Rotary Wing (RW) Mishaps in DVE- Latest Statistics

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ABSTRACT

Brownout (BO) is the condition where there is little or no out-the-cockpit window visibility caused by dirt and dust being stirred up by the rotor downwash and then re-circulated by the rotor blades of a helicopter during taking off or landing in an arid climate. Similar conditions can be created by landing or taking off in snow (whiteout WO) or over water. It should be noted that WO in snowy conditions is also commonly referred to as "snowball" by aircrew to distinguish this particular condition from atmospheric WO caused by omnidirectional cirrus cloud formation, fog, or overcast sky over continuous snow surface or intermittent cloud blend in with snow-covered terrain. In general, Degraded Visual Environments (DVE) cause pilots to rely on inadequate cockpit instrumentation, callouts by on-board aircrew, and innate piloting skill to successfully execute a DVE landing. Flying in DVE has always been a challenge for rotary-wing pilots. Since NATO has been operating in the arid climates (e.g., Iraq, Africa and Afghanistan), Rotary-Wing Brownout (RWB) is responsible for approximately 75% of coalition helicopter mishaps. In their 2013 report at the conclusion of the HFM-162 task group, rotary wing mishaps due to DVE were summarized for each of the contributing nations. Those statistics are presented here and, in some cases, updated to 2016. Recommendations for improvements to RW aircraft are made that would help reduce the loss of aircraft and lives.

1.0 UNITED STATES DEPARTMENT OF DEFENSE STATISTICS

The US Department of Defense (DoD) has an inventory of over 7000 Rotary-Wing (RW) aircraft since 1985 (Mapes, 2005). This includes RW aircraft in the US Army, US Navy and Marines, and US Air Force. The primary takeaways are that the DoD BO Class-A mishaps have occurred largely at night and during the landing phase over this time period. Secondary observations are that a slightly higher fraction of the takeoff and day conditions existed for the destroyed aircraft than the other Class-A BO mishaps. In the US Air Force, more than 30 Special Operations RW aircraft and 60 crew-members have lost their lives during landing in desert environments in DVE since 1990. The US Air Force reports that since 2005 there have been 22 Class A RW mishaps, six are attributed to operations in DVE with no fatalities and 5 injuries. The US Army reports 73 Class A helicopter mishaps from fiscal year 2000 – 2016 attributed to operations in DVE. DVE mishaps account for 46.2% of Army aviation fatalities (Dickinson, 2017). Most of the Army fatalities occurred in cruising, not hovering flight, and were the result of flight in instrument meteorological conditions or night, not brownout. The US Navy reported 2 fatalities and 38 personnel injured in brownout/whiteout mishaps in their helicopter operations since 1985. The assessed cost of DoD aircraft destroyed 2000-2013 from BO amounted to about $533M total from 26 losses (Greer, 2015). Few lives are lost due to RWB and few injuries occur compared to other causes in the nearly 1000 lost or damaged US DoD helicopters (1985 – 2005) even though RWB landings are the overall largest cause of RW airframe loss in the US Services. Recent 'DVE' data calls include RWB with controlled flight into terrain from a cruising configuration at velocities well above those seen in hovering mishaps. Mishaps grouped under 'DVE' mix two distinct types of mishaps that are amenable to mitigation with completely different solution sets.

US DoD aircraft mishaps are grouped into discrete classes based on the total property costs associated with them or the personnel casualty (fatality/injury severity) levels involved. The accidents involving the highest cost for property damage or involving loss of life are called Class-A mishaps. These involve the rotorcraft destruction, a total damage cost in excess of $2M (which represents an increase from the $1M threshold before 2009), a fatality or permanent total disability. The focus for this paper is on Class-A mishaps (particularly the subset that includes total aircraft destruction).

The numbers of Class-A mishaps attributed to BO by year across all the US services from 2000 to 2013 are illustrated in Figure 1 (Greer and Schwartz, 2013). The stacked bars use the scale on the left and are composed of destroyed aircraft and other (repairable) Class-A incidents. The cumulative total numbers of Class-A mishaps are also displayed with the overlaid lines using the scale on the right side. The top chart is for OIF (Operation Iraqi Freedom) /OEF (Operation Enduring Freedom) while the bottom chart is for the Rest of World (ROW), with the same scales. A spike in mishaps during the rapid ramp up of operations is clearly shown for 2003 in OIF/OEF. Although the BO phenomena was well understood dating back to at least the 1980's (with the infamous mishap during the failed attempt to rescue Iranian hostages), the US military's level of exposure to BO environments was not significant until 2002. Despite the significant reduction from 2003 to 2004, BO mishaps persisted through 2013 with smaller spikes over this time frame. For the ROW, by comparison, relatively very few BO mishaps occurred over this time period. Overall, 26 of the 53 Class-A BO mishaps (approximately 49%) resulted in an aircraft destroyed. Interestingly, this percentage is somewhat higher for ROW than for OIF/OEF.

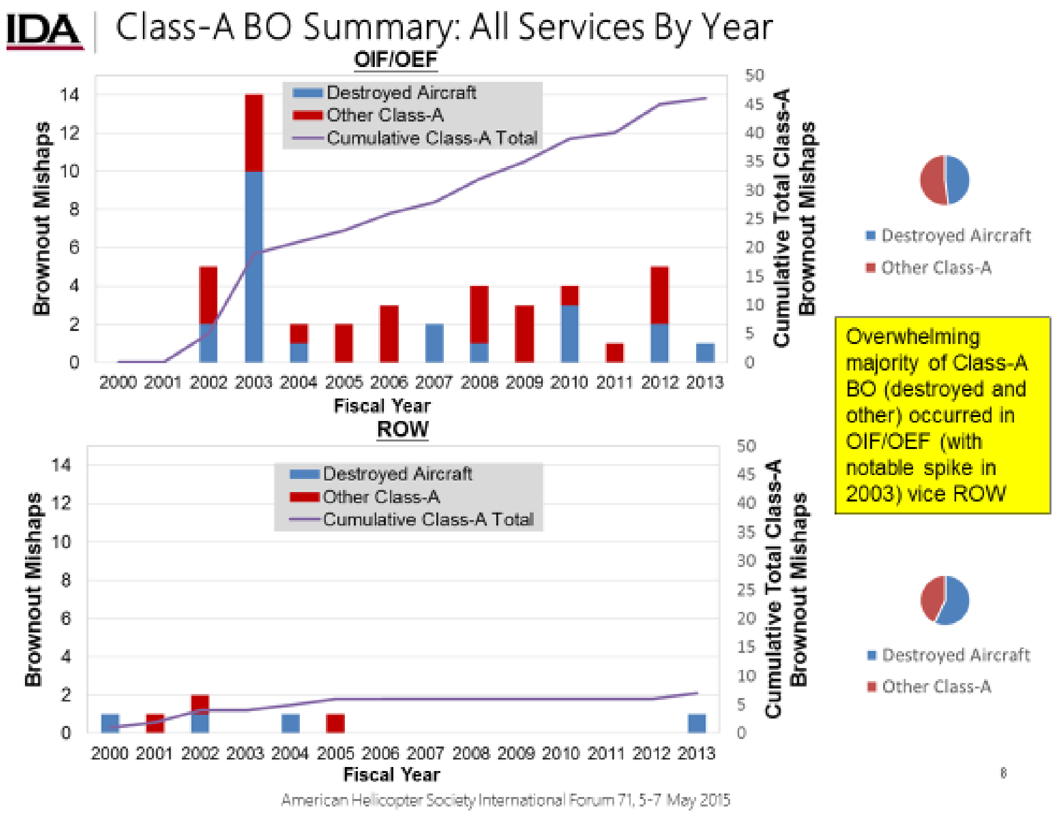
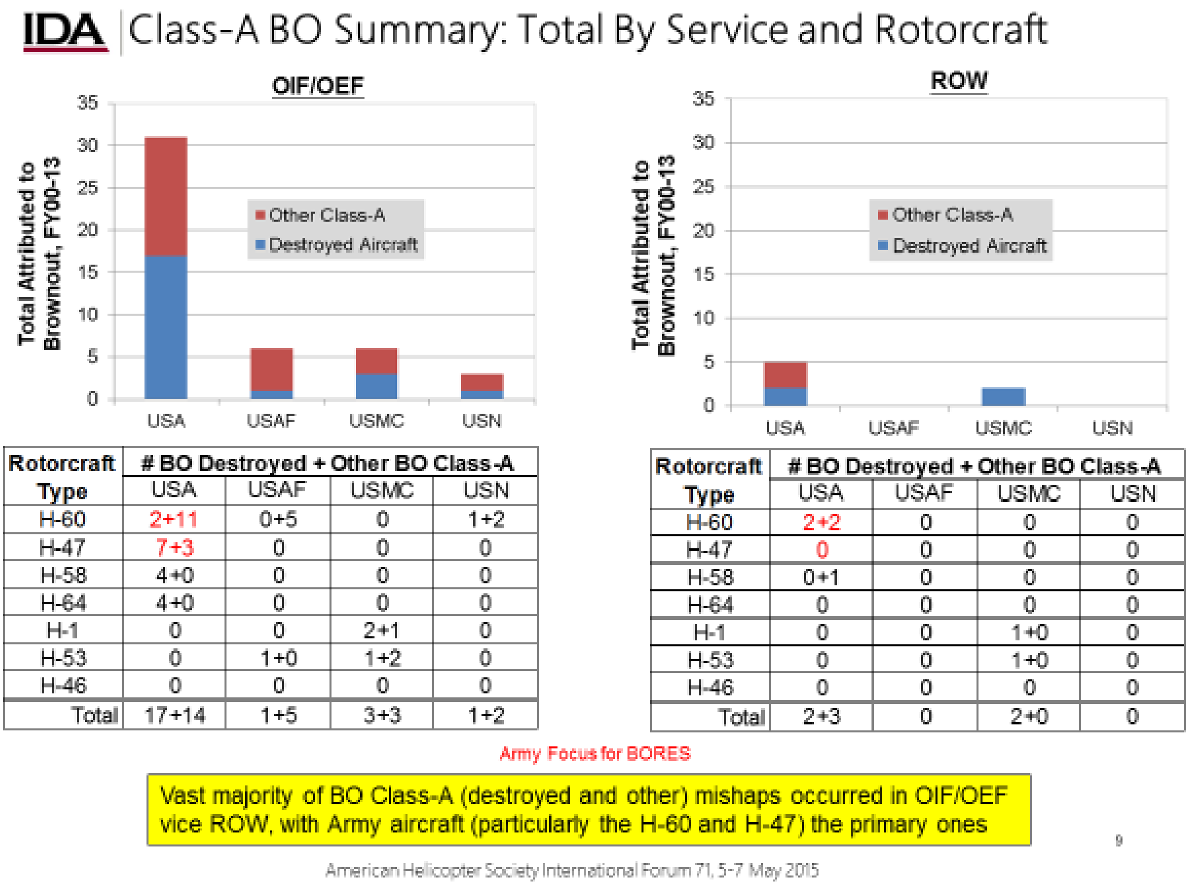


Figure 1. **Class-A BO Summary: All US DoD Services by Year (Greer et al, 2015)**

The total number of US service specific Class-A mishaps attributed to BO across the 2000-13-time period is shown in Figure 2, again with the stacked bars composed of destroyed aircraft and other (repairable) Class-A incidents (Greer et al, 2015).



OIF/OEF:

Rotorcraft Type	# BO Destroyed + Other BO Class-A			
	USA	USAF	USMC	USN
H-60	2+11	0+5	0	1+2
H-47	7+3	0	0	0
H-58	4+0	0	0	0
H-64	4+0	0	0	0
H-1	0	0	2+1	0
H-53	0	1+0	1+2	0
H-46	0	0	0	0
Total	17+14	1+5	3+3	1+2

ROW:

Rotorcraft Type	# BO Destroyed + Other BO Class-A			
	USA	USAF	USMC	USN
H-60	2+2	0	0	0
H-47	0	0	0	0
H-58	0+1	0	0	0
H-64	0	0	0	0
H-1	0	0	1+0	0
H-53	0	0	1+0	0
H-46	0	0	0	0
Total	2+3	0	2+0	0

Figure 2. Class-A BO Summary: Total by Service and Rotorcraft (Greer et al, 2015)

With the breakout of these mishaps between OIF/OEF and ROW operations, it is again clearly apparent that the overwhelming majority of BO Class-A mishaps occurred in OIF/OEF vice the ROW (Greer et al, 2015). The Army has by far the largest number of BO Class-A mishaps (roughly 68% of the overall total) mostly in support of Central Command (CENTCOM) operations over this time period. The USMC and the USAF have the next highest total combined number (approximately 15% and 11% respectively) followed by the USN (at about 6%). The table under each bar chart shows the type of rotorcraft that constitute each bar. Within each cell, the first number listed is the number of aircraft destroyed and the second number represents other Class-A mishaps. For the Army, the H-60 and H-47 are the predominant Class-A BO mishap contributors with the H-47 being the aircraft suffering the greatest number of losses due to BO. Within the Army, most of these mishaps were with aircraft in the Active force (versus Guard/Reserve forces). For the Air Force and Navy, the H-60 is the main aircraft type experiencing a Class-A mishap due to BO. For the Marine Corps, the H-53 and H-1 are the primary contributors to the BO Class-A mishaps. While not shown in the table, it is interesting to note that all four of the Army AH-64 attack aircraft were lost early in OIF/OEF, whereas the Army H-60 and H-47 transport aircraft Class-A mishaps due to BO were spread throughout this time period. A MV-22 aircraft experienced a hard landing in BO (2013) which was classified as a Class-A mishap. All four of the crew walked away.

The number of Class-A mishaps attributed to BO by phase of flight and diurnal condition for all the US services is presented in Figure 3. The pie charts are partitioned by destroyed aircraft (loss) and other Class-A mishaps for OIF/OEF, the ROW, and total combined. The underlying data are for all the services across the 2000-13-time period. The primary takeaways are that the BO Class-A mishaps have occurred largely at night and during the landing phase over this time period. Secondary observations are that a slightly higher fraction of the takeoff and day conditions existed for the destroyed aircraft than the other Class-A BO mishaps. Similarly, a slightly higher fraction of the takeoff and day conditions existed for OIF/OEF versus the ROW Class-A BO mishaps.

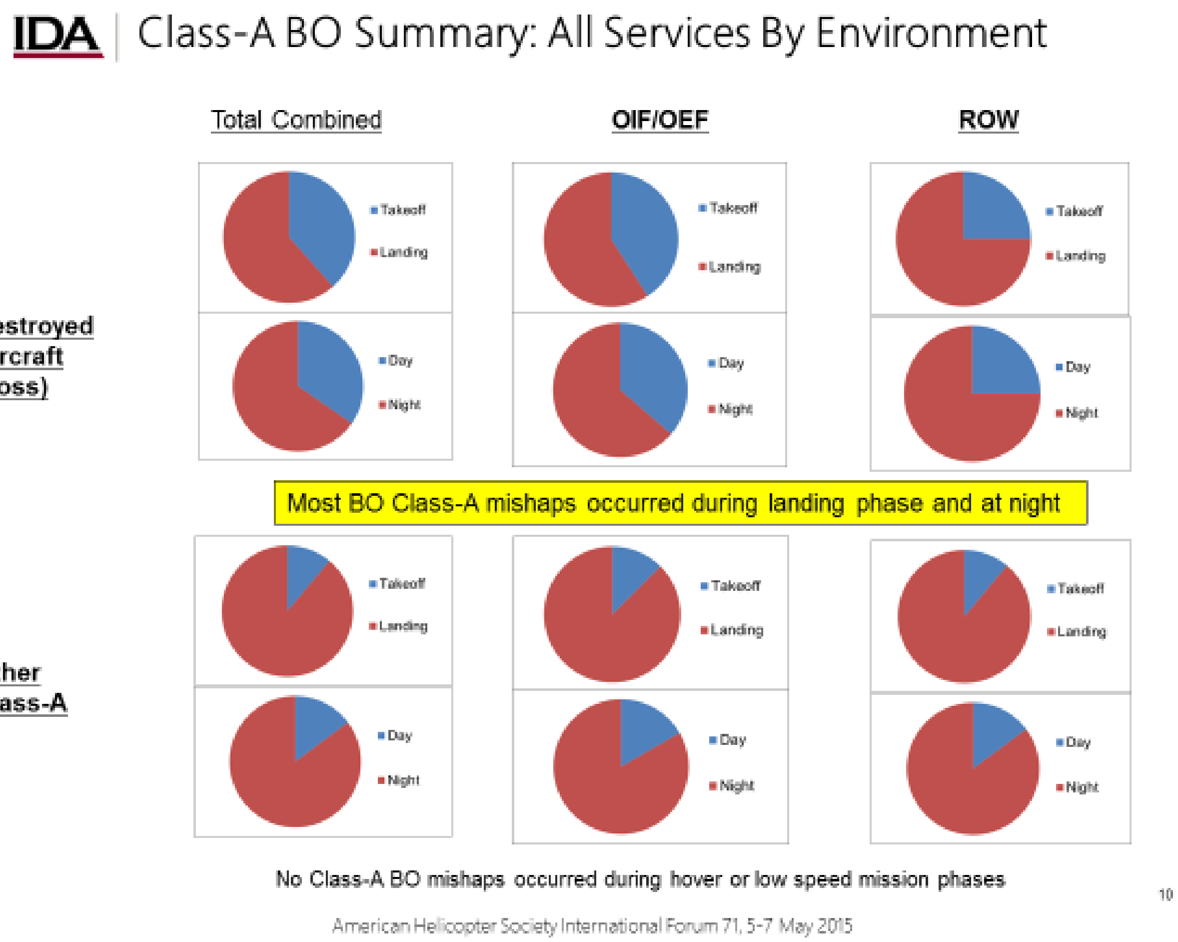


Figure 3. Class A BO Summary: All Services by Environment (Greer et al, 2015)

2.0 OTHER NATO NATIONS REPORTING

Other NATO countries also reported RWB mishaps that impact operations. The United Kingdom (UK) experienced 24 brownout mishaps involving material damage in the 5-year period 2005 – 2009 of which, 70% were assessed as being due to Spatial Disorientation (SD) and/or mishandling and 30% were attributed to an unseen Landing Site (LS) hazard. The UK reports

RW mishaps in DVE have decreased over the recent past (Curry, Bushby 2016). Since 1973, Bundeswehr (German Defense Forces) has recorded a significant number of mishaps (>30) in association with dust or snow. RWB contributed to a Canadian Forces (CF) Griffon (CH146) crash in Afghanistan in 2009, during take-off, which resulted in three fatalities and three injuries. Between 1986 and 2006, there were 2 whiteout related accidents and 54 incidents in the CF (Cheung, 2016). Norway cites 13 whiteout/brownout mishaps since 1982. France has experienced eight brownout mishaps over the past 15 years, most occurring in Africa. In Sweden, whiteout was a contributing factor in at least one fatal and one minor mishap. The Netherlands reports a CH-47 Chinook D did not notice left drift during an approach in Afghanistan. The aircraft rolled over on the ground, caught fire and was destroyed.

CONCLUSIONS

For every brownout death in the US Army, there are 10 to 14 cruise CFIT deaths. Also, brownout is not a routine ops tempo problem, it is a specific risk associated with the war in the dessert and was worse earlier on. Training and tactics have beaten it way down (Mapes, 2016). RWB doesn't generally kill people or totally destroy aircraft. Controlled Flight Into Terrain from cruise velocity, not hovering velocity, is the biggest cause of death in helicopters with mid-air collisions a distant second (Mapes, 2005). Many of the DVE RW mishaps are characterized by injuries rather than deaths, primarily since they occur at low altitudes. In any event, even injuries adversely impact the availability of combat personnel and negatively affect readiness and the mission. This lecture series will address improvements in sensors, display graphics/symbology and training which are collectively helping to reduce the threat of RW mishaps in DVE.

RECOMMENDATIONS FOR WAY AHEAD (Mapes, 2016)

Lifesaving and crashworthiness recommendations

NATO helicopters need Helicopter Terrain Avoidance and Warning Systems (HTAWS). Commercial off the shelf (COTS) hardware is available (Mapes, 2007). It is estimated an HTAWS system would prevent 54% of the fatal H-60 mishaps in the US DoD services (Mapes, 2016). Bring data-link weather data into all helicopter cockpits. Provide COTS traffic warning technology to prevent midairs (the second leading cause of human factor mishap fatality in military helicopter operations in the US DoD). All helicopters need wire detection technology. Wire cutters should be installed on all helicopters (Mapes, 2007). Develop extensive simulator training for Human Factor Mishap Scenarios.

Occupants of mishap helicopters above Effective Translational Lift (ETL) cannot be adequately protected, the only protection is mishap prevention through increased situational awareness (Mapes, 2007). Injuries and deaths in low speed mishaps can be mitigated:
-All occupants should use the 5-point lap and shoulder restraints (Wright, 2013)
-Airbag installation should be encouraged (Wright, 2013)

-Stroking seats should be standard for all occupants (Mapes, 2007)
-Head protection use should be required of all occupants (Mapes, 2007)
-Continue to improve rear compartment seating (Mapes, 2007; Wright 2012)
-Crew positions should be designed to eliminate (minimize) the need for any crewmember to be out of a crashworthy seat below ETL (Mapes 2007)
-Maximize use and acquisition of twin rotor multiengine designs (Mapes, 2007)
-Move pilots out in front of forward rotor head (Mapes, 2007)
-Prevent occupancy beneath heavy components (Mapes, 2007)

Aircraft Saving Recommendations

All helicopters need technology permitting safe flight and the maintenance of situational awareness (SA) in DVE including brownout /whiteout conditions, particularly at night (Mapes, 2007):
-Automated hover with instant availability (Mapes, 2007)
-Automated landing systems (Mapes, 2007)
-Sensor based systems
-Intuitive hover and landing graphics on cockpit displays (including tactile cues)
-Effective simulator training as well as in-flight training
-All helicopters without rearward visibility (AH & OH) should be equipped with technology to prevent tail rotor strikes (Mapes, 2007):
--Warning systems that notify the pilot when an object is in the proximity of the tail rotor (Mapes, 2007).
--Automated systems permitting hover over a fixed position without drift (Mapes, 2007).

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Appendix A Specific cases of DVE mishaps by nation

1.0 UNITED STATES

1: US – A UH-l was operating in an area that had been heavily used by tanks. The aircraft landed about 35 meters (m) from the tank trail to pick up a soldier. The PC, who was flying the aircraft from the left seat, took off. But before the aircraft reached transitional lift, it was engulfed by powdery dust blown up from the tank trail by rotor wash. The aircraft drifted to the right. The PC knew there were trees in front of the aircraft, and he pulled in torque and turned to the right to avoid a tree that was 55 feet high. The aircraft had flown about 380 feet when the blades hit four trees in quick succession, then hit the ground nose-low, rotated on its nose, and rolled onto its left side.

Case 2: US – A HH-60 approached into a survivor's location. As the Aircraft descended below 200 feet AGL and began to establish a hover, it encountered severe brownout conditions that obscured all outside references from the cockpit. Brownout at such high altitude is extremely rare and was completely unanticipated. At this point, the pilot determined the need for a go-around, called "on the go", and initiated a go around. Approximately one to two seconds after leaving the dust cloud, the aircraft impacted rising and rolling terrain. The helicopter skipped up the side of the hill on its belly for several feet until the momentum dissipated. The helicopter then rolled 5 – 7 times down the hill coming to rest on its right side approximately 180 feet below the point of impact.

2.0 UNITED KINGDOM

Case 1: UK – A Lynx helicopter took off to a night/day sortie under white light configuration when origin of a warning light was diagnosed. The crew paused the take-off not recognizing the forward move of the post lift-off dust. The moving dust caused a vection illusion (a visually induced sensation of self-motion) of rearward drift. To counter this perceived drift attitude additional forward adjustment was made with insufficient power setting. The aircraft struck the ground 50 m in front of the departure point.

3.0 GERMANY

Case 1: Germany – A serious category B incident occurred during an intended landing in Rustaq, Afghanistan involving a CH-53GS. Recognizing a drift, the pilot decided for a go around. During the take-off, the rotor hit a wall followed by the fuselage front and side sections striking a tree. Though heavily damaged, the aircraft was able to return to its base. In his final report, the Director of Bundeswehr Flight Safety stated that the "technical tools to support the crews during dust landings (e.g., sensor-based or automatic landing technology) must be developed".

4.0 CANADA

Canada specifics (Cheung, 2016)
Case 1: **Sea King, off the coast of Denmark, 2006**
Case 2: Cormorant, in Canada, 2008
Case 3: Griffon involved NVG and dust ball hard landing at Yuma (19 Jan 2008)
Case 4: Griffon in Afghanistan (6 July 2009) 2 CF and 1 UK personnel killed, 3 injured
Case 5: Chinook roll over in Afghanistan (16 May 2011)

5.0 NORWAY

Case 1: Norway – The Lynx was flying westward following the northern shoreline of a snow-covered lake in slight snow showers. The forward visibility was 2 – 4 km, but left hand visibility was very poor with no defined horizon due to dense snow showers. Slightly up-sloping terrain with small trees sticking out of the snow were visible on the right-hand side. As the shoreline turned southwest, a slight left turn was started at about 15 degrees bank. Shortly after the helicopter hit the snow-covered lake it slid about 140 m before coming to a standstill. All three crew-members were convinced they had good clearance to the lake at the time of impact.

Case 2: Norway – After a difficult NVG snow landing to pick up an injured soldier, the Bell 412 crew had to shovel away a snow pile on the left of the aircraft for better rotor clearance. The pile had been invisible on NVGs during high and low recce. During take-off in white out, the helicopter drifted forward and hit the top of a tree with the nose and belly. The only damage was a broken left pitot tube.

Case 3: Norway – It was a very dark night, with the crew on NVGs, during a Bell 412 medevac pick-up exercise near Meymaneh Afghanistan. The LZ seemed normal on high and low recce. They entered brownout three seconds before landing. Then the tail stinger unexpectedly touched the ground one sec before landing, hitting a 50 – 80 cm terrain elevation, not visible on NVGs. The only damage was the anti-collision lights falling off.

Norway DVE Mishaps update (Stagnes, 2016)

2006: Bell 412, tree strike, white out
2008: Bell 412, tree strike, white out

2009: Bell 412, tree strike during takeoff, white out
2011: Bell 412, tree strike, white out
2012: Sea King, accident during landing, possible white out as contributing factor
2014: Bell 412, contact between tail stinger and ground, brown out

6.0 NETHERLANDS

Case 1: Netherlands – A CH-47 Chinook D did not notice left drift during an approach in Afghanistan. The aircraft was operating 80 NM south of Kandahar under marginal VMC night-time conditions. Poor visibility conditions due to brownout obscured all necessary visual outside references in the final phase of the approach. The drift was detected too late to take corrective action and the aircraft rolled over on touchdown, coming to rest lying on its left side. A fire started in the rearward part of the helicopter and destroyed it.

7.0 SWEDEN

Case 1: Sweden – During a flight in an Augusta Bell 412HP in northern Sweden the weather got bad with heavy snow and since it was early evening the light conditions were poor. The pilot decided to continue with reduced altitude and airspeed. When the weather situation got worse the pilot decided to land. At an altitude of five meters the helicopter had a tail wind and shortly after they completely lost all ground references. The helicopter crashed with major damage of the helicopter but with no serious personnel injuries.

8.0 FRANCE

Case 1: France – Three Pumas helicopters on a patrol flight under NVG. First aircraft landed provoking whirling dust. The second aircraft hovered in about 15 ft. height, waiting for dissipation of the dust. A lateral drift was not detected and the puma bumped vegetation. The pilot in command decided to go around. After flight inspection showed a structural damage of the stabilizer.

Case 2: France – A Puma helicopter under NVG on a night training flight for dust landings. On short final approach the pilot flying lost outside references. Not being alerted by the pilot flying the pilot in command lost SA, the aircraft bumped into the ground.