Controlled Flight into Terrain (CFIT) Accidents in Helicopter EMS & Offshore Operations

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Abstract
Controlled Flight into Terrain/Obstacle/Water (CFIT) accidents continue to occur during helicopter EMS (HEMS) and offshore operations. In the last few years, the number of CFIT accidents in HEMS is increasing. In 2003 and 2004, there were three and five HEMS accidents, respectively, which are believed to be CFIT accidents. In offshore operations, a S-76 went down in the Gulf of Mexico in early 2004, which is also believed to be a CFIT accident.

Honeywell developed a version of the Enhanced Ground Proximity Warning System (EGPWS) specifically designed for helicopters. The helicopter EGPWS provides Terrain Awareness Display and Terrain Alerting System customized for helicopter operations. A high-resolution terrain/obstacle database is included in the system. By knowledge of the aircraft’s 3-D location, speed and track, EGPWS can “see” conflicting terrain/water/obstacles along the flight path that may not be seen by the pilots or a radio altimeter, and provides visual and aural alerts to the pilots when a threat is detected.

Some EMS and offshore helicopter CFIT accidents from recent years were studied and their accident profiles were simulated using a Helicopter EGPWS. The analysis results show a helicopter EGPWS would have provided sufficient warning and situational awareness to the pilots if the system was installed.

Helicopter CFIT Accidents
Controlled Flight into Terrain (CFIT) is a type of accident in which a perfectly working aircraft is flown into the ground, man-made obstacles or water. For the purpose of this study, wire strike accidents are excluded.

Based on NTSB preliminary accident reports, in 2003 and 2004, there were 11 turbine-powered helicopter accidents, which can be classified as CFIT accidents, involving Part 135 operators in the U.S. (including their Part 91 operations) and 41 lives were lost in the accidents.

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Table 1 – 2003/2004 CFIT (All Part 135 operators)

It is important to note that 8 of these accidents involved EMS operators, three in 2003 and five in 2004. This is a significant increase in the number of helicopter EMS CFIT accidents compared to the number from previous 10 years, averaging one accident a year. The Air Medical Physician Association (AMPA) estimated there were 140,500 helicopter EMS flight hours in 1990 and 217,500 hours in 2001. The helicopter EMS CFIT accident rate was kept less than 1 per 100,000 flight hours until the recent year. This highlights the significance of year 2004. Figure 1 shows the number of EMS helicopter CFIT accidents between 1992 and 2004. An EMS operation is categorized as Part 91 during a ferry flight (e.g., on their way to pick up a patient).

Another remarkable difference in 2004 is that all helicopter EMS CFIT accidents occurred while operating under Part 135 in contrast to other years.
During the 12 year period between 1992 and 2004, there were 19 EMS helicopter CFIT accidents. 84% of those accidents happened during night time and 58% of the CFIT accidents happened in VMC condition as shown in Figure 2.

While about 38% of all helicopter EMS flights are conducted at night according to AMPA, 84% of the EMS helicopter CFIT accidents occur at night. In significant contrast to helicopter EMS CFIT accidents, 29% of 42 helicopter CFIT accidents occurred during nighttime in other (non-EMS) Part 91/135 operations during the same 12 year period as shown in Figure 3.

As pointed out in many accident statistics, the majority of the EMS helicopter CFIT accidents occur during cruise phase impacting terrain.

The EMS and offshore industries as well as NTSB are currently studying the effectiveness of helicopter Enhanced Ground Proximity Warning System (EGPWS) as a tool to enhance flight safety. In fact, there are some proactive operators who are already operating with a helicopter EGPWS. Some positive outcomes have been reported by EGPWS equipped operators.

The helicopter EGPWS systems are briefly described below followed by simulation results of helicopter EMS and offshore CFIT accidents using EGPWS.

**EGPWS "Look Ahead" Algorithms**

In early 2000, Honeywell began developing "look ahead" algorithms specifically tailored to helicopter operations. These algorithms use the present 3-D position, speed and track of the aircraft, together with stored terrain database, to predict a potential terrain threat ahead of the aircraft.

Error-tolerant algorithms have been developed, which consider aircraft position error, aircraft altitude error and terrain database error, to predict conflicts with terrain ahead of the aircraft. The voice messages "Caution Terrain" and "Warning Terrain" are given if the "look ahead" algorithm detects the conflict. The "look ahead" algorithms are carefully designed to minimize unwanted alerts in order to be effective. Therefore, the design approach for the "look ahead" algorithms has been to lean toward the prevention of nuisance alerts.

Because the environment in which helicopters are operated can be significantly different depending on the time of day (day/night) or the meteorological condition (VMC/IMC), two types of "look ahead" protections were designed - "normal mode" and "low altitude mode". The "normal mode" provides more look-ahead protection than the "low altitude mode", and is recommended for IMC or night operation. On the
negative side the "normal mode" may be more prone to
nuisance alerts. The "low altitude mode" (also known as
"tactical mode") is suitable for day VFR operations where
the aircraft is operated in close proximity to terrain. The
desired mode can be selected by the pilots using a switch in
the cockpit.

The "look ahead" algorithms have a caution
envelope and a warning envelope as shown in Figure 5.
The caution envelope typically provides about 30 seconds
of alert in "normal mode" and about 20 seconds in "low
altitude mode". The warning envelope typically provides
about 20 seconds of warning in "normal mode" and about
15 seconds in "low altitude mode". Both envelopes are
modulated based on speed, proximity of runways, etc. to
provide nuisance alert free environment under normal
helicopter operations. The algorithms are not based on
"time to impact". The look-ahead algorithms work in the
same manner with man-made obstacles included in the
terrain/obstacle database except voice messages become
“Caution Obstacle” and “Warning Obstacle”.

![Figure 5 - Look Ahead Envelopes](image)

EGPWS Terrain Awareness Display (TAD)

For enhancing the pilots’ awareness to potential
threatening terrain in controlled flight toward terrain
situations, a map display of the surrounding terrain is very
helpful. The EGPWS is designed to provide an output that
can be used to depict a terrain map on an EFIS Navigation
Display, Weather Radar indicator or Multi Function
Display (MFD). An example of a Terrain Awareness
Display is shown in Figure 6 and the color code is
explained in Figure 7. The color bands were chosen by
pilots who participated in the initial flight evaluations.

Two numbers in lower left corner of the display
are often called “PEAKS” values. The upper value, 05 in
this example, represents the elevation of the highest terrain
(in 100’s of feet) shown on the display. It is 5,300 feet for
this case. The lower value, 01 in this example, represents
the terrain elevation at black/green boundary. It is 1,000
feet in this case.

![Figure 6 – Example of Terrain Awareness Display](image)

![Figure 7 - TAD Color Code](image)

In the event of an alert or warning, the Terrain
Awareness Display can be configured to automatically
"pop up" (if TAD has not been selected) and reset the
display range to 5 nm (2.5 nm in low altitude mode).
Manual selection of the terrain display is also available to
the pilots.

The terrain is displayed referenced to the
aircraft’s altitude. The display, therefore, requires no
mental calculations by the pilots to assess their
relationship to the threatening terrain. No charts or
reference to instruments are required.
When the terrain threat is within the "Caution Terrain" range, the conflicting terrain on the display turns solid yellow. When the terrain threat reaches the warning level ("Warning Terrain"), the conflicting terrain is painted in solid red.

**Effectivity Analysis of Helicopter EGPWS**

1. **A Recent Helicopter EMS CFIT Accident**

   On August 21, 2004, about 11:50 p.m. PST, a Bell 407 helicopter operating as an air ambulance flight, impacted mountainous terrain in cruise flight and was destroyed near Battle Mountain, Nevada. All five persons on board were killed. According to preliminary information, the helicopter crashed shortly after picking up an infant patient and the infant’s mother for a flight to a Reno hospital. Dark night, visual meteorological conditions prevailed. The accident site was along the direct course line from Battle Mountain Hospital to Derby Field Airport in Lovelock. The helicopter impacted rugged mountainous terrain on the eastern slope of the Tobin Range in Pershing County at a Global Positioning System (GPS) location of 40 degrees 27.147 minutes North, 117 degrees 29.517 minutes West, and an elevation of 8,644 feet. The debris path was along a magnetic bearing of 230 degrees. Evidence of a high-speed impact and a fire has been reported. The flight was being operated as a commercial 14 CFR Part 135.

   The simulated aircraft track is plotted on a sectional map in Figure 8. The profile plot in Figure 9 shows the simulated aircraft altitude in blue and the profile of the mountain in brown.

   The pilot would have seen a terrain picture shown in Figure 10 approximately 90 seconds prior to impact if EGPWS was installed. The terrain display clearly shows a terrain conflict ahead of the aircraft in yellow, indicating the terrain is at or above the aircraft’s present altitude. The “upper PEAKS” value indicates the maximum terrain elevation in the area is 9,700 feet.

   35 seconds from impact, EGPWS would have given the first aural alert “Caution Terrain”. The conflicting terrain detected by the EGPWS look-ahead algorithms are now depicted in solid yellow as shown in Figure 11. Also note that the display range is automatically set to 5 NM.
Aural warning “Warning Terrain” would have been given approximately 21 seconds from impact. The conflicting terrain detected by the EGPWS look-ahead warning algorithms are now depicted in solid red as shown in Figure 12.

Although the EGPWS terrain display cannot be used for navigation, the display can provide pilots a much higher level of situational awareness.

It should be clear from information depicted on the terrain display shown in Figure 10, there is conflicting terrain in three miles ahead of the aircraft. This information is available a long time before EGPWS gives the aural alerts and warnings.

2. A Recent Helicopter Offshore CFIT Accident

On March 23, 2004, at about 1918 Central Standard Time, a Sikorsky S-76A helicopter crashed about 30 minutes after takeoff from Galveston International - Scholes Airport, Galveston, Texas. The 2 crewmembers and 8 passengers onboard were killed. The helicopter was destroyed due to impact forces with the water. No emergency or distress calls from the aircraft were reported before the accident. The wreckage was located about 70 miles southeast of the departure airport. The flight was being operated as a commercial 14 CFR Part 135.

This probable accident scenario was simulated using a helicopter EGPWS. The simulation result is described below.

This aircraft most likely impacted the ocean with very small vertical speed, something like 150 feet per minute. Although many people think EGPWS is designed only for flight into a “mountain”, the fact is that EGPWS can provide good protection for a descent over flat terrain/water accident scenarios. As described in a previous section, EGPWS, not only looks ahead of the aircraft, it also looks below the aircraft for safe terrain clearance appropriate for a given phase of flight. When the aircraft descend below the safe terrain clearance, EGPWS will issue “Caution Terrain” alert. If the descent continues, the message changes to “Warning Terrain” warning. EGPWS can also provide an “Altitude Callout”. It can be configured so that EGPWS gives an aural message “Altitude Altitude” as the aircraft descend through a certain radio altitude threshold set by a bug on the radio altimeter.

Assuming DH Bug was set at 400 feet

Assuming a shallow rate of descent of 150 feet per minute and that the DH bug was set at 400 feet, the
EGPWS simulation result shows an “Altitude Altitude” advisory callout would have been given 160 seconds prior to impact. A “Caution Terrain” alert would have been given at approximately 240 feet, 97 seconds before impact. At approximately 200 feet, 84 seconds prior to impact, the alert would have switched to “Warning Terrain” warning.

**Conclusions**

Based on the helicopter accident analysis, Controlled Flight into Terrain accidents can occur during day and night, in VMC and IMC conditions, regardless of pilots’ experience level. Although it is not intuitive, a CFIT accident does happen during day VFR flight. It is also important to realize that a CFIT accident does not happen only in mountainous environment. CFIT risks even exist over a flat terrain or water.

The EGPWS Terrain Awareness Display provides a high level of situational awareness to helicopter pilots. Many CFIT accident situations can be avoided long before the “Look Ahead” algorithms detect a threat and issue aural alerts by simply “seeing” terrain on the display. In accident situations over flat terrain or water, EGPWS provides “radio altitude callout” in addition to aural alert and warning when a helicopter descends below safe altitude. The EGPWS can help in significantly reducing the CFIT risk. However, proper pilot training on CFIT awareness is equally important to reduce the CFIT risk.

**Reference**