NATIONAL TRANSPORTATION SAFETY BOARD
OFFICE OF AVIATION SAFETY
WASHINGTON, D.C.

February 17, 2009

SURVIVAL FACTORS GROUP CHAIRMAN'S FACTUAL REPORT OF INVESTIGATION

A.	**ACCIDENT**	**:**	**LAX08PA259**
	LOCATION	:	Weaverville, California
	DATE	:	August 5, 2008
	TIME	:	1941 Pacific Daylight Time[1] (PDT)
	AIRCRAFT	:	Sikorsky, S-61N Helicopter, N612AZ, Operated by Carson Helicopter Services

B. SURVIVAL FACTORS GROUP

Group Chairman	:	Cynthia L. Keegan National Transportation Safety Board Washington, DC
Member	:	Kristin Poland National Transportation Safety Board Washington, DC
Member	:	Eric West Federal Aviation Administration Washington, DC
Member	:	Marianne Kump BAE Systems Safety Products Inc. Pompano Beach, FL
Member	:	Boyce Bingham U.S. Forest Service Juneau, AK
Member	:	John Harris Carson Helicopter Services, Inc. Grants Pass, OR

[1] All times are Pacific Daylight Time, based on a 24-hour clock, unless otherwise noted. The time of the accident is approximate, and based upon various witness accounts.

C. SUMMARY

On August 5, 2008, about 1941 Pacific daylight time,[2] a Sikorsky S-61N helicopter, N612AZ, impacted trees and terrain during the initial climb after takeoff from Helispot 44, located at an elevation of about 6,000 feet in mountainous terrain near Weaverville, California. The airline transport pilot, the safety crewmember and seven firefighters were killed; the commercial copilot and three firefighters were seriously injured.[3] Impact forces and a postcrash fire destroyed the helicopter. The helicopter was being operated by the United States Forest Service (USFS) as a public flight to transport the firefighters from Helispot 44 to another location. The helicopter was registered to Carson Helicopters, Inc. (CHI) of Grants Pass, Oregon, and leased to Carson Helicopter Services, Inc. (CHSI) of Grants Pass. The USFS had contracted with CHI for the services of the helicopter.[4] Visual meteorological conditions prevailed at the time of the accident, and a company visual flight rules flight plan had been filed.

D. DETAILS OF THE INVESTIGATION

1.0 Aircraft Configuration

N612AZ was equipped with a pilot seat, a co-pilot seat and 18 passenger seats. There were five rows of forward facing double passenger seats on the right side of the cabin. A double crewmember seat faced aft on the forward left side of the cabin and six rows of forward facing single passenger seats on the left side of the cabin. The aft facing double and first single seats, on the left side of the cabin, were designated for helicopter crewmembers. An aisle in the center of the cabin separated the passenger seats on either side of the cabin. Two main entry doors were located on the right side of N612AZ and two emergency exit hatches were located near the center of the cabin on each side of the fuselage. A third emergency exit hatch was located on the left side of the aft fuselage. The helicopter was configured with 20 windows[5] (one on either side of the cockpit, and 10 on the left and 8 on the right side of the fuselage) equipped with removable rubber seals that allowed the window frames to be utilized as emergency exits See Figure 1 for N612AZ's cabin diagram.

[2] All times in this report are expressed in terms of a 24-hour clock and Pacific daylight time unless otherwise noted.
[3] The safety crewmember was a USFS Inspector Pilot.
[4] Initially, the NTSB was informed that the contract was between the USFS and CHSI. For further information refer to the Operations Factual Report.
[5] Tabs on the interior and exterior window seals were designed so that when the tabs were pulled the rubber seal surrounding the window separated allowing the window to eject and creating an opening for emergency egress.

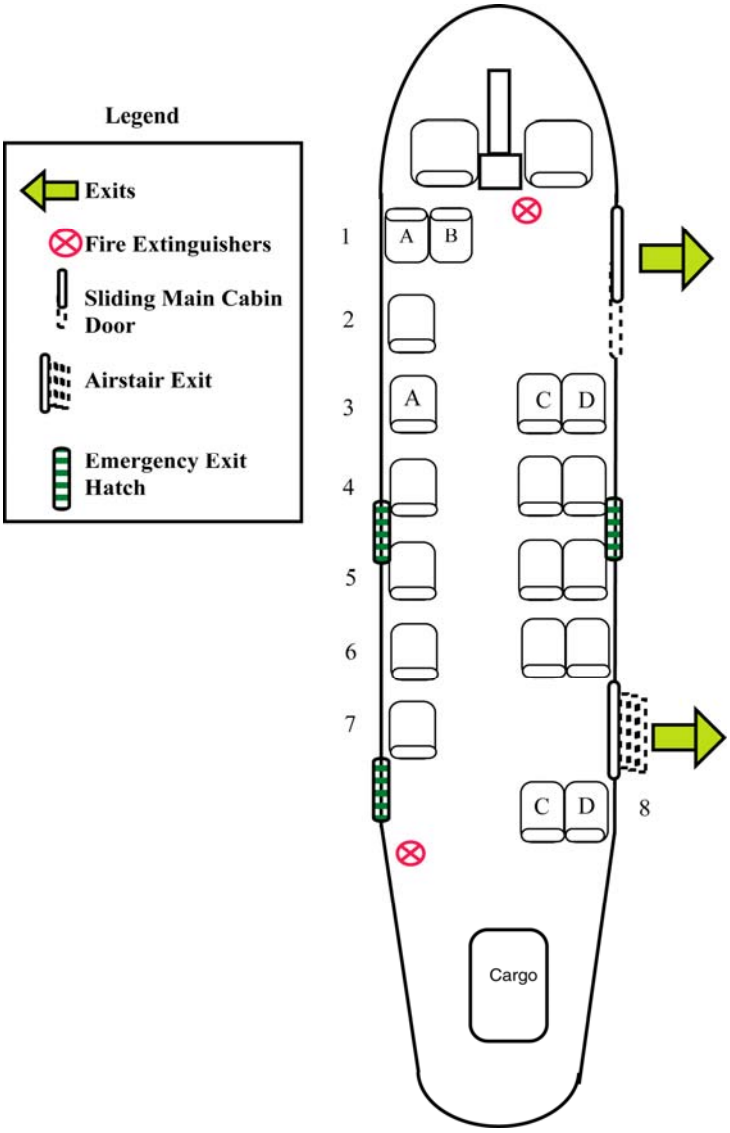

Figure 1 N612AZ Cabin Diagram

2.0 Crew Information

See the Accident Factual Report for the co-pilot's interview statement.

3.0 Occupant Information

3.1 Helitack Helicopter Crew Member Interviews

The Survival Factors Group interviewed the Forest Service Helitack helicopter crewmembers[6] (HECM) that briefed and assisted the passengers with boarding and with their restraints prior to the accident flight.

3.1.1 HECMs

HECM Huntoon
Trinity Helibase

HECM Huntoon was interviewed on September 24, 2008 by Survival Factors Group Members Cynthia Keegan (NTSB), Kristin Poland (NTSB), Marianne Kump (BAE Systems Safety Products), Boyce Bingham (USFS), Scott Benavides (Sikorsky Helicopters[7]), and Eric West (FAA)

HECM Huntoon has worked for the US Forest Service (FS) for the past 5 years, and worked as a firefighter for the past 3 years. Her work as HECM began at the end of April 2008. Her duties include assisting passengers with boarding the helicopter and loading tools and cargo in the helicopter. She received training in loading and unloading passenger and cargo. Her training involved a few days of learning how to load and unload the helicopters, the various seat and restraint systems, and filling out the helicopter manifest. She learned the seating and restraint system on the Sikorsky S-58 and S-61N and she received information about passenger briefings on these helicopters. She was trained that loading of heavier passengers was more critical on the S-58 helicopter than it was on the S-61N. She was trained to seat passengers in the forward seats first on the S-61N and leave the rear seats empty if it was not a full flight. Her training occurred at the beginning of year and was specific to the model helicopters she was assigned. She knew there were 4-point restraints in the S-61N and how to buckle and release the restraints. She also knew that the cabin seat backs pivoted forward.

On the day of the accident she was briefed at the Trinity Helibase station about the days' mission and flights. The briefing included her duties for the day and the assignment of equipment and duties for each HECM. When she arrived at Helispot H44 (H44) she ensured the manifest was complete, and she lined the firefighters up to board the helicopter. The firefighters boarded the helicopter from the aft air stair and occupied the cabin seats from the front to the rear of the cabin. She assisted the passengers in the

[6] U.S. Forest Service Interagency Helicopter Operations Guide (IHOG) classifies a Helicopter Crew member (HECM) as a trained member of a helicopter crew responsible for the following: 1. Constructing helispots, manifests, loads, and unloads cargo and personnel, marshals helicopters, rigs external loads; 2. Assists with daily inventory checks, ensures operational readiness of the helicopter unit, performs tool, equipment, and vehicle maintenance and refurbishment; 3. Participates in proficiency checks and drills; 4. Participates in safety sessions and critiques, provides preflight safety briefings to the passengers, and ensures own and others' safety and welfare in all aspects of his/her job; and 5. Completes aviation forms, vehicle reports, and requisitions as required.

[7] Mr. Benavides was originally a member of the Survival Factors but was removed because he was a contractor for Sikorsky rather than a permanent Sikorsky employee.

rear cabin with their restraints and FS Inspector Pilot Ramage[8] assisted the passengers in forward cabin with their restraints. The other HECMs helped load the cargo.

She stated that many of the firefighters do not often fly in the helicopters and she noticed that some of the passengers had problems buckling the 4-point restraints. The problems occurred because the firefighters attempted to secure their shoulder harnesses before securing the lap restraints. She instructed passengers to secure the lap restraints first and tighten the straps before securing the shoulder harness. She did not have any problems latching the buckles for the passengers. She thought it took longer to adjust the 4-point restraints, compared to the time it took to latch the restraints, but she believed that because the restraints were 4-point restraints they were safer as long as they were worn properly. Her first flight in N612AZ occurred earlier on the day of the accident. She had flown on N612AZ to Burt Ranch where several HECMs were dropped off. She then flew in N612AZ to H44 where she and the remaining HECMs were dropped off.

She had not experienced problems releasing the 4-point restraints on the S-61N in the past, and she did not know if any other helicopters were equipped with different restraints. The typical fire-fighting outfit is Nomex pants and shirt, ear and eye protection, gloves, boots, and hard hats with chin straps. The firefighters wore leather gloves during the flight. This was her first year as HECM.

She helped fasten the passenger restraints on board N612AZ by latching the lap belts, tightening the lap restraints, securing the shoulder harness and tightening the shoulder straps. After the passengers were buckled in, she went through the cabin and pulled on the passenger's restraints to make sure they were secure. She checked the rear half of the cabin and Ramage checked the forward half of the cabin for the security of the passenger restraints. She said that the shoulder restraints attach to the back of the seats and the lap belts were mounted on the seat frames. There were 4 seats in the rear cabin that were not occupied, and the aft facing front seat on the left side of the cabin was not occupied. She thought the seating configuration for N612AZ was 15 passenger seats in the cabin. The firefighter's individual equipment weighed about 35 pounds for each firefighter. All of the passenger restraints on N612AZ were the same 4-point design.

Another Forest Service HECM provided the pre-flight passenger safety briefing, to passengers before they boarded N612AZ, in accordance with the FS National Wildfire Coordinating Group, Incident Response Pocket Guide (IRPG). See Attachment 1 for the IRPG Helicopter Passenger Briefing. HECM Huntoon helped passengers secure their seatbelts because on two previous sorties on the accident aircraft the firefighters took a long time to buckle their restraints.

She noticed right away after N612AZ took off that something was wrong. The helicopter sounded quieter and she felt that something was not right. The rotor struck trees and debris started to fly through the air and she turned around and ran. After the

[8] Ramage was a U.S. Forest Helicopter Inspector Pilot, and was performing flight attendant duties and assisting the flight crew during the accident flight.

debris stopped flying through the air she ran back to the edge of the hill. She could not see the helicopter over the ridge of the hill but she saw smoke rising from the wreck and she assumed that a fire broke out. She did not see how the survivors evacuated the wreckage.

As she approached the accident site she could only get within 20 feet of the wreckage because the fire was too hot and she was concerned that the wreckage may explode. She found the co-pilot about 150 feet from the nose of the wreckage and she tried to help him. Another Carson helicopter arrived and dumped water on the wreckage, although the water did not put out the fire. She said that because H44 was a remote Helispot, there was no immediate fire extinguishing resources to deal with the fire. See Attachment 2 for photographs of N612AZ wreckage.

HECM Vassel
Trinity HECM
Senior Firefighter Forestry Technician

HCEM Vassel was interviewed on December 18, 2008 by members of the Survival Factors Group including Cynthia Keegan (NTSB), Marianne Kump (BAE Systems Safety Products), Boyce Bingham (USFS), John Harris (Carson Helicopter Services)

HECM Vassel is senior firefighter who has held this position for the past 8 years. His duties include loading and creating manifests of passengers and cargo, assisting the base manager, training new recruits, and completing the load calculations. He has served as the airbase radio operator.

He was temporarily based at Willow Creek Helibase for 4-5 days before the accident occurred. Earlier during the day of the accident the Willow Creek Helibase Manager and he were scheduling flights to get the firefighters off the mountain because of predicted lightning storms on the mountain. HECM Vassel stated that his base manager requested he go to H44 about 1 hour ahead of time so when N612AZ arrived he could brief the load manager (HECM Lingenfelter.) He and HECM Peters flew to H44 in a French manufactured Eurocopter (USFS operated) helicopter. He arrived at H44 before N612AZ arrived to create the manifest and brief the firefighters who had arrived there on foot.

HECM Peters assisted him with putting together 5 manifests and coordinating the flights from H44. The accident manifest was the 3rd manifest he and HECM Peters created. Each manifest has an original and a copy and the second to last HECM to leave the Helispot takes the original manifests with them back to base where it gets filed in the USFS archives. The original manifest for the last flight out is taken by the last HECM to leave the Helispot (who also has the copies of the day's manifests) and a copy of the manifest is placed under a rock at the departure point. This is done (copy of the last flights manifest under the rock and the days original manifests carried separately) to provide a record for all flights leaving the Helispot.

His responsibilities at H44 included receiving a brief from the other HECMs, getting the manifest for the flight crew, and assessing the landing area for obstructions and hazards. He also talked to the safety officer and provided safety briefings to two crews of firefighters in accordance with the IRPG. He arrived at H44 at about 1630. He really did not like the landing area because it was half dirt and rocks and he moved some rocks and tree branches around to protect the rotor wash from kicking up the dry dirt. Another Carson ship came in and put down half a load of water to wet down the H44 to keep the dust down.

HECM Vassel stated that before the accident flight he gave a safety briefing to the passengers. HECM Vassel described safety equipment specific to the aircraft they boarded i.e. the location of the fire extinguishers, and how the restraints latched. HECM Vassel told the firefighters that their restraints were 4-point harnesses and they should help their buddies with buckling the restraints. HECM Vassel told them that they should "twist the handle" and he pointed to the middle of his belly and showed with his hand how the buckle rotated to unbuckle the restraint. HECM Vassel stated the Forest Service does not use an exemplar restraint to show how the restraints adjust and latch. During the safety briefing HECM Vassel had an open format for questions but none of the passengers had questions about the restraints. He said that the "passengers gave him a look like they understood how to operate the restraints" when he described how the restraints buckled. HECM Vassel instructed HECM Peters to read the IRPG Helicopter Passenger Briefing "word for word."

He did not experience any problems with the restraints on board N612AZ and he liked the way the rotary restraints latched and thought they were very comfortable. The S-61N is the only helicopter he had flown in with a 4-point rotary restraint. Other helicopters, like Helicopter 506 (a Sikorsky S58 based at Trinity) had lap restraints with different latch type buckles. He thought that one helicopter had different 4-point restraint that he had not seen before, but he was not sure which helicopter it was.

He also briefed the firefighters to stow their red fusees (road flares) and that no red should be visible from their packs, to remove their tools before boarding the helicopter, and to provide a list of tools and cargo for the manifest. He briefed between 28 and 30 firefighters, and then provided another briefing to the next group of firefighters. The firefighters were moved to a safe staging area to protect them from the downwash of the helicopter landing at H44. The firefighter's names were called out and a group of firefighters were taken over to a staging area to prepare them for the flight. About 20 minutes passed between the briefing and the passengers boarding the helicopter.

The heavier passengers were seated in the front of the cabin. HECMs Ross and Huntoon helped the passengers board N612AZ on the right side of the helicopter while he stayed on the left side of the helicopter. HECM Vassel did not assist passengers boarding the helicopter. Initially there were 44 people at H44; however half of them were taken

off the mountain before the accident flight so there were about 22 people remaining on the mountain who observed N612AZ depart.

He could see the passengers through the windows on the left side of the helicopter but he was unable to see or hear if they had trouble fastening their restraints. The passengers boarded first and then the other HECMs loaded the gear and other cargo. He specifically asked everyone to bag personal gear (to be loaded in the black tub in the rear of the cabin) before boarding N612AZ. There were 2 chainsaws on the manifest, but the Dolmars[9] were not on N612AZ before it took off. The hand tools and chain saws are put in the belly in the rear of the helicopter. The only hazardous material on board the helicopter was the red fusees (flares) the firefighters carried inside the external sleeve of their packs. The firefighters were required to make sure the flap of their packs covered the fusees.

HECM Vassel reported that they were running late [getting the firefighters off of H44] and N612AZ was returning from refueling and there was another helicopter that got into the "mix" He called back to base and asked them to hold the other helicopter. The airspace above the ridge became open and he could hear the flight crew getting ready to take off because he had an earpiece in his ear. The other HECMs closed the aft stair at the back of the cabin and N612AZ began to lift off. It seemed labored as N612AZ took off and it moved very slowly. He stated that the captain normally took of slow; "it was his way". He began walking toward the direction of flight and he kept thinking, "Go, Go, Go!" As soon as N612AZ moved forward, and he heard what sounded like hail and tree branches began flying through the air and the helicopter started to descend. The rotor struck trees; the helicopter slid down a tree, went over on its left side, and impacted the ground. There was virtually no forward momentum before the helicopter struck the trees. Both engine turbines were spinning for about 30 seconds after the helicopter crashed. One turbine sped up then the other sped up. The main rotor stopped spinning, but the tail rotor may have still been spinning.

Everyone said "Oh my God" and HECM Lingenfelter yelled for the people on the ground to stay back (from the burning wreckage.) He and about 15 people where standing near a group of trees, and HECM Lingenfelter and his 4 loaders were on the opposite side of where the helicopter had lifted off. They all merged into the shape of a horseshoe walking toward the accident site. Vassel was closest to the wreckage, and he called the Willow Creek Helibase on his radio (a Bendix King handheld transmitter radio) and reported they had an aviation mishap and he yelled that N612AZ was down. During his first call to Willow Creek he did not report the fire, the next call he said fire involved. He ran back up to the top of the ridge because radio communication signal was weak near the wreckage.

Everyone began moving in closer to the wreckage but explosions, fire and bursts of heat prevented them from getting closer than 50 feet. Survivors began coming out of

[9] A Dolmar is a container that holds fuel and oil to power the chainsaws that the firemen use to for firefighting.

the burning helicopter and he watched them run into the woods. The fire was mid ship coming out the escape hatch about 50 feet into the sky. He was standing off the nose of the helicopter about 50 feet. He saw the copilot come out of the wreckage on fire. Someone yelled to extinguish the fire on the copilot and he saw another survivor coming out of the wreckage. He went down the hill and tried to help the injured. The copilot was injured the worst. He did not see anyone attempt to get out of the wreckage that could not make it out. He kept hearing explosions and the fire enveloped the wreckage so fast that there was nothing they could do except help the survivors who escaped the wreckage.

HECM Lingenfelter came up to him and reported his assessment of the accident site. He assessed the medical supplies, and stokes stretcher and started directing people to different areas to help the survivors and to search for additional survivors. Vassel organized the other HECMs to help the survivors and triage the survivor injuries to determine the most critically injured, and he and HECM Lingenfelter organized the firefighters to search the woods for additional survivors that had evacuated N612AZ and wandered into the woods.

There was a brief moment of chaos because it was so unbelievable what happened. The chaos and confusion came from the firefighters on the ground that witnessed the crash. The firefighters were yelling, but the HECMs remained calm because they were trained to deal with this type of emergency. The HECMs worked really well together. He assigned several of the firefighters to help look for survivors to keep them calmed down. Some people ran up the hill to get medical supplies and sleeping bags to keep the survivors warm. There were 7 HECMs and about 15 firefighters on the mountain when the accident occurred.

HECM Vassel stated that he became the Incident Commander (IC) because H44 was his designated Helispot and because none of the other more qualified IC's "stepped up" as the IC, so he took charge and became the IC. HECM Vassel also stated that he was IC-5[10] "incident commander in training" and there were other more qualified IC trained HECMs at H44 when the accident occurred. About thirty minutes after the accident a helicopter arrived with medical personnel on board. A more Qualified IC arrived on one of the three EMS helicopters and the new IC informed HECM Vassel that he was a fully trained and qualified IC, therefore, HECM Vassel relinquished his IC position to the more qualified IC (HECM Vassel did not know the IC's name.) He briefed the new IC and then started another search party.

After he radioed back to the Willow Creek Helibase he gave HECM Lingenfelter his radio and he put a search party together to look for survivors in the woods near the wreckage. He and the other HECMs kept running down the hill looking for survivors because they heard shouts coming from the forest surrounding the wreckage. They later realized the shouts were coming from the searchers who were yelling for survivors in the

[10] See the Survival Factors Emergency Response Specialist Report for additional information about USFS incident command.

forest. After the accident, the other HECMs assisted him with providing blankets for the survivors, triaging the survivors, and searching the woods surrounding the accident for survivors. The HECM were trained to respond to accidents such as this. The firefighters kept coming to him, and he instructed them to help the HECMs check on the survivors and help search the woods for survivors. A Carson helicopter arrived and dumped water on the accident helicopter with its belly tanks. The dumped water produced a lot of smoke and he kept telling everyone not to breathe the fumes because of the burning magnesium in the wreckage.

His IC training included human factors risk assessment and a review of accident scenarios and drills. There were a couple of different accident scenarios that they learn. If the accident occurs somewhere other than on the mountain they are instructed to call 911. When N612AZ crashed he made an assessment and then immediately got on the radio and called Willow Creek Helibase. He was trained to access the injuries and triage the survivors, secure the accident site, and seek preservation of the wreckage. After the accident he radioed Willow Creek and reported that N612AZ was down and there was fire involved. He did not report how many passengers were on the helicopter because he was busy trying to coordinate the rescue of the occupants. He did not think the quantity of passengers on board the helicopter was more important then helping the survivors. The four survivors were his main concern during the response to the accident.

Because Ramage arrived at H44 on board N612AZ and remained on board while the firefighters boarded the helicopter HECM Peters and Vassel did not know that Ramage was on board the accident helicopter. Later that evening, he learned that Ramage was on the accident flight. Ramage was on the manifest (for N612AZ) for the flight into H44, however, because they were unaware that he was on the helicopter, HECM Vassel and the other HECMs did not list Ramage on the accident flight's manifest.

He was careful about what he said on the radio because other people monitored the radios and so he did not want to report the names of the occupants on board N612AZ. There was no physical crash plan in place for H44 other than the requirement to call back to base and follow the Forest Service Procedures if an accident occurs. The HECMs have a card (from the IHOG and on him at the time of the accident) that they are supposed to follow if they are by themselves and an accident occurs. The HECMs are required to follow the list of instructions on the card and call 911 or make radio contact. He called the Helibase at Willow Creek.

He knew there were fatalities as soon as he got to the ridge at the rocky outcropping and he thought to himself that no one is coming out of the wreckage, but then he saw 4 survivors emerge from the fiery wreckage. The fire was mid-way at the center of the cabin and coming out the tail, and began less than 30 seconds after the helicopter impacted the ground. The survivability of the accident would have been very different if there were no fire. The fire was everywhere, and the engine turbines where still spooling when he called back to base. He made the radio call to base within 2 minutes after the accident.

A helicopter arrived and dumped water on the wreckage about ½ hour after the accident and then an EMS helicopter arrived with paramedics on board from Redding Mercy Hospital, and flew the most critical, the copilot out first. Two other US FS Helicopters arrived after the EMS helicopter and flew the 3 other survivors out of H44. Two of the helicopters landed on the ground at the same time with proper separation. The third and final Med-Evac helicopter landed about a mile down the ridge and as soon as the first EMS Helicopter departed H44, HECM Vassel asked HECM Lingenfelter to call the third Med-Evac helicopter to land at H44 to pick up the last survivor. The first EMS helicopter arrived about dark, second EMS helicopter got there about 5 minutes later. HECM Vassel stated that about 1½ hour elapsed between loading the first survivor and removing the last (fourth) survivor from the accident site. He stated that the accident happened at 7:40 p.m. and it was approximately 9:30 p.m. by the time the last survivor was airlifted off the mountain. None of the survivors were rescued out of the burning wreckage; if a survivor got out he escaped on his own.

The firefighters received wilderness first aid training, and first responder training. All of the firefighters wear leather gloves; jackets buttoned all the way up to the neck, fire helmets and Nomex pants. When he wears his flight gloves it is easy to unbuckle the restraints, but he has not worn the leather gloves that the firefighters wear so he does not know the difficulty or ease of releasing the rotary restraints while wearing the leather gloves. The difference between Trinity Helibase and H44 is that H44 has tall trees that the helicopter must rise above to depart from the site. N612AZ's takeoff earlier the day of the accident looked normal.

3.1.2 Passenger Interviews

Occupied Seat: 3D
Age: 42 years old
Height: 5 feet, 6 inches
Weight: 145 pounds

The occupant was interviewed by members of the Survival Factors Group including: Cynthia Keegan (NTSB), Kristin Poland (NTSB), Marianne Kump (BAE Systems Safety Products), Boyce Bingham (USFS), Scott Benavides (Sikorsky Helicopters[11]), Eric West (FAA)

He has worked for Grayback Forestry[12] as a full time firefighter for the past 2 years. His responsibilities are fighting fires and working fire lines. He has flown in other helicopters before the accident however the accident flight was his first flight on a Carson

[11] Mr. Benavides was originally a member of the Survival Factors but was removed because he was a contractor for Sikorsky rather than a permanent employee.
[12] Grayback Forestry is a civilian firefighting contract service that was dispatched and contracted by the Forest Service for this mission.

S-61N helicopter. He has flown in an older, larger S58T helicopter and another smaller helicopter with only 4 passenger seats.

When he and the other firefighters were waiting for the helicopter to pick them up at H44 and the HECM told him the seat belts were "kind of funky" and to be aware that the restraints were different than other restraints. He was the first firefighter to board N612AZ, and he occupied the outboard seat of the double first seat on the right side of the cabin. The restraints were buckled at each seat when he boarded the helicopter. After he found his seat he understood why the HECM said the restraints were funky because he noticed how different the 4-point restraints seemed from other restraints. He buckled his restraint and pulled the right shoulder harness tight and he kept the left shoulder harness loose because he had a feeling that he should leave one side loose. He noticed that other firefighters received assistance buckling their restraints from the HECM but he did not. The passenger seated in the inboard seat next to his also buckled his restraint without assistance. He figured out how to release the restrain by watching others receive assistance buckling their restraints. His restraint was different than any other he had used before. The other restraints he had used on other helicopters had flip latch buckles. He did not understand how the 4-point restraints released. He thought that to release the restraints the buckle had to be turned one way to unlock one side of the restraint and the other way to unlock the other side of the restraint. He buckled his restraint and checked to make sure it was securely buckled.

The helicopter went straight up when it took off. He looked over at the "co-pilot," and the "co-pilot" told them to duck their heads. (The survivor was asked to clarify the location of the "co-pilot" and he indicated that he was located in the cockpit.) He looked up and saw the helicopter going into trees. The helicopter seemed to shimmy to the left and then to the right and he felt it crash on the right side of the fuselage. He "blacked out" and awoke and something was on top of him pinning him down. He could only see black, and he tried to turn his restraint buckle but it would not release. He thought he heard the firefighter seated in the seat next to his making noise after the crash, but he was not aware of anyone else stirring after the accident. He could not get his restraint buckle released so he pulled the shoulder restraints off and wiggled out of the lap belt. He fell to the ground and "blacked out" again. He awoke and looked for the closest exit and saw flames coming towards him. He looked for other passengers but did not see anyone else and he thought the other passengers were unconscious. He "punched out a window," crawled out of the helicopter and "blacked out" again. The two other survivors evacuated out of the same window that he escaped out of. When he awoke he saw another firefighter. He crawled to a tree and "blacked out" again. After he awoke someone told him to run, and that is the last thing he remembered before he was rescued.

He was wearing a hard hat, Nomex shirt and pants, earplugs, leather gloves, and eye protection. His main concern during the accident was the seatbelt. He believes that because he could not get out of his seatbelt most of the other passengers would have escaped out of the helicopter if it were not for the seatbelts. Once he awoke from the blackout he did not see or hear anyone. He believes that if he could not have wiggled out of seatbelt that he would have been dead. He believes that if he had not kept his left

shoulder harness loose, he would not have been able to get out of his seatbelt. He does not know if his seat was intact after the accident. He did not know if his seat back pivoted forward. He did not try to remove his leather gloves after the crash to unbuckle his seatbelt. He was still wearing his leather gloves when he came out of helicopter.

He suggested that the firefighters should be made aware of the exit locations, where others are seated, and how to operate the restraints. He received a safety briefing before the flight and he was told where the fire extinguishers were located, the location of the safety windows and how to open them. The firefighters were briefed about the order of seating (front to back) and to wear leather gloves, Nomex clothing, protective glasses, and to keep their equipment secure during the flight. The briefing also included that during an emergency the windows popped out easily. No one demonstrated the release of the restraints to the firefighters before they boarded the flight. The Helitack HECM came on board and showed some of the firefighters how the restraints latched. On prior helicopter flights he was shown exactly where everything was and he was aware that the other aircraft had different restraints than those on board N612AZ. The other restraints had 4-point lift up buckles (like old fashioned car buckles).

His injuries included: a cracked vertebrae, ripped tendons and ligaments in his neck, lacerations of his mouth and lip and burns on his lips, headaches, pain in from his shoulders down to his feet.

Occupied Seat: 3C
Age: 20 years old
Height: 6 feet, 3 inches
Weight: 180 pounds

The occupant was interviewed by members of the Survival Factors Group including: Cynthia Keegan (NTSB), Kristin Poland (NTSB), Marianne Kump (BAE Systems Safety Products), Boyce Bingham (USFS), Scott Benavides (Sikorsky Helicopters), Eric West (FAA)

He worked for Grayback as a firefighter for the past 1 1/2 years. He only fought forest fires. He was wearing green Nomex jacket and pants, boots, t-shirt, hardhat and leather gloves during the accident flight. This was his first time on the S-61N helicopter. He had only ridden on one other smaller older helicopter before the accident flight. He was a little nervous before the flight because this was only his second flight in a helicopter.

After he arrived (on foot) at H44, forty minutes had passed before N612AZ arrived to pick them up. A HECM gave the firefighters a safety briefing that included the locations of the emergency exit window hatches and how to punch out the windows in an emergency situation. A HECM provided an oral safety briefing before the flight but no one demonstrated the use of the restraints like the flight attendants do on a commercial

aircraft. This was the first time he saw a rotary 4-point restraint on a helicopter. He had flown on another smaller older helicopter and the restraints were similar to those installed in commercial airplanes.

He grabbed his gear and walked toward the helicopter, and gave his gear to a HECM to load on the cargo. He was the second firefighter to board the helicopter and he sat in the front right inboard passenger seat. He faintly remembers putting his seatbelt on and he asked his seatmate how to buckle his restraint. He unbuckled the restraint at his seat, and sat in his seat and refastened his restraint. His restraint was difficult to buckle. He latched and unlatched his buckle a few times before take off to see how it worked while wearing his gloves. He did not have any problem releasing the buckle wearing his gloves. He tightened the adjusters on his restraints so his seatbelt was snug.

He stated that the helicopter lifted off and got about 150 feet in air, and dipped forward and then lost power and started going down. The nose dropped rapidly, and dipped again then the rotor hit trees, and the helicopter descended faster and faster. He heard Ramage yell for the passengers to put their heads between their legs. He tried to put his head between his legs and leaned forward during the impact, but his head was not all the way between his legs. After the crash, he regained consciousness and his head was still between his legs. His seat back had broken and there was something on top of him that felt like a seat or an engine. He thought that all the other seats behind him had broken. After the crash he tried to unlatch his seatbelt but he was unable to release the buckle. He began to panic. He pulled on the buckle to try to release the buckle again but the buckle would not release. He was not sure that he tried to rotate the buckle. He thought there was a push turn required to release the buckle. He did not think that his leather gloves prevented him from releasing the buckle.

After he could not get the buckle unlatched he pulled at his shoulder restraints and thinks he may have loosened the lap belt. He got his arms free of his shoulder restraints and wiggled out of the lap restraint. His seatmate punched out the window and he lifted himself through the window opening. When he climbed out the window hatch he did not have to climb on top of anything to get to the window opening. He and the passenger that occupied seat 3D evacuated out of the same window exit. When he pulled himself out of the window, he burned his legs on the window frame. He was soaked in fuel, and he ran about 200 yards from the wreckage and fell to the ground.

It seemed to him that the other passenger seats in N612AZ had broken away during the accident. He was not sure if other firefighters were conscious or trying to evacuate after the crash. He thought he heard the passengers in seats 5C and 5D talking when he was evacuating the helicopter. There was fire and smoke throughout the cabin immediately after the crash. The cabin caught fire instantly because of jet fuel that burst from the helicopter during the crash. There was fire in middle of helicopter and behind him, and he heard 2 explosions after he evacuated the cabin.

Although he did not receive individual instructions on the operation of his seatbelt from the “inspector pilot” he saw the inspector pilot provide instruction about the use of

the seatbelt to his seatmate and other passengers. The inspector pilot also asked his seatmate to relay the instructions about how his seatbelt released to other passengers on board the helicopter. He understood that he should put two fingers on the seatbelt buckle, push in on the buckle, and then turn the buckle. He thought that all the passengers understood how the buckles latched but not how to unlatch the buckles.

His seatbelt secured him during the impact. After the accident he noticed his legs were scratched and torn and he remembered that there was something heavy on his legs after the crash. He described his injuries as; a broken nose, dislocated jaw, lacerated liver, blurry vision, 2 broken teeth, multiple fractured cheekbones, minor burns on his ears, and lacerations on his face below his left eye. He did not sustain any injuries on his hands. He recommended that cabin seats should be designed so that the seat remained attached to the floor during a crash and that an easier restraint is installed like the type in commercial airplanes rather than one that you have to put your fingers in, and push and turn. He was not sure if his seat broke and when he got up he was standing straight up even though the helicopter was on its right side.

Occupied Seat: 6C
Age: 18 years old
Height: 6 feet, 1 inch
Weight: 165 pounds

The occupant was interviewed by members of the Survival Factors Group including: Cynthia Keegan (NTSB), Marianne Kump (BAE Systems Safety Products), Boyce Bingham (USFS), Scott Benavides (Sikorsky Helicopters), Eric West (FAA)

Grayback employs him as a fire crewmember, and this was his first year as a wilderness firefighter. Prior to entering the helicopter, he received a safety briefing that lasted approximately 6 minutes. During the briefing he and the other firefighters were told that in case of an accident, the seats lean forward and to put their head between their legs and brace for impact. Additionally, he was told where the main door and window exits were located, and if a fire should break out, there were two switches behind the cockpit for the extinguishers. He was also told where to board the helicopter, about the four-point restraints, and how to latch and unlatch the restraints. He was one of the last two passengers to board N612AZ.

When, he got into the helicopter, no one helped him fasten his restraint; he "figured it out himself." He found the restraint unbuckled when he approached his seat. He had problems fastening his restraint and described it as "pretty tricky." At first he could not get his restraints to latch and the buckle seemed off center. He said that it was positioned "weird" and be had trouble latching the top shoulder harness latches. He got all 4 latches into the buckle before take off. He tightened his lap belt but left the shoulder harnesses loose. He stated that the aircraft did not lift off for about 15 minutes after boarding, which provided enough time for him to figure out his restraint. Everyone got

in the helicopter and he noted that the Forest Service HECM got into the seat that he described as the seat identified as 1A on Figure 1

As the helicopter lifted off, he tried to yell to his friend seated next to his. He remembered something not feeling right during the takeoff, and after they took off, he looked out the window and saw the helicopter hitting the tops of the trees. He looked out the front window and saw a large tree and the helicopter started falling to the left really fast, and the lights went out in the cabin. He remembered hearing sirens in the cockpit. He thought he was knocked out when the helicopter impacted the ground. The helicopter jerked to the left and then he remembered being on his left side and the cabin was on fire. The fire was in the middle of the helicopter extending from behind his seat all the way to the front of the helicopter.

After the impact, he was in his seat on its left side but the passenger seated to his right was no longer next to him. There was nothing was on top of him as he tried getting out of his seat. He looked around and then looked for the person sitting next to him but he did not see his seatmate. He tried to get up and then tried to unbuckle his restraint but it would not unbuckle. He turned the buckle with his right hand and pivoted it toward the left (counterclockwise). He grabbed the entire buckle with his left hand and used his right hand to twist the faceplate of the buckle. He had gloves on after the crash and did not take the gloves off to try to open the restraint. The buckle top cover was plastic and he thought that maybe the buckle had gotten too hot and would not unlatch. He started to pull the shoulder harness from his shoulders and then tried to crawl out of the lap belt but the seat came with him. He was unsure if his seat back pivoted forward or remained fixed to the seat bottom. He knew that his seat separated from the floor because his seat came with him when he stood up and he was restrained to his seat by his seatbelt. He also surmised that if the seat had remained attached to the floor, he would have been suspended on his left side restrained in his seat. He pushed his lap belt off his hips and crawled to the back of the helicopter to get away from the fire in the cabin.

He looked for an exit and saw light through an overhead window. He punched out the window (the last window on the right side of the helicopter), and crawled outside and burned his shins on the top of the window exit hatch. He jumped off the helicopter onto the ground and ran about 30 feet uphill towards H44 where N612AZ had departed. Posner (a Task Force Leader) picked him up and helped him away from the wreckage. He was the second survivor to leave the accident scene on a Med-Evac helicopter. He was taken over to a dirt airstrip and was moved to another helicopter for transport to Redding Memorial Hospital.

His injuries consisted of L1 and L3 fractured vertebrae, first and second degree burns on his face, second-degree burns on his ears, and burns on both wrists and both shins. His left wrist was burnt where he wore his metal watch. His hands were not injured. He was wearing his firefighter protective equipment (PPE) that consisted of: fire boots, Nomex pants and shirt, leather gloves, hardhat, and earplugs. His shirt was buttoned all the way to the top. He had previously flown in a 4-passenger helicopter on the way to the site. The restraints in that helicopter were similar to a car seat belt with a

lift buckle and a diagonal shoulder restraint. He had only seen the 4-point rotary buckle in N612AZ and in a racecar but the racecar buckle had a push button in the center of the buckle to release the buckle. He suggested the push button release was a better design than the rotary buckle release design.

4.0 Airplane Damage and Wreckage Site

Impact forces and a post impact fire consumed the fuselage and cabin except for sections of the seat components made of steel, and some internal restraint and seat components. The Survival Factors group examined a Carson Helicopter Services, Inc. sister-ship in Grants Pass, Oregon, and examined the N612AZ wreckage for the remains of seats and restraints. The examination of the sister-ship at Carson Helicopter Services provided the Survival Factors group familiarization of the seats and restraints on board the Sikorsky S-61N accident helicopter. See Attachment 3 for photographs of the Carson sister-ship (N61NH.)

4.1 Carson S-61N Sister-Ship Cabin Exam

On October 29, 2008, the Survival Factors Group visited Carson Helicopter Services, Inc. in Grants Pass, Oregon to document the cabin of a similarly configured S61N helicopter (sister-ship.) The sister-ship was registration N61NH. N61NH was configured with 5 rows of double seats on the right side of the cabin, similar to N612AZ, however, the aft right seat faced aft instead of forward (as in N612AZ.) There were 4 single forward facing seats on the left side of the cabin in N61NH, compared to the 6 single forward facing seats in N612AZ. N61NH also had aft facing double seat on the right side of the cabin, and N612AZ's right rear double seat was forward facing. N61NH was configured with Burns 650 and Aerosmith H25-A1 series seats that were the same design as the seats installed in N612AZ. All the seats in N61NH were equipped with Schroth (Part 1-10-Y30401, manufactured 05/08.) See Figure 2 showing the cabin interior of N61NH.

Figure 2. Photograph of N61NH interior cabin looking aft

The Burns 650 inboard seat legs attached to the cabin floor by depressing a spring loaded pin on the single stud hold down fitting at the base of the seat leg. When the pin is depressed, the stud hold down fitting's steel collar can be moved upwards to release cleats that pivot outward and release from the floor mounted pan fitting. The inboard seat legs can be folded underneath the seat. See the photograph in Figure 3 showing the seat attachment to the cabin floor.

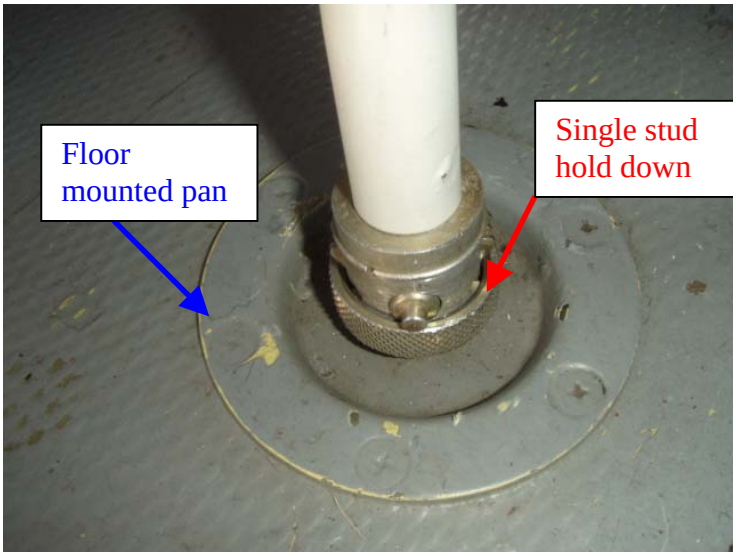

Figure 3. S61N seat leg attachment to the cabin floor

The outboard seat mount consists of a seat track mounted to the side of the cabin (about 15 inches above the floor.) Forward and aft single pin hold down fittings provides

seat attachments to the cabin sidewall. The aft single pin hold down fitting is spring-loaded and locks the seat into the cabin sidewall seat track. See the photograph in Figure 4 showing a view of the bottom of a seat with an extended aft spring-loaded single pin hold down fitting.

Figure 4. Photograph of a single pin hold down fitting

The Burns 650 double seat had a 1.00 inch diameter tubular steel frame and contained the follow data:

Burns Aero Seat, Inc.
Model No. 650D-2-39
Part Number 6502 101
Serial Number 110970
Date of Mfr 6/74
Facing Forward
Weight – unreadable
Type 4
Conforms to FAA TSO C-39

The Aerosmith H25-1 double seat had a 1.75 inch diameter tubular steel frame and contained the following manufacture information:

Aerosmith Inc.
Type 4
Forward Facing
Serial No. 21082
Model H25-A1
Part No. 1412-1
Other Spec – Drawing: 1400

The Aerosmith H25-A1 inboard seat legs were designed with an "X" shaped steel support tube between the forward and aft inboard legs. Its lap restraint end fitting shackles were round steel rings with through bolts (similar to the round rings and through bolts found in the wreckage.) The center of the double seat had a single round ring for attachment of the center lap restraints. The seat had a spring loaded retention lock for the single pin hold down fitting at the outboard end of its aft crosstube. The 1.75-inch diameter Adel clamp mounted on the lower seatback crosstube secured the shoulder restraints. The seat and restraints weighed 37.4 pounds.

Another double seat did not contain a manufacture data tag but a yellow serviceable tag attached to the seat identified the seat as a Burns part number 650-2-39. The double seat had a single seat cushion for both seats and individual seatback cushions for each seat. The forward and rear crosstube for the outboard seat had extension locks that secured the single pin hold down fitting rods inside the crosstubes. The service tag on the seat showed that the seat and restraint weighed 37.2 pounds and the total time that the seat was in service as 38,446.2 hours. Carson mechanics weighed the double Burns 650 series seat and the single Burns 650 seat with the restraints attached. The double seat weighed 37.2 pounds and the single seat weighed 21.6 pounds. Both the Burns and Aerosmith H25-A1 seats were designed so that the seat back pivoted forward without a mechanical stop to retain the seatback during forward or downward impact forces.

The Director of Maintenance for Carson Services west coast division informed the Survival Factors Group that the seats that were installed in N612AZ prior to the accident were Burns Aero 650 series single and double folding seats. See the Maintenance Records Group Factual Report for information regarding the seat and restraints on board the accident helicopter. See Attachment 4 for Sikorsky Aircraft design drawings of the Burns Aero 650 and Aerosmith single and double seats.

4.2 Seat and Restraint Use

A Survival Factors group member sat in a Burns model 650 seat equipped with a 4-point Schroth rotary restraint. The restraint was adjusted, and fastened while wearing leather gloves (similar to the occupants in the accident) and again without the leather gloves. The restraint was more difficult to adjust and release when wearing the leather gloves. The group member also fastened the restraint, bent forward in the seat, and attempted to release the Schroth restraint with gloves. The restraint released without difficulty.

The distance was measured between the rows of double seats at the tops of the seat backs and between the seat cushions and crossbar of the seat in front of each seat. The average dimension between the upper seat back on the right side of the cabin measured 33.5 inches between each double seat and 12 inches between the lower seat bottom and the back of the seat crosstube in front of each double seat. The forth row of double seats at the inboard seat was angled aft and measured 14 inches at the inboard seat and 12 inches at the outboard seat between the seat bottom and the aft crosstube in front

of the seats. The dimension between the top of the single seat backs measured 32, 36, and 35- inches between seats from first seat to the last seat respectively. The dimension between the seat bottom cushions measured 12.5, 13.5, and 14.0 from first seat to the rear of the single seats.

4.3 Seat and Restraint Wreckage

The Survival Factors Group traveled to Sacramento, California, on October 28, 2008 to Plain Parts, Inc. (a wreckage salvage company) to examine the wreckage and document cabin components that had been recovered from the accident site. See Attachment 2 for photographs cabin interior wreckage.

4.4 Seats

The remains of 4 double seat frames from the right side of cabin, an aft facing double seat frame from the left side of the forward cabin, and 3 single seats from the left side of N612AZ's cabin were identified. All of the seat frames were charred and no fabric or seat cushion remained attached to the steel seat frames. The four snap-on end fittings and 2 shoulder end fittings for the double seats remained attached to each seat. Each snap-on end fitting contained a cotter pin and was properly attached to the seat frame. The restraint material was consumed by fire and no material was present on the restraint buckles or restraint hardware found in the wreckage. The remains of the seats were cataloged in the order that each seat was documented.

1 Right – Forward Facing Double Seat

The inboard seat legs remained attached to the seat frame and were folded under the inboard seat. The single stud hold down fitting (that secure the seat legs to the cabin floor) remained attached to the forward seat leg, and the single stud hold down fitting had separated from the aft inboard seat leg. The pan fittings (integral to the cabin floor) were not attached to forward and aft single stud hold down fittings. The outboard upper seat back frame was bent downward and its outboard side brace was bent inboard at the top of the frame. The forward and aft cross-tubes were bent inboard. The forward and aft single pin hold down fitting that secure the outboard seat cross-tubes to the cabin sidewall had separated.

2 Right – Forward Facing Double Seats (identified as seats 4C and 4D)

The seat legs were fractured at the upper side brace at the forward and aft attachments. Both legs had the single stud hold down fittings at the base of the seat legs. The floor mounted pan fitting was attached to the aft single stud hold down fitting remained attached to the floor mounted pan fitting. The melted floor structure surrounded the pan fitting contained a fuel probe that was identified coming from the positioned beneath the cabin floor adjacent to the aft inboard double seat leg associated with seats 4C and 4D. The outboard upper seat back frame was bent forward and downward and its outboard side brace was bent inboard at the top. The forward and aft

cross-tubes were bent inboard. The single pin hold down fittings that secure the outboard seat cross-tubes to the cabin sidewall had separated from both tubes.

3 Right – Forward Facing Double Seats

The inboard seat legs were bent inboard (toward the center of the seat) and the single stud hold down fitting that clips into the cabin floor had separated from the seat legs. The forward and aft cross-tubes remained intact. The single pin hold down fitting that secure the seat to the cabin sidewall had separated from both tubes.

4 Right – Forward Facing Double Seats

The inboard seat legs were fractured from the seat frame. The aft cross tube was intact on the outboard side. The frame for the seat bottoms had fractured and was missing and only the center two seat bottom supports remained attached to the seat. The aft single pin hold down fitting that secures the outboard seat cross-tube to the cabin sidewall had separated from the tube.

1 Left - Aft Facing Double Seats (no shoulder harnesses)

This seat was mounted on a raised platform and was equipped with only a lap restraint. The four standoffs (seat legs) were intact, and the seat mount attach fittings were intact. The four snap-on-end fitting for the lap restraints were properly attached to the seat frame, and contained cotter pins. The aft cross-tube remained intact, and the forward inboard crosstube was bent upward. The single pin hold down fittings that secures the seat cross-tubes to the cabin sidewall were intact.

2 Left – Forward Facing Single Seat

The seat back frame was intact. The seat bottom frame was bent inboard and the inboard aft support was fractured at the aft end of the frame. The seat legs were bent inboard and the single stud hold down fitting remained attached to the floor mounted pan fitting. The forward single stud hold down fitting separated from the seat leg. The bolt on end fitting remained attached to the seat frame, and the shoulder harness attachment had separated from the seat back mount plate. The forward and aft cross-tubes remained intact. The single pin hold down fitting that secure the outboard seat cross-tubes to the cabin sidewall had separated from both tubes.

3 Left – Forward Facing Single Seat

The inboard seat legs remained attached to the seat frame and the single stud hold down fittings had separated from the bottom of the seat legs. The inboard seat pan frame was bent outboard toward the center of the seat. The inboard hinge bracket that secures the seat back to the seat bottom was fractured. The forward single pin hold down fitting that secures the outboard seat crosstube to the cabin sidewall had been cut (during the

wreckage removal) and the aft single pin hold down fitting was intact but fractured at the threaded end of the fitting.

4 Left – Forward Facing Single Seat

The inboard seat legs remained attached to the seat frame and the single stud hold down fittings remained attached to the seat legs. The floor mounted pan fitting remained attached to the inboard seat leg. The seat leg diagonal tube was compressed upward, and the inboard seat bottom frame was buckled upwards. The inboard hinge bracket that secures the seat back to the seat bottom was fractured. The single pin hold down fitting that secures the seat crosstube to the cabin sidewall was missing.

Crew Seat Frame Pieces

The vertical posts and lower seat frame for the flight crewmember seats were found in the wreckage. Both were charred and were the only pieces that corresponded to the flight crew seats. The lower seat frame for one of the seats was fractured at the forward tube.

Cabin sidewall single pin hold down fittings

Three seat (double or single) pins were found in the wreckage. One of the pins had the folding inboard piece attached. There was one other folding inboard piece that had separated from a pin.

4.5 Restraints

The restraints on the accident helicopter, part number 1-10-Y30401 were 4-point static harness, connected to the seat via snap-on hooks at the lap and a single bolt-on fitting at the shoulder. The restraint is adjustable on both shoulders and laps via in-line adjusters. The adjustment allows for proper fit for various sized passengers from 5th percentile females to 95th percentile males. The restraint system is certified to TSO C-114 requirements.

4.5.1 Restraint Description

The Schroth rotary buckle (part number SL 12.5) on the 1-10-Y30401 restraint is certified to meet the requirements of Society of Automotive Engineering (SAE) AS8043A. Schroth rotary buckle SL 12.5 unlatches by twisting the buckle cover 90 degrees in either direction as shown in Figure 5 below. This particular buckle series incorporates what is known as a “lost motion” feature. For a “lost motion” buckle, the first approximate 30 degrees of rotation in either direction does not actuate the locking pins (i.e., release of the latches). This feature is designed to prevent items such as tool belts, firearms worn by passengers or crew from inadvertently unlatching the buckle.

SAE Aerospace Standard (AS) 8043B "Restraint Systems for Civil Aircraft" specifies that the rotational force by twisting/torsion motion shall release with less than 13Kn or 30 pounds of force. According to the Schroth Qualification Test Report, the buckle release force with load applied to the lap and shoulder belts ranged between 9.7 and 14.2 pounds.

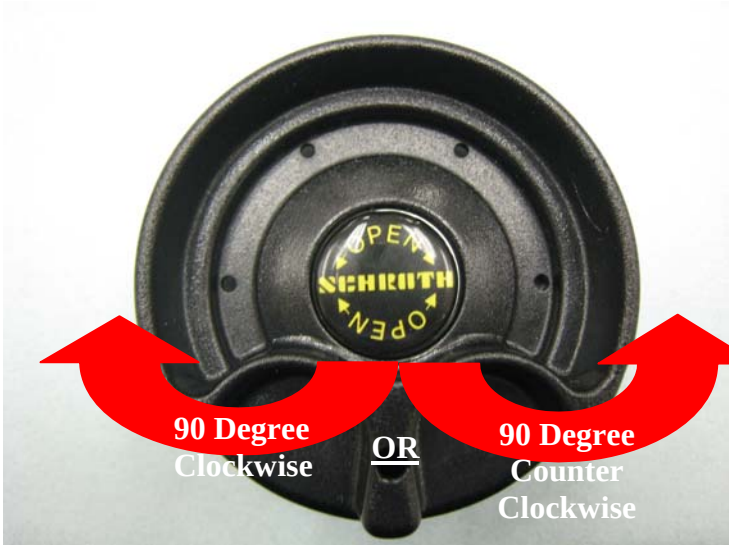

FIGURE 5. Schroth Buckle Cover Movement

Twisting the buckle cover actuates a cam style component within the buckle the movement of the cam creates a downward motion on a spring-loaded plate. The plate is designed to capture the spring loaded locking pins of the buckle. The locking pins have a flanged end installed below the plate. A downward motion on the plate causes the pins to move down, and tilt members convert the rotational motion into a vertical motion causing the release plate to move down and forcing the flanged pins to move down. As the pins move down, the latches retained within the buckle are simultaneously released. The latches are pushed out of the buckle by springs located at the tip of each latch. The springs are installed in the buckle-retaining cage. (A description of the retaining cage follows in the latch installation section.)

4.5.2 Schroth Latch Installation

Schroth rotary buckle SL 12.5 is designed with receptacles for insertion of 5 latches into the buckle. The accident restraint design did not include a fifth point latch connection and therefore the bottom or anti-submarine receptacle was not used in its design. The retaining cage includes a hole within each receptacle space for the locking pin to protrude. Four of the five locking pins are designed to accept latches and the fifth pin is fixed to one side of the restraint. The fixed pin holds the restraint to the buckle. When the buckle is rotated and releases the latches the fixed pin does not move and the latch in this position remains engaged in the buckle. The locking pins that do move and can accept a latch for locking the occupant into the restraint are beveled. As the latch is

inserted, the bevel on the pin creates a downward force the makes the pin move down and out of the way of the latch. As soon as the hole in the latch is lined up with the pin the pin moves upward and captures the latch. Figure 6 below identifies the components mentioned in the description above.

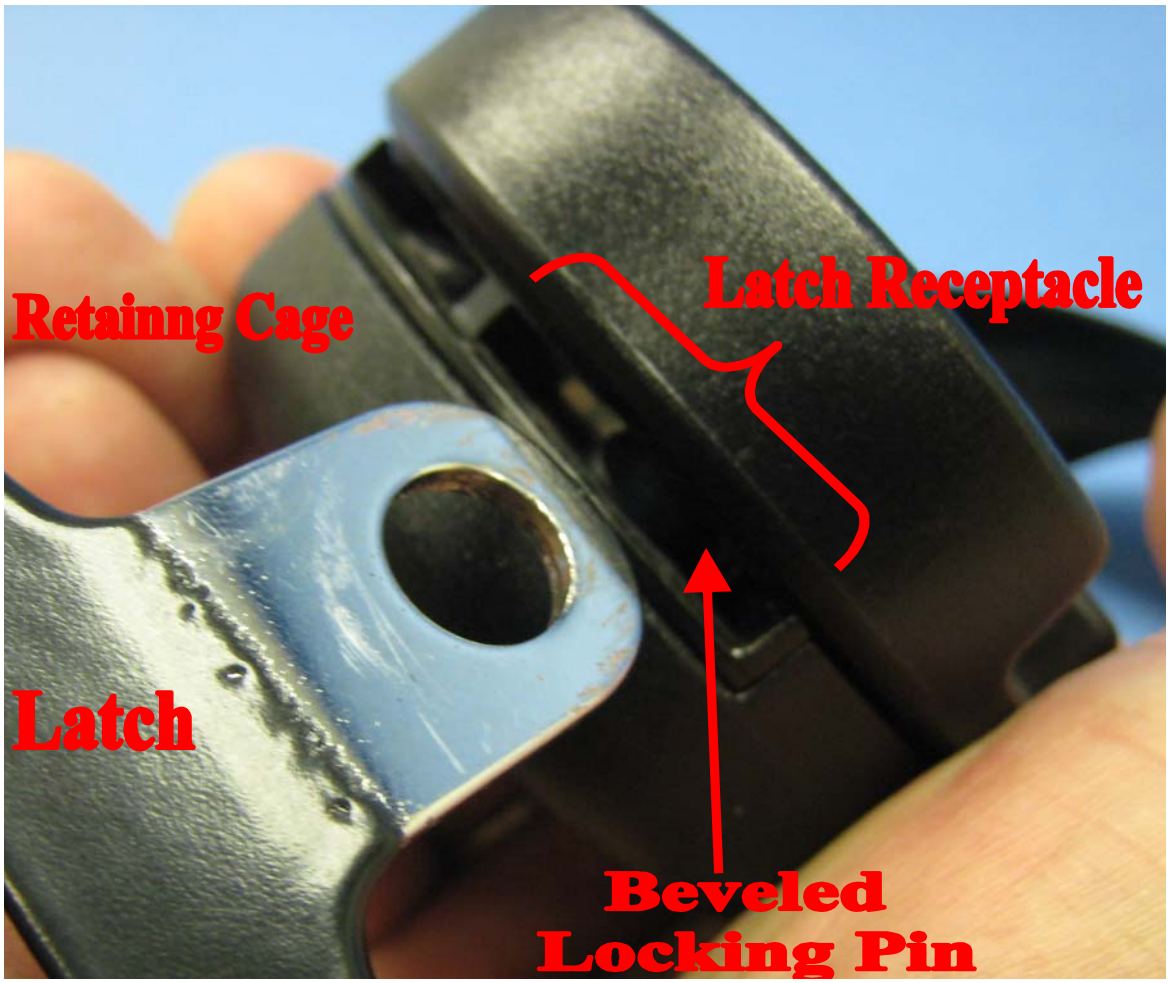

FIGURE 6. Insertion of Latch into a Schroth Buckle

4.6 Restraint Examination

The Survival Factors Group examined an exemplar Schroth seatbelt buckle in the NTSB laboratory on September 24, 2008. The buckle was disassembled and examined to understand its internal components and to understand how the latches release from the buckle. Thirteen passenger buckles, and a flight crewmember buckle (buckle #5 in the table below) from the accident helicopter were examined in the NTSB laboratories. Two other passenger buckles were found in N612AZ's wreckage and are included in the following buckle documentation chart. See Attachment 5 for photographs of the restraints from N612AZ.

Buckle #	Tilt Members	Latches Engaged	Pins and Central Screw
Buckle #1	3	All latches engaged in correct positions.	Right shoulder strap pin missing. Central screw intact.
Buckle #2	2	All latches engaged in correct positions.	Pins intact and central screw partially melted
Buckle #3	3	All latches engaged in correct positions.	Pins intact and central screw intact
Buckle #4	3	All latches engaged in correct positions.	Pins intact and central screw intact.
Buckle #5 (Pacific Scientific)	None	4 Latches engaged.	
Buckle #6	3	Right lap not engaged but discolored where it would latch into the buckle, shoulder latches engaged.	Pins intact and central screw melted but intact.
Buckle #7	3	Right lap latch in crotch position. All others latched.	Pins engaged and center screw intact
Buckle #8	3	Right lap latch is engaged 180 degrees opposite its correct engagement.	Pins and Central Screw intact.
Buckle #9	3	Left fixed latch engaged, all others not engaged. 8 springs in package, and D-ring strap retainer present.	Pins and Central screw intact. Extra pin in pkg.
Buckle #10	3	Right lap latch is engaged 180 Degrees opposite its correct engagement. Shoulder latches not engaged.	Pins and Central Screw intact.
Buckle #11	2	Lap latches engaged properly and Shoulder latches not engaged.	Pins and central screw intact
Buckle #12	2	All latches engaged in correct positions	Pins and central screw intact.
Buckle #13	2	All latches engaged except the right shoulder harness latch is not engaged, and the left shoulder is engaged 180 opposite its correct engagement.	Pins and central screw intact. Excess of burned debris around this buckle.

Buckle #14	3	Right Lap engaged. Fixed left lap latch and shoulder latches not engaged.	One beveled right lap pin engaged, one beveled and one fixed pin loose.
Buckle #15	3	Lap and shoulder latches properly installed and intact	latching pins intact and central screw partially melted.
Buckle #16	3	Right lap latch is engaged 180 degrees opposite its correct engagement. Right shoulder and left fixed latch intact and latched. Left should latch was not engaged but found in the wreckage and shiny where it had been engaged.	The left pin is missing and the central screw is intact.

4.7 Restraints Components

A portion of a right shoulder restraint fitting with the latch, adjuster and melted webbing were found in the wreckage. There was a piece of D-ring attached to the back of the restraint piece.

One snap-on end fitting (the same as the snap-on end fitting on an Aerosmith H25A-1 seat) with cotter pin intact was attached to a ring attachment. Another snap on end fitting was found loose in the wreckage. Two loose shoulder restraint end fittings: one with an Adel clamp (used to attach the shoulder restraint to the seat support) and the other fractured and separated from the end fitting were found in the wreckage. One lap latch fitting and 3 shoulder latch fittings (one encased in melted and charred wreckage) were found. Fifteen D-Rings (holds loose webbing to the restraint webbing) and 44 web adjusters were found in the wreckage. Eight of the web adjusters had the adjuster springs intact, 5 had the adjuster bars fixed and 21 had loose adjuster bars. A fire extinguisher handle was found in the cabin wreckage. The handle had separated from the extinguisher.

4.8 Left Emergency Exit Hatch

The left emergency exit hatch and rubber window seal were found in the wreckage. The exit hatch plexi-glass window was shattered and missing and its handle was stowed. The upper frame of the hatch was bent upwards, and its interior latch handle was in the stowed position. The rubber seal was intact and contained the pull-tabs on the exterior and interior side of the seal.

5.0 Seat and Restraint Certification

The aircraft was originally certified to Civil Air Regulations Part 7, Rotorcraft Airworthiness Transport Categories, and effective August 1, 1956. The purpose of this

regulation was to establish airworthiness requirements for transport category multi-engine rotorcraft. Subpart D, Design and Construction, Section Personnel and Cargo Accommodations, Paragraph 7.355 Seats and Safety Belts describes the use of occupiable seats, belts, harnesses (if used) and adjacent parts to avoid serious injury during emergency landing conditions. Paragraph 7.260, under Section Emergency Landing Conditions, specifies the ultimate inertia forces relative to the surrounding structure experienced by the occupants to enable the escape of serious injury in a minor crash landing. These loads are listed as upward 1.5g (downward 4.0g), forward 4.0g, and sideward 2.0g.[13] The 4-point Schroth restraints on the accident aircraft met the Technical Standard Order TSO-C114, Torso Restraint Systems.

5.1 U.S. Forest Service/Carson Helicopters Contract – Passenger Restraints

The U.S. Department of Agriculture Forest Service established contract AG-024B-C-08-9340 with Carson Helicopters Inc. on June 6, 2008. Section C, Description Specification/Exhibits, Subsection D. General Equipment, 8. through 10. states there must be:

> 8. Seat belts for all seats. One set of individual lap belts for each occupant.
> 9. FAA-approved double-strap shoulder harness with automatic locking inertia reels for each front seat occupant. Shoulder straps and lap belts shall fasten with one single-point, metal-to-metal, and quick-release mechanism. Standard factory shoulder harnesses are acceptable for Aerospatiale and Bell transport category helicopters. Military style harnesses are acceptable. (Exhibit 4, Restraint Systems Condition Inspection Guidelines.) See Attachment 6 for Exhibit 4 from U.S. Forest Service Contract AG-024B-C-08-9340.
> 10. FAA approved single diagonal shoulder harness with inertia reel integrated with the lap seat belt with one single point metal-to-metal, quick release mechanism for each passenger position. For aircraft equipped with airline type seats, a single or a double FAA approved shoulder harness integrated with a seat belt with one single point metal-to-metal quick release mechanism for each passenger position.[14]

A Forest Service representative informed Safety Board staff that a USDA Forest Service Airworthiness Inspector inspected N612AZ on June 26, 2008 for compliance of contract AG-0124B-C-08-9340, and issued an Interagency Fire Helicopter Data Card (approving N612AZ to operate for the Forest Service.)

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[13] Title 14 CFR Part 29, Section 29.561, Subpart C – *Strength Requirements Emergency Landing Conditions* currently lists seat design loads as: upward 4g, forward 16g, sideward 8g, downward 20g, and rearward 1.5g.

[14] A Forest Service representative informed Safety Board staff that N612AZ was equipped with airline type seats (as apposed to military side facing seats) and the restraints (the Schroth 4-point restraints) were single point release restraints (as opposed to a separate release for the shoulder harness) as required by the contract.

5.2 FAA DER Restraint Approval for Carson S-61N Helicopters

N612AZ's maintenance records included FAA Form 8110-3 "Statement of Compliance with the Federal Aviation Regulations" Report No. SR2006-1 NC, dated July 12, 2006. The document was issued by Carson Helicopters and was signed by FAA Designated Engineering Representative (DER) David A. Lawson, Jr. DERT-830332-NE. Report SR2006-1 NC provided structural design data and analysis for the installation of shoulder harness restraints on the seats installed in the S-61N (Serial Numbers: 61216, 61220, 61242, 61465, 61472, 61744, 61426, and 61453.) The accident helicopter (N612AZ) was serial number 61297 and was not owned by Carson Helicopter Services, Inc. when Report SR2006-1 NC was issued.

On September 19, 2008, Carson Helicopters, Inc. issued FAA Form 8110-3. DER David A. Lawson DERT-830332-NE signed this form. The form referenced report CH-08233 and was titled; Stress Report, "Installation of Seat Harness" for the S-61N helicopter, and 5 separate Form 8110-3 were issued for S61N Serial Numbers: 61220, 61474, 61216, 61242, and 61744. Report No. CH-08233 Revision "Structural Substantiation of Shoulder Harness Installation on Sikorsky S-61L/N Model Helicopters" accompanied the Form 8110-3, and states that it demonstrates that the Shoulder Harnesses installed on the Sikorsky Model S-61L/N helicopters meets the requirements of civil air regulations (CAR) Part 7, Rotorcraft Airworthiness; Transport Categories. Report No. CH-08233 references Burns 650 and Aerosmith H25-1 seat part numbers (like the seats installed in N612AZ) and provides the analysis for the installation of 4-point restraints similar to the way the Schroth 4-point restraints were installed in the N612AZ. See Attachment 7 for copies of Reports SR2006-1 NC and CH-08233, and the associated FAA Form 8110-3.

5.2.1 DER Interview

The Survival Factors Group interviewed David A. Lawson, Jr. (DERT-830332-NE) on December 18, 2008, by members of the Survival Factors Group including: Cynthia Keegan (NTSB), Kristin Poland (NTSB), Marianne Kump (BAE Systems Safety Products), Boyce Bingham (USFS), John Harris (Carson), and Pocholo Cruz (NTSB.)

His aerospace engineering background began after he graduated from college in 1989[15]. He worked at the Boeing Commercial Airplane Group, Seattle, Washington, between 1990 and 1995 on damage tolerance and stress analysis of the Boeing 737-700 and 777-200 main landing gear and engine strut attachments and main landing gear. He worked at Lockheed-Martin Tactical Aircraft Systems, Fort Worth, Texas, in 1996 as a stress engineer on the F-22 Raptor advanced tactical fighter. In 1997 he worked at

[15] Mr. Lawson attended the University of Texas in Arlington, Texas between August 1985 and August 1987, and received a Bachelor of Science in Aeronautical Engineering from the Polytechnic University in Farmingdale, New York in December 1989.

Northrop-Grumman (Vought Aircraft), Dallas, Texas on durability and damage tolerance of the C-17 Globemaster III, and for the material review board (MRB) doing stress analysis. In 1997 and 1998 he worked as a stress engineer at the Boeing Defense and Space Group, Seattle, Washington, on the X-32 Joint Strike Fighter, and in 1998 he worked for Lockheed-Martin Skunk Works, Palmdale, California on the F/X-35 Joint Strike Fighter. Between 1999 and 2002 he worked as the Supervisor of the Structural Analysis Department at EDO Marine and Aircraft Systems, Amityville, New York doing damage tolerance on weapon release systems for the F-22 Raptor.

Between 2002 and 2005 he worked as a safety engineer for the FAA's New York Aircraft Certification Office (ACO) on damage tolerance, fatigue and static strength analysis and on major alterations and repairs of airplanes and rotorcraft. He also worked as a DER advisor to 16 structural DERs between 2000 and 2005. In 2006 he worked as a fatigue analyst for Sikorsky Helicopters, Stratford, Connecticut on the MH 60R and MH 60S Sea Hawk. During his work at Sikorsky he also worked as a consultant DER (when he was approached by Carson to do a structural analysis for a seat alteration.) In 2007 he worked as a DER and MRB structural analyst for Eclipse Aviation Corporation, Albuquerque, New Mexico reviewing and approving damage tolerance, fatigue and static strength reports for the production certification of the EA500 Very Light Jet (VLJ). In 2007 and 2008 he worked at Adams Aircraft Industries, Denver, Colorado, performing damage tolerance analysis and DER for the structural substantiation of flight control systems and landing gear on the A700 VLJ type certification project.

He has recently worked with Korea Aerospace Industries (KAI) on small passenger (four passenger) aircraft design, and he currently is a structural analyst and DER Consultant for Lawson Aerospace LLC, New York, New York, performing FAA data approval in support of type certificate projects and major alterations and repairs for transport category airplanes and rotorcraft in accordance with Title 14 Code of Federal Regulations (CFR) Parts 23, 25, 27 29 and 31. He has worked as a DER for the past 3 years. He met Frank Carson (Owner of Carson Helicopters) and Jeff Hill about 5 years ago while working at the FAA. About 2 years ago Mr. Carson contacted him and requested he look at the loads for putting a 4-point restraint on the S-61N seats. According to Mr. Lawson the Forest Service asked Carson to add shoulder harnesses to the seats and Carson asked him to do a structural analysis and complete a form 8110-3. It took him approximately 3 days to complete the shoulder harness analysis for Carson.

The technical information he used to evaluate the installation of the restraint harnesses on the S-61N seats, consisted of the seat drawings, photographs of the seats and restraints, the analysis of seats and AC 43-13.2 and classical analysis referred within engineering manuals. Mr. Lawson was working at Sikorsky at the time and was able to dig up an old analysis of the seats and look at a similar helicopter at Sikorsky. The certification basis he used for the S-61N seats was CAR 7, Amendment 4 plus anything else that was appropriate for that specific model of helicopter. The design requirements he addressed during his approval of the design data included the occupant weight, the structural design limits of the seat and a factor of safety. He also addressed the transfer

of loads to the seat structure. He wanted to ensure the seat structure could withstand the loads applied through the 4-point restraint.

His knowledge of the design and operation of the seats was limited to the drawings and photographs of the seats. There were no operating manual or instructions on how the seat operated. The drawings showed the materials of the seats, and he determined the loads that a restrained occupant could withstand by the dimensions and material of the crossbar where the shoulder restraints attached to the seat. His inclination about the Forestry Services request to Carson to change the lap restraints to 4-point restraints was "why make the change?" However, his job was to determine if the seats could withstand the load of installing the shoulder harness on the aft crosstube, so that is what he did when he completed the 8110-3 approval.

The purpose of Report Number CH-8233, dated September 19, 2008, was because Carson was putting the shoulder restraints on other public use aircraft and they requested that he complete a more formalized data analysis of the attachment to the Burns and Aerosmith seats. He completed the original 8110-3 approval for Carson in July 2006 with a pencil and paper, so he wanted to create a more formalized analysis for the recent data request. The September 2008, CH-08233 contained the same data, but it was a more professional report. The restraints that he reviewed in the July 12, 2006, 8110-3 approval and Report CH-08233 were for the 4-point restraints. He was not aware who manufactured the restraints. His data showed that the seat crosstube could accommodate the installation of the shoulder restraints. The 4-point restraints that attached to the S-61N seats were technical standard order (TSO) restraints. The Adel clamp that attached the shoulder restraint to the seat crosstube was the same type hardware used to attach the restraints to civil aircraft, and Carson's helicopters were public use aircraft.

Mr. Lawson stated there was no requirement for him to create a Major Alteration or Repair (FAA) Form 337. The Form 337 is used by FAA flight standards and by the aircraft mechanic to approve the installation of the restraints. He was not approving the installation of the restraints he was approving data in support of the installation. He created a form 8110-3 approval for each Carson helicopter and he provided Report No. Ch-08233 was the engineering data for the installation of the shoulder restraints on board each helicopter.[16] Carson did not request that he revise the July 2006 8110-3 to include N612AZ before the accident occurred.

The Forest Service called Mr. Carson a couple months ago and requested that he (the DER) provide his approval of form 8110-3 showing compliance for the installation of the shoulder restraints on the remainder of the Carson helicopters. Carson informed him that they wanted to show the Forest Service that the certification basis for the restraints installed on the S-61N/L seats met the requirements of CAR 7, Amendment 4 and that the restraints were in compliance with the applicable requirements. The only other time prior to September 19, 2008, that he provided engineering data (FAA Form

[16]A Carson representative informed the Survival Factors group that N612AZ (S/N 61297) was not included in the September 19, 2008 report it was destroyed in the accident before Report CH-8233 was issued.

8110-3) for Carson was when he completed Report Number SR 2006-1, dated July 12, 2006. Carson contracted him twice to do the same engineering analysis for different serial number aircraft.

He said that if the backrest folds forward during a crash, a folding seatback would apply a bending moment to the legs of the seat and give a load similar to the load transferred to the seat by a lap belt. The loads from a shoulder harness would only apply tension loads to the crossbar on the back of the seat. When a person is moving forward, the loads move forward, translating to the horizontal seat bar. If the seat back locks during a crash, the loads would be applied very differently to the shoulder harness, than if the seat back moved forward with the shoulder harness.

6.0 Medical and Pathological

6.1 Injury Table

Injuries	Flight Crew	**Passengers**	Other	Total
Fatal	1	8	0	9
Serious	1	3	0	4
Minor	0	0	0	0
None	0	0	0	0
Total	2	11	0	13

6.2 Survivor Injuries and Occupant Pathology

The co-pilot and one surviving passenger were transported to Mercy Medical Center, in Redding, California. The other two surviving passengers were taken to U.C. Davis Medical Center, Sacramento, California. Trinity and Shasta County contracted the autopsies of the fatally injured occupants on board N612AZ with the Forensic Medical Group, Inc., Fairfield, California. See Attachment 8 for the injury chart describing the occupant injuries.

Cynthia L. Keegan
Senior Survival Factors Engineer

Attachments

1. IRPG Helicopter Passenger Briefing
2. Photographs of N612AZ wreckage
3. Photographs of the Carson sister-ship (N61NH.)
4. Sikorsky Aircraft Design Drawings - Burns Aero and Aerosmith Seats
5. Photographs of the restraints from N612AZ
6. Exhibit 4 from U.S. Forest Service Contract AG-024B-C-08-9340.
7. Reports SR2006-1 NC and CH-08233, and the associated FAA Form 8110-3.
8. Injury Chart describing the occupant injuries.