contracts. Neither these anomalies and irregularities, nor the weight of the aircraft itself, however, were among the causes of the crash. The sole effect of the anomalies and irregularities in the weight documents for N612AZ was to make it difficult to determine the weight of the aircraft at the time of the accident with 100% certainty. After discovering these anomalies and irregularities, Carson modified its operations and procedures, including, but not limited to, improving internal controls over the weighing process, to minimize the chance of such anomalies and irregularities occurring in the future.

The anomalies and irregularities in the weight documents for N612AZ did not affect the operational performance of the aircraft during the accident flight. The aircraft did not exhibit flight characteristics consistent with its being overloaded. If it had, the pilots never would have attempted to fly it. The PIC and the SIC were experienced pilots with more than 50 years and more than 23,000 hours of flight time between them. They would have known, within seconds of bringing the aircraft up to a momentary hover, that the engines were being excessively stressed by the combined weight of the aircraft and payload. The pilots then would have immediately landed the aircraft to offload some of the payload. In his post-accident interview, the SIC noted how well the aircraft was flying and that nothing unusual was noted in the gauges or aircraft flight characteristics when they initially lifted off from H-44.

While it is impossible to pinpoint an exact weight for N612AZ at the time of the accident, it is possible to determine its likely weight based on a detailed analysis of the best weight documents that exist for the aircraft. That analysis (based on historical weights for the aircraft as detailed later in this Submission) shows that N612AZ's empty aircraft weight on August 5, 2008 likely was between 13,289 lbs. and 13,537 lbs., with the most likely weight no more than 13,432 lbs.

Using any of these weights in combination with the known weight of the final flight payload and the proper meteorological data, see sections II.C.5.b and V.B.3 below, demonstrates that the aircraft should have had a substantial performance margin available to successfully complete the accident flight.

b. The meteorological conditions

The CVR recovered from the wreckage contains very specific data on the temperature and wind conditions at the time of the crash. As required by the contract pursuant to which the Forest Service was operating the aircraft, N612AZ was equipped with a Sky Connect Automated Flight Following (AFF) system.[18] The Sky Connect AFF system utilizes an Iridium satellite network transceiver with an internal GPS. The installed Sky Connect AFF system provides full GPS data on N612AZ's flight operations on the day of the accident, including flight path, speed, and altitude. The data from the Sky Connect AFF system [Exhibit 3] provides independent confirmation of almost exactly where the aircraft was when the meteorological data recovered from the CVR was gathered.

The CVR data shows that at 1930, the Forest Service helitack crewmember on the ground told the pilots by radio that winds were out of the southeast at 3 to 5 knots, a statement confirmed by post-accident interviews with the SIC. Additionally, the witness statements of Forest Service helitack crewmembers Alex Rhea, Ulf Peters, and Byron Buchner each confirm the CVR data showing that winds were from the southeast at 3 to 5 knots on N612AZ's final takeoff from H-44. The southeast direction of the 3 to 5 knot wind clearly indicates that this wind was a headwind which would increase N612AZ's performance on takeoff.

Three minutes later, at 1933, the Sky Connect AFF system showed the aircraft passing through 6,300 ft., only 355 ft. in elevation above the helispot. A little more than one minute later, at 1934 (and certainly at a much lower altitude), the SIC called out the temperature as 20° C. Less than 40 seconds later, the next Sky Connect AFF data point showed N612AZ was already on the ground at 5,945 ft. elevation. Putting the CVR and the Sky Connect AFF data together, when the SIC read out the air temperature as 20° C, the aircraft had to have been descending on its short, final approach to H-44. At 1939, four minutes after landing at H-44, the SIC is heard on the CVR discussing the temperature as between 12 to 13° C cooler than the 32° C mission planning temperature, or 19 to 20° C.

The 19 to 20° C temperature at the accident scene reported by the SIC was accurate within 1° C. The SIC took this data from a temperature gauge directly in his left line of sight near his head. On July 28, 2008, less than 10 days before the accident, Carson had inspected that gauge and found it operating properly.[19] Additionally, the calibration of several identical temperature gauges used in other Carson aircraft over a multi-year period had all been tested and calibrated by an independent company, and all were tested accurate to within 1° C.[20]

[18] Sky Connect AFF is a Forest Service approved satellite transponder system, which automatically reports flight information every two minutes on the flight path, speed, and altitude from the aircraft on which it is installed.

[19] Sikorsky, the manufacturer of the gauge, has stated that the gauge is accurate plus or minus 1 to 3° C. Carson's policy, however, is to repair or replace any temperature gauge found to be more than 1° in error.

[20] Carson has given the NTSB investigators all of this inspection, testing, and calibration data. [Exhibit 4]

6. N612AZ should have had sufficient power to successfully complete the accident flight

a. The altered performance charts in the company's aircraft's flight manual did not affect power available to N612AZ

Carson acknowledges that in the course of this investigation, altered performance charts have been found in the company's flight manuals, and that these charts had been erroneously used in bid documents associated with Carson's Forest Service contracts. The altered performance chart consists of the data for an FAA-approved 2.5 minute power available chart superimposed over the header and footer of a 5 minute power available chart (including the FAA approval stamp) in such a manner as to appear that the performance available at 2.5 minute power is available using 5 minute power. Carson does not know, and has not been able to learn, where these altered performance charts came from or how they were created.

As it has with the weight anomalies and irregularities, Carson has reevaluated and changed its operations and procedures in response to the discovery of the altered performance chart, to minimize the chances that any altered performance charts will be again inserted into Carson flight manuals. These changed procedures include the way the company handles submissions to the FAA and the approved performance chart documents, once the FAA returns them. Carson has also made improvements in its procedures for disseminating flight manuals and the distribution of changes or amendments to flight manuals, as well as in management oversight procedures for control of documents submitted for contract proposals.

None of the above, however, matters for this investigation. What matters is that the mislabeled charts had no effect on the performance of N612AZ, and in fact the mislabeled "5 minute" power available chart actually presents valid performance data for "2.5 minute" power. On its final flight, N612AZ was flying for far less than 2.5 minutes from takeoff to crash. Thus, even if the aircraft were flying under 2.5 minute power, it was not exceeding the manufacturer's or the FAA's limitations for the use of such power. Moreover, the FAA-certified Sikorsky Flight Manual makes it clear that there are several flight envelopes under which the 2.5 minute charts can be utilized, and, in contrast to other twin engine helicopter manuals, the Sikorsky manual does not state that the 2.5 minute power chart can only be used for emergency use or single engine operations.

In any case, when the correct performance parameters for the aircraft on August 5, 2008 are used, it is clear the aircraft had sufficient performance available with properly functioning engines to remain within the margins of the power available charts approved for use with the aircraft. Accordingly, N612AZ's weight, in combination with the meteorological conditions present at the time of the final flight, and the output that should have been generated by the aircraft's engines, show that N612AZ should have been able to successfully complete its final flight.

b. **N612AZ should have had sufficient power during the accident flight**

Carson agrees with the methodology used by the NTSB in the Hover Study Report [Docket No. 426604] to arrive at aircraft performance margins. However, Carson disagrees with some of the conclusions in the report because the study uses temperature, weight, and wind conditions that are incorrect for the flight when calculating performance margins.

i. **Weight**

The excessive weight for N612AZ used by the operations group affects the gross weight power margins available on the three takeoffs from H-44 on the day of the accident. Carson is confident that the operations group's listed weight, 13,845 lbs., is erroneous, and Carson has shown that the most likely weight for the aircraft, based on an average of the best available data for the empty weight of N612AZ prior to the crash, is 413 lbs. lower, or no more than 13,432 lbs.

ii. **Temperature and Wind**

As detailed in sections II.C.5.b and V.B.3, the best available weather data is from the readings and conditions read out on the CVR by the trained professionals at the site (including the SIC and the Forest Service helitack crewmembers). That data is far superior to the synthetic temperature and wind numbers made up by averaging numbers from weather stations many miles from the accident scene – the data on which the operations group relied. The operations group's choice to use interpreted or derived averages instead of actual data materially skews the results of the analysis of the available power margins on the takeoffs from H-44 that day.

A comparison of the first with the third takeoff illustrates how the operations group's made-up data changes the results. The onsite, pilot-determined data shows:

First takeoff from H-44 – calm winds, 29° C.

Third takeoff from H-44 – 5 knot headwind, 20° C.

And, the Hover Study's own power figures and sensitivity study reveal:

First takeoff from H-44, HOGE payload margin is 230 lbs. (or +650 lbs. with Carson aircraft weight).

Third takeoff from H-44, HOGE payload margin positive at least 480 lbs. (or at least 900 lbs. with Carson weight).

Accordingly, even assuming calm winds at H-44 on the accident takeoff (although the Forest Service helitack manager is heard on the CVR telling the pilots that they have a 5 knot wind on the nose of the aircraft, and this was what the SIC confirmed in the post-accident interview), the performance margin is positive 330 lbs.

What is striking about the correct data is that, because of density conditions, on its first takeoff from H-44, N612AZ actually had a smaller performance margin available – anywhere from 100 to 250 lbs. of positive margin – than it did during the accident takeoff. Even so, during this more challenging first flight the aircraft lifted off, came to a hover, flew away on exactly the same flight path as it did on the accident takeoff, and successfully completed its mission with no issues.

iii. Conclusions drawn from the correct weight, temperature, and wind data

On the accident takeoff, using the most reliable aircraft weight of no more than 13,432 lbs. empty, plus 5,156 lbs. in crew, fuel, and payload, for a total of no more than 18,588 lbs., and the correct temperature (20° C), and wind (5 knot headwind) data, the aircraft had at least 900 lbs. positive margin of HOGE performance, using the performance figures from the Hover Study. Crucially, even if the operations group's overstated aircraft weight of 13,845 lbs. is used, along with the correct temperature, the aircraft still had a positive performance margin of at least 480 lbs.

Both of these performance margins are more than what was available to the aircraft on the first takeoff of the day from H-44. N612AZ lifted off from H-44 on the third takeoff and came to a hover, just as it did on the first takeoff. The aircraft had the power to lift up to a hover yet, when it began the transition to forward flight, it soon began to lose both altitude and main rotor RPM. Nonetheless, despite an increased available performance margin and an identical departure path, the aircraft could not fly away as it did on the first takeoff. There could have been only one reason for this – power loss.

As shown in the independent flight performance evaluation tests, section 11.4. below, an exemplar helicopter loaded to 100 lbs. more than the NTSB-perceived excessive gross weight was capable of lifting off and hovering 400 ft. out of ground effect under the same conditions. The test flight aircraft had no trouble maintaining a positive rate of climb even with the collective pulled to maximum pitch conditions. The main rotor RPM never drooped lower than 94% under these conditions and still maintained a positive rate of climb, even though no experienced pilot would fly the aircraft in this fashion. The main rotor RPM on the accident aircraft shown on the CVR data drops at a fast and steady rate. This cannot be duplicated under any normal power conditions, even with the aircraft loaded at weights considerably higher than the accident aircraft. As the test flights of an S-61 similarly equipped to N612AZ at the time of the accident prove, this type of rotor droop can only be induced when power is partially lost from one engine.

D. The Gauges And Engines Recovered From The Wreckage Show A Loss Of Engine Power

N612AZ had three different torque gauges, including one mounted on the outside of the fuselage, just outside the left pilot window (for vertical reference operations), and two on the instrument panel. Only one of these gauges – the external reference gauge – was recovered completely intact and uncompromised, with no breakage and no apparent terminal heat damage (this gauge probably survived intact due to being buried in the dirt on impact).

This recovered gauge showed that the number 2 engine had approximately 30% less torque than the number 1 engine when aircraft instrument power was lost.[21] Both of the other torque gauges also showed the number 2 engine with less power, in varying degrees. Both of those gauges, however, suffered more damage than the outside and may not be reliable. This torque differential between the aircraft's two engines indicates that the number 1 engine was fully functional, while the number 2 engine was losing, or had lost, some power and was potentially slowing down.

In addition to the gauges, N612AZ's engines themselves support the conclusion that the aircraft lost power in at least one engine immediately prior to the crash. Significant differences between the condition of the aircraft's two engines were observed when they were disassembled after the accident. The number 1 engine exhibited signs of significant damage, including serious foreign object damage consistent with a fully operating engine sucking in foreign material on impact, as well as damage caused by the impact of the crash and heat damage. In marked contrast, the number 2 engine had virtually no damage, wear, internal damage marks, or foreign object damage. The difference with respect to foreign object damage is typically caused by an operating engine sucking in large amounts of dirt, rocks, or similar material.

These differences support a conclusion that while the number 1 engine was operating when the aircraft crashed, the number 2 engine was likely operating at less than full power. The number 1 engine absorbed the most impact and dirt from the crash on the left (downward) side, and the number 2 engine was mounted higher above the impact point, which may account for some of the differential. However, the two engines are mounted less than 24 inches apart, and the difference in their condition is not sufficiently explained by the attitude at impact. In addition, the 3D cams that control fuel metering to the engines were found to be rotated in two very different positions in each of the aircraft's two engines.

Accordingly, the gauges and engines recovered from the wreckage show that N612AZ crashed due to a loss of engine power.

E. The CVR Sound Spectrum Data Provides Further Confirmation That N612AZ Crashed Because Of A Loss Of Engine Power

The CVR evidence likewise points to the rapid decrease in main rotor RPM as the cause of the N612AZ crash. The decrease occurred even with gas generator speeds at topping, which indicates the main rotor has not received full power. The aircraft had already demonstrated enough power to come to a hover, and the rapid loss of main rotor RPM is not consistent with an aircraft that is too heavy.

The pilots were highly experienced. The PIC was a 20,000 hour pilot (with more than 8,000 hours in the S-61 aircraft) who was well known within the pilot community for being extremely careful with his flying. Had the aircraft been too heavy, the PIC would have certainly felt this as he came to a hover, or the SIC would have noted abnormal power readings. In either

[21] Aircraft power is lost when Nr falls below 90%; at this point, all gauges stop in place.

case, the PIC would have immediately returned to the ground from the hover, and offloaded equipment and/or personnel.

Instead, the SIC is heard on the CVR reading 90% torque and 103% on the main rotor RPM as the aircraft comes to a hover. These power readings are completely consistent with the aircraft's flight attitude at that time. The CVR shows that, very shortly after this reading, the main rotor begins to droop rapidly. The independent flight testing at this density altitude and weight has confirmed that even minor correction action, a minimum deflection in collective input from the pilot, should have been enough to restore main rotor RPM under normal flight conditions. This type of corrective action would be second nature to a pilot with Mr. Schwanenberg's years of experience.

The CVR shows that despite whatever pilot inputs may have taken place, the main rotor RPM drooped rapidly to an unrecoverable state. This type of main rotor RPM droop curve with no significant flattening or stabilization is virtually unheard of for this rotor system when normal power is being supplied. See discussion of independent flight test, section 11.F. below.

1. The CVR gas generator speeds and synthetic power study data is of poor quality, unreliable, and does not point to a cause other than power loss

Carson has serious questions about the quality of the CVR spectrum noise plots. This data is not taken directly from engine monitoring parameters, or from dedicated sound pickups on the S-61 helicopter. Instead, the data is recorded by two microphones mounted near the glare shield inside the cockpit of the aircraft. These microphones also record all other sounds and noises within the dynamic range of the microphones. The main rotor RPM is plotted from the planetary gear mesh of the transmission and is relatively clearer than the gas generator speeds of the engines.

A review of the original noise plots in the Sound Spectrum Study [Docket No. 419427] shows that while the plotted traces from the main rotor RPM gear mesh are relatively clear and can be discerned, the original noise plots for the gas generator speeds, which are the sixth harmonic of the actual frequency, are extremely noisy and difficult to trace. A harmonic of the original frequency was used because the original engine sound data frequency was too noisy.

When asked about the type of application of filtering that was used to extract data from the original very poor noise plots to arrive at the very clean plots being used by the operations group for its power data and synthetic power studies, the NTSB sound engineer said that the delineation of the noise plots "was subject to a great deal of interpretation."

The original plots show that the gas generator data, particularly from the second and third takeoff from H-44, are of marginal quality. There is no margin of error or confidence interval assigned in the study, probably because it is not possible to assign a confidence interval to noise data retrieved and interpreted in this fashion. Carson was only given a copy of the raw sound CVR data at the Technical Review meeting in late April. Carson is having the quality of the data assessed by an independent lab as of the date of this Submission. Carson will submit the results of this data assessment to the NTSB once it is complete.

The operations group has placed a great deal of faith in the Ng plots from this data and has used these plots and the underlying data to generate synthetic engine numbers. The operations group asked GE to produce a synthetic power study based in part on the gas generator speeds retrieved from the noise data. The data the operations group is using, however, suffers from two primary flaws: First, the gas generator speed is not necessarily an indicator of torque output in a free turbine. Torque output can be affected by other factors independent of gas generator speed. It is quite possible to have Ng at full topping, but suffer reduced torque output in the engine. This has happened to Carson's aircraft before and is described in the GE Maintenance Manual. Second, the original poor quality of the data for the harmonic of the gas generator noise data calls into question any premise built upon assumed gas generator speeds. As confirmed in the independent flight tests, there is no need to rely on synthetic data, because there is real world data that clearly shows what the S-61 composite bladed aircraft can do in similar flight circumstances.

The GE power study in the docket uses information from the gas generator plots to make assumptions about the power available. The synthetic numbers produced by this study are based on artificial assumptions about conditions and power. These artificial assumptions are also incorrect as the test flight, which involved flying a similarly equipped aircraft in similar density conditions with payloads exceeding the accident aircraft, demonstrates. The GE study (and to a lesser extent, the Hover Study) shows the aircraft with virtually no margin of power at the operations group's weight. The real world flight evaluation, on the other hand, showed that at weights considerably higher than this, an exemplar composite bladed S-61 tuned to the same power specifications could repeatedly pick up the loads, fly to well out of ground effect, and come to a stationary hover with normal pilot inputs. At a minimum, this casts serious doubt on the quality and reliability of the basic assumed data used as the foundation of the GE power study and the Hover Study.

F. An Independent Flight Test Confirmed That Power Loss To An Engine Was The Cause Of The Loss Of Performance Which Led To The Crash Of N612AZ

The operations group made up their minds early on to focus almost exclusively on the weight of N612AZ and altered performance charts as the possible cause of the crash. The operations group consequently turned a blind eye on any other possible causes and rejected Carson's many requests for a flight test to evaluate the performance of an identically equipped S-61 under the accident conditions. Carson could not get the operations group to budge, even after Carson offered to provide the NTSB with aircraft, pilots, and flight time free of charge.

Carson finally had no choice but to go ahead anyway and commission an independently conducted and witnessed flight test. This independent flight test confirmed the results of Carson weight and performance analysis – N612AZ should have had more than adequate power to successfully complete its final flight. The test flight further confirmed that N612AZ's engines were not generating the power they should have, and that this power loss was the root cause of the crash.

Carson had Whipple Aviation Services, Inc. conduct the flight performance evaluation test. The test was conducted on November 3, 2009, of an S-61 helicopter, similarly equipped as N612AZ at the time of the accident. [Exhibit 5 is a copy of Whipple Aviation Services, Inc.'s report of the flight performance evaluation test] The purpose of the flight performance evaluation test was to assess the performance of a model S-61 helicopter when configured like N612AZ, and flown at a density altitude similar to that experienced during N612AZ's final takeoff from H-44. The test aircraft was also flown at various gross weights, including one far heavier than the excessive weight the operations group ascribed to N612AZ.

The results of the flight performance evaluation test showed that the model S-61 helicopter was able to successfully fly at <u>all</u> weights, <u>including</u> the overstated weight the operations group has ascribed to the aircraft. The <u>only</u> way the test pilot could duplicate the loss of altitude N612AZ experienced immediately prior to the crash was to significantly reduce power to one of the aircraft's engines. These tests provide even more proof that N612AZ did not crash as a result of weight or performance chart issues, but as a result of engine power loss.

1. Test specifics

a. Preparations

The performance evaluation test took place on November 3, 2009. Before the test aircraft was placed in the Experimental Category for purposes of the performance evaluation test, it was de-fueled and weighed in Reno, Nevada, the day of the test, utilizing calibrated scales and with an FAA Designated Airworthiness Representative as a witness. The load cell used to track and control the weight of the aircraft was calibrated on September 9, 2009. The engines were tuned and calibrated to match the topping limits and power output of N612AZ as of August 4, 2008 (the last power check performed prior to the accident). Winds were calm for the evaluation flights. The flights were monitored by Whipple Aviation Services, Inc., an independent aviation consultant, and were videotaped. The five pilots observing the test flights had a combined total of more than 60,000 flight hours of helicopter experience.

b. The aircraft

The test aircraft was an S-61N longbody, fixed gear helicopter leased to Carson solely for use in the performance evaluation test by its owner, Cougar Helicopters, whose pilots flew the aircraft throughout the test. The test aircraft was equipped in firefighting configuration, with a 700 gallon water bucket and 200 ft. longline. The use of the longline attached to a calibrated load cell on the aircraft allowed precise metering of the water/weight load to allow accurate control of the weight of the aircraft during the flight performance evaluation test.

Although N612AZ was equipped with a fixed Fireking tank at the time of the accident, because the Fireking tank is configured so that the projection of the sides of the tank does not protrude enough to interfere with the lift-generating downwash of the rotor system, there is no difference in lift capacity between an S-61 equipped with a Fireking tank and an S-61 equipped with the longline/bucket combination (other than the weight of the tank itself). Thus, the test aircraft had identical performance characteristics to N612AZ as it was configured at the time of the accident.

c. The flights

The test aircraft was flown at density altitudes ranging from 8,450 ft. to 8,551 ft., with all but one test altitude exceeding the operations group's theoretical density altitude for the accident. The winds at the location and altitude of the test were negligible and did not influence the test results.

On each of the two test runs, to achieve the desired density altitude, the test aircraft picked up its water/weight load from a lake at 5,588 ft. above mean sea level and then ascended to the desired pressure altitude of 6,700 ft. The aircraft then came to a hover at 400 ft. above ground level, completely out-of-ground effect. The collective pitch control was then pulled up to its maximum stop in order to reduce main rotor RPM as low as possible.[22] The test aircraft was then held in position to duplicate sustained maximum rotor droop conditions.

2. The flight results

For the first flight, the aircraft weighed 19,100 lbs. From the stabilized out-of-ground effect hover described in the previous paragraph, the collective pitch control was pulled up to its maximum stop: main rotor RPM decayed to 94% and stabilized there. The main rotor RPM would not droop below 94%. Although main rotor RPM decayed to 94%, the test aircraft still exhibited a 200 ft. per minute positive rate of climb. A one inch lowering of the collective resulted in main rotor RPM recovery to 100% within two seconds.

During the second flight, eight separate hover performance tests were conducted. Each test was completed at slightly different gross weight.

<u>Tests 1 through 5</u> The test aircraft weight ranged from 18,300 lbs. to 18,643 lbs. From a stabilized out-of-ground effect hover at 400 ft. above ground level, the collective pitch control was pulled up to maximum stop and sustained: main rotor RPM drooped to 94%, then stabilized and would not decay below 94%. Throughout tests 1 through 5, the aircraft exhibited positive rates of climb varying from zero to 300+ ft. per minute. A one inch lowering of the collective pitch brought main rotor RPM back to 100% or above within two seconds.

<u>Tests 6 through 8</u> The test aircraft weight ranged from 19, 393 to 19,543 lbs. The aircraft flew from the water pickup site up to 400 ft. above ground level and came to a stabilized hover out-of-ground effect. The collective pitch control was pulled up to maximum stop and

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[22] A typical takeoff profile in any helicopter would require the pilot to increase collective stick input to increase pitch in the main rotor blade to the point where the aircraft becomes airborne. Once the aircraft is aloft and the decision to translate into forward flight is made, the collective stick input is further increased to the point that the main rotor droops to the best rate of climb and then reduced to maintain that main rotor RPM. In the tests that were performed, the collective was increased past that point to the upper stop of its travel.

sustained: main rotor RPM drooped to 94%, but would not decay below 94%. Throughout tests 6 through 8, the aircraft very slowly settled, with power, into a rate of climb of negative 250 ft. per minute. A one inch lowering of the collective pitch brought main rotor RPM back to 100% or above, and the aircraft exhibited immediate positive rates of climb.

Test 8

This particular test was structured to evaluate the effect on aircraft performance of a loss of power to the number 1 engine. This test was conducted identically to all of the others, up to and including pulling the collective pitch control up to maximum stop and sustaining. However, once that was done, the speed selector lever (throttle) for the number 2 engine was reduced, lowering the engine torque output to 70%. Main rotor RPM rapidly decayed below 91% without stabilizing or hesitating and the aircraft developed a rapid negative 500 to negative 600 ft. per minute rate of descent. The collective was then lowered one inch, the speed selector lever advanced to restore full power to the number 2 engine, and the aircraft immediately recovered torque and main rotor RPM and was flown into a climb.

The data collected from these eight tests shows that, regardless of any confusion or disagreement concerning the weight or weather conditions at the time of the accident, with normally operating engines and rotor system, even according to the operations group's faulty weight and weather assumptions, N612AZ should have had sufficient power to safely take off and complete its final flight, even at the higher weight the operations group has ascribed to the aircraft. Because a higher density altitude results in a corresponding diminution in the performance of the engines of an S-61, conducting the tests at this higher altitude than the accident flight meant that, but for a power loss to one of its engines, N612AZ would have had even greater performance available on the accident flight.

3. Conclusion: power loss to an engine caused the loss of performance which led to the crash of N612AZ

In each of the eight test flights, even at weights exceeding 19,500 lbs. – well above what the accident aircraft could have weighed (no more than 18,588 lbs. fully loaded) and well above what the operations group asserts it weighed (19,001 lbs. fully loaded) – the test aircraft successfully (i) picked up water weight from a lake at an altitude of 5,588 ft.; (ii) flew up to 400 ft. above ground level and well out of ground effect; and (iii) came to a stabilized hover. From a stabilized out-of-ground effect hover, maximum sustained collective input, representing maximum rotor droop conditions well beyond what would normally be experienced, resulted in a droop to a stabilized 94% main rotor RPM. In every test, except the one in which power to the number 2 engine was reduced, the rotor system would not droop below the stabilized 94% main rotor RPM. Even at this stabilized condition, the test aircraft generally exhibited positive rates of climb. And, even in instances of negative rates of climb, the settling was slow and the main rotor RPM did not droop quickly. The most minor collective correction (i.e., lowering the collective by one inch) by the test pilots resulted in recovery of the rotor system and a return within two seconds to 100% or better main rotor RPM and positive rates of climb.

Even at weights several hundred pounds greater than the likely weight of N612AZ at the time of the accident – and weights significantly in excess of the weight erroneously ascribed to N612AZ by the operations group – the only condition in which the test aircraft could be induced to exhibit rapid rotor droop below 94% main rotor RPM with unrecoverable flight conditions was through reducing power to one engine by approximately 25%. Restoration of power and minimal collective correction resulted in immediate recovery of the main rotor RPM and a return to a positive rate of climb, even when the test aircraft weighed 19,400 lbs.

The flight performance evaluation test clearly demonstrated that an identically equipped and configured S-61 helicopter loaded to weights heavier than the accident aircraft, at the same density altitude, and with the composite main rotor system could repeatedly:

- Safely ascend and come to a hover well out of ground effect and fly loads the same as, or greater than, those carried by N612AZ at the time of the crash.

- Maintain a 94% main rotor RPM and hover even with maximum droop induced by maximum collective input.

- At all but the heaviest possible weights, still maintain a positive rate of climb under these maximum droop conditions.

- Recover main rotor RPM to 100% or greater in fewer than two seconds and immediately register a positive rate of climb with a very minimal deflection of collective input.

The only condition under which the test aircraft replicated the rapid main rotor RPM decay below 91% as shown on the CVR spectrum analysis from N612AZ was when power to one engine was decreased by 25%.

In short, the flight performance evaluation test results confirm that, at the time of the accident, if N612AZ had not lost power to the rotor, the aircraft still should have been able to successfully take off and complete its mission.

G. Conclusion

The factual evidence from the accident itself, including the CVR data, eyewitness observations, and the gauges and engines retrieved from the wreckage, points to a power loss as the cause of the accident. The independently conducted and witnessed flight performance evaluation test confirmed that the only way to induce flight characteristics similar to those experienced by N612AZ immediately prior to the crash was to reduce power to one of the aircraft's engines. Regardless of any anomalies or irregularities in the aircraft's weight documents or in the performance charts located in the aircraft's flight manual, N612AZ's engines should have had more than ample power to successfully take off and complete the accident flight. That N612AZ did not do so is confirmation that the aircraft's engines were not delivering the power they should have.

III. FACTUAL FINDING: FUEL CONTROL UNIT CONTAMINATION CAUSED THE N612AZ POWER LOSS

The source of the power loss that led to the crash of N612AZ was significant contamination in the aircraft's FCUs. In addition to having had FCU-related engine power issues during the months leading up to the accident, the FCUs recovered from the accident wreckage contained a significant amount of contamination.

During its own post-accident investigation, Carson learned that contamination such as that found in N612AZ's FCUs has long been known to cause engine power loss. During its investigation, Carson found out about numerous S-61 mishaps, ranging from recoverable power lapses to full blown crashes, which were found to have been caused by FCU contamination-related engine power loss, and which had occurred in the years leading up to the accident. As detailed in section IV below, Carson has uncovered evidence that the manufacturer of the S-61, the manufacturer of the S-61 engines, and the company that overhauled the S-61 engines each knew, for years prior to the accident, that FCU contamination could pose a hazard. That evidence also reveals that these three companies did nothing to either address the hazard or warn the helicopter operations community or the flying public about it.

A. N612AZ Had Previously Experienced A Power Loss Due To A Contaminated FCU

During the 11-week period leading up to the crash, N612AZ had at least two problems with its FCUs. On May 12, 2008, N612AZ was hovering at a water site during a firefighting mission. As full power was engaged, the number 2 engine stuck at 50% torque, with all indicators showing normal operating conditions, that is normal T5, Ng, and fuel pressure. The FCU on the number 2 engine was swapped out and the malfunctioning unit was sent to Columbia Helicopters for repair. The initial work order report from Columbia Helicopters [Exhibit 6] showed that the FCU was very contaminated with foreign material. This work order report showed that Columbia Helicopters replaced the PRV in the FCU but the unit still had power fluctuations while run on a test cell.[23]

[23] No final report on this FCU was issued by Columbia Helicopters because, after the crash of N612AZ, Carson requested that Columbia Helicopters ship this FCU to Hamilton Sundstrand, the unit's manufacturer, for further analysis. This unit was shipped to Hamilton Sundstrand but, for reasons that have not been explained in this investigation or otherwise, prior to being shipped, the unit was disassembled down to its smallest parts, those parts were stripped and cleaned, and then the hundreds of tiny pieces were commingled together in two plastic bags. The cleaning of these parts rendered them useless for inspection or analysis and the haphazard shipping of these parts damaged them beyond any further use. According to the Hamilton Sundstrand employee who witnessed the opening of the boxes containing the disassembled FCU, the unit should be scrapped. Columbia Helicopters' disassembly of this FCU makes it

On June 7, 2008, N612AZ experienced another FCU problem, this time with the FCU installed on the number 1 engine. After experiencing Ng and fuel pressure flux at high power, mechanics changed out the FCU and sent the problem FCU to Columbia Helicopters for overhaul analysis and repair. After the problem FCU was replaced, the aircraft flew normally. Carson subsequently reclaimed this FCU from Columbia Helicopters and it is currently in Carson's possession in "as removed" condition. Since the FCU is in "as removed" condition, Carson asked the operations group to conduct further analysis on it, but it refused.[24]

B. N612AZ Flew The Accident Flight With Significantly Contaminated FCUs

The NTSB Materials Lab Report on the FCUs from N612AZ [Docket No. 430172] revealed a significant amount of contaminant materials in the PRV of both FCUs, but particularly the number 2 FCU, which had been replaced less than three months before. The number 2 PRV was in a stuck position, and light pressure from an arbor press was used to separate the valve body from the valve itself.

A long, fibrous strand visible to the naked eye was removed from the balance groove of the PRV, and the particulate size of the contaminant material ranged from 2.5 to 25 microns. In addition to significant amounts of contaminant material in both FCUs, there was severe longitudinal scoring on the inside walls of the PRV valve body, and a large amount of particulate matter inside the valve on the number 2 FCU, with similar but less scoring and contaminant material in the PRV of the number 1 FCU. This type of contamination and physical damage to a PRV can adversely affect the power output of the engine and cause a loss of power similar to that suffered by N612AZ immediately before it crashed.

On the JFC26 FCU[25], the PRV regulates the fuel brought from the fuel pump to the throttle valve. It regulates pressure and metering to the rest of the FCU, which affects fuel delivery to the rest of the engine. The clearance of the spool to the sleeve or valve body of the PRV is 0.0004 inches. Material in the PRV of the size and type shown in the NTSB report is well in excess of the valve body clearance and can (a) cause scoring of the valve walls, or slowing or sticking of the valve; and (b) directly affect the proper metering of fuel to the rest of the FCU and thereby affect the power of the engine. It is known that particulate matter inside the PRV can cause, and also has caused, sticking and slowing of the valve, which can cause several problems, such as engine surging, variations in topping power, and a loss of power to the engine, even at topping.

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impossible to determine the condition of this previously installed unit on the accident aircraft or the possible reasons for the failure of this FCU to perform properly.

[24] N612AZ also may have experienced FCU problems on August 2, 2008, only three days prior to the accident. On that day, the crew noticed Ng fluctuations on the number 2 engine. The tach generator was replaced as an initial troubleshooting measure and the aircraft did not experience any further problems until the accident itself. The aircraft did not fly on August 3 or 4.

[25] JFC26 is the model number ascribed to the particular model FCU installed in the CT58 engine, which is used in S-61 aircraft.

Equally important, the narrow clearance of the PRV acts as a collection point for contaminants circulating in the FCU. The presence of contaminants of the size found in the PRVs and filter screens in N612AZ's FCUs means that these contaminants were likely present in other valves within the FCU, such as the pilot valve, which controls stator vane actuator position. Stator vane actuation or "failure to respond" will cause the power turbine system to reach maximum Ng while simultaneously exhibiting reduced T5 and reduced torque.

The scanning electron microscope photographs of the contaminant material found in N612AZ's FCUs show that such contaminants are more than large enough to cause these types of power loss issues. The aircraft as certificated by Sikorsky has a 40 micron fuel filter, which has interstices (holes) large enough to let particles of this size get into the FCU.

GE's and Columbia Helicopters' own maintenance manuals confirm that contaminant material, even in very small amounts, can affect FCU operation and adversely affect engine power management. See section IV.A below. Previous studies of material in PRVs for the JFC26 FCU state that contamination that collects in the PRV is a clear indicator that contamination is present elsewhere in the FCU, which would compromise engine performance.

The contamination found in N612AZ's PRVs is similar to that found in at least two other instances of FCU failure in units serviced by Columbia Helicopters. Transport Canada found that contamination similar to that found in N612AZ's FCUs caused the PRV to stick and that contributed to the crash of a Hayes Helicopter Services S-61 in 2002. See section III.C below. Such contaminant in, and physical damage to, the FCU and PRV is the most likely source for the power loss leading to the crash of N612AZ.

C. Similar FCU Contamination Has Been Involved In, Or The Cause Of, Other Instances Of S-61 Power Loss

Carson's independent, post-accident research and inquiries have uncovered numerous other incidents of power loss in S-61 aircraft traceable to FCU contamination besides the contamination-related power problems experienced by N612AZ prior to the crash on August 5, 2008.

Croman Corporation	On July 17, 2009, an SH-3H (the military version of the S-61) being operated by Croman Corporation crashed while battling the Backbone Fire in Northern California. In this incident, the pilots were snorkeling water from a dip tank they had accessed several times previously the same day, and upon liftoff from the tank, the pilots reported a sudden "droop" condition (loss of main rotor RPM) and then collided with the tank. This accident resulted in severe damage to the aircraft and injuries to the crew. The cause of this accident is still under investigation, but at Carson's urging, the NTSB had the FCU's from this aircraft examined at Columbia Helicopters' facility. A significant amount of contaminant was found in the FCUs and at least one type of contaminant found was a fibrous material similar to that found during N612AZ's FCU teardown. On November 20, 2009, Columbia Helicopter's FAA

Part 145 repair facility issued an FAA SDR (Service Difficulty Report) to all operators, indicating, "Initial disassembly of the FCU, SVA, and PRV showed contamination from an unknown external source."

Hayes Helicopter Services

On December 16, 2002, an S-61 operated by Hayes Helicopter Services crashed without loss of life near Lake Errock, British Columbia, Canada. Although the initial problem leading to the incident was a non-FCU-related malfunction to the aircraft's number 1 engine, the number 2 engine did not respond and compensate for the sudden loss of power to the number 1 engine, thereby causing the aircraft to plummet to the ground. A report on the accident by the Transportation Safety Board of Canada [Exhibit 7] found that the failure of the number 2 engine to compensate for the power loss in the number 1 engine was caused by a sticking PRV. According to the Transportation Safety Board of Canada, the sticking PRV was a result of contaminant within the FCU. The Transportation Safety Board of Canada further stated that, "Collective experience from U.S. operators of this FCU show that sticking or jammed PRVs also lead to unpredictable and degraded engine performance." As discussed previously, the FCU from this accident is one of two FCUs that were the subject of a report produced by GE in 2005 which acknowledged the presence of foreign contaminant in the unit's PRV.

Presidential Airways

On August 16, 2009, an S-61 operated in Afghanistan by Presidential Airways experienced sudden, in-flight total torque loss in one engine, with reduced T5 and fluctuating Ng readings. The aircraft involved in this incident had been previously owned by Carson. The FCU installed on the aircraft was replaced and the aircraft experienced no further problems. The removed FCU was then examined at Columbia Helicopters' overhaul facility and found to contain a significant amount of contaminant material; the PRV was completely stuck by long strand material in the valve body. In response to this incident, on October 23, 2009, and then again on November 20, 2009, Columbia Helicopters' FAA Part 145 repair facility issued a Service Difficulty Report through the FAA SDR System to all operators. [Exhibit 8] The November 20 Service Difficulty Report stated that Columbia Helicopters inspection revealed this FCU was contaminated from an external source.

Forest Service

The Forest Service has experienced a number of power loss incidents with helicopters flying with the same FCU as that installed on the S-61. The Forest Service has issued a number of reports concerning those incidents through the interagency Aviation Safety Communique (SAFECOM) database. [Exhibit 9]

D. Similar FCU Contamination Has Been Involved In, Or The Cause Of, Other Incidences Of S-61 Power Loss Experienced By Carson

2004

A Carson S-61 experienced a loss of torque, Ng fluctuations, and a stuck PRV on one of its FCUs. This problem FCU, along with the FCU removed from the Hayes Helicopter Services aircraft, was the subject of the GE Report discussed in section IV.A below. The GE Report shows that this FCU had foreign contaminant material in the PRV. The contaminant material shown in the photographs in the GE Report is nearly identical to the foreign material in the NTSB Materials Lab Report in this accident investigation.

2007

Carson S-61 N103WF experienced torque fluctuations. The FCU was swapped out and the torque fluctuation issue was resolved. The problem FCU removed from this aircraft was not sent in for overhaul and in July 2009 Carson sent this FCU to an independent testing lab which found that this FCU had contaminant material in the PRV and the filter screens ranging in size from 2 to 30 microns. The contaminant found was similar in size, physical characteristics, and chemical composition to the material displayed in photographs of the contamination in the FCU removed from the accident aircraft. This contaminant also appeared to be similar to the contamination shown in the GE Report on the foreign containment material in the FCUs that are the subject of the GE Report discussed at section IV.A. All four of these FCUs (the N103WF, the FCU removed from N612AZ after the accident, and the two FCUs discussed in the GE Report) show material that is very similar, and all four came from aircraft that exhibited power fluctuations and/or torque loss due to the FCU.

September 2, 2008

Carson S-61 N905AL was in straight and level flight at 100 knots and experienced a sudden and severe torque split with the number 2 engine dropping from 95% to 8% torque. Indicators were normal for T5 and Ng was steady at 103%. The aircraft was able to do a run-on landing and no one was injured. The FCU was changed and the problem did not recur. This problem FCU was sent to Columbia Helicopters for overhaul and the subsequent report from Columbia Helicopters indicated that severe foreign contaminant material was found inside the FCU and the PRV had enlarged clearances. The PRV was replaced. This unit was overhauled and cleaned before it could be examined by the NTSB.

E. Conclusion

Contamination in the aircraft's FCUs caused the power loss that led to the crash of N612AZ. The FCUs recovered from the accident wreckage contain a significant amount of contamination. Such contamination is known to cause engine power loss and has been found to have done so in numerous S-61 mishaps.

IV. <u>FACTUAL FINDING</u>: GE, COLUMBIA HELICOPTERS, AND SIKORSKY ALL KNEW OF THE DANGER OF CONTAMINATED FCUS FOR YEARS, YET TOOK NO ACTION

For more than five years prior to the accident, GE, a party to this investigation and the manufacturer of the engine used in the S-61 aircraft; Columbia Helicopters, the company that overhauled and repaired N612AZ's engines and FCUs,[26] and Sikorsky, the manufacturer of the S-61, knew of the hazard presented by contamination in FCUs, discussed it privately among themselves, and did nothing about it.

Carson became aware that it was beginning to have increased instances of power fluctuations with the FCUs during this time period, and preliminary work order reports that came back to Carson from Columbia Helicopters indicated contaminant material in the FCUs. On at least two occasions during this time period, Columbia Helicopters notified GE that Carson was having more problems of this type and asked GE to work with Sikorsky to investigate and/or resolve the issue.

Carson, however, was only aware of its own occasional issues with this power loss, and had a smaller fleet of S-61 aircraft flying primarily external loads until 2007-2008. Other than sharing the GE Report of 2005, Carson was unaware that other S-61 operators were having issues with contaminated FCUs and was unaware that Sikorsky and GE had long-standing awareness of this issue. In any event, it is the duty of the manufacturers to authorize a repair or change to the aircraft system in the face of a recognized problem and then obtain FAA approval for the repair or change. Only then can an operator, such as Carson, implement the repair.

A. GE And Columbia Helicopters Note In Their Maintenance Manuals The Threat Of Power Loss

In 2005, GE analyzed two FCUs Columbia Helicopters had sent to GE for further analysis. [Exhibit 10] One was a Carson unit that had engine Ng fluctuations which exhibited a stuck PRV. The other FCU came from the engine of the Hayes Helicopter Services S-61 that crashed in Canada in 2002. The post-analysis report GE sent to Carson shows that both units had foreign contaminant material in the PRV. The material shown in the micron photographs in the

[26] Until Carson worked with Erickson Aircrane's overhaul facility so that it could overhaul the engines and FCUs used in the S-61 model helicopter, Columbia Helicopters was the only provider of such services in the western hemisphere. Prior to Erickson Aircrane's entry into this market, the only other provider of such services in the world was Hamilton Sundstrand (the manufacturer of the FCU) in the Netherlands.

GE Report is nearly identical to the foreign material in the NTSB Materials Lab Report on the contaminant found in the FCUs recovered from N612AZ.

Both the GE Maintenance Manual for the CT58 engine and Columbia Helicopters' manual for the JFC26 FCU mention the potential problems caused by large micron contaminant material in the JFC26 FCU analyzed in the GE Report. According to the GE CT58 Engine Maintenance Manual [excerpts attached as Exhibit 11], contamination in the fuel within the PRV and FCU system can harm all FCU components. The GE Manual states that high gas generator speed at topping with low power output (i.e., low main rotor RPM) is a known condition and can be caused by contamination in the fuel system:

> 1. Troubleshooting gas generator speeds – C.
>
> Trouble: Ng stays at maximum with Nf torque abnormally low when under load (indicates low power output).
>
> Probable cause: Stator Vanes remain closed. Troubleshooting: # (4) - Check fuel filter systems for contamination. Corrective action: Replace fuel control and pilot valve. Correct source and clean fuel system as necessary.

GE CT58 Engine Maintenance Manual, at 175.

Similarly, Columbia Helicopters' engine training maintenance manual says that contaminant in the PRV is a problem:

> If the filter goes into bypass, all of the dirt, metal shavings, etc. get flushed directly through the fuel control. Often it ends up in the PRV valve: At this point, the fuel control will no longer respond to droop . . . contaminants like this may pass through the PRV many times, resulting in intermittent failures to respond.

B. In January 2010, Sikorsky Finally Took Emergency Action To Have The S-61's 40 Micron Fuel Filters Replaced With 10 Micron Fuel Filters

The S-61 model helicopter was designed and manufactured by Sikorsky and was an adaptation of the military H-3 model helicopter for civil use. The S-61 has two main fuel tanks – one in the front of the aircraft and the other in the rear. Each fuel tank is equipped with a metal mesh screen fuel filter on the fuel lines feeding the engines. What Sikorsky chose not to adapt, however was the H-3's 10 micron fuel filter element. For decades, the military H-3 helicopter has been equipped with a 10 micron fuel filter element, while Sikorsky specified a much coarser 40 micron filter for the civilian, S-61 version. Since at least 2002, Sikorsky, along with GE and Columbia Helicopters, has been aware of numerous documented instances where fuel system contaminants pass through the airframe main fuel filters and the FCU filter of the S-61 and cause malfunctions of the FCUs, resulting in engine power failures. None of these companies told Carson about this safety hazard. During this same period, the military H-3 helicopters, which have the same fuel system and engines, have not experienced similar fuel contamination-caused engine problems. Despite its superior knowledge, Sikorsky did not adopt the 10 micron fuel filter standard for the S-61 until January 2010.

On January 15, 2010, Sikorsky issued an Alert Service Bulletin [Exhibit 12]. The Sikorsky Alert instructs helicopter operators to replace the preexisting 40 micron fuel filters in S-61s with 10 micron fuel filters. The Sikorsky Alert provides independent, third party confirmation that defects in the FCUs played a critical role in the crash of N612AZ.

The Sikorsky Alert specifically refers to the hazards that outside contaminants have posed when they end up in the FCUs of S-61s. Given the number of instances of contaminants being found in the fuel control pressure regulating valves, the potential exists for possible seizures of the fuel control pressure regulating valves. As discussed in section III.B, the Materials Lab Report, the NTSB's own lab analysis of the FCUs recovered from the wreckage of N612AZ, describes significant contamination in the PRV in the FCUs from the aircraft's number 2 engine. This contamination may have caused the aircraft to experience PRV seizure such as that described in the Sikorsky Alert Service Bulletin. This seizure may have directly led to sudden power loss, which may have ultimately resulted in the crash of the aircraft.

Sikorsky's Alert is highly significant for at least four reasons. First, the 40 micron fuel filter, which Sikorsky required on the S-61 for years, allowed significantly more particulate matter into the FCUs than would be allowed by the fuel filters installed on virtually any diesel engine currently on the commercial market. Commercial earth moving equipment, trucks, and boats all operate with 10 micron fuel filters because 40 micron filters are deemed too large to properly filter engine-damaging contaminants out of the fuel system.[27] And, of course, the 40 micron fuel filter allowed much more particulate matter to get in the FCU of the S-61 than the 10 micron fuel filter that Sikorsky recently directed to be installed in the aircraft.

Second, in its Alert, Sikorsky minces no words about how central the fuel filter issue is. The language of the Sikorsky Alert makes it clear that the installation of the 10 micron filter is not a normal product recall or parts replacement notice. The Sikorsky Alert warns operators that "[c]ompliance is essential," and instructs them to replace the filters within 150 flight hours of the release of the Alert.

Third, the Sikorsky Alert requires operators to affirmatively state in writing that they are in compliance, or state that the Alert does not apply to their aircraft.

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[27] The Carson fuel trucks supplied under this contract are equipped with 0.5 micron filters, which ensure a clean external fuel supply. However, this does not prevent particles or contaminates which are already inside the closed fuel system from being introduced into the FCUs, as seen from the micron photographs. For example, Carson recommended that the operations group examine the fiberglass collector unit contained in the center fuel cell of the aircraft, and supplied a sample of the collector material to the NTSB for testing. The fiberglass material in the wall of the collector has a high degree of similarity to the fibrous materials contained in the FCUs, and Carson has recommended further examination of this and other system components by the operations group.

Fourth, the Sikorsky Alert underscores the importance of the independently conducted and witnessed flight performance evaluation test to an understanding of the probable cause of the crash of N612AZ. Through this test, Carson was able to assess the flight and engine performance of an S-61 model helicopter similarly equipped to N612AZ under environmental conditions similar to those present at the time of the accident. The results of the test demonstrate that, at the time of the accident, N612AZ should have been able to successfully take off and complete its mission – even at the excessive weight that has been ascribed to the aircraft in the NTSB's draft operations report, and even under the disputed meteorological conditions contained in that draft report. The flight performance evaluation test clearly demonstrates that N612AZ would not have crashed but for engine power loss, which is known to be caused by FCU contamination. But for the very contamination which the NTSB's own report shows, and which the Sikorsky Alert Service Bulletin ties to fuel control unit problems, N612AZ may not have suffered any power loss and may not have crashed.

C. Sikorsky, GE, And Columbia Helicopters Have Failed To Respond To A Clear Threat To Aviation Safety

Carson has discovered documents that show that both GE and Columbia Helicopters knew of the dangers of contamination in the FCUs installed in the S-61 model helicopter as early as 2002.[28] These documents discuss the potential for engine power loss resulting from contamination in FCUs and the need to replace the 40 micron filter with a 10 micron filter.[29]

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[28] Carson obtained these documents through discovery in the wrongful death litigation relating to the accident in In re Helicopter Crash Near Weaverville, California, 8/5/08, Case No. 3:09-md-2053, in the United States District Court for the District of Oregon. Because it does not have any formal investigative authority, Carson had to seek these documents in litigation. Carson long believed that such documents existed. Carson expressed this belief to the operations group and urged it to obtain documents relating to FCUs obtained from parties to the investigation other than Carson.

[29] These documents include (1) an email exchange dated February 26, 2003 between Bob Neihart, Engine Shop Supervisor at Columbia Helicopters, and GE [Exhibit 13]; (2) an email from GE safety inspector David Gridley (Mr. Gridley has personally participated in this investigation on behalf of GE) to a GE project engineer dated September 11, 2003 [Exhibit 14]; (3) an email dated November 25, 2003 from Dave Wolf, Carson's Chief Inspector, to Don Berg, Q.A. Auditor at Columbia Helicopters, forwarding an earlier email from Mr. Wolf to Ron Garman and Robert Clendening of GE [Exhibit 15]; (4) GE internal email dated October 6 and 8, 2004 [Exhibit 16]; (5) a GE internal Service Revealed Difficulty Report dated October 13, 2004 [Exhibit 17]; (6) the Columbia Helicopters' overhaul manager's notes from a 2005 visit by GE employees to Columbia's facility [Exhibit 18]; (7) an email dated February 17, 2006 from Mr. Wolf to GE's customer support center [Exhibit 19]; (8) a GE internal Service Revealed Difficulty Report with a requested closeout date of February 28, 2006 [Exhibit 20]; (9) a GE internal Service Revealed Difficulty Report dated June 20, 2007 [Exhibit 21]; (10) an email exchange between GE safety inspector and Sikorsky dated January 9, 2008 [Exhibit 22]; and (11) an email from GE to Sikorsky dated August 6, 2008 [Exhibit 23]. Each of these documents is discussed in this Submission.

1. **An email dated February 26, 2003, from Columbia Helicopters to GE**

After acknowledging that GE has failed to respond to prior inquiries, Columbia Helicopters highlights the issue of contaminant in the FCU and the grave danger it presents in language that describes precisely what happened on the last flight of N612AZ:

> This may be a very big problem. We have had several engines fail to accelerate when collective is applied. The problem is traced to contamination that sticks the PRV valve in the fuel control. I consider this a flight critical problem. This problem normally occurs at the worst possible time.

2. **An internal GE email dated September 11, 2003**

This email leaves no doubt that Mr. Gridley, GE safety inspector and a participant in the investigation of the crash of N612AZ, is clearly aware of the danger of contaminant in an S-61 FCU. The following is a description of the 2002 Hayes Helicopter Services accident:

> The helicopter experienced a loss of power to the main rotor (Hayes 2002 incident) . . . . The TSB of Canada suspects that, when a higher single engine power was demanded of it, the #2 engine may have experienced power fluctuation problems due to a "sticking" PRV in its FCU . . . . It was reported by TSBC that the PRV was found to be contaminated by debris found in the airframe and FCU filters.

3. **An email dated November 25, 2003 from Carson's Chief Inspector Wolf to Columbia Helicopters**

Mr. Wolf's email shows that Carson was trying to get GE and Columbia Helicopters to pay attention to the issue of contamination in the FCUs as early as November 2003:

> Other than the loss of income to our company when we lose the helicopter services for a day or so there is the possibility of an in-flight problem which could have an adverse effect. We understand that the Hayes incident has been attributed to the inability of an engine to perform properly when the other engine experienced a mechanical problem. We strongly suggest that GE investigate[] these FCU/PRV contamination issues.

4. **Internal GE emails dated October 6 and 8, 2004**

These emails discussed recent FCU contamination issues experienced by another S-61 helicopter operator (ERA Aviation) and the need to discuss the contamination issue with Columbia Helicopters:

> CT58 main Fuel Control removals have been excessive in the last few months. Various contamination issues have been discussed to resolve

removal rate. Will be visiting vendor (Columbia) to discuss probable cause.

5. **An internal GE email dated October 13, 2004**

This email discussed the presence of contaminant in two different FCUs and the malfunctions caused by that contamination:

> The Carson valve sent to GE was received in the stuck condition. . . . The silica fibers were the dominant contaminates found in the valve assembly during inspection and is determined to be the root cause of the valve seizure. . . . The findings of the silica fibers in both valve components from two different operating regions remains a concern until its source can be located.

6. **Columbia Helicopters overhaul manager's 2005 notes**

The Columbia Helicopters overhaul manager's notes from a meeting with GE reveal GE's nonchalant attitude toward the FCU contamination issue in 2005:

> Inadequate fuel control filter and bypass valve. General Electric has not done any work on this. It appears they are not very interested even though we feel that this has caused several fuel control contaminations causing engines not to accelerate.

7. **An email dated February 17, 2006 from Carson to GE**

In two emails, Carson again tried to get GE to pay attention to the FCU contamination issue:

> This is the fourth instance of FCU fluctuations and of finding the PRV contaminated, even though we remove the FCU filter every 30 hrs of operation. We have operated the S-61 for over 30 years and up to about 5 years ago we never experienced any type of FCU contamination. Even though GEAE looked at this problem previously with a PRV from one of our FCU's we wish to strongly stress that we believe there is a problem with the fuel filtering regarding this system.

GE never responded to Carson's urgent message. But GE admitted privately that FCU contamination was a problem. For example,

8. GE internal Service Revealed Difficulty Report dated February 28, 2006

GE's internal Service Revealed Difficulty report states that contamination in the FCU can cause a PRV to stick:

> Engine operated by Carson Helicopters was removed for fluctuations of Ng, T5 and torque on April 11, 2005. Subsequent fuel control overhaul by Columbia Helicopters found the PRV stuck. . . . PRV sticking has been seen before, most recently due to glass fibers between sleeve and piston of undetermined origin.

Yet another acknowledgement by GE of the threat of FCU contamination.

9. GE internal Service Revealed Difficulty Report dated June 20, 2007

In this internal Service Revealed Difficulty Report, GE continued to acknowledge the threat that FCU contamination represents:

> The engine filtering system is rated to 40 micron. Additionally, the Silica fibers found down to 2.5 micron are measured in the diameter of the fiber. The fiber lengths are significantly higher than 40 micron and it ability to pass through the aircraft filter or engine fuel filter are greatly dependent on how it enters the filters (axially or sideways). These findings are identical to past SRD findings for the same operator as documented in SRD closeout A-PROJ-04-002 dated 10/13/2004. . . . The source of the silica (glass) fibers that were found should be closely investigated . . . . It is also suggested that the aircraft fuel system be reviewed to ensure that adequate measures are in place to minimize risk of bypassing the aircraft barrier filters . . . and incorporate a finer filtration system to bring it up to similar standards with related fuel systems for the T58 applications . . . . Until the source of the Silicon Fibers has been identified and addressed this failure mode of the PRV remains a High Risk for continued service, particularly for this operator."

Although Carson had repeatedly inquired about a fix for this situation, GE never informed Carson of these SRD findings. Carson was not aware of these SRD findings until it obtained these documents in discovery in the wrongful death action.

10. Email exchange dated January 9, 2008 between Sikorsky and GE

Although GE never told Carson the risk that the contamination issue could pose to a helicopter operator, GE secretly discussed it with Sikorsky, as illustrated in the following January 9, 2008 email exchange:

> From Sikorsky:
>
> I have received your request for status of the proposed S-61 fuel filter size change from 40 microns to 10 microns. We have reviewed this issue and are curious when GE's position moved from a "recommendation" (GE letter dated 2/9/07, attached) to a "potential safety issue" (e-mail below),and what drove that change in classification.
>
> GE's response:
>
> As described in the referenced GE letter of Nov 28, 2005, GE has become aware of a condition that can cause power fluctuations, erratic operation or slow acceleration of CT58 engines. The conditions has been linked to solid foreign contaminants entering and lodging in the fuel control pressure regulating valve (PRV), in turn causing the PRV to bind or seize.

11. An email from GE to Sikorsky dated August 6, 2008

The final GE communication with Sikorsky on this issue (of which Carson is aware) was sent on August 6, 2008, the day after N612AZ crashed:

> One item we are still tracking on our safety PMT is incorporation of 10 mic mesh fuel filters. <u>This has been around for a couple of years now,</u> with the last communication from SAC that they were working with new supplier, Honeywell, on this. . . . Are you aware of the status of this filter?

D. Carson Repeatedly Urged The That This Issue Be Investigated

Throughout this investigation, Carson has repeatedly stressed the importance of looking into GE's, Columbia Helicopters', and Sikorsky's knowledge of the FCU contamination issue. Carson requested that the operations group obtain and review these entities' documents relating to FCU contamination at almost every physical meeting it has had with the operations group. Carson's pleas fell on deaf ears every single time. The operations group's refusal continued even after Carson pointed it to the discussion in the GE and Columbia Helicopters manuals concerning FCU contamination and the GE report on the Carson and Hayes Helicopter Services FCUs, and after Carson highlighted the importance of Sikorsky's emergency action earlier this year to improve fuel filtration in the S-61.

E. **Recommendation:** The NTSB Should Fully Investigate The Safety-Of-Flight Issue Posed By FCU Contamination

The internal documents and correspondence uncovered by Carson leave no doubt that GE, Columbia Helicopters, and Sikorsky all knew of the hazard presented by contamination in FCUs for years prior to the accident, and kept it a secret. The Board Members should order the operations group to do what it takes to warn the public of this hazard and have GE, Sikorsky, and Columbia Helicopters eliminate it now.

V. THE INVESTIGATION DID NOT FOCUS ON THE CAUSE OF THE CRASH

The operations group has focused almost exclusively on the irregularities and anomalies in the weight documents for N612AZ and the performance charts in the aircraft's flight manuals as the potential cause of the crash. This single-minded focus has led to a shaping of the investigation and findings to support a conclusion that the crash is a result of these weight and performance chart issues. This single-minded focus also resulted in the operations group minimizing compelling evidence that power loss due to contaminated FCUs was the root cause of the crash.

Carson is deeply disturbed by what appears to have been a choice by the operations group to embark on this predetermined course in an effort to minimize the importance of serious errors which the operations group made very early in this case. As discussed in greater detail below, following the engine teardown inspection, the engine and FCU parts recovered from the wreckage were left unattended and unsecured at Columbia Helicopters' facility, a company with a clear interest in the outcome of this investigation. Only after Carson insisted were steps taken to recover those critical engine and FCU parts. Unfortunately, once those critical engine and FCU parts had been recovered, it became clear that this evidence had been tampered with – parts were missing, parts had been swapped between FCUs, and new parts had been mixed in with the accident aircraft's parts. After Carson expressed its concern about these matters, the investigative focus appeared to shift to the weight and performance chart issues.

A. The Errors In The Investigation

1. Failure to properly maintain chain of custody and secure the FCU parts led to crucial evidence being lost or destroyed

The two engines from the wreckage of N612AZ, with FCUs, were recovered and sent for disassembly and examination to Columbia Helicopters' overhaul facility in Aurora, Oregon on August 13 to 14, 2008, at the direction of the NTSB. Representatives of the NTSB, the Forest Service, Carson, GE, the FAA, Sikorsky, and Columbia Helicopters attended the inspection and teardown.[30]

[30] Columbia Helicopters was not then, and is not now, a party to this investigation. Carson's understanding is that the engine teardown occurred at Columbia Helicopters' facility because that company, as the sole provider of FCU and engine overhaul services for the S-61, would have all of the necessary tools and equipment to perform the teardown. Columbia Helicopters employees participated in, and were present for the entire duration of, the teardown.

Before the teardown began, the inspection attendees met in a conference room that had been set aside for their use in a Columbia Helicopters training trailer. The teardown took place in an area within Columbia Helicopters' large maintenance shop, not in a separate room with a door that could be closed or locked to control access to the engine or FCU parts. The area was nothing more than a part of the larger maintenance shop floor set off by shelves and other furniture arranged to create a workspace. Columbia Helicopters employees were doing their regular work on the other side of the non-wall partitions in plain view of the teardown.

Each engine was broken down piece-by-piece and notes and photographs were taken as parts were removed. Once parts were removed they were generally put in a labeled bag and placed on a storage rack. The teardown revealed significant differences in the condition of the two engines. The NTSB Group Chairman's field notes from the teardown and the Airworthiness Group Report [Docket No. 426650] show that the operations group knew on August 14, 2008 that there was a significant difference in the condition and position of the bellows parts, as well as the position of the 3D cams that are affected by the bellows assembly on the FCUs. These differences could have a serious effect on the available power between the two engines. At the time of the teardown, there was general group consensus that a power loss in one engine appeared to have been the source of the differing conditions of the two engines.

Upon completion of the teardown, the component parts of the FCUs were placed in specific bags and stored on shelves located in the main area of Columbia Helicopters' large maintenance shop, unsecured and without any monitoring of persons who might access the parts. Columbia Helicopters retained sole custody of the FCUs until August 18, 2008, when, at Carson's insistence, the NTSB directed Columbia Helicopters to send the units to NTSB Headquarters.

When these units were inspected 10 days later at NTSB Headquarters, the inspection revealed that the units had been packed in two separate boxes, not in the bags they were put in during the teardown. In addition, numerous component parts from the initial teardown were missing. These missing parts have not been found. Equally important, some parts were swapped between the two units. Finally, the boxes shipped to NTSB Headquarters also contained additional component parts that were not present at the teardown and other parts had been switched between the two FCUs.

Immediately after Carson raised concerns about this, the operations group shifted focus to the Forest Service's determination that certain of Carson's aircraft were overweight and that an altered performance chart may have been used. From then on, the role that the weight of the aircraft and the performance charts may have played in causing the accident were overemphasized, and FCU contamination was underemphasized, if not completely ignored.

2. The internal inquiry into the operations group's handing of the parts had significant flaws

After Carson twice requested that the NTSB conduct a full investigation into the handling of the FCUs or refer the matter to the appropriate authorities to determine whether evidence has been tampered with or destroyed, the NTSB determined to treat this issue as an "internal" matter and conducted its own investigation. The report from this internal investigation

[Exhibit 24] was initially placed on the public docket and subsequently removed without explanation. The investigative report makes it clear that this investigation did not meet the NTSB's normally high standards.

a. The report has a factually incorrect timeline

The timeline presented in the NTSB's investigative report and in the appended witness declaration of Investigator-In-Charge Jim Struhsaker contains many factual errors. The report states that Carson party representatives were present on August 13 and 14 and then left to prepare on Friday, August 15, for a memorial service on August 16. The suggestion is that Carson arbitrarily left a day early and that Mr. Struhsaker made repeated attempts to talk to Carson on August 15 about a party member returning to Columbia Helicopters. That is not what happened.

The actual sequence of events was that the Carson party members left the evening of August 14 in order to attend the memorial service for the Grayback firefighters on August 15. In his witness statement, Mr. Struhsaker states that the Carson party members "announced" they were leaving for the memorial service the day before, implying that this was a surprise. In point of fact, the memorial service had been planned by the Forest Service six days earlier. All the members of the operations group were aware that Carson's attendance was necessary. This is confirmed by the witness statement of Michael Hauf appended to the report: "Prior to the engine examinations, it was known that Carson was going to return to Grants Pass to attend the memorial service for the fallen Carson crew and therefore would not be present on Friday, August 15^{th}."

Carson made every effort to return the crew chief from the accident aircraft back to Columbia Helicopters as quickly as possible after the service, flying him on a private aircraft directly into the Aurora airport and arriving at 3 pm. The operations group, however, had already left.

b. The report improperly minimizes the importance of the missing parts

According to the report, page 11, "there was not a specific discussion on 15 August regarding the parts that are now missing as they were not thought to be central to the accident because their effect on the fuel control unit's normal operation had been discounted by the end of the day on August 14^{th}." The report also states, on page 4, that "No discrepancies were noted at the end of the two day examination or during the last day during the debriefing."

What in fact happened was that the entire team noted that there was a major difference between the internal condition of the number 2 engine and that of the number 1 engine. The number 2 engine had virtually no damage, or wear or internal damage marks or foreign object damage, in marked contrast to the number 1 engine, which exhibited all of these characteristics. In addition to the engines, the 3D cams of the FCUs were in completely different positions. The 3D cam position can be changed by the T2 bellows assembly, which in turn affects metering of the fuel to the engine. There was much discussion about what could have caused this, along with discussions about possible FCU component failure.

The possible issues with the T2 bellows assembly as well as the cam and other parts remained an active topic throughout the following months and were discussed again at the December 2008 team meeting. In other words, the importance of the FCUs was not discounted by the end of the day on August 14, and there were several discrepancies with the components and engines that are clearly described in the Airworthiness report.[31]

The NTSB's investigative report also omits the fact that parts were swapped and changed between units. The report states, on page 9, "no physical irregularities were noted with the received FCU's or accompanying component parts when the boxes were opened." It also states, on page 11, "The NTSB has determined that the condition upon receipt of the main fuel control units and the condition of the received parts were not in a significant different condition from that which existed at the conclusion of the teardown on August 15th, 2008." And on page 10, the report states "We have no evidence that the units were altered from the condition they were in on August 15th, 2008."

The facts are just the opposite. All party members present when the FCUs arrived in Washington, DC noted that the packages Columbia Helicopters sent, in addition to not containing the missing parts, had the T2 bellows housing assemblies switched between the number 1 and number 2 FCU packages. These parts were originally separate and, in addition, packaged in plastic bags with the respective units on August 14 and 15. When these parts reached Washington, DC, they were not in the plastic bags they had been placed in during the teardown and had been swapped between units. To quote operations group member Mr. Hauf, who was present at the time, "the housing assemblies from FCU# 1 and FCU #2 were mismatched."

c. The investigative report mistakenly concludes that the NTSB maintained proper custody of the evidence

The text of the investigative report says that current NTSB protocols were followed and controls monitored over the workshop area, evidence, and parties participating in the teardown. As noted by Mr. Struhsaker, that was not in fact the case: "I do recall that there were several clear plastic bags with parts on the table next to the wall in the training room. . . . . When the team left the training room that day, I recall that the fuel control units were on the table in the training trailer." In other words, when the operations group left Columbia Helicopters that evening, the FCUs and parts were left strewn out over a table in a trailer. Leaving parts in this condition does not constitute the securing of evidence or proper care for chain of custody of evidence.

d. The investigative report did not resolve the issue

The investigative report contains at least one more internal contradiction. Thus, the report claims, "the loss of the subject parts in all probability occurred during the investigative activities and in the presence of all parties to the NTSB investigation on August 14th, 2008."

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[31] If there were a decision to discount the role of the missing parts, that decision was made after Carson's employees had left the teardown for the pre-arranged memorial service and that decision was never communicated to Carson.

There is not only no evidence to substantiate this claim, but the report itself says that "[i]t is not possible to determine with certainty how the parts were either removed from or were lost during the engine and fuel control unit examinations." The unfortunate truth is that, as of the date of this submission, nobody has found or been able to account for the missing parts.

3. The NTSB drafted and released a misleading Materials Lab Report on the FCU contamination

The operations group wrote the initial Materials Lab Report in April 2009 [Exhibit 25] and promised to release that report to the public docket by October 20, 2009. Despite this promise, the operations group waited until November 17, 2009 to release a revised Materials Lab Report [Docket No. 430172]. Although materially different from the initial report, the revised report was labeled identically and contained nothing that would let a reader know that it was a revision of an earlier-produced report. The revisions to the initial report were done such that the report states that the operations group conducted a blockage test[32] on the FCU filters from the accident aircraft before an unknown amount of contaminant material from those filters was removed when, in actuality, the blockage test was done after the contaminant material was removed, which materially affects the results of the blockage inspection and is the reverse of the normal procedure for such analysis.

Carson brought the misleading way the report was drafted to the attention of Investigator-in-Charge Struhsaker but he refused to modify the report in any way. Mr. Struhsaker took the position that this was an issue to be discussed at the technical review meeting in this investigation. Only after Carson elevated its concerns about the misleading report to the Director of the NTSB's Office of Aviation Safety did the NTSB issue an "Errata Sheet" [Docket No. 441070] which purported to address Carson's concerns. However, the Errata Sheet still failed to make clear the dates of the blockage test and the removal of materials for analysis. The material was removed from the filters in the first week of February 2009, and the blockage test was conducted in the third week of October 2009, more than seven months later and after an unknown additional handling of the filters. After continued requests by Carson, the operations group finally agreed following the technical review meeting to revise the report to include this important information. Notwithstanding its agreement, as of the date of this Submission, the operations group has yet to issue another errata sheet or otherwise correct the misleading report.

4. The NTSB's initial light blockage test was not done according to manufacturer specifications and is itself misleading

Carson requested that a blockage test be conducted on the filters. Before that test was conducted, however, an unknown amount of contaminant material was removed from the filters. For that reason, the results are of limited use.

Moreover, the light blockage test was not conducted in accordance with GE's procedures. The operations group conducted the test as follows:

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[32] A light blockage test consists of shining a light through the filters and counting the number of filter interstices that are blocked by contaminant material to arrive at a percentage of blockage.

> Fiber optic light was inserted inside a screen filter. When viewed from outside the screen with a 12.5x glass, the available open areas were estimated by the amount of light that passed the inner 40 micrometer screen. The estimate takes into account the available open areas around the circumference of the filter.

Revised Materials Lab Report at 3.

A footnote in this section states, "Plugging in this report is defined as interstices in the filter occluded by . . . particles such that light transmitted from a high-intensity light guide will not pass through." Using these test methods, the revised Materials Lab Report estimates the blockage of the number 1 FCU filter as 10% for the permanent screen and 25% for the removable screen, and the blockage of the number 2 FCU filter as 20% blockage for the permanent screen and 50% for the removable screen.

The GE Maintenance Manual SEI-182 [excerpted at Exhibit 11], however, details a materially different procedure than just estimating light transmission through the filter:

> Position a small light within the filter element and then visually inspect the filter element with a 10 power glass. It is necessary that an estimate of the degree of cleanliness be established. Count a representative sample of openings for a given area in the filter screen. Any element which has 70% or more of available open area plugged is operating in partial or full by-pass and therefore indicates the need to reduce the filter inspection/cleaning time interval.

GE Maintenance Manual SEI-182 at 216.

Thus, using the correct procedure, after actually counting filter interstices with visible blockage, if 70% of the area is occluded, then the filter is in by-pass mode. Because this procedure was not followed and a mistake was made in determining the blockage of the number 1 FCU filter, and an unknown amount of contamination was removed prior to the blockage test, it is very likely that the actual percentage of blockage in the number 2 FCU filter was higher than estimated by the operations group.

There were many more problems with the test that also undermined its usefulness. Material was removed for analysis from the filter from one side of the seam in the filter, and the blockage inspection was done elsewhere on the filter. But, the materials lab scientist could not state which side of the seam he removed material from. Any inspection after 20 months of repeated handling/dumping, drying of contents, and uncertainty as to exactly where material was actually removed from the filter cannot possibly be accurate or in compliance with good scientific protocol. No reliable conclusions regarding the amount of blockage or the inspection/maintenance intervals for the filters can be drawn by the operations group based on this flawed inspection. Whether the filter was at one point clogged beyond normal is impossible to ascertain at this point, although the filter is still 50% clogged, even at this late date.

Finally, even if the filters were allowing proper flow of fuel to the FCU, this simply means that the filters were not in bypass mode. Adequate flow of fuel to the FCU does not resolve the issue of the contaminants that are small enough to flow through the coarse filter but large enough to cause malfunction inside the FCU. The particles found in all of these FCUs and PRVs are already small enough in at least one dimension to pass through the filters, but more than large enough to cause FCU metering issues, or PRV seizure, once these contaminant materials are in the FCU. Thus, the possibility that the FCUs allowed fuel flow does not make it any less likely that contamination in the FCUs led to the power loss that caused N612AZ to crash.

5. The operations group refused to take part in or acknowledge the results of the flight test commissioned by Carson

To better understand the response of a model S-61 aircraft to the accident conditions, Carson conducted an unofficial, preliminary flight test in mid-October 2008 using an aircraft similarly equipped to N612AZ and under similar load and flight conditions to the accident aircraft. Carson's preliminary testing showed that the aircraft would fly with positive rates of climb, even at weights exceeding the accident aircraft's and with the collective pulled to maximum position. The only condition under which the aircraft would exhibit the droop below 94% main rotor RPM exhibited by N612AZ immediately prior to the crash was when power to one engine was reduced.

This discovery prompted Carson to ask the operations group to conduct a formal flight testing in conjunction with Carson. At the request of the operations group, Carson submitted a preliminary flight test plan on October 30, 2008. [Exhibit 26] In response, the operations group said and did nothing.

Carson subsequently asked the operations group on multiple occasions to participate in flight testing with an exemplar helicopter, both in written emails and verbally. This time the operations group did not simply remain silent, but rejected the requests without explanation. Carson still kept trying. At the technical meeting on July 30, 2009, Carson reiterated its request and offer to conduct flight testing. Carson offered to:

- Provide an exemplar longbody S-61 helicopter similarly equipped to N612AZ at the time of the accident.
- Provide a flight crew.
- Make the aircraft and flight crew available for testing at any location of the NTSB's choice within the United States.
- Provide or procure from a third party the recording equipment, aircraft weighing scales, and any other required test equipment that the NTSB desired.
- Arrange for an independent FAA approved Designated Engineering Representative to place the aircraft in Experimental category for the testing.

- Accept any reasonable flight regimen or testing sequence required by the NTSB.
- Accept the NTSB as the test leader.
- Allow any personnel required by the NTSB on board the aircraft as observation witnesses.
- Fly the aircraft with weights exceeding the accident aircraft under maximum flight conditions as prescribed by the NTSB to record the aircraft response characteristics.

All of this would be done at no cost to the NTSB.

The operations group told Carson that the NTSB does not conduct flight testing, and would not do any for this investigation under any circumstances. Carson was left with no choice but to conduct the test on its own.

Carson contracted with a third party, independent safety audit service to conduct flight testing at Carson's considerable expense. See section II.F. The eight separate test flights conducted confirmed that, with normally operating engines, N612AZ should have been able to fly and hover out of ground effect with loads exceeding the operations group's estimate of the accident aircraft in similar density conditions. The only condition that could induce the rapid and unrecoverable rotor droop experienced by N612AZ immediately prior to the crash was reducing power to one engine. These test results were shared with the operations group immediately.

B. After The FCU Evidence Issue Arose, The Focus Shifted To Aircraft Weight And Performance Charts As Being The Cause Of The Crash

1. The operations group has overstated the weight of N612AZ

Almost immediately after Carson began to raise its own concerns regarding the handling of crucial FCU evidence in this case, the operations group began to focus on the issues surrounding the weight of N612AZ as a potential cause of the crash of the aircraft. Although there are no documents that can be used to determine the weight of N612AZ at the time of the accident with 100% accuracy, there are documents that can be used to reconstruct the highest probable weight of the aircraft with a high degree of certainty. That weight is no more than 13,537 lbs. Despite this, the operations group have alleged in the Operations Report [Docket No. 426753] that the empty aircraft weight of N612AZ was 13,845 lbs. at the time of the accident. Although this alleged weight is several hundred pounds in excess of what the aircraft could have weighed, it is clear from the independently conducted and witnessed flight performance evaluation test that, barring some problem leading to a loss of power, N612AZ should have had adequate power to lift even the exaggerated weight the operations group ascribes to the aircraft.

The Operations Report bases its weight for N612AZ on an unsigned Chart C weight document for the aircraft that reflects the installation of the Fireking tank and aerial hoist on March 25, 2008. The weight of the March 25 equipment additions is then added to the empty weight of N612AZ as set forth in a January 4, 2008 Chart B weight document which was "prepared by" Dave Wolf, the Chief Inspector in Carson's Perkasie, Pennsylvania facility, but "witnessed" by Rod Manogue, the Chief Mechanic in Carson's Perkasie facility. Carson employees who observed this weighing have stated that the Chart A equipment list associated with this January 4, 2008 weighing mistakenly omitted several items of equipment that were installed on the aircraft at that time, including seats and a rescue hoist. These Carson employees based their statements on their recollection that N612AZ had been used for hoist testing on December 27, 2007 and that the seats and hoist had been installed (and were necessary) for the hoist testings but had not been removed prior to the reweighing of the aircraft on January 4. The December 20, 2007 installation of the hoist, certain other equipment, and three or four seats is acknowledged on pages 30 to 31 of the Operations Report.

The maintenance documents for N612AZ contain no evidence that this equipment, weighing almost 250 lbs., was removed between the hoist test on December 27, 2007 and the January 4, 2008 weighing of the aircraft. If the recollection of the observers of the January 4, 2008 weighing is correct (and there is no reason to doubt it), the operations group's weight for N612AZ is almost 250 lbs. more than it should be based on these equipment errors alone. Once these equipment errors are accounted for, the approximate weight of the aircraft is consistent with Carson's estimates.

Carson estimates that the empty weight of N612AZ on August 5, 2008 was between 13,289 lbs. and 13,537 lbs., with the most likely weight being no more than 13,432 lbs. (an average of known weights). Using any of these weights, in combination with the known weight of the final flight payload and the proper meteorological data, the aircraft should have had a substantial performance margin available to successfully complete the accident flight.

Carson began its estimate of the weight of N612AZ by gathering the most reliable weight documents for the aircraft:

June 21, 2007 weight document prepared by Canadian Helicopters Corporation [Exhibit 27]	Carson purchased N612AZ from Canadian Helicopters Corporation in August 2008. This weight document is the record of the last Chart C weight of N612AZ prior to the sale to Carson. As noted in the Chart C weight of June 21, 2007, the aircraft was configured for offshore operations and had many components installed which would later be removed by Carson (e.g., sponsons, liferafts, etc.).
August 6, 2007 weight shown in the initial Airworthiness DAR Inspector's report for N612AZ [Exhibit 28]	This one page Conformity Inspection Record states the empty weight of the aircraft as 12,491 lbs.
August 15, 2007 Chart B, [Exhibit 29]	The Chart B for this weight was prepared and signed by Mr. Wolf and was created in association with the first hoist test flown using N612AZ.
December 27, 2007 weight calculations [Exhibit 30]	These spreadsheet calculations were created by Carson pilot Bob Boyd in conjunction with the hoist test flown on December 27, 2007.
January 4, 2008 Chart B [Exhibit 31]	This Chart B was prepared by Mr. Wolf but witnessed by Mr. Manogue.

Starting with the weights in these reliable base weight documents, Carson next subtracted the weight of the extraordinary equipment installed on the aircraft at the time of the weighing in order to reach a base empty aircraft weight. These calculations are shown in the following table:

Weight Document	06/21/07	08/06/07	08/15/07	12/27/07	01/04/08
Gross Weight	13,279	12,491	13,073	12,369	12,328
Removed Items	Offshore Gear (-519), Sponsons (-615), add back Aux. Battery (88)	Sponsons (-615), add back Aux. Battery (88)	Sponsons (-615), Hoist (-135), Bubble Windows (-36), Cargo Hook (-75)	Hoist (-135), Bubble Windows (-36), Cargo Hook (-75)	Hoist (-135), Bubble Windows (-36), Cargo Hook (-75)
Empty Aircraft Weight	12,233	11,964	12,212	12,123	12,082

Next, Carson added the total weight of the components that were known to be installed on the aircraft at the time of the accident.

Based on this analysis, the total empty weight of N612AZ on August 5, 2008 was no more than 13,537 lbs., using the heaviest of the verifiable weight documents (the signed and witnessed August 15, 2007 hoist test weight) as a starting point. Using the lightest of the verifiable weights (the weight from the August 6, 2007 Airworthiness DAR Inspector's Report) as a baseline, the total empty weight of N612AZ on August 5, 2008 was no more than 13,289 lbs. Using the average of the verifiable weights as a baseline, the total empty weight of N612AZ on August 15, 2008 was no more than 13,432 lbs. All of these weights are well below the 13,845 lbs. the operations group assumes N612AZ weighed at the time of the accident. Most importantly, in light of the independently conducted and witnessed flight performance evaluation test, it is clear that N612AZ should have had enough engine power to successfully complete its final flight at any of these weights, even the grossly excessive weight the operations group has ascribed to the aircraft.

2. The importance of the altered performance charts has been overstated

Carson again acknowledges that the NTSB's investigation has uncovered the presence of altered performance charts in the company's flight manuals. While Carson does not know, and has not been able to determine, the source of these altered performance charts or how they were created, Carson has reevaluated and changed its operations and procedures to minimize the chances that any altered performance charts will be again inserted into Carson's flight manuals. Carson has changed the way it handles submissions to the FAA seeking new or updated performance charts, as well as the way it handles approved performance chart documents once they are received by the company and supplied for bid documents. The company has also improved its procedures for disseminating amendments or changes to performance charts and flight manuals to the field.

While a mislabeled performance chart was erroneously utilized in bidding on Carson's Forest Service contracts and then propagated into the company's flight manuals, the mislabeled "5 minute" power available chart actually presents valid performance data for "2.5 minute" power. The FAA-certified Sikorsky Flight Manual makes it clear that there are several flight envelopes under which the 2.5 minute charts can be utilized, and, unlike other twin engine helicopter manuals, the Sikorsky manual does not indicate that the 2.5 minute chart can only be used in emergency situations or for single engine operations.

In any case, if valid performance characteristics for N612AZ on August 5, 2008 are used, the aircraft had enough performance available with properly functioning engines to remain within the margin of the power available charts. The mislabeled chart was not a causal factor in the crash.

3. Erroneous meteorological assumptions have been made based on flawed data

In addition to overstating the weight of the N612AZ and the importance of the altered performance charts to N612AZ's ability to successfully carry out its final mission on August 5, 2008, the operations group has made a series of erroneous assumptions with respect to the meteorological conditions at the time of the accident.

The assumptions about the meteorological conditions at the time of the accident are important. Aircraft weight, temperature, wind speed, and wind direction are all central variables in determining the performance of any helicopter, including N612AZ. Power output from the engines varies significantly depending on increases or decreases in temperature. Moreover, while a headwind can help lift a helicopter aloft and improve the aircraft's performance characteristics, a tailwind can have the opposite effect. The positive or negative effect of a particular wind is magnified depending on the velocity of the wind. In almost every instance, the operations group has chosen to ignore the actual meteorological data from either witness reports or the CVR. In almost every instance, the operations group's choices have the substantive effect of diminishing the performance margin calculated for N612AZ.

The CVR data recovered from the accident aircraft clearly shows that the temperature at H-44 at the time of the accident was approximately 20° C. Although the SIC announces twice on the CVR that the temperature at the time of the accident takeoff was 20° C, the Operations Report rejects this figure in favor of a temperature based on data extrapolated from weather stations located miles from the accident site. The Meteorological Report assumes that the aircraft was probably 500-700 ft. above the ground at the time these temperature readings were made. The NTSB meteorologist has admitted this is a rough estimate.

In this case, however, there is no need to guess. There is data available that brackets the aircraft's position when the SIC reads the temperature. By cross referencing the CVR data and the 2 minute interval Sky Connect AFF data, the aircraft location is known with precision:

- At 1930:33, the Forest Service helitack crewmember on the ground informs the pilots that winds are the same as before, out of the southeast at 3 to 5 knots.
- At 1933:26, the aircraft passes through 6,300 ft. elevation, only 355 ft. in elevation above the helispot.
- At 1934:52 (more than one minute later and certainly much lower), the aircraft is on short final bearing and the co-pilot calls temperature as 20° C.
- Less than 40 seconds later, the next Sky Connect AFF data point shows the aircraft already on the ground at 5,945 ft. elevation.

This data shows that when the SIC reads the temperature, the aircraft is on its short final approach to landing and very close to H-44, descending, and certainly well less than 300 ft. above the helispot location. The dry adiabatic cooling rate (per the Meteorological Report) is 3° C per 1,000 ft. of elevation. The average adiabatic cooling rate is about 1.8° C. Thus, using the NTSB's own adiabatic cooling rate, in conjunction with the clear data from the CVR and Sky Connect AFF system, the temperature on the ground is 20.33° C at most.

The CVR further confirms that the air temperature at H-44 was approximately 20° C – at 1939:18, four minutes after the aircraft landed at H-44, the SIC is heard to be carefully considering the temperature as between 12 to 13° C cooler than the 32° C mission planning temperature (or 19 to 20° C). The temperature gauge from which the SIC was reading was directly in his left line of sight near his head. As discussed previously, the temperature gauge from which the SIC was reading had been recently checked and found to be properly functioning.

The Operations Report states that in a post-accident interview, the SIC said that the temperature just prior to the accident was 22° C. What is not stated in the Operations Report, however, is that this interview took place weeks after the accident, at a time when the SIC had recently recovered from a two week drug-induced coma and was still being treated with high levels of Methadone. In addition, the SIC also said in the interview that he initially checked the temperature at 22° C and 5,700 ft. pressure altitude (<u>or more than 700 ft. below H-44</u>) while en route to the first landing at H-44. Later in the interview, when he was questioned about the conditions for the entire day, the SIC says that "Uh, 22 degrees when we were up on the hill . . . ." This value is identical to the initial reading he mentioned earlier in the interview for conditions during the first landing at H-44, and it is not at all clear from the question or his answer that he is describing conditions "immediately prior to the accident" as the Operations Report assumes.

The Operations Report thus appears to favor the nebulous temperature statement from an interview given a month after the accident over a clear temperature reading taken directly off the CVR during the third landing at H-44. There is no reason to give the SIC's understandably hazy post-accident, hospital bed recollection credence while discounting the concrete data from the CVR.

Carson provided extensive evidence establishing that, even using the NTSB's own meteorological information, the temperature and wind data in the Meteorological Report was incorrect. Carson commissioned a report on the weather conditions from an outside expert meteorologist familiar with this region. [Exhibit 32] In this report Dr. Elizabeth Austin states

> The NTSB Meteorological Factual Report utilizes the NAM 0300Z August 6, 2008 forecast product, not an analysis product due to the proximity in time to the accident time (0241Z August 6, 2008). In addition, the NTSB uses a single point sounding from this forecast product and does not analyze what is going on regionally and discusses the temperature and winds at the 850mb level and not the 825mb level, which is closer in altitude to the accident site elevation. This is important due to the fact that this is a forecast product and also the data resolution. The regional plots of the 0300Z August 6, 2008, 825mb level (or 5,800 feet MSL level over the region) forecast winds and temperatures are in figures 19 and 20, respectively. These plots show that at the 5,800 feet MSL level (or ~150 feet below the accident site) the winds were 8 to 10 knots from 109° and the air temperature was in the 19 to 21°C range.

There are serious and fundamental problems with the presentation of the meteorological data in the Meteorological Report. The Meteorological Report contains a large amount of regional weather information which is not helpful in determining the conditions at H-44 at the time of the accident. This area is rugged, remote and comprised of extremely steep and varied terrain with severe topographic changes. This numerous ridges and valleys create an environment characterized by microclimates, or localized areas where the meteorological conditions are significantly different from surrounding or nearby areas. Additionally, at the time of the accident, a 55,000 acre wildfire was burning in direct proximity to the accident scene. Utilizing information from one or two weather readings taken 6 to 12 miles away and attempting to smooth the data and extract temperatures is problematic at best when compared with the temperature and wind data on the CVR.

The Meteorological Report also contains a chart that depicts the RAWS data observed from Backbone, the closest automated recording station to H-44. Notwithstanding its being the "closest" RAWS station, Backbone is located more than 6 miles and across the mountains from H-44 and is at 4,700 ft. elevation, significantly below H-44. The RAWS data in the Meteorological Report is approximately 27 to 25° C during the same time frame. Using the

Backbone temperature data that was provided in the initial weather summary and assuming the adiabatic cooling rate utilized by NTSB, the following applies:

> Cooling lapse rate at 5.5° F as listed:
> Backbone – (average between 25 to 22°) 23.5° C, 4,700 ft. elevation
> H-44 - 5,945 ft. elevation
> 1,249 ft. difference, 6.9° F lapse difference

This analysis results in a correlated temperature for H-44 of 19.7° C – virtually identical to that called out by the SIC on the CVR. However, even if the revised temperatures in the RAWS data in the Meteorological Report are used, the temperature at Backbone was 77° F at 1949 and, using the NTSB's own adiabatic cooling rate, results in a temperature at H-44 of 70° F, or 21° C.

In addition, the Meteorological Report contains a National Oceanographic and Atmospheric Administration (NOAA) Air Resources Lab (ARL) North American Model (NAM) sounding for 2000 on the day of the accident. This is apparently a smooth model created from available data that uses an algorithm to create a forecast sounding over the accident site at different time slices. For the 2000 time slice, the model shows that an altitude corrected temperature for 6,235 ft. (the approximate altitude at which the aircraft was on short final prior to landing when the copilot called out the temperature as 20° C) is 19.8° C, almost identical to the temperature actually read from Backbone and then corrected at the standard cooling rate for elevation and almost identical to the temperature data from the CVR. All three of these temperatures – the extrapolated temperature from Backbone, the NOAA ARL model temperature, and the actual temperature read by the SIC – are within 0.3° C of each other.

Despite the rich combination of data evidencing that the temperature at H-44 at the time of the accident was approximately 20° C, the Meteorological Report assumes that the temperature at the accident site was 23° C. This temperature is derived for the accident helicopter's flight based on analysis of the MesoWest data collected by the University of Utah. An examination of the MesoWest system reveals that the MesoWest recording site closest to H-44 is Backbone. All other temperatures in this region are extrapolated from the Backbone RAWS data, meaning that they are no more accurate than any of the other smooth data already provided, and undoubtedly of limited use to factor in changes in localized temperature due to fire conditions, sunlight, localized winds, or microclimate effects. In fact, this 23° C data point is an outlier based on (1) the previous datasets; (2) the standard cooling rate calculation; (3) the NOAA ARL model data; and (4) the actual temperature read by the SIC at H-44. It does not align with any other available data.

Throughout the investigation, Carson pointed out the inconsistencies in the temperature presentation in the Meteorological Report. The Meteorological Reports' chosen 23° C assumption for the accident takeoff is not supported by facts, and is at best a smooth approximation. It is not the best data available. The best data is the multiple temperature readings announced by a professional pilot on the CVR at the time and place of the accident. The FAA, the Forest Service, and the Department of Transportation all rely on temperature data read by trained professional pilots for mission planning, load calculation adjustments, real-time aviation weather reports, and flight safety decisions made in flight operations all over the United States on a constant basis. The Meteorological Report provides no justification for ignoring the best temperature data available in place of computer modeled approximations from many miles away across severe, mountainous, and fire-ravaged terrain. Unfortunately, this deeply flawed data is carried forward into the Operations Report and Hover Study [Docket Nos. 426753 and 426604, respectively].

An unfortunately similar approach is taken with respect to assumptions concerning wind direction and velocity at the time of the accident. In its first draft Operations Report, the operations group assumed that N612AZ took off into a 5 knot <u>tail</u>wind for weight calculations, even though all of the meteorological data showed that there was a 5 knot <u>head</u>wind at the time of the accident. This mistake adversely affected the helicopter lift performance calculations and thus affected the conclusions of the Hover Study.

Carson pointed out that on the CVR the Forest Service helitack crewmember on the ground at H-44 during the accident takeoff tells the pilot that there is 3 to 5 knots of headwind, which was also confirmed in the copilot interview. While the operations group did alter its report as a result of Carson's input, it decided to assume that there was no wind on the accident takeoff, yet again adversely (and erroneously) affecting the calculation of N612AZ's performance margins in the NTSB's reports.

The Meteorological Report shows that in the RAWS data from Backbone, winds were consistently from the south-southeast, with a headwind at H-44, at 3 to 9 knots and gusting up to 16 knots, with winds increasing in the afternoon. The NOAA ARL model for H-44 at 2000 shows winds from the southeast at 4 to 12 knots depending on altitude, with winds of 8 knots at 5,800 ft. Several of the witness statements, including those of weather-trained, Forest Service helitack personnel whose job it is to keep track of wind velocity and direction, describe winds from the southeast at 3 to 5 knots on the final takeoff at H-44. The regional RAWS data from Backbone, the witness data, the CVR data, the recorded interview with the copilot and at least some photographic evidence, all show that there was a moderate 3 to 5 knot headwind blowing from the southeast during the accident takeoff.

C. <u>Recommendation</u>: The NTSB Should Put In Place Concrete, Mandatory Procedures To Safeguard Against Errors In Investigations

The operations group in this case has focused almost exclusively on the irregularities and anomalies in N612AZ's weight documents and the performance charts in the aircraft's flight manuals as a potential cause of the crash. As a result, (1) the investigation and factual findings were shaped to support the conclusion that the crash is a result of these weight and performance chart issues; and (2) compelling evidence that engine failure or power loss due to contaminated FCUs was the root cause of the crash was minimized. This shift in focus occurred after serious investigative errors were made. It is important for the NTSB to take steps to ensure that these kinds of internal errors do not occur again, just as Carson has taken positive steps to correct identified errors in its own procedures.