Eurocopter Submission

Submitted to the Bureau d'Enquêtes et d'Analyses
and the National Transportation Safety Board on 3 December 2012

I. Accident Information:

NTSB Accident #:	CEN11FA599
Operator:	Air Methods Corporation
Aircraft Type and S/N:	Eurocopter AS 350 B2, S/N 3728
FAA Registration:	N352LN
Date & Time:	26 August 2011, 1841 CDT
Location:	Mosby, Missouri

II. History of Flight

On August 26, 2011, at 1841 central daylight time (all times CDT), a Eurocopter AS 350 B2 helicopter, N352LN, was destroyed when it impacted terrain following a loss of power near the Midwest National Air Center (KGPH), Mosby, Missouri. The pilot, flight nurse, flight paramedic, and patient received fatal injuries. The emergency medical services (EMS) equipped helicopter was registered to Key Equipment Finance, Inc., and operated by Air Methods Corporation, doing business as LifeNet in the Heartland. The 14 Code of Federal Regulations Part 135 medical flight departed from the Harrison County Community Hospital, Bethany, Missouri, about 1811, and was en route to KGPH to refuel when the accident occurred. After refueling, the pilot intended to depart and land at Liberty Hospital in Liberty, Missouri, which was located about 7 nautical miles (nm) from KGPH on a 235 degree heading. Visual meteorological conditions prevailed at the time of the accident, and a company visual flight rules (VFR) flight plan was filed.

The purpose of the air medical inter-facility transport flight was to transport a patient from the Harrison County Community Hospital to the Liberty Hospital Heliport (8MO2) in Liberty, Missouri. The request was received by the company's communication center at 1719 and the pilot was notified at 1720. At 1730, the pilot reported to the communication center that he departed from the helicopter's base at Rosecrans Memorial Airport (KSTJ) in St. Joseph, Missouri. He reported that he lifted off with two hours of fuel and 3 persons onboard and was en route to Bethany, Missouri. Approximately 28 minutes later, at 1758, the helicopter landed at the Harrison County Community Hospital helipad to pick up the patient.

While the helicopter was shut down on the helipad, the pilot contacted the company's communication center by telephone and notified them that about half way through the flight from KSTJ, he realized that he did not have as much fuel onboard as he originally thought and that it would not be enough to complete the original mission flight plan. After a discussion about possible fueling and re-routing options, the pilot elected to stop en route at KGPH for fuel and then proceed to the Liberty Hospital helipad to drop off the patient. The person, who was providing flight following to N352LN at the company's communication center, informed the pilot that the distance to Liberty Hospital was 62 nm and that KGPH was 58 nm.

At about 1811, the flight departed from the Harrison County Community Hospital helipad. Approximately one minute later, the pilot contacted the company's communication center and reported that he had 45 minutes of fuel and 4 persons onboard and was en route to KGPH. He asked the flight follower at the company's communication center to contact the fixed base operator at KGPH to let them know that the helicopter was inbound for fuel. At 1841, the helicopter impacted a farm field about 1.7 nm miles north-northeast of KGPH. There was no post-impact fire.

At 1754, the surface weather observation at the Charles B. Wheeler Downtown Airport (KMKC), Kansas City, Missouri, located about 21 nm southwest of the accident site, was: wind 110 degrees at 6 knots, 10 miles visibility, clear sky, temperature 31 degrees Celsius, dew point 13 degrees Celsius, altimeter 29.96 inches of Mercury.

III. Eurocopter Participation in the Accident Investigation

American Eurocopter accident investigators were notified by the NTSB of the accident on the evening of the day it occurred. As the helicopter and engine were both designed and manufactured in France, the Bureau d'Enquêtes et d'Analyses (BEA) was notified shortly thereafter, and a French BEA Accredited Representative was assigned to the NTSB's investigation. The BEA Accredited Representatives appointed Eurocopter, American Eurocopter and Turbomeca accident investigators as Technical Advisors to assist with the NTSB's investigation, as well. Two American Eurocopter accident investigators traveled to the accident site on the evening of the day of the accident to assist the NTSB team with its onsite investigation. Both investigators continued to assist the NTSB as BEA appointed Technical Advisors throughout the duration of the investigation.

IV. Aircraft Information

The accident aircraft was a Eurocopter AS 350 B2 helicopter, manufactured as serial number 3728 by Eurocopter in 2003. According to the FAA aircraft registry, the helicopter received its FAA normal-standard airworthiness certificate on February 6, 2004 and was registered as N352LN to Key Equipment Finance Inc. on March 30, 2005.

The Eurocopter AS 350 B2 is powered by a single Arriel 1D1 free turbine engine. The helicopter is equipped with a three-blade main rotor system which rotates clockwise (when looking from above), a conventional tail rotor, and skid-type landing gear.

The accident helicopter was equipped with an Air Methods EMS Interior, which was configured with the pilot seat in the front right position, three medical crewmember seats mounted on the aft cabin bulkhead facing forward, and one patient litter oriented longitudinally on the left side of the cabin.

According to the aircraft daily flight logs, the aircraft had accrued a total time of 3,655 hours 10 minutes. There were no significant maintenance discrepancies identified during the investigation. Please see FAA Maintenance Summary for additional details concerning the maintenance history of the aircraft.

V. Wreckage and Impact Information

The last GPS position of the helicopter recorded by Air Methods' automated GPS flight following system before the accident was about 0.9 nm from the accident site at 1841; it showed the helicopter was about 373 feet AGL with a 116 knot ground speed. The aircraft wreckage debris path was located in a farm field, oriented on a heading of approximately 250°, on a direct path towards KGPH from the Harrison County Community Hospital helipad.

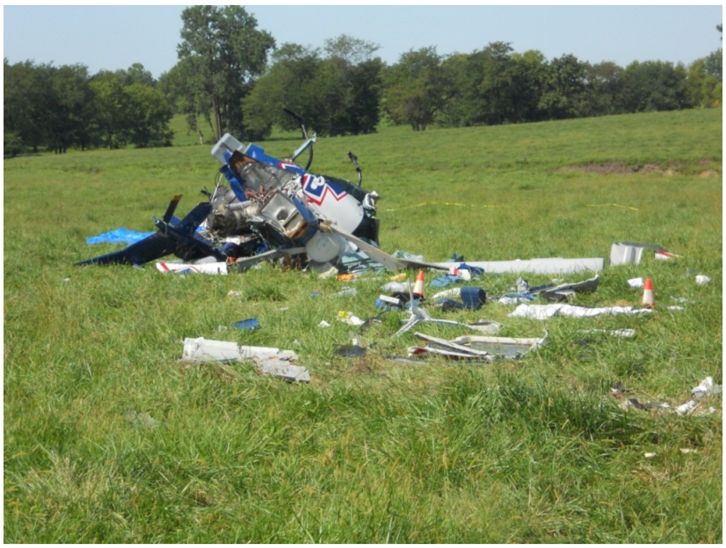


Photo 1: Main Wreckage

The aircraft structure was heavily fragmented and scattered along the debris path (approximately 100 feet in length). All impact signatures were consistent with low main rotor RPM (NR) and a high rate of descent. The impact signatures to the components of the airframe structure were consistent with the initial impact occurring in a nose-low and slight left-bank attitude, oriented opposite the direction of travel.

The main rotor and tail rotor drive systems were examined for mechanical continuity and power signatures. No pre-impact anomalies were identified, and signatures indicated a lack of power/RPM on impact.

The helicopter's fuel tank was intact and located in the midst of the main wreckage. No fuel was observed and no odor of fuel was noted at the accident site; less than one liter of fuel was found in the fuel system tank and lines (which were generally intact). The airframe fuel filter system was removed from the airframe by the investigative team for inspection; no fuel was observed in the lines on the engine side of the filter, and only a residual amount of fuel was observed in the lines on the tank side of the filter. When the drain valve at the bottom of the filter bowl was depressed, no fuel was observed. No fuel was seen in the sight glass. The fuel quantity gauge was removed from the wreckage and retained by the NTSB IIC for future examination.

The helicopter's instrument panel was configured with Night Vision Goggle (NVG) lighting and filters. The brightness switch on the caution-warning annunciator panel was found on the low (dim) setting.

VI. Tests and Research

The engine, fuel tank assembly, fuel gauge, and caution-warning annunciator panel were retained and shipped to American Eurocopter in Grand Prairie, Texas for further examination.

Fuel system:

According to the AS350 B2 Flight Manual, Section 3.3, (Warning-Caution-Advisory Panel and Aural Warning), Paragraph 2.2 (Amber Lights): the caution-warning annunciator panel are colored "- Red to indicate a failure requiring immediate action, and - Amber to indicate a failure which does not require immediate action." The illumination of the amber light identified as "FUEL" on the Warning-Caution-Advisory Panel indicates a "Fuel quantity less than 60 liters (15.8 US gal)." The 'Pilot Action' is specified to "Avoid large attitude changes" with an additional "Note: Remaining usable fuel allows approximately 18 minutes level flight at maximum continuous power." There are no aural warnings for amber-colored caution advisory lights.

The fuel tank assembly with quantity probe still intact, caution-warning annunciator panel, and the fuel quantity gauge from the accident helicopter were examined as a system under the supervision of the NTSB at American Eurocopter's Grand Prairie, Texas facility on October 14, 2011. No pre-impact anomalies were identified. The system performed as designed, and the level at which the "FUEL" light illuminated was 17.7 gallons, which would have provided the pilot slightly more time before flameout than as indicated in the flight manual. The quantity indication provided by the fuel gauge was accurate at all levels.

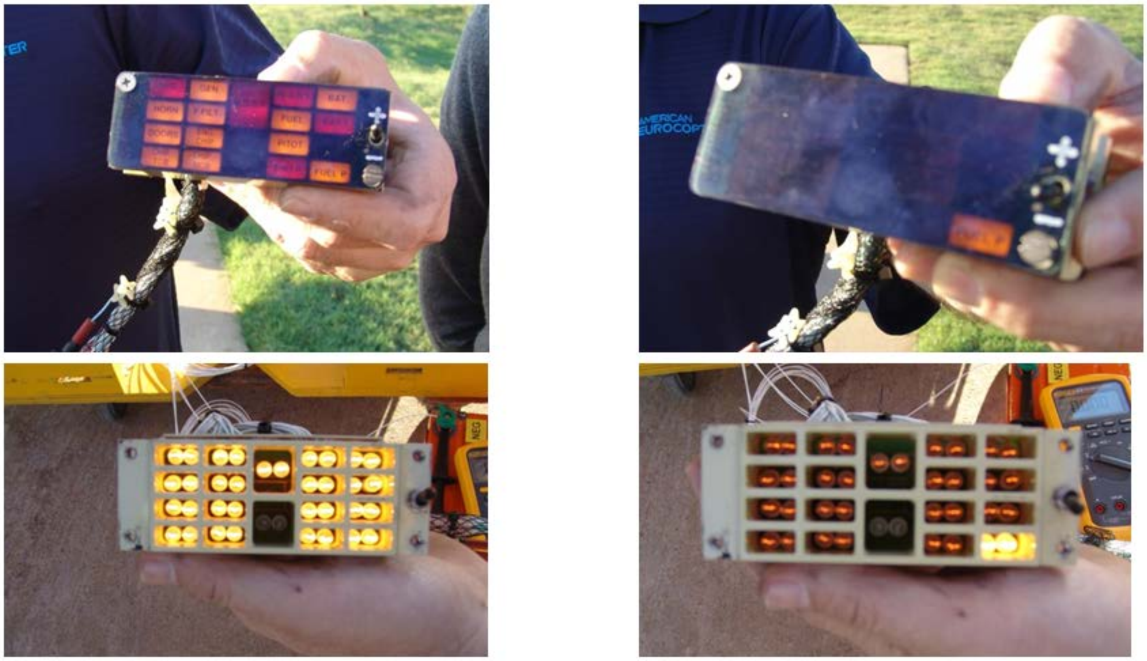
Caution-warning annunciator panel:

An operational check of the caution-warning annunciator panel was performed, which revealed that all lights were working properly. Examination of the individual light bulb filaments revealed the filaments of both "FUEL" bulbs exhibited a slightly stretched coil and smaller bend radii in the filament profile at the bulbs support wires when compared to an exemplar light bulb. The slightly stretched filament coil indicates that the "FUEL" light was illuminated at the time of impact.

As noted above, the instrument panel was configured with Night Vision Goggle (NVG) lighting and filters. The brightness switch on the caution-warning annunciator panel was found on the "-"/ "dim" setting at the accident site. During the examination, the panel was illuminated in daylight conditions and observed in both "bright" and "dim" settings. With the panel in the "dim" position as it was found at the accident site, only the "FUEL P" light (the only light that does not convert to the dim setting by design) was conspicuously illuminated. It is unknown whether the panel was switched to the "dim" setting during the previous NVG training flight and never returned to "bright" for the accident flight, switched to "dim" during the accident flight, or if this setting occurred during impact.

On “**Bright**” with NVG lens and no Lens

On “**Dim**” with NVG lens. and no Lens



Note: Bottom center light port is not used.

Photos 2 through 5: Caution-Warning Annunciator Panel

Engine:

The engine was examined under the supervision of the NTSB at Turbomeca USA’s Grand Prairie, Texas facility. No anomalies were identified during the examination which would have precluded normal operation. Rotational damage observed on the axial compressor (nose cone) was determined to be as a result of residual rotation following the engine flameout which occurred seconds before the impact. All findings were consistent with a loss of engine power due to fuel exhaustion and subsequent damage due to the impact.

VII. Operational Findings

Pilot information:

The investigation revealed the pilot, age 34, held a commercial pilot certificate with rotorcraft-helicopter and instrument-helicopter ratings issued on September 22, 2005. He had been employed by Air Methods since September 2010 and held an FAA second-class medical certificate with no limitations. Prior to being employed by Air Methods, the pilot flew for the U.S. Army. In the resume he presented to Air Methods, the pilot indicated that he had a total of 2,071.1 rotorcraft flight hours, of which the vast majority was flown in twin-engine models.

Information provided by Air Methods indicates that the pilot accumulated a total of 104 flight hours in the AS350 B2 and 32 flight hours in the AS350 B3 between October 10, 2010 and August 26, 2011. He flew 18 hours within the 30 days prior to the accident and 74 hours within the 90 days prior to the accident.

Pilot training:

According to information presented in the NTSB's Operations Factual Report, the pilot started his Basic Indoctrination Training on September 13, 2010. He started his Initial New Hire Training for the AS350 B, BA, and B2 on October 4, 2011, in N352LN. After receiving 4.2 hours of flight training, he completed the FAR 135.299 Airman Competency/Proficiency Check on October 6, 2010. All areas of the examination were graded as 'S' (satisfactory) and no discrepancies were noted. Instrument procedures were not practiced; however, an ILS approach arrival was performed. Power failures, autorotations to a power recovery (but without a reduction in power), and hovering autorotations (oral only) were performed.

Information reviewed regarding the pilot's training did not reveal any evidence that the pilot had conducted any practice autorotations with a reduction in engine power or any practice autorotations to the surface (also referred to as "touchdown" autorotations) during his employment at Air Methods.

Possible distraction during accident flight:

It was discovered by members of the investigation team that the pilot was sending and receiving text messages (2 outgoing, 4 incoming) during the accident flight. According to cell phone records retrieved by investigators, the last incoming text message was delivered approximately 10 minutes before the accident occurred.

VIII. AS 350 B2 Engine Flame-Out and Autorotation Information

AS 350 B2 Engine Flame-Out: Audio Warnings, Indications, & Emergency Procedure:

Section 3 of the AS 350 B2 Flight Manual provides information regarding helicopter emergencies, the warnings or alerts associated with a particular emergency, and the procedures to follow once the emergency has been identified.

Continuous tone audio warnings are provided when main rotor rpm (NR) is below 360 or when hydraulic pressure drops below 30 bars. An intermittent tone is provided when NR is above 410 rpm.

The above-mentioned tones are only operative if the "HORN" button is pushed in per the normal procedures. When this push-button is out, at nominal rotor speed, the HORN light of the warning-caution-advisory annunciator panel illuminates to alert the pilot that the HORN is muted.

Section 3.1 of the flight manual contains the following information about the symptoms of a flame-out in flight, as well as the emergency autorotation landing procedure to apply in the event of an engine failure (flame-out).

The symptoms listed for an engine failure (flame-out) are as follows:

- Jerk in the yaw axis (only in high power flight)

- Drop in rotor speed (aural warning sounds below 360 rpm as described above)
- Torque at zero
- Ng falling off to zero
- Generator warning light illuminates
- Engine oil pressure drop warning light illuminates

In the event of an engine failure (flame-out) in flight, carry out “Autorotation Landing Procedure following Engine Failure” as listed below:

1. Set low collective pitch.
2. Monitor and control rotor rpm.
3. Establish approximately 65 kt (120 km/hr – 75 mph) airspeed.
4. Move the fuel flow control lever to the shutdown position.
5. According to the cause of the loss of the engine:
    - Relight the engine [dependent on altitude]
    - Otherwise: close the fuel shut-off cock, and shut off generator, alternator if installed, electrical power master switch (if smell of burning).
    - Maneuver to head the helicopter into the wind in final approach.
    - At a height of approximately 65 ft (20 m) above the ground, flare to a nose-up attitude.
6. At height 20-25 ft (6-8 m) and at constant attitude, gradually apply collective pitch to reduce the sink-rate.
7. Resume level attitude before touch-down, and cancel any side-slip tendency.
8. Gently reduce collective pitch after touchdown.

Step 2 of the autorotation procedure refers to monitoring and controlling main rotor rpm (NR). The NF/NR gauge is a dual gauge representing engine free turbine speed (NF) and rotor rpm (NR). The green arc represents the 375-394 rpm NR range. See figure below.

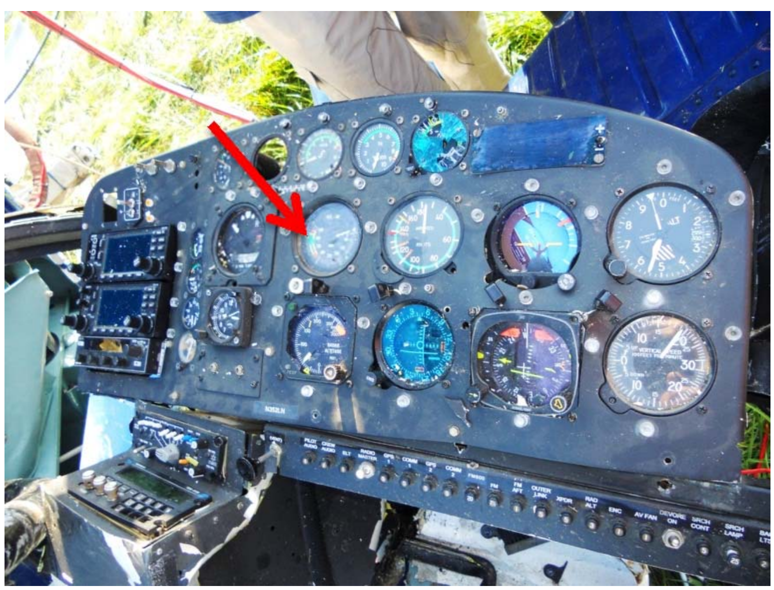


Photo 6: N352LN pilot instrument panel (post-accident).
Location of the NF/NR gauge indicated by the red arrow.

For most helicopters, the general rule is that the pilot can control the helicopter with NR decayed down to 80%; ability to control of the helicopter with NR below 80% is questionable. The low safety limit (red line) for NR in the AS 350 B2 is 320 RPM; below this RPM and dependent on other conditions that exist at the time (i.e. altitude, airspeed, weight, density-altitude), the pilot's control of the rotor disc could be so degraded that recovery of NR would not be possible.

IX. Autorotation Demonstrations in Aircraft and Flight Simulator

The NTSB IIC and investigation team requested aircraft and simulator demonstrations of autorotations in various profiles, as well as the correct procedure for a practice (training) autorotation. For the purposes of the investigation, two types of autorotations were discussed:

1. Practice autorotation: An autorotation performed per the flight manual training supplement procedure in which the collective is reduced as or just before power is reduced to 67% NG to simulate a loss of engine power. (Please see attached procedure.); and

2. Forced landing autorotation: An autorotation conducted following a loss of engine power or other emergency event requiring the pilot to shut down the engine in flight. (To be conducted in accordance with the "Autorotation Landing Procedure following Engine Failure" listed above in section VIII.)

Flight Demonstrations:

Members of the investigation team were divided into four groups for aircraft demonstrations, which were conducted in an AEC-owned AS 350 B3 helicopter due to the lack of availability of an AS 350 B2. The autorotation characteristics of both variants are the same. The practice autorotation procedure is similar, except the AS 350 B3 is equipped with a twist-grip throttle unlike the AS 350 B2, which is equipped with a floor-mounted fuel flow control lever. An AEC instructor pilot sat in the left front seat, and a pilot from each of the four investigation sub-groups had the opportunity to perform the following maneuvers:

1. Practice autorotation with no power reduction to 67% NG; initiated at ~1200 feet AGL and 80 knots; recovery at bottom (no touchdown) – this maneuver is not in accordance with the Flight Manual training supplement;
2. Practice autorotation with power reduction to 67% NG; initiated at ~1200 feet AGL and 80 knots; touchdown – in accordance with the Flight Manual training supplement; and
3. Practice autorotation with power reduction to 67% NG; initiated at ~1200 feet AGL and 120 knots; touchdown – in accordance with the Flight Manual training supplement.

Simulator Demonstrations:

The simulator used for the simulator demonstrations was an Indra full-motion AS350 Simulator, certified to FAA Level B standards. Members of the investigation team were divided into four groups for simulator demonstrations (not the same groups as for aircraft flights). Again, an AEC instructor pilot sat in the left front seat, and a pilot from each of the four investigation sub-groups sat in the right front (pilot) seat. Each person seated in the right front seat had the opportunity to conduct the following maneuvers:

1. Practice autorotation with no power reduction; initiated at ~1200 feet AGL and 80 knots; recovery at bottom (no touchdown) – this maneuver is not in accordance with the Flight Manual training supplement;
2. Practice autorotation with power reduction (67% NG); initiated at ~1200 feet AGL and 80 knots; touchdown – in accordance with the Flight Manual training supplement; and
3. Forced landing autorotation(s) following an unannounced full loss of power at approximately 275 feet AGL and 115 knots (similar altitude and airspeed to what was likely experienced during the accident sequence).

Simulator Demonstration Results:

1. The failure to reduce collective pitch in a timely manner resulted in unrecoverable low rotor RPM.
2. A coordinated combination of reduction of collective pitch and aft cyclic were required to maintain rotor RPM and execute a successful autorotation.
3. When an unannounced loss of power was initiated at ~275 AGL and ~115 knots:
    a. A proper response (down collective/aft cyclic[1]) resulted in an average time of about 25 seconds between the unannounced loss of power and touchdown; and
    b. An improper response (failure to reduce collective pitch or pull cyclic aft) resulted in an average time of four to five seconds between the unannounced loss of power and impact with terrain.

Importance of Power Reduction when Practicing Autorotations:

The simulator demonstrations illustrated the fact that without a reduction in power (partial or full) during a simulated autorotation or forced landing, the symptoms of a loss of power or flame-out, as listed above in Section VIII, are either not present or much less significant.

Significance of Airspeed, Attitude and Altitude When a Loss of Power Occurs:

The simulator demonstrations confirmed the well-known fact that airspeed and attitude are two significant factors that affect how the pilot should appropriately respond with cyclic inputs when faced with a loss of engine power. For example, a pilot who is flying at a very low airspeed, when faced with a loss of power, would need to initially lower collective pitch (to maintain NR) and push the cyclic forward to establish 65 kts in accordance with the autorotation procedure, whereas a pilot flying at a very high airspeed with a nose down attitude would be required to lower collective pitch and pull aft cyclic when faced with a loss of power to establish 65 kts in accordance with the autorotation procedure. The latter is a description of the airspeed/attitude scenario the accident pilot apparently faced when the loss of

[1] Proper cyclic input depends on airspeed and attitude of the aircraft; cyclic should be adjusted to establish 65 kts.

power occurred during the accident flight. Furthermore, the altitude of the helicopter when a loss of power occurs is significant in that it could limit the time the pilot has to execute a complete autorotation, as well as the option to attempt to re-light the engine. More altitude allows more time to conduct a proper and complete autorotation if the pilot reacts correctly and in a timely manner following the initial loss of power.

X. Summary of Findings

1. A thorough inspection of the aircraft and its systems, including the fuel system, was conducted by the investigation team; no pre-impact anomalies were identified which would have precluded normal operation.
2. No fuel was observed at the accident site; less than one liter of fuel was found in the fuel system tank and lines.
3. Damage and signatures at the accident site were consistent with a loss of engine power during flight and subsequent failure of the pilot to maintain main rotor RPM and perform a proper autorotative descent following the engine flame-out.
4. The pilot became aware of his low fuel state when en route to the Harrison County Community Hospital and made a decision to continue with the patient transport flight.
5. Although the pilot reported he had approximately 45 minutes of fuel onboard at the time he departed from Harrison County Community Hospital, it was calculated by the investigation team, and was evident based on the time of the accident, that the aircraft departed with approximately 30 minutes of fuel onboard.
6. Although recoverable as demonstrated in an actual aircraft and in a simulator, and per the Height/Velocity diagram, the low altitude of the helicopter when the flame-out occurred was not ideal for an autorotation following a loss of engine power.
7. The vast majority of the pilot's experience was in twin-engine helicopters, and company training records did not reveal any evidence that the pilot had conducted any practice autorotations with a reduction in engine power during his employment at Air Methods.
8. The pilot was sending and receiving text messages during the accident flight.

XI. Conclusions

Eurocopter concludes the probable cause of the accident was the pilot's decision to conduct the flight with a known low fuel state, which resulted in a loss of engine power due to fuel exhaustion. Also causal were the pilot's failure to maintain rotor RPM (NR) and failure to execute a proper autorotative descent following the loss of power.

Contributing factors may have been the pilot's primary background flying twin-engine helicopters and lack of recent training in autorotations with a power reduction, the low altitude of the aircraft when the loss of power occurred, and the pilot's possible distraction due to outgoing and incoming text messages during the accident flight.