Aviation Investigation Final Report

Location:	Reno, Nevada	**Accident Number:**	SEA08GA194
Date & Time:	September 1, 2008, 18:10 Local	**Registration:**	N4235T
Aircraft:	Lockheed P2V-7	**Aircraft Damage:**	Destroyed
Defining Event:	Powerplant sys/comp malf/fail	**Injuries:**	3 Fatal
Flight Conducted Under:	Public aircraft		

Analysis

Just after the airplane's landing gear was retracted during takeoff for a retardant drop mission, a ball of fire was observed coming out of the left jet engine before the airplane rolled steeply to the left and descended into the terrain. Prior to takeoff, the captain said he would make the takeoff and provided a takeoff briefing concerning the runway to be used and his intentions should an emergency develop. Shortly thereafter, the captain informed the co-pilot that this would actually be his (the co-pilot's) takeoff. On the cockpit voice recorder, the co-pilot stated "Same briefing (sound of laughter)". The co-pilot did not give an additional takeoff briefing beyond the one given by the captain and the captain did not ask the co-pilot to give one. During the initial climb, the captain said he detected a fire on the left side of the airplane and the co-pilot responded that he was holding full right aileron. At no point did either pilot call for the jettisoning of the retardant load as required by company standard operating procedures, or verbally enunciate the jet engine fire emergency checklist. Recorded data showed that the airplane's airspeed then decayed below the minimum air control speed, which resulted in an increased roll rate to the left and impact with terrain. The 11th stage compressor disc of the left jet engine failed in fatigue, which caused a catastrophic failure of the compressor section and the initiation of the engine fire. Metallurgical examination of the fracture identified several origin points at scratches in the surface finish of the disk. The scratches were too small to have been observed with the approved inspection procedures used by the company. A review of the FAA sanctioned Approved Aircraft Inspection Program, revealed no shortcomings or anomalies in the performance or documentation of the program. A post-accident examination of the airframe and three remaining engines revealed no anomalies that would have precluded normal operations.

Probable Cause and Findings

The National Transportation Safety Board determines the probable cause(s) of this accident to be: The failure of the flight crew to maintain airspeed above in-flight minimum control speed (Vmca) after losing power in the left jet engine during initial climb after takeoff. Contributing to the accident was the crew's inadequate cockpit resource management procedures, the failure of the captain to assume command of the airplane during the emergency, the flight crew's failure to carry out the jet engine fire emergency procedure, and the failure of the crew to jettison the retardant load.

Findings

Aircraft	Airspeed - Not attained/maintained
Personnel issues	CRM/MRM techniques - Flight crew
Personnel issues	Aircraft control - Flight crew
Personnel issues	Lack of action - Flight crew

Factual Information

History of Flight

Initial climb	Powerplant sys/comp malf/fail (Defining event)
Initial climb	Loss of engine power (partial)
Initial climb	Loss of control in flight
Uncontrolled descent	Collision with terr/obj (non-CFIT)

HISTORY OF FLIGHT

On September 1, 2008, about 1810 Pacific daylight time, N4235T, a Lockheed P2V-7/SP-2H airplane, was destroyed after impacting terrain following a loss of power and loss of control about 2 miles northwest of the Reno/Stead (4SD) Airport, Reno, Nevada. The airplane, using the call sign Tanker 09, was registered to Neptune Aviation Services Inc., of Missoula, Montana, and operated by the California Department of Forestry and Fire Protection (CAL FIRE). The airline transport licensed captain, who occupied the left crew seat, the airline transport licensed co-pilot, who occupied the right crew seat, and the flight mechanic, who occupied the cockpit jumpseat, were killed. Visual meteorological conditions prevailed for the Public Use air drop flight, which was being operated in accordance with Title 14 Code of Federal Regulations (CFR) Part 137, and a company flight plan was filed and activated. The flight was originating at the time of the accident.

According to Neptune Aviation Services' records, the accident flight crew had flown 1 firefighting support mission on the morning of the accident. The purpose of the accident flight was to support the Smitty fire, which was located about 85 nautical miles south of 4SD.

According to records provided by the United States Department of Agriculture (USDA) Forest Service, at 1730 the Sierra Front Interagency Dispatch Center (SFIDC) submitted an initial attack resource order to the Reno/Stead Air Attack Base for two air tankers to support the Smitty Fire. At 1735, the resource order was received and the crew of Tanker 09 was notified of the dispatch. At 1743, Tanker 09 was loaded with 2,070 gallons of fire retardant. At 1755, Tanker 09 registered in micro motion data as "completed loading." At 1758, the captain radioed ramp instructions to not cancel their hotel rooms. They would be returning to Reno/Stead.

In an interview conducted by the NTSB investigator-in-charge (IIC), the accident airplane's regularly assigned crew chief reported that on the morning of the accident he arrived at the tanker base at about 0900. The crew chief further reported that upon his arrival he did a walk-around, performed his checks of the airplane and noted no anomalies. The crew chief stated that the captain fueled the right wing, the co-pilot fueled the left wing, and after the co-pilot completed fueling he did his walk-around inspection of the airplane, with no anomalies noted.

The crew chief reported that after all crew members were aboard, the radial engines were started followed by the jet engines being started; again, no anomalies were noted. After takeoff at about 1000, the airplane departed to the south, proceeded to the retardant drop area and made two drops before returning to the air attack base. The crew chief stated that after landing and shutting down, no fuel was added; his post-flight walk-around inspection did not reveal any anomalies with the airplane. He continued by stating that the crew then had lunch at the tanker base, and after lunch he looked over the accident airplane again, and again no anomalies were noted. The crew chief stated that about 1730 the accident crew received a dispatch notice, after which he and the accident flight mechanic preflighted the airplane; again, no anomalies were noted. The crew chief revealed that the accident flight mechanic had requested to take the flight, which the captain authorized. The crew chief stated that while standing at the rear and to the left of the airplane, he observed the radial engines being started, the magnetos being checked, and the jet engines started; no anomalies were noted. The crew chief reported that he witnessed the accident airplane on the runway ready for takeoff, again viewing it from the left side, and again said he didn't observe any anomalies. He reported that he watched the airplane take off, observed the landing gear retract and lock in the wheel wells, "… and when the airplane was approximately 200 feet I saw a ball of fire, with flames coming out of the left jet. It was in a 10 to 15 degree left bank." The crew chief stated that he made a call to the tanker base to inform the flight crew that they had a left jet fire. The crew chief stated that after the airplane went out of view, the next thing he saw was a ball of fire.

At 1801:32.8, after both radial engines had been started, the Cockpit Voice Recorder (CVR) indicated that the captain briefed the co-pilot where they were going on the map – near Reno.

At 1804:04.6, the CVR indicated the captain said, "Go ahead and start your engines."

From 1805:06.7 to 1806:28.0, the captain and co-pilot proceed through the challenge and response Before Takeoff checklist.

At 1805:44.3, the CVR recorded the co-pilot say, "Briefing."

At 1805:45.5, the CVR indicated the captain said, "Okay, this will be a VFR departure off of runway three two. Same numbers, same calls. Ah, if we get into the air we enter a left downwind, come back around for three two. I don't want to pack the load. Any questions?"

At 1806:09.3, the CVR recorded the captain tell the co-pilot, "Actually, this will be your takeoff."

At 1806:14.4, the CVR indicated the co-pilot said, "Same briefing (sound of laugh)."

At 18:07:05.8, the CVR recorded the sound of increasing engine speed.

At 1807:16.5, the CVR indicated the co-pilot said, "Got rudder control."

At 1807:27.7, the CVR indicated the captain said, "Eighty, cross checked."

At 1807:38.9, the CVR indicated the captain said, "One oh eight, rotate."

At 1807:43.9, the CVR indicated the co-pilot said, "Positive rate."

At 1807:55.5, the CVR indicated the co-pilot said, "METO (Maximum Except Take Off) power."

At 1808:00.2, the CVR indicated the sound of decreasing engine speed.

At 1808:05.4, the CVR indicated the co-pilot said "Whoa," followed by a sound of heavy breathing.

At 1808:10.5, the CVR indicated the captain said, "We got a fire over here. A big ol fire."

At 1808:15.2, the CVR indicated the co-pilot said, "I'm holding full right aileron."

At 1808:28.8, the CVR indicated the captain made a sound of heavy breathing..

At 1808:31.0, the CVR indicated the captain made a sound of heavy breathing.

At 1808:32.3, the CVR indicated the sound of impact. End of recording.

The recorded data revealed that during the emergency the flight crew did not perform the engine fire emergency procedure for the jet engine that failed, nor did the captain attempt to assume command of the airplane during the emergency.

The wreckage site was located at a measured distance of 1.2 nautical miles from the departure end of Runway 32, on a measured magnetic heading of 289 degrees. The impact heading was on a measured magnetic bearing of 260 degrees, and the airplane came to rest on a measured magnetic heading of 250 degrees.

Three air attack base personnel submitted witness statements to the NTSB IIC:

Witness #1, the air attack base ramp manger, reported that as he watched Tanker 09 proceed down the runway on its takeoff roll he was talking with one of Tanker 09's mechanics who said that the left side gas jet was on fire as the airplane was lifting off. The ramp manager further stated that at this point he tried calling the crew of Tanker 09 to inform them that they had an engine fire, but there was no response. The ramp manager reported that he observed the wing had become fully engulfed in flames, followed by the fire increasing before the airplane banked to the left and crashed "in a ball of flames."

Witness #2, the assistant air attack base manager, reported that prior to Tanker 09's takeoff roll, he issued a "roll time" of 1806, then observed the flight crew running up the radials and the turbines prior to the takeoff roll. The assistant base manger said that during the airplane's

takeoff roll he observed "an unusually bright orange glow coming from the left wing." The assistant base manager revealed that when he observed the airplane begin a left turn, the glow of the fire increased. The assistant base manager reported, "I watched as the aircraft slowly rolled left about 45 degrees of bank, about 200 to 300 feet above ground level (agl). The fire grew explosively and engulfed the left wing. The aircraft attitude at 45 degrees of bank appeared to be a sideslip, like the right rudder was given, and then continued to roll left past 60 degrees [of bank] as the aircraft yawed back left and impacted the ground left wing first, slightly nose down."

Witness #3, the air attack base manager stated that on the day of the accident he was functioning as the Parking Tender for Tanker 09, and that he marshaled the airplane out on the accident flight. The base manager reported that after marshaling the airplane out, he went upstairs to the dispatch office and heard Tanker 09 call "rolling," and at the same time "I heard the jet assist and the plane rolling down Runway 32." The base manager stated that he subsequently heard another ground crewman yell, "Oh no. Oh no." The base manager stated, "I could see the left jet engine was on fire. It gave the appearance of a meteor with a tail of fire trailing the left side. It also appeared that the whole left wing was ablaze and the plane was turning left before impact. From my vantage point it seemed the aircraft was between 300 to 500 feet agl (above ground level) before it started losing altitude."

Additionally, four witnesses who were located outside of the airport property submitted witness statements to the NTSB IIC:

Witness # 1 reported observing the airplane depart Runway 32 with its left wing on fire. The witness further reported hearing two "exploding noises," followed by seeing the airplane in a left turn before being out of control. The witness reported observing the airplane flipping upside down in a nose down attitude and going through power lines before impacting the ground.

Witness #2 reported hearing a "small explosion" as the airplane took off and observed its left engine on fire. The witness stated that it appeared the airplane "…struggled to level out and climb, then it turned over and hit the ground."

Witness #3 reported that while exiting an interstate highway which borders the airport, "…my wife and I noticed an orange light over the airfield. The light got larger and we realized we were watching an aircraft going down. After about 5 seconds the aircraft impacted the ground with a large fireball."

Witness #4, a first responder to the accident site, reported that while observing the airplane proceeding to the north, "I heard the aircraft engine make a loud backfire." The witness stated that the airplane then went behind some trees and out of sight, and then she heard a loud explosion, followed by observing a large plume of black smoke.

PERSONNEL INFORMATION

The Captain

The captain, age 61, held an airline transport pilot certificate with the ratings and limitations of airplane multiengine land, commercial privileges for airplane single-engine land, and type ratings for the CE-500, DC-3, DC-3TP and the L-P2V. He obtained his L-P2V type rating on August 23, 1984. Additionally, he held flight instructor and airframe and powerplant mechanic certificates. His most recent FAA first-class medical certificate was issued on January 25, 2008, with no limitations or waivers.

According to Neptune Aviation Services' records, the captain had accumulated 9,520 total flying hours, of which 2,860 were in the L-P2V. He had flown 5, 55, and 118 hours in the past 24 hours, 30 days, and 90 days respectively. The captain's most recent FAR 61.58 pilot-in-command proficiency check was completed on February 21, 2008.

The captain completed Crew Resource Management Training on February 8, 2008, and on February 22, 2008, he was authorized to act as a FAA pilot proficiency examiner on P2V 5 & 7 series airplanes. On February 28, 2008, the captain completed Neptune Aviation Ground Training, and on March 18, 2008, he was designated as a company initial attack training pilot. The captain's most recent Forest Service Airplane Pilot Qualification and Approval Record was dated April 10, 2008.

The captain's original date of hire with Neptune Aviation Services was July 10, 1998. He was employed as a United States Forest Service Pilot from 1978 to 1998, and again from April 2004 until November 2007. The captain returned to Neptune Aviation Services to assume the role as company chief pilot on November 1, 2007.

The Co-pilot

The co-pilot, age 41, held an airline transport pilot certificate with the ratings and limitations of airplane multiengine land, commercial privileges for airplane single-engine land, and a type rating for the L-P2V. He obtained his L-P2V type rating on April 29, 2006. Additionally, he held flight instructor and airframe and powerplant mechanic certificates. His most recent FAA first-class medical certificate was issued on December 26, 2007, with no limitations or waivers.

According to Neptune Aviation Services' records, the co-pilot had accumulated 2,812 total flight hours, of which 324 were in the L-2PV. He had flown 5, 55, and 121 hours in the past 24 hours, 30 days, and 90 days respectively. His most recent FAR 61.55 second-in-command qualification check was completed on March 3, 2008. He completed Crew Resource Management Training on February 14, 2008, and Neptune Aviation Ground Training on February 18, 2008. His most recent Forest Service Airplane Pilot Qualification and Approval Record was dated April 9, 2008.

The co-pilot's date of hire with Neptune Aviation Services was July 1, 2002.

The Flight Mechanic

According to Neptune Aviation Services records, the flight mechanic, age 25, was hired on May 1, 2008. The flight mechanic held airframe and powerplant mechanic certificates and a private pilot certificate with an airplane single-engine land rating. Company personnel reported that this was the flight mechanic's first operational flight on the L-P2V.

AIRCRAFT INFORMATION

N4235T, serial number 150282, was manufactured by the Lockheed Aircraft Corporation in 1962. A mid-wing, 4-engine airplane, it was originally developed by the United States Navy as an anti-submarine warfare airplane.

The airplane is powered by two radial, 18 cylinder, aircooled, Curtiss Wright R3350-32WA engines, rated at 2,800 horsepower, driving Hamilton Standard hydromatic propellers, and two auxiliary Westinghouse J34-WE-36 turbojet engines, each rated at 1,500 pounds of thrust. The turbojet engines were installed to improve takeoff characteristics at increased gross weights and to furnish additional power when required.

The airplane's left outboard engine (position #1) was a Westinghouse J34-WE-36 turbojet engine, serial number 211235. Total time on the engine was 703.4 hours, 384.4 hours since overhaul, and 64 hours since its last inspection.

The airplane's left inboard engine (position #2) was a Curtiss Wright R3350-32WA radial engine, serial number W549601. Total time on the engine was 5,000 hours, 49 hours since overhaul, and 64 hours since its last inspection.

The airplane's right inboard engine (#3 position) was a Curtiss Wright R3350-32WA radial engine, serial number W573623. Total time on the engine was 4,587 hours, 560 hours since overhaul, and 64 hours since its last inspection.

The airplane's right outboard engine (position #4) was a Westinghouse J34-WE-36 turbojet engine, serial number 211233. Total time on the engine was 441 hours, 126 hours since overhaul, and 64 hours since its last inspection.

Neptune Aviation Services' Inspection Program

Neptune Aviation Services' P2V-5's and P2V-7's are maintained under an Approved Aircraft Inspection Program (AAIP) as set forth by the Federal Aviation Administration [Title 14 CFR Part 91.409 (f) (4)]. Incorporated in the AAIP program is a Phase D inspection, which contains a tracking/signoff sheet that lists each routine work card that is included in the inspection. The work cards themselves define the specific tasks to be completed.

Phase D inspections are required within 12 calendar months of the previous Phase D inspection, and are normally performed in conjunction with a Phase B and Phase C inspections during the off season while the airplanes are back at their home base in Missoula, Montana. The Phase D inspection, which emphasizes landing gear systems, reciprocating and jet engines, and propellers, contains 75 work cards. The only compressor-specific inspection work card is Work Card J-7-7.1. That card appears as part of the D inspection, and delineates ten inspection steps. Those steps area as follows:

a. Inspect rotor blades for foreign object damage and chafing.
b. Inspect housing for blade tip rubbing.
c. Inspect eleventh stage disc to rear seal for required minimum radial clearance (0.025").
d. Inspect front of first stage disc to rear of inlet vane assembly for required minimum clearance using gauge 243188S1 or 243037S2.
e. Inspect front and rear face of each compressor stage disc to adjacent wire shroud for required minimum axial clearance using gauge 243186S2 or 244235S1.
f. Inspect housing for cracks.
g. Inspect ignition unit and leads for chafing.
h. Inspect rotor discs for cracks, nicks and corrosion.
i. Inspect vanes for cracks, nicks, corrosion and looseness.
j. Refer to AN 02B-110BA-2, 02B-110BC-2 for limits, repair and blending.

Additional instructions for inspection and repair of J34 engines with aluminum compressor rotors (the 11th stage compressor rotor is stainless steel on all J34's) is provided by Steward-Davis Service Bulletin #215, Revision E. This bulletin states that, "At each B inspection and each Class "C" line maintenance, or at any time the compressor cover is removed, inspect the forward and rear faces of each compressor rotor disc (except the forward face of the first stage disc and the aft face of the 11th stage disc) for nicks, corrosion, or cracks."

Service Bulletin #215 further instructs through a note to, "Use a strong light and a 10-power magnifying glass to perform the above inspection, with particular attention directed towards the inlet and outlet edges of each blade root groove section." The bulletin further states that, "Any crack in any location on the compressor rotor is reason for rejection of the engine to an overhaul activity."

According to Neptune Aviation Services, if they discover any discrepancy on any one of the compressor's stages that would normally be the basis for a compressor overhaul, they consider that reason enough to permanently retire the entire compressor assembly from service.

The last six Phase D inspections performed on J34-WE-36 jet engine Serial Number 211235 were at the following dates and times:

10/21/03	D	612.8	TT	282.5	SMOH	
4/7/04		D	612.8	TT	282.5	SMOH

6/7/05	D	612.9	TT	282.6	SMOH
4/25/06	D	638.8	TT	307.7	SMOH
2/8/07	D	677.0	TT	346.0	SMOH
7/30/08	D	703.0	TT	372.0	SMOH

During the last D inspection of engine Serial Number 211235 (7/30/08) there were nine non-routine work cards generated by discrepancies found. Those discrepancies and the corrective actions taken are as follows:

1. Removed and replaced fuel nozzle set due to coked-up and dirty fuel nozzles.
2. Installed serviceable combustion chamber liner due to crack in chamber liner.
3. Cleaned and inspected EGT harness, and replaced six EGT probes due to EGT probes being inoperative.
4. Re-welded two broken off combustion chamber liner mount bosses on the diffuser.
5. Replaced ten first stage turbine nozzle vanes due to cracking.
6. Replaced second stage turbine nozzle due to at least three cracked vanes.
7. Replaced two blades on second stage turbine wheel due to blade waviness and/or cracks.
8. The number three bearing carrier assembly was disassembled, cleaned, inspected and resealed due to bearing oil leakage.
9. Three broken machine screws were replaced on the inboard jet pylon aft truss.

Turbojet Engine Serial Number 21135 Installation History

After in-depth inspection and analysis, it was determined that the 11th stage compressor disc had failed near the transition radius between the disc web and the bolting ring. This engine was manufactured by Westinghouse, identified as model J34-WE-36, serial number 211235.

The engine originally had been in service with the United States Navy, and at the time of its initial civilian installation on a Black Hills Aviation P2V on May 16, 1986, it had accrued 458.7 hours since new, and 128.4 hours since overhaul. Its installation history is as follows:

5/16/86	Installed as #2 on T-11(N14447),Black Hills Aviation, @458.7 TT
1/13/92	Removed from T-11 (N14447), Black Hills Aviation, @ 562.0 TT
8/31/98	Neptune test run @ 562.0 TT
4/7/99	Placed in storage @ 562.0 TT
6-15-99	Installed on N63819 for ferry flight @ 562.0 TT
3/25/00	Installed as #1 on N4235N @ 562.0 TT
9/21/01	Removed from N4235N @ 612.8 TT
10/21/03	Installed as #1 on T-07 (N1386K) @ 612.8 TT
1/16/06	Removed from T-07 (N1386K) @ 638.8 TT
4/02/06	Installed as #2 on T-11 (N14447) @ 638.8 TT
10/11/06	Removed from T-11 (N14447) @ 674.28 TT
10/11/06	Installed as #1 on T-09 (N4235T) @ 674.28 TT

Turbojet Engine Serial Number 21135 Time/Cycle/Overhaul History

On July 17, 2008, at the time of Neptune Aviation Services' transition from the bound hard-copy standard engine log to an electronically archived records system, the engine's estimated total time was 703.4 hours, and its estimated time since major overhaul was 384.4 hours. These estimates were based, in part, upon Neptune Aviation Services' procedure of using one-tenth of the time the airplane accumulated on a flight as the time to be added to the jet engine's total time.

The total number of engine cycles for engine Serial Number 211235 are based upon estimates derived from known Navy and civil operational procedures, and either total number of flight hours or total number of flights. The NTSB Maintenance Group Chairman estimated that the engine accumulated 100 to 300 cycles during the time it was operated by the Navy, about 1,200 cycles during the time it was operated by Black Hills Aviation, and about 2,712 cycles while being operated by Neptune Aviation Services. Its total cycles are then estimated as being somewhere in the 4,000 to 4,300 range.

The engine underwent installation of an overhauled turbine rotor assembly (Part Number 60E963-11) twice since being put into civilian operation. The first was during a build-up completed in August of 1998, when the engine was returned to an airworthy condition after being in storage for about six and one-half years. This build-up was documented on Work Order #1330M, dated February 18, 1998, and in an engine log entry dated August 31, 1998. The second was during a build-up that took place in October of 2003, after an engine removal in November of 2003 due to "cracks in turbine." That build-up was documented on Work Order 2623M, dated October 12, 2001, and in an engine log entry dated October 21, 2003.

The records indicated that the failed compressor rotor assembly had been with the subject engine since the engine's incorporation into the civilian fleet, and that the assembly had not undergone overhaul or exchange while in civilian service. The assembly itself (Assembly Number 43J966-11) consists of the one-piece aluminum compressor rotor shaft containing stages one through ten (Part Number# 43J965-5), and the steel eleventh stage disc (Part Number 60E575-2).

Jet Engine Total Time and Usage Sequence

At the time of the accident Neptune Aviation Services had no method to track the actual time that the jet engines operated during any one sortie or over their lifetime of operation. Instead, the means by which jet engine operating time was recorded and tracked was to use a number equal to ten percent of the airplane's flight time for each sortie as the operating time of the jet engine. This figure was based upon the assumption that during most retardant drop sorties the jet engines were operated about one-tenth of the total flight time.

According to Neptune Aviation Services, the two J34-WE-36 jet engines on their P2Vs are

normally only used for takeoff and for retardant drop runs. The jet engines are normally set for takeoff power at 100 percent, then set at METO (maximum except takeoff) power (95 percent) for climb. After the airplane is leveled off at cruise altitude, which is usually around 4,000 to 5,000 feet above ground level, the jet engines are brought to idle, and after stabilizing there, are shut down by bringing the throttle to the OFF position. After the throttle is brought to the OFF position, the pylon air inlet doors remain open for 90 seconds, and then are hydraulically closed. During that 90-second pre-closing delay, the airplane is normally at a cruise speed of about 170 knots.

For retardant drops the jet engines are normally restarted about five miles from the drop zone, and remain at idle until the beginning of the drop run. At the beginning of the drop run the jet engines are set at 50 percent power, and are then pushed up to METO power immediately after the drop. They stay at METO power during the climb to the altitude at which the airplane will return to its base. Once the airplane is at cruise altitude, the jet engines are shut down, and again go through the 90-second air inlet door closing delay. If multiple partial-load retardant drops are made on the same sortie, after the first drop the jet engines are brought back from 50 percent to idle at a point in time left to the pilot's discretion. They then remain at idle until the beginning of the next drop run, when they are pushed back up to 50 percent power. After the second drop run they are either set to METO or idle, depending upon whether or not there will be an additional run.

Cockpit Voice Recorder

The airplane was equipped with a Universal Cockpit Voice Recorder (CVR). The airplane was not equipped with a Flight Data Recorder (FDR). Title 14 CFR Part 137 did not require the airplane be equipped with either component.

Appareo GAU 2000 Flight Recorder

The airplane was equipped with an Appareo GAU 2000 Flight Recorder. The GAU 2000 utilizes Global Positioning System (GPS), micro-electro-mechanical systems (MEMS) technology, the airplane pitot-static system, the outside air temperature probe, and crash-hardened removable flash memory to capture a variety of parameters. In its standard configuration, the GAU 2000 collects GPS position, altitude, yaw, pitch, roll, and airspeed. Additionally, the GAU 2000 records acceleration, rotation rates and magnetic field strength along the roll, pitch, and yaw axis. The unit has a GPS accuracy of 2.5 meters, a roll and pitch accuracy of 1.5° RMS, and a yaw accuracy of 2.0° RMS. While the standard unit records at 4 Hz, the USDA Forest Service configures their units to record at 8 Hz. The Appareo GAU 2000 is mounted in the nose cone of the SP-2H.

METEOROLOGICAL INFORMATION

At 1755, the Automated Surface Observing System (ASOS) at the Reno/Tahoe International Airport (RNO), Reno, Nevada, located about 13 nautical miles southeast of the accident site,

reported winds 010 degrees at 8 knots, visibility 10 statute miles, sky clear, temperature 22 degrees Celsius, dew point minus 8 degrees Celsius, and an altimeter setting of 30.12 inches of Mercury.

WRECKAGE AND IMPACT INFORMATION

Investigators from the National Transportation Safety Board, The Federal Aviation Administration, Neptune Aviation Services, The USDA Forest Service, and The United States Department of The Interior examined the wreckage at the accident site.

An initial assessment of the wreckage revealed that debris was concentrated in 3 areas, which included the initial debris field located along the overrun area of the departure runway, a secondary debris field located about 325 feet east of the initial impact point, and the main wreckage area, which was located about 1.2 nautical miles from the departure end of Runway 32, on a measured magnetic heading of 289 degrees. The airplane had sustained catastrophic destructive impact forces and extensive thermal damage throughout.

The initial debris field consisted primarily of components from the airplane's #1 (left) jet engine, and extended over an area of about 1,750 feet, extending from the departure end of Runway 32, oriented along its extended centerline. The initial component in the debris path was the jet engine's left hand cowling, which was located 860 feet from the departure end of runway 32. The engine's 11th stage compressor disc and mating shaft was located 106 feet west of the engine cowling and about 875 feet from the departure end of runway 32, while the jet engine's bearing housing was 238 feet northwest of the engine cowling and about 1,100 feet from the departure end of runway 32. The jet engine's compressor housing was found about 108 feet northwest of the engine bearing housing and about 1,200 feet from the departure end of runway 32. The engine's combustion chamber was located 30 feet north of the compressor housing and about 1,220 feet from the departure end of runway 32. The engine's compressor was located about 1,795 feet northwest and 40 feet left of the runway's extended centerline, and about 0.9 miles southeast of the airplane's initial impact point.

The secondary debris field consisted of a concentration of various parts of the left wing, which was located about 325 feet east of the first impact point with terrain, extending about 440 feet in length on an east/west orientation, and about 230 feet in width on a north/south orientation. The debris field consisted of the following: left wing air seal, left wing leading edge rib assembly, upper left wing door assembly skin, left wing aft bathtub fitting cover, left wing rib attachment T-extrusion, piece of left wing rib, left wing tip latch, left wing stiffener, left wing stiffener extrusion, left wing main fuel tank filler access door, left aileron or flap skin, left wing upper stringer and skin, left wing red navigation lens, left wing flap rub strip and skin, a "Z" channel, left wing clip and rib assembly, and additional left wing aileron or flap skin.

The main wreckage area's first identified point of contact (FIPC) was evidenced by impact with a set of powerlines on the east side of the airport's west perimeter road, which is oriented in a north-south direction. The airplane subsequently impacted a chain linked fence and terrain

located on the west side of the 25-foot wide perimeter road at an elevation of 5,072 feet mean sea level (msl); the elevation of the airport is listed as 5,050 feet msl. The predominately flat terrain slopes gently upward to the west, characterized by a sparse concentration medium height scrub brush. The airplane impacted terrain on a measured magnetic heading of 260 degrees, and came to rest on a measured magnetic heading of 250 degrees. The debris path, oriented on a measured magnetic heading of 242 degrees, covered a measured distance of 750 feet in length and 585 feet in width. A fanned pattern covering the site, estimated to be about two-thirds of the total wreckage area on an east-west orientation, was evidenced by a reddish-orange coloring of the terrain, consistent with that of the fire retardant load the airplane was carrying. The accident site exhibited a burn pattern along both sides of the energy path, outboard of the concentrated fire retardant spill.

The initial impact point (IIP) with terrain was evidenced by a crater about 10 inches in depth and 18 inches in diameter. Components of the right outboard wing were located about 18 feet to the left of the IIP. The vertical stabilizer, horizontal stabilizer, varicam and rudder were all located about 185 feet from the IIP on a measured magnetic heading of about 253 degrees, while the aft fuselage, center wing section and #2 propeller hub were located about 263 feet from the IIP on a measured magnetic heading of 264 degrees.

The left wing, nose section, and left main landing gear were found further west and in line with the debris path, on a magnetic heading of about 255 degrees and about 366 feet from the IIP. The left jet fuel shutoff valve was identified and observed in the OPEN position. The left main tire was located about 360 feet west-northwest of the left main landing gear and about 665 feet from the IIP. The airplane's fire retardant tank, which was located about 35 feet west of the right outboard engine, was destroyed as a result of impact forces.

The airplane's left outboard engine, serial number 211235, was located about 580 feet from the IIP on a measured magnetic heading of 239 degrees. A visual examination at the wreckage site revealed that the engine's compressor section had separated prior to impact.

The airplane's right outboard engine, serial number 211233, was found about 318 feet from the IIP on a measured magnetic heading of 240 degrees, and about 260 feet east of the left outboard engine. An onsite examination of the engine revealed signatures consistent with an engine producing power. No preimpact anomalies were observed.

The forward section of the airplane's left inboard engine, serial number W549601, was located about 435 feet west-southwest of the IIP on a measured magnetic heading of 246 degrees. The engine's associated supercharger and accessory case, which had separated during the impact sequence, were located about 348 feet from the forward section of the engine on a measured magnetic heading of 228 degrees. An onsite examination of the engine revealed no preimpact anomalies. An examination of the engine's associated propeller revealed that the propeller hub's pitch cams (lugs) were not in the low pitch or feathered position. The propeller tachometer indicated a reading of 2,600 revolutions per minute (RPM).

The forward section of the airplane's right inboard reciprocating engine, serial number W573623, was located about 420 feet southwest of the IIP on a magnetic heading of 234 degrees. The engine's associated supercharger and accessory case, which had separated during the impact sequence, were located about 258 feet from the forward section of the engine on a measure magnetic heading of 222 degrees. An onsite examination of the engine revealed no preimpact anomalies. An examination of the engine's associated propeller revealed that the propeller hub's pitch cams (lugs) were not in the low pitch or feathered position. The propeller tachometer indicated a reading of 2,500 RPM.

MEDICAL AND PATHOLOGICAL INFORMATION

Autopsies of the two pilots and the crew chief were conducted by the Washoe County Medical Examiner/Coroner, of Reno, Nevada. The manner of death for all three crewmembers was attributed to "blunt force trauma."

Toxicology tests were performed on both pilots by the FAA Civil Aeronautical Institute (CAMI), Oklahoma City, Oklahoma, on specimens obtained during the autopsies.

The results of analysis of the specimens for the captain contained no findings for volatiles and tested drugs. There were no tests for carbon monoxide or cyanide.

The results of analysis of the specimens for the copilot contained no findings for volatiles and tested drugs. There were no tests for carbon monoxide or cyanide.

TESTS AND RESEARCH

The 11th Stage Compressor Disc

The left outboard jet engine's 11th stage compressor disc, P/N 60E575-2, was sent to the National Transportation Safety Board Materials Laboratory Division in Washington, D.C., for examination and analysis. (Refer to NTSB Materials Laboratory Factual Report No. 09-001.) A Senior Metallurgist reported that the disc was fractured in two major pieces, the smaller piece containing about half of the rim and one third of the web. The remainder of the rim and web and the entire bore were contained in the large piece that also had a portion of the compressor rotor extension shaft attached.

The initial optical examinations of the fractures revealed extensive post-separation damage to the majority of the fracture surface on the smaller piece. The fracture on the larger piece was relatively undamaged and clear fracture features were visible on the majority of the break. A flat, relatively smooth, fracture area with curved boundaries was visible in the portion of the fracture adjacent to the thicker bolting ring. Features within this region were consistent with fatigue progression. At the leading and trailing edges of the fatigue region, the fracture surface was rougher and quickly transitioned to 45-degree shear planes consistent with overstress separations. Chevron markings within the overstress fracture indicated progression away from

the fatigue region.

The fatigue region was circumferential around the disk. The fatigue crack measured 2.7 inches long circumferentially and penetrated 0.23 inch of the measured 0.29 inch thickness of the disc. The fatigue region contained curved arrest lines indicating that fatigue initiation was in a relatively small area on the forward face of the disc. Optical
inspections of the disc did not reveal any major damage or corrosion in the fatigue region of the origin area.

The radius and surface surrounding the fatigue origin area had a ground surface finish with a circular lay that was visually estimated to be 63 microinch RMS, meeting the engineering drawing's 63 microinch RMS requirement. Closer optical examinations uncovered a single deeper and wider scratch at the edge of the fracture that included the origin area. The portion of the scratch that remained on the inboard fracture face (on the larger piece) measured approximately 0.35 to 0.55 inches long circumferentially and terminated just past the origin at one end. Near the fatigue origin, the scratch measured between 0.0013 to 0.0016 inch wide and 0.0010 to 0.0015 inch deep.

Scanning electron microscopy (SEM) of the fatigue region uncovered fatigue striations and fatigue fracture features emanating from several tightly clustered fatigue origins. The SEM examination revealed a particle embedded in the disc at the end of the scratch.

Energy dispersive x-ray analysis (EDS) of the particle determined that it was comprised mainly of aluminum and oxygen, consistent with an aluminum oxide abrasive particle.

Although the surface finish was visually estimated to meet the 63 microinch RMS drawing requirements, roughness measurements using a contact profilometer determined the finish to be between RA 50 microinch and 187 microinch depending on the location of the measurement.

Visual examination of the web and transition radius surfaces revealed many additional examples of individual scratches approximately equivalent to the width and depth of the scratch noted at the fatigue origin.

Note: According to the NTSB laboratory technician that completed the examination of the failed 11th stage compressor disc (Materials Laboratory Factual Report 09-001), a 10-power magnifying glass would not have been sufficient to identify the scratch associated with initiation of the fatigue crack in the transition radius as an anomaly. Additionally, the laboratory Factual Report itself stated that a visual examination of the web and transition radius surfaces revealed many additional examples of individual scratches approximately equivalent to the width and depth of the scratch noted at the fatigue origin.

Exemplar 11th Stage Compressor Discs Examination

Three Neptune Aviation Services exemplar 11th stage compressor discs were sent to the NTSB Materials Laboratory for examination and analysis. Two discs, s/n 628492-V39 and s/n 60946, were reportedly retired from service, but no service times were available. The third disc, s/n 32018, was reported as a new surplus.

A Senior Metallurgist reported that the examination revealed no obvious cracks observed during high magnification visual inspections of the forward bolting ring radius, the location of the fatigue cracking in the accident disc. The metallurgist further reported that upon initial viewing, the new disc, s/n 32018 appeared to have a noticeably finer surface texture than the other discs. The pattern of scratches on each disc appeared the same with a relatively uniform fine finish, punctuated by generally random, deeper, wider scratches. A similar pattern was seen on the accident disc.

The metallurgist reported that in order to quantify the surface texture, a contact profilometer measured the surface approximately radial to the disc and calculated the roughness. The surface roughness of disc s/n 60946 measured Rq (RMS) 84 µin, while disc s/n 628492-V39 measured Rq 72 µin. Disc s/n 32018 measured Rq 33 µin. The drawing requires a surface finish of 63 µin RMS (Rq) or finer. (Refer to the NTSB Materials Laboratory Factual Report No. 09-022.)

Structures

A Safety Board structures engineer performed an examination of the airplane's left wing as a result of the #1 jet engine experiencing an uncontained engine failure. The engineer reported that sections of the forward spar exhibited minor to moderate thermal damage, and all spar pieces recovered exhibited severe impact damage and fragmentation. Aileron movement was accomplished through a series of push-pull tubes and bell cranks that run along the forward side of the forward spar. The aileron push-pull tubes were fractured in numerous locations along their lengths and there was no evidence of non-impact related damage. The majority of the rear spar was recovered in 6 pieces, which exhibited moderate to severe thermal damage, severe impact damage, and fragmentation. The left aileron was recovered in 2 pieces, separated from the left wing, and exhibited moderate impact and thermal damage. The outboard half of the aileron spring tab was separated from the aileron, with a small 2-inch diameter penetration on the inboard portion of the spring tab from the lower surface through the upper surface. Several pieces of left wing upper and lower skin were identified. All pieces exhibited severe impact damage and varying degrees of thermal damage. None of the pieces exhibited any impact penetration signatures, and no evidence of an over pressure event was present in any of the left wing wreckage examined. As a result of the post-crash fire/heat damage on the left wing structure near the jet attach point; no obvious evidence of an in-flight fire could be distinguished.

Recorded Data and Aircraft Performance Study

A Safety Board performance specialist evaluated the data recovered from the Appareo GAU

2000 Flight Recorder. (Refer to NTSB Recorded Data and Aircraft Performance Study.) The specialist reported that the data revealed the airplane lifted off at 18:07:40 with an airspeed of about 130 knots, and achieved a maximum rate of climb of 600 feet per minute just prior to reaching its maximum altitude of about 250 feet above ground level (agl).

Data recovered from the flight recorder revealed the following flight sequence relative to the time, altitude and airspeed of the flight:

TIME (PDT)	Altitude (mean sea level)	Airspeed (knots)
18:08:23	5,289	184
18:08:24	5,308	163
18:08:25	5,299	159
18:08:26	5,296	153
18:08:27	5,291	144
18:08:28	5,283	130
18:08:29	5,270	110
18:08:30	5,249	84
18:08:31	5,221	53

The flight sequence indicates that the airplane decelerated through the published minimum air control speed (Vmca) of 108 knots at 18:08:29. This is also the same airspeed at which the accident airplane's roll rate is recorded increasing rapidly left-wing down, which is consistent with an engine failure and the airplane banking into the failed engine.

Vmca refers to engine-out operations and is the minimum speed that directional control can be maintained while banked 5 degrees into the operating engine(s).

ADDITIONAL INFOMRATION

Engine Malfunctions – Engine Failure

According to NATOPS Flight Manual NAVAIR 01-75EEB-1, dated April 15, 1973, the manual states in part, "Failure of one engine during flight or takeoff will not ordinarily result in a critical flight condition. Failure of a jet engine during takeoff will result in a controllable yaw and may not necessitate aborting the takeoff since the reciprocating engines supply sufficient power for takeoff at maximum gross weights. "The manual list the minimum control speed (Vmc) as 108 knots indicated airspeed (IAS).

Emergency Jettison (dump) of Retardant Load

The Neptune Aviation Services Vice President of Operations (VP of Ops) revealed that pilots are instructed that they are to jettison their retardant load should an engine failure be experienced on takeoff. The VP of Ops reported that during pilot training all pilots are tested on simulated engine failures during takeoff with a simulated full load of fire retardant. Pilots are

expected to successfully carry out the procedure for jettisoning the retardant load, as well as the procedure for dealing with the engine failure, each to acceptable company training standards.

Neptune Aviation Services' P-2V Emergency Checklist

According to Neptune's P-2V Emergency Checklist, the following emergency procedures for a jet engine fire are as follows:

1. JET THROTTLE.....OFF
2. Emergency Shutoff SW.....SHUT OFF
3. JET DOOR CIRCUIT BREAKER.....PULLED
4. CROSSFEED.....SET
5. FUEL TANK SEL (BURNING JET SIDE)...OFF

Vmc

According to the FAA's Pilot's Handbook of Aeronautical Knowledge (FAA-H-8083-25A), minimum control speed (Vmc) is the minimum flight speed at which a light, twin-engine airplane can be satisfactorily controlled when an engine suddenly becomes inoperative and the remaining engine is at takeoff power.

Vmca

According to the FAA's Pilot's Handbook of Aeronautical Knowledge (FAA-H-8083-25A), Vmca is defined as the "minimum control speed in the air, with one engine inoperative, (critical engine on two-engine aircraft) operating engine(s) at takeoff power, maximum 5 degree bank into the good engine(s).

Pilot Information

Certificate:	Airline transport; Commercial	**Age:**	61,Male
Airplane Rating(s):	Single-engine land; Multi-engine land	**Seat Occupied:**	Left
Other Aircraft Rating(s):	None	**Restraint Used:**	
Instrument Rating(s):	Airplane	**Second Pilot Present:**	Yes
Instructor Rating(s):	Airplane multi-engine; Airplane single-engine	**Toxicology Performed:**	Yes
Medical Certification:	Class 1 Without waivers/limitations	**Last FAA Medical Exam:**	January 25, 2008
Occupational Pilot:	Yes	**Last Flight Review or Equivalent:**	February 21, 2008
Flight Time:	9520 hours (Total, all aircraft), 8701 hours (Pilot In Command, all aircraft), 118 hours (Last 90 days, all aircraft), 55 hours (Last 30 days, all aircraft), 5 hours (Last 24 hours, all aircraft)		

Co-pilot Information

Certificate:	Airline transport; Commercial	**Age:**	41,Male
Airplane Rating(s):	Single-engine land; Multi-engine land	**Seat Occupied:**	Right
Other Aircraft Rating(s):	None	**Restraint Used:**	
Instrument Rating(s):	Airplane	**Second Pilot Present:**	Yes
Instructor Rating(s):	Airplane multi-engine; Airplane single-engine	**Toxicology Performed:**	Yes
Medical Certification:	Class 1 Without waivers/limitations	**Last FAA Medical Exam:**	December 26, 2007
Occupational Pilot:	Yes	**Last Flight Review or Equivalent:**	March 3, 2008
Flight Time:	2812 hours (Total, all aircraft), 1725 hours (Pilot In Command, all aircraft), 121 hours (Last 90 days, all aircraft), 55 hours (Last 30 days, all aircraft), 5 hours (Last 24 hours, all aircraft)		

Other flight crew Information

Certificate:	Private	**Age:**	25,Male
Airplane Rating(s):	Single-engine land	**Seat Occupied:**	Center
Other Aircraft Rating(s):	None	**Restraint Used:**	
Instrument Rating(s):	None	**Second Pilot Present:**	Yes
Instructor Rating(s):	None	**Toxicology Performed:**	No
Medical Certification:	Class 2 Without waivers/limitations	**Last FAA Medical Exam:**	April 6, 2006
Occupational Pilot:	No	**Last Flight Review or Equivalent:**	
Flight Time:			

Aircraft and Owner/Operator Information

Aircraft Make:	Lockheed	**Registration:**	N4235T
Model/Series:	P2V-7 SP-2H	**Aircraft Category:**	Airplane
Year of Manufacture:		**Amateur Built:**	
Airworthiness Certificate:	Restricted (Special)	**Serial Number:**	150282
Landing Gear Type:	Retractable - Tricycle	**Seats:**	3
Date/Type of Last Inspection:	July 30, 2008 AAIP	**Certified Max Gross Wt.:**	80000 lbs
Time Since Last Inspection:	64 Hrs	**Engines:**	4 Turbo jet
Airframe Total Time:	10217 Hrs as of last inspection	**Engine Manufacturer:**	Westinghouse
ELT:	C91 installed, activated, did not aid in locating accident	**Engine Model/Series:**	J34-WE-36
Registered Owner:	Neptune Aviation Services Inc.	**Rated Power:**	1500 Lbs thrust
Operator:	Neptune Aviation Services Inc.	**Operating Certificate(s) Held:**	

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual (VMC)	**Condition of Light:**	Day
Observation Facility, Elevation:	RTS,5050 ft msl	**Distance from Accident Site:**	2 Nautical Miles
Observation Time:	17:55 Local	**Direction from Accident Site:**	305°
Lowest Cloud Condition:	Clear	**Visibility**	10 miles
Lowest Ceiling:	None	**Visibility (RVR):**	
Wind Speed/Gusts:	8 knots /	**Turbulence Type Forecast/Actual:**	/
Wind Direction:	10°	**Turbulence Severity Forecast/Actual:**	/
Altimeter Setting:	30.12 inches Hg	**Temperature/Dew Point:**	22°C / -8°C
Precipitation and Obscuration:	No Obscuration; No Precipitation		
Departure Point:	Reno, NV (4SD)	**Type of Flight Plan Filed:**	Company VFR
Destination:	Reno, NV (4SD)	**Type of Clearance:**	None
Departure Time:	18:10 Local	**Type of Airspace:**	

Airport Information

Airport:	Reno/Stead Airport RTS	**Runway Surface Type:**	Asphalt
Airport Elevation:	5050 ft msl	**Runway Surface Condition:**	Dry
Runway Used:	32	**IFR Approach:**	None
Runway Length/Width:	9000 ft / 150 ft	**VFR Approach/Landing:**	None

Wreckage and Impact Information

Crew Injuries:	3 Fatal	**Aircraft Damage:**	Destroyed
Passenger Injuries:		**Aircraft Fire:**	In-flight
Ground Injuries:	N/A	**Aircraft Explosion:**	None
Total Injuries:	3 Fatal	**Latitude, Longitude:**	39.694721,-119.904441

Administrative Information

Investigator In Charge (IIC):	Little, Thomas
Additional Participating Persons:	Robert L Drake; Federal Aviation Administration; Washington, DC Greg A Jones; Neptune Aviation Services; Missoula, MT Tom Humman; California Department of Forestry; McClellan, CA Colleen Sadeski; Lockheed Martin Aeronautics Company; Marietta, GA
Original Publish Date:	March 23, 2010
Investigation Class:	Class
Note:	The NTSB traveled to the scene of this accident.
Investigation Docket:	https://data.ntsb.gov/Docket?ProjectID=68841