



SAFETY CONSIDERATIONS

METHODS TO IMPROVE HELICOPTER PILOTS' CAPABILITIES

TRAINING LEAFLET



HE 1





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Introduction

The European Helicopter Safety Implementation Team (EHSIT) is a component of the European Helicopter Safety Team (EHEST). The EHSIT is tasked to process the Implementation Recommendations (IRs) issues identified from the research conducted by the European Helicopter Safety Analysis Team (EHSAT) (see Final Report - EHEST Analysis of 2000 – 2005 European helicopter accidents¹).

This leaflet is the first in a series of safety related leaflets and publications aiming at improving safety by sharing good practises. These leaflets will be accompanied by web based training materials including videos, which will be available freely to all pilots in order to enhance flight safety by addressing recognised training related issues.

Aim

Data from the EHSAT review confirm that a continuing significant number of helicopter accidents is due to pilot disorientation in the Degraded Visual Environment, Vortex Ring State, Loss of Tail Rotor Effectiveness and Static & Dynamic Rollover. Therefore, the aim of this leaflet is to improve the safety of helicopter operations by providing pilots with the relevant information for each of these topics in order to allow a basic understanding of the causes, the prevention and the recovery actions thereby enabling pilots to make better, more informed decisions.

¹ Document ref.: Final Report - EHEST Analysis of 2000 – 2005 European helicopter accidents (ISBN 92-9210-095-7)



1. DEGRADED VISUAL ENVIRONMENT (DVE)

A continuing significant number of accidents are due to pilot disorientation in a degraded visual environment (DVE). Research has demonstrated the strong relationship between helicopter handling characteristics and available visual cues.

This has clearly shown that there are likely to be visual cueing conditions, helicopter handling characteristics and pilot capabilities which, although manageable individually, can be predicted to be unmanageable when in combination.

Analysis indicates that any, or a combination of, the following three scenarios could result in a serious accident:

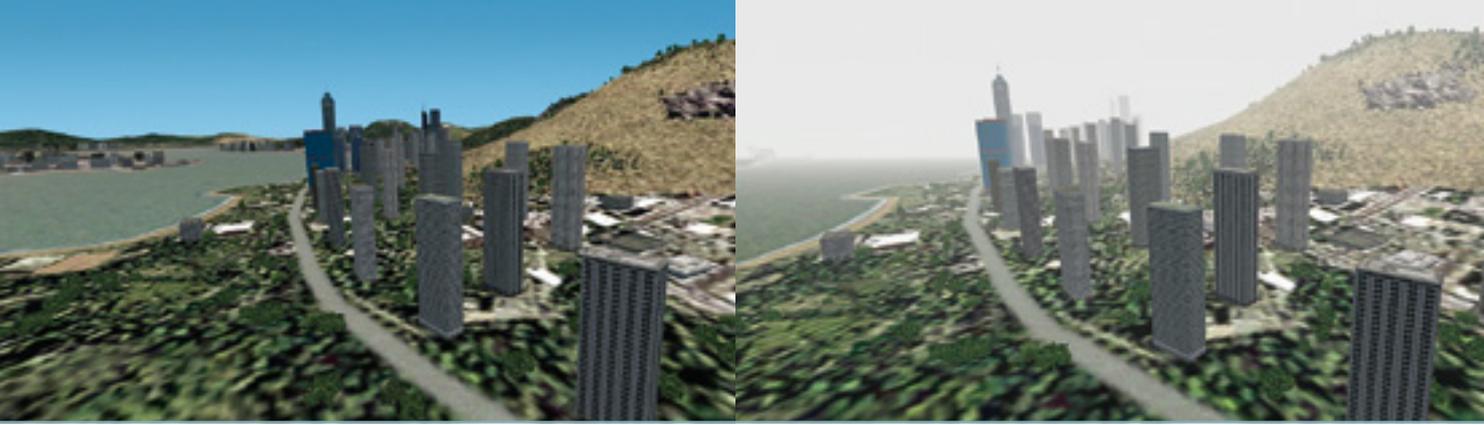
- A »** Loss of control when attempting a manoeuvre to avoid a region of impaired visibility, i.e. backtracking, climbing above or descending below the DVE.
- B »** Spatial disorientation or loss of control when transferring to instrument flight following an inadvertent encounter with IMC.
- C »** Loss of situational awareness resulting in controlled flight into terrain/sea/obstacles or a mid air collision.

1.1 Helicopter Handling Characteristics

The inherent instability of the helicopter is a major factor in such accidents. For small un-stabilised helicopters, it is the pilot who has to provide the stability and he needs visual cues to do so.

1.2 Pilot Capabilities

Whilst most pilots receive limited basic training in 'flight with sole reference to instruments', the competence in this skill can deteriorate rapidly and therefore cannot always be relied upon to safely extricate the unprepared pilot from an inadvertent IMC situation.



1.3 Visual Cues

Evidence shows that for a significant number of fatal accidents the primary causal factor was degraded visual cues. Common factors, which act to degrade the available visual cues, include:

- A »** Low levels of ambient light leading to a general reduction in the quality of the visual scene and the available optical cues, e.g. at dusk/night.
- B »** Reduced visual range and/or loss of sight of the ground/surface of the sea due to the effects of fog or cloud.
- C »** The presence of atmospheric haze or sun glare.
- D »** A lack of surface texture or features such as buildings, roads and rivers, or lack of street lighting etc. when flying at night.
- E »** A lack of texture on the surface of the sea/water, i.e. calm water.
- F »** Poorly delineated sloping or rising ground contours i.e. snowfields.
- G »** Misleading cues such as a false horizon from, for example, a distant row of street/road lights.
- H »** Obscuration due to precipitation or misting on the cockpit windows.

1.4 Risk Analysis

When planning a visual reference flight 'with the surface in sight', there are a number of obvious risk factors which should be taken into consideration prior to take-off:

- 1 »** The aircraft is certificated for VFR/VMC flight only.
- 2 »** The pilot is not trained/current for instrument flight operations.
- 3 »** The pilot is not trained/current in recoveries from unusual attitudes.
- 4 »** The navigation will be by map and visual reference, perhaps with GPS backup.
- 5 »** The flight is planned to take place at a height at which the surface cannot be clearly defined.
- 6 »** A segment of the route involves over-flight of a rural, unpopulated area or large featureless areas such as water, snow etc.
- 7 »** The flight is at night or in conditions of atmospheric 'gloom'.
- 8 »** Flight at night when there is no moon, or the stars and moon are obscured.
- 9 »** There are, or are likely to be, significant layers of low level cloud en-route (4/8 – 8/8).
- 10 »** The visibility is, or is likely to be, limited en-route, i.e. visual range at or close to the minimum required for conducting a safe flight, (which may be significantly higher than the stated state minima).
- 11 »** There is a significant probability of encountering mist/fog/haze en-route.
- 12 »** There is a significant probability of encountering precipitation en-route.



If these risk factors are considered as a risk assessment checklist, it can be seen that the magnitude of risk increases with the number of risks 'ticked'. For example:

- If risks 1 to 4 were to be ticked, this would only pose a normal, acceptable level of risk provided that the flight were to be undertaken in good VMC conditions.
- If risks 1 to 9 are ticked, experience indicates that **the flight should not be undertaken.**
- Risks 7 to 12 all add to the type of conditions that would make it **extremely unlikely that a pilot would be able to maintain control of the aircraft's attitude by visual references alone.**

1.5 In Flight

Once a flight is underway other risk factors may come into play:

- 13** » There is a low level of ambient light.
- 14** » There is no visual horizon, or the horizon is only weakly defined at best.
- 15** » There are few, if any, visual cues from the ground plane.
- 16** » Changes of speed and height are not perceivable, or only poorly perceivable by visual reference alone.
- 17** » Reducing height does not improve the perception of the horizon or cues on the ground.
- 18** » The view from the cockpit is obscured due to precipitation/misting.
- 19** » The cloud base is lowering causing an unintended descent to retain similar forward visual cues.

These factors will add to the inherent risk of the flight already assessed by the risks ticked prior to the flight. For example:

- Even if only risks 1 to 4 were to be ticked prior to flight, the overall risk would increase significantly were any of risks 13 to 19 to be subsequently encountered en-route.
- Risks 13 to 19 all point to the need for extreme caution (i.e. gentle manoeuvres only!) and **serious consideration should be given to terminating the flight and conducting a safe, controlled precautionary landing as soon as is safe to do so.**

1.6 Loss of Visual References

If external visual references are lost then to prevent spatial disorientation, a pilot will need to transfer his attention immediately onto the aircraft instruments and use them to establish a safe flight profile. A rapid risk assessment, taking into consideration the weather, terrain, aircraft limitations, fuel and pilot's capability is critical to a speedy establishment of a nominated safe flight profile. This may require the pilot, once established on instruments, to conduct a turn back, a descent or a climb to a safe altitude or a combination of these.

1.7 Conclusion

Risk analysis and timely decision-making are essential tools to be used by the pilot during both the planning and the flight stages. Constant updating and evaluation of all of the available information should assist the pilot to recognize dangers inherent to a degraded visual environment. This will assist the pilot to carry out the appropriate actions in order to prevent the situation from developing into a critical stage for which the pilot may not have the relevant skill level, capabilities and/or helicopter instrumentation to cope with safely.



2. VORTEX RING STATE

Often considered as the equivalent of the fixed-wing stall, Vortex Ring is a condition of powered flight where the helicopter “settles” into its own downwash. Consequently, the Rate of Descent (ROD) will increase dramatically (typically, at least three times the ROD before entering Vortex Ring), for the same power setting.

2.1 Conditions for Vortex Ring

Vortex Ring is likely to occur when descending in powered flight at an airspeed below 30 Kts with a Rate of Descent (ROD) close to the main rotor “downwash velocity”.

Downwash velocity or induced velocity is defined as the airspeed of the airflow drawn down through the rotor disc (Froude formula). The induced velocity is a function of the helicopter type and gross weight. For example, a three bladed helicopter with a rotor diameter of 10.69m and a weight of 2,250 kg would result in an induced velocity of 10 m/s (2000 ft/min). Whereas, for a two bladed helicopter type with a rotor diameter of 11m and a weight of 1,000 kg the induced velocity is 6.5 m/s (1300 ft/min.).

Therefore, although Vortex Ring State is shown to be dependant on the helicopter type and weight, a commonly accepted unsafe ROD is considered to be in excess of 500ft/min.

2.2 Effect of Vortex Ring

- Vibrations as vortices break away at the blade tips
- Less responsive (sluggish) pitch & roll controls as a result of the unstable airflow constantly modifying the thrust and moment of control
- Fluctuations in power requirement (torque or MAP²) as the large changes in drag cause thrust variations
- Abnormally high ROD as vortex develops, which can be in excess of 3,000ft/min.

2.3 Vortex Ring pilot recovery actions

Recovery actions may be taken by cyclic and/or collective application. However, depending on the rotor system, cyclic input alone could be insufficient to modify the helicopter attitude to gain airspeed. It is also possible to recover from Vortex Ring by reducing the collective to minimum pitch. However, the loss of height during recovery by collective

² Manifold Air Pressure

pitch reduction is greater than the corresponding loss of height by cyclic input, which is the result of the ROD in autorotation at low airspeed being very high.

Therefore, the following recovery actions should be initiated at the incipient stage to minimise the loss of height:

- Apply a positive forward cyclic input to achieve an accelerative attitude³ to gain airspeed
- If an accelerative attitude cannot be reached, decrease collective pitch to enter autorotation and then apply forward cyclic, as required to increase airspeed.

2.4 Vortex Ring avoidance

Since the recovery actions will entail a considerable loss of height, it is imperative to avoid Vortex Ring especially when close to the ground. Therefore, a ROD in excess of 500ft/min. at an airspeed of less than 30Kts whilst in powered flight should be avoided. Therefore, the following operations should be conducted with great care:

- Confined areas recce and approaches
- Downwind approaches
- Steep approaches
- Hover Out of Ground Effect (HOGE)
- Low speed autorotation recovery
- Downwind quick stops
- Aerial photography

TO EXIT VORTEX RING

1. Apply a positive forward cyclic input to achieve an accelerative attitude to gain airspeed.
2. If airspeed increases; recover helicopter when IAS reaches 40 Kt.
3. If airspeed does not increase; decrease collective pitch to enter autorotation and then apply forward cyclic, as required to increase airspeed.

³ Depending on rotor system recommended nose down attitude can vary

3. LOSS OF TAIL ROTOR EFFECTIVENESS (LTE)

On a single rotor helicopter, one of the main functions of tail rotor thrust is to control the helicopter heading. If tail rotor thrust is insufficient, an unanticipated and uncommanded yaw may occur. This phenomenon has been a contributing factor in a number of helicopter accidents and is commonly referred to as LTE.

For the purpose of this leaflet, LTE is considered to be an insufficient tail rotor thrust associated with a control margin deficiency which can result in an uncommanded rapid yaw rate. This yaw may not subside of its own accord and if not corrected can result in the loss of a helicopter.

3.1 When Does LTE Happen?

LTE is more likely to occur when the critical yaw pedal is close to the full travel position. The critical yaw pedal is considered to be the right pedal for clockwise rotating main rotor systems and the left pedal for anti-clockwise rotating ones.

LTE is generally encountered at low forward airspeed, normally less than 30kt, where:

- The tail fin has low aerodynamic efficiency
- The airflow and downwash generated by the main rotor interferes with the airflow entering the tail rotor
- A high power setting requires a yaw pedal position which is close to its full travel
- An adverse wind condition increases the tail rotor thrust requirement
- Turbulent wind conditions require large and rapid collective and yaw inputs

The following are some of the operations where pilots can typically find themselves at **a low height, low airspeed and a high power setting**, where **the wind** velocity is difficult to determine and the pilot is often preoccupied with positioning the aircraft for the task:

- Powerline and pipeline patrol sectors
- External load
- Hoisting
- Fire fighting
- Landing site reconnaissance
- Low speed aerial filming/photograph
- Police and HEMS
- High Density Altitude (DA) landing and takeoff
- Ship-Deck Landing and Take-Off

3.2 How can LTE be avoided?

During flight planning pilots must consider the Rotorcraft Flight Manual, especially regarding performance in relation to the critical wind azimuths, the DA at which they are operating, the helicopter All Up Mass (AUM) and flight characteristics.

During the flight, pilots should be constantly aware of the wind conditions and the available tail rotor thrust margin, which is represented by the critical pedal position.

Whenever possible, pilots should avoid combinations of the following:

- Adverse wind conditions at low airspeed
- Uncommanded yaw
- Large and rapid collective and yaw inputs at low airspeed
- Low airspeed flight in turbulent wind conditions

3.3 Recovery from LTE

Pilots should be aware that if they enter a flight regime where any, or a combination of the above occur, they are entering a potential LTE situation and they must be able to recognise the onset and commence the positive recovery actions without delay. Recovery actions will vary according to the circumstances, if height permits, attaining forward airspeed without increasing power (if possible reducing power) will normally resolve the situation. Therefore, as these actions may involve a considerable loss of altitude, it is recommended that pilots identify a clear escape route in advance of the operations listed above.

TO EXIT LTE

1. Apply full opposing pedal to the direction of turn
2. Adopt an accelerative attitude to gain forward airspeed
3. If altitude permits; reduce power

4. STATIC & DYNAMIC ROLLOVER

4.1 Static Rollover

Static rollover occurs when the helicopter pivots about one skid/wheel in contact with the ground to such an extent that the helicopter's Centre of Gravity (C of G) moves beyond the skid/wheel. Once the static rollover angle is exceeded removal of the original force causing the roll will not stop the helicopter rolling motion. This typically corresponds to a roll angle in excess of 30° for most helicopters, **SEE FIGURE 1**.

Critical Rollover Angle

The critical rollover angle for a helicopter can be described as either the maximum lateral slope angle upon which the helicopter can land, yet maintain its main rotor disc parallel to the natural horizon, or the maximum flapping angle of the main rotor system. Typically, most helicopters have a critical rollover angle of 13° to 17° and if it is exceeded, application of full opposite cyclic will not stop the helicopter rolling motion.

4.2 Dynamic Rollover

This generally occurs when a helicopter is taking off, landing or hovering with one skid/wheel in contact with the surface. The helicopter may begin to roll about the point of contact with the surface (pivot point). The pivot point could be for example a skid/wheel, stuck or restrained to ground, ice, soft asphalt or mud. It could also be a skid/wheel contacting a fixed object/ground whilst hovering sideways or during slope operations. Dynamic rollover can occur at roll angles far less than the static or critical rollover angles.

FIGURE 1
STATIC ROLLOVER

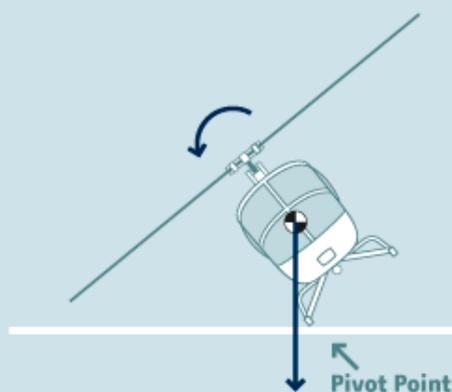
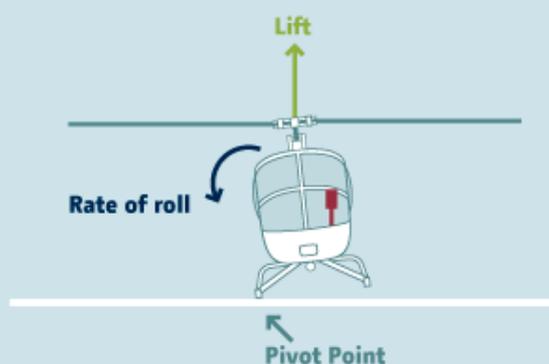


FIGURE 2
LIFTING TO THE HOVER



Excessive application of collective in combination with a rolling motion about a skid/wheel can result in sufficient roll momentum that full opposite cyclic cannot counteract, even before reaching the critical rollover angle.

Lifting to the Hover (SEE FIGURE 2)

- Collective is raised and lift generated
- The right skid is stuck and becomes the pivot point
- Left cyclic keeps the disc level with the horizon
- A small roll rate develops

Dynamic Rollover (SEE FIGURE 3)

- Collective is raised further and more lift generated
- Critical rollover angle is reached
- No more left cyclic is available to level the disc
- Horizontal component of the rotor thrust will add to the roll rate
- The roll rate increases

Corrective Action (SEE FIGURE 4)

- Lower collective to remove the horizontal component of the rotor thrust in an attempt to stop the roll before the C of G is beyond the pivot point
- The helicopter will continue to roll due to its inertia and may roll beyond the static rollover angle if the collective is not lowered soon enough.

FIGURE 3
DYNAMIC ROLLOVER

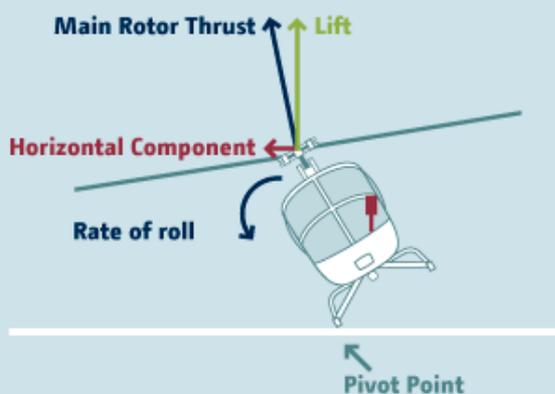
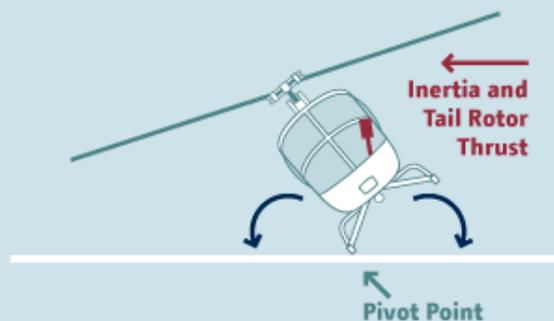


FIGURE 4
CORRECTIVE ACTION



4.3 Precautions

- » Any change in lateral C of G will modify the lateral cyclic requirement and availability
- » Always practice hovering Engine Off Landing (EOL) into the wind
- » When hovering or taxiing close to obstacles/ground use extreme caution
- » Whenever possible, slope operations should be conducted into the wind
- » During take-off and landing, especially on a slope, all control inputs should be made slowly, smoothly and gently; helicopter sideward motion should be avoided
- » During slope operations if the upslope skid/wheel starts to leave the ground before the down slope skid/wheel, lifting to the hover should be aborted
- » On landing, if the cyclic control limit is reached, further lowering of the collective may cause a rollover
- » When landing or taking off on a floating platform that is pitching and/or rolling, extreme caution should be exercised

IMPRINT

Disclaimer:

The safety improvement analyses and recommendations produced by the EHSIT are based on expert judgment and are supplementary to the official reports of the accident investigation boards (AIBs). Such recommendations, and the safety improvement actions that may follow, are solely aimed at improving helicopter safety, are not binding and under no circumstances should be considered to take precedence over the official AIB reports. The adoption of such safety improvement recommendations is subject to voluntary commitment, and engages only the responsibility of those who endorse these actions. The EHSIT accepts no responsibility or liability whatsoever with regard to the content or for any actions resulting from the use of the information contained in these recommendations.

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**For a download of the Helicopter Preflight Planning Checklist
please visit our website:**

<http://www.easa.europa.eu/essi/ehestEN.html>

HELICOPTER INFO

Type	Registration	Weight
	Longitudinal	Lateral
CG Take-off		
CG Landing		
CG Alternate		
Fuel on board	Fuel required	Endurance
Tech. Log		
Helicopter documents to be carried	Original or copy of the Third party liability Insurance Certificate	<input type="checkbox"/> Yes
	Certificate of Registration	<input type="checkbox"/> Yes
	Certificate of airworthiness (ARC)	<input type="checkbox"/> Yes
	Original or copy of the Noise Certificate (if applicable)	<input type="checkbox"/> Yes
	Original or copy of the Air Operator Certificate	<input type="checkbox"/> Yes
	Radio licence	<input type="checkbox"/> Yes
	Ops Manual / Flight Manual	<input type="checkbox"/> Yes
Hours required for task	Hours before next inspection/CRS	
Configuration	Equipment	

PERFORMANCE CLASS (IF APPLICABLE)

	Departure	En route	Destination
Max. take-off/landing Weight			
Max. Hover Weight IGE			
Max. Hover Weight OGE			
OEI service ceiling			

FUEL

Basic or Empty Weight	+	VFR FUEL	IFR FUEL
Fuel	+	Start-up	Start-up +
Crew	+	Taxi	Taxi +
Internal Load	+	Trip	Trip +
External Load	+	5 % or 10% contingency	Alternate +
T/O Weight		20 min res	+ 10% contingency +
Trip Fuel	-	Discretion	+ 30 min res +
Landing Weight		Total Ramp	Additional +
Alternate Fuel	-	FUEL ACCORDING TO JAR OPS 3	Extra +
Landing Weight at Alternate			Total ramp



HELICOPTER PREFLIGHT PLANNING CHECKLIST

TYPE OF FLIGHT	DATE	BRIEFING TIME
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WEATHER AT DEPARTURE POINT / EN ROUTE / ARRIVAL / ALTERNATE		
Metar		
TAF		
Weather chart	Significant weather chart	
Upper winds	Freezing level	Icing
Surface wind	Sunrise time	Sunset time

TASK		
Notams	Departure	En route
	Arrival	Alternate

Communication details	Call sign						
		DEP	ENR	ENR	DEST	ALT 1	ALT 2
	ATIS						
	GND						
	TWR						
	APP						
	INFO						

Navigation aids	Departure	En route
	Arrival	Alternate

Airfields	DEP	ENR	DEST	ALT 1	ALT 2

Flight plan	PPR/Landing approval
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Timings	Loading	Start-up
	T/O	Land

PERSONAL INFO	Valid documents to be carried	Pilot license and Medical cert.	<input type="checkbox"/> Yes
		Type rating/IR	<input type="checkbox"/> Yes
		Flight recency	<input type="checkbox"/> Yes
		Passports or identity card	<input type="checkbox"/> Yes



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