Chapter 5 – RISK MANAGEMENT STRATEGIES TO COUNTER BROWNOUT

5.1 INTRODUCTION

Hardware (airframe) and technological improvements that deal with DVE (especially brownout and whiteout) will require considerable research and development and considerable resources to implement and are a relatively distant goal. In the short term, Nations should aim to enhance their DVE procedures and training without delay. Unsurprisingly, training strategies and techniques for brownout/whiteout take-offs and landings vary considerably between Nations and are difficult to standardize. This is largely due to the availability of resources and subtleties in individual countries' training doctrines and their operational requirement. However the broad principles should concur and thus merit further examination. This chapter outlines the general risk management strategies in DVE operations, but will specifically focus upon the **procedural controls** necessary for safe flight in DVE.

5.2 PRINCIPLES OF RISK MANAGEMENT

As mentioned in previous chapters, transitions in reduced visibility pose a significant risk to aviation, crews and passengers; the maneuvers should thus be subjected to a hierarchy of control. A hierarchy provides a principled approach to risk management, prioritizing risk reduction before risk protection, i.e., measures listed earlier should be scoped and implemented (where possible) in preference to later measures. The hierarchy is listed below with examples of aviation control measures:

- Hazard **elimination**, e.g., use of hardened or sealed LZs only.
- **Risk reduction** (frequency and severity), e.g., reduce the need to undertake DVE transitions; avoid areas with poor surfaces; use surveyed sites only.
- **Procedural controls**, e.g., use procedures to minimize time within the obscurant cloud; enhance aircrew performance through quality training; implement strategies to manage workload, Crew Resource Management (CRM) and fatigue.
- Introduce **technical enablers**, e.g., automation, drift indication, head-up symbology, see-through technology.
- Provide collective and personal **protection**, e.g., aircraft survivability, aircrew equipment assemblies, Survive Evade Resist and Extract (SERE) training.
- Provide rapid **emergency response** capability.

5.3 CONTRIBUTORY FACTORS

The ability to maneuver the aircraft safely in DVE will depend upon several factors:

- Aircraft Factors:
  - Undercarriage configuration and tolerance.
  - Rotor configuration – tandem, tilt, tail rotor.
  - Stability and Centre of Gravity (CG).

- All Up Mass (AUM).
- Power available – influenced by density altitude, engine air particle separators, demist.
- Technological enablers including the human interface.

- Aircrew Factors:
  - Training, experience and currency.
  - Crew coordination, use of rear crew, use of constituted crews, division of tasks.
  - Aircrew performance – alertness, workload, physiological effects (e.g., heat).

- Environmental Factors:
  - Density altitude.
  - Weather – cloud cover, wind, precipitation. Consider effect on Thermal Imagery (TI) and Night Vision Devices (NVD).
  - Light levels – glare especially when combined with dust haze, heat shimmer and minimal shadow can make assessment of the LZ very difficult; conversely low light levels and poor contrast make night operations difficult.
  - Terrain/structure (natural or man-made).
  - Nature of surface – sealed, loose, water content. Small stones may cause windscreen damage.
  - Size of LZ.
  - Notable with multi-ship operations.
  - Surrounding obstructions. Consider the difficulty in visualizing wires.
  - Slope.

- Operational Factors:
  - Operational imperative – risk/benefit ratio.
  - Recce – the ability to survey the LZ prior to touchdown.
  - Threat level.
  - Multi-ship operations.
  - LZ lighting.

In general, aircraft factors (esp. technological enablers) will determine the range of potential transitions; aircrew are then trained to meet the operational requirement; environmental and operational factors will then determine which transition is actually used.

5.4 LANDING TECHNIQUES

Landing is the most hazardous of all transitions in DVE particularly within low light conditions and a non-permissive environment. The mission commander should risk assess the sortie prior to departure, and balance

the tactical, environmental, aircrew and platform risks against the operational imperative. Appropriately constituted crews, systematic planning and thorough preparation are essential prerequisites. A marked and surveyed LZ should be used wherever possible. Over-flight, noting obstructions, surface material, Hover Reference Markers (HRM), overshoot options, actual LZ height (RadAlt – BarAlt comparison) and wind direction is desirable in all cases, although the tactical situation may be a constraining factor. Approaches are always conducted into wind where possible; if the wind is oblique; consider using the upwind pilot as the Handling Pilot (HP) as HRM are likely to remain outside the recirculation cloud for longer. The aircraft must always have sufficient power to initiate an overshoot should the crew become disorientated or lose essential references. Finally, crews should be alert to potential illusions of scale (e.g., stunted trees) and ground aberrations (e.g., irregular sand ridges).

Potential techniques for landing in DVE are as follows:

- **Zero speed landing** – the most commonly used approach, balancing the time in recirculation against the risks of unseen obstructions or an unknown surface.
- **Short running landing** – aircrew must be confident about the surface but can expect reduced exposure to recirculation and improved aircraft stability. If the surface is known to be smooth (e.g., dirt landing strip) then a faster run-on landing may be used thus avoiding all recirculation until after touchdown.
- **Low hover and land** – whilst this enables a final survey of the LZ, aircrew must expect significant recirculation.
- **High hover and vertical descent** – this technique requires Hover Out of Ground Effect (HOGE) power. It is the preferred option in benign conditions especially if the aircrew are uncertain of surface conditions or obstructions; the technique is ideally supported by automation and/or synthetic orientation cues, unless the LZ has only a thin layer of dust or snow.

5.4.1 Zero Speed Landing

A typical procedure starts at the run-in or approach phase with the aircraft trimmed and steady at a pre-determined height Above Ground Level (AGL) and pre-determined ground speed. A height hold may be used to reduce workload. During this run-in, or as part of an over-flight reconnaissance, the Handling Pilot (HP) aims to select initial ground reference markers against which he can monitor the angle of approach and latterly, any drift. At the same time, the Non-Handling Pilot (NHP) will scan the landing site (with observation aids or TI if available), carry out pre-landing checks, establish an overshoot track (set on the heading bug) and close vents, windows and cockpit curtains. At a predefined “Gate”, in order to enter into the approach, the HP will initiate a constant angle, slow descent (typically 200 – 300 fpm, 61 – 91 mpm) with a decelerative attitude “held against the springs”. The approach angle is commonly slightly steeper than a standard visual approach to reduce the build-up of the recirculation cloud (crews must also be alert to the risk of vortex ring / settling in power). During the constant angle approach the NHP or the middle seat crew will monitor and call out height, ground speed and Rate Of Descent (ROD) information. The HP will continue to monitor the sight angle approach picture and monitor ground speed using a lateral visual scan. At an intermediate point, perhaps initiated by the RadAlt alarm, the HP may then refine reference marker selection and the aircraft pitch to ensure a zero speed landing. Height indicators and the advancement of the recirculation cloud are provided by the rear crew from this point on. The crew “talk down” allows the HP to maintain “eyes out” visual scan throughout and concentrate on basic attitude, yaw and power control. Just prior to landing it is probable that reference markers will be lost as the advancing recirculation cloud engulfs the cockpit. At this point it may still be acceptable to continue onto aircraft touchdown provided the

imperative to land remains and the aircraft remains in a safe configuration, i.e., stabilized, in a safe attitude, without drift or yaw and the LZ has been visually assessed as suitable. If these parameters are not met the crew should initiate an overshoot or go-around. At touchdown, and prior to lowering the collective, the HP should then check that the reference markers are below blade path, the aircraft is not yawing and the slope is within limits. At touchdown the aircraft should have no lateral drift and no forward ground speed. A small run on could be accepted if circumstances allowed. Touchdown should be firm to ensure the aircraft passes quickly through the ground effect. The workload throughout the approach is high, but if it is controlled and precise, the workload remains manageable and severe attitude changes at the point of touchdown are avoided. See Figure 5-1.

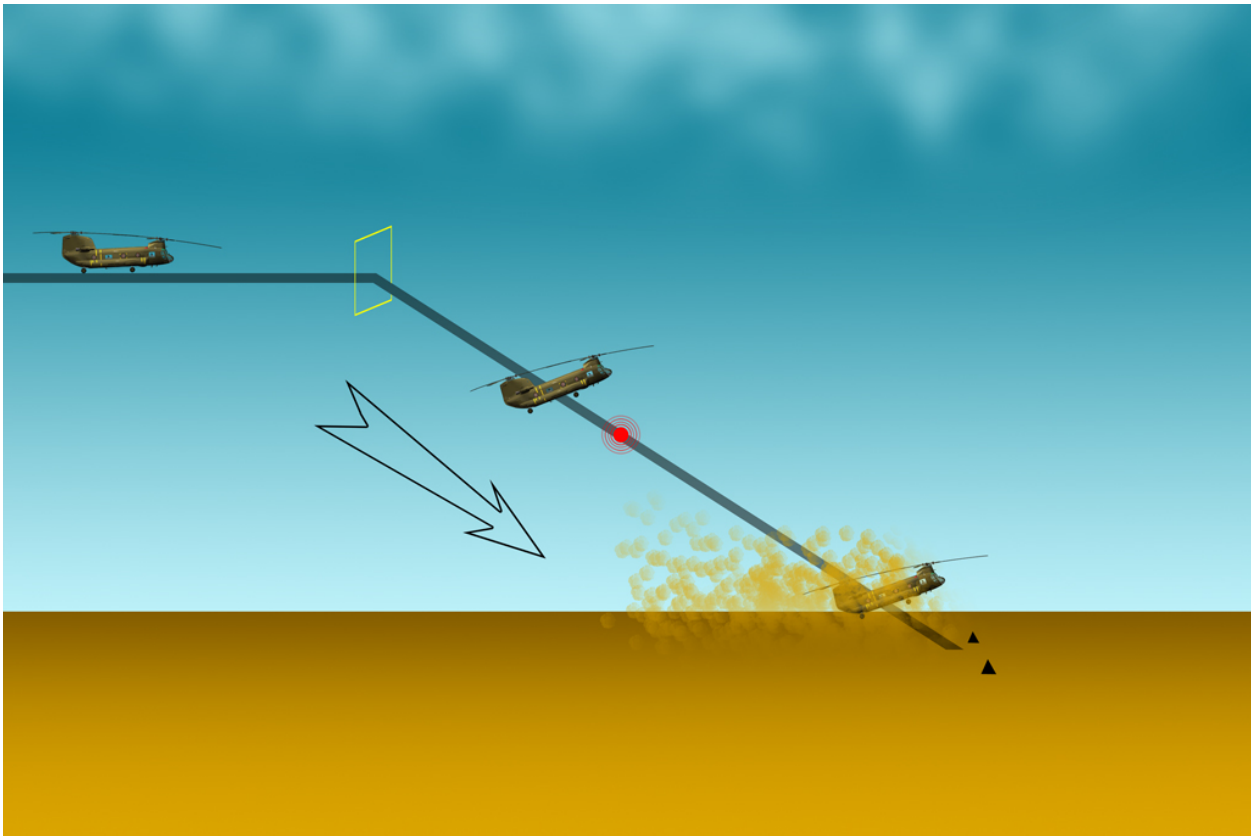

Figure 5-1: Zero Speed Landing.

Notable Risks: Excessive pitch up attitude at the point of touchdown may result in a tail (-rotor) or ramp strike. There is a potential to succumb to drift and spatial disorientation, especially if the aircraft fails to pass through ground effect and remains in a low hover.

5.4.2 Short Running Landing

This procedure is similar to the zero speed but culminates in a short run-on landing. At the “Gate”, the pilot either adopts a lesser decelerative attitude or delays the full decelerative attitude until the RadAlt alarms at the intermediate point. The aircraft will then touchdown with a small amount of forward speed. The faster approach speed allows less time for the recirculation cloud to develop and keeps the cloud further aft of the

cockpit. The aircraft attitude at touchdown may vary: a level attitude is used for aircraft susceptible to tail strike (e.g., nose wheel or skids) or for faster run-on speeds (to keep the recirculation clear of the cockpit); a flared attitude may be held if the aircraft is less susceptible to tail damage (e.g., tandem rotor or tail wheel) or where the run-out must be contained. See Figure 5-2.

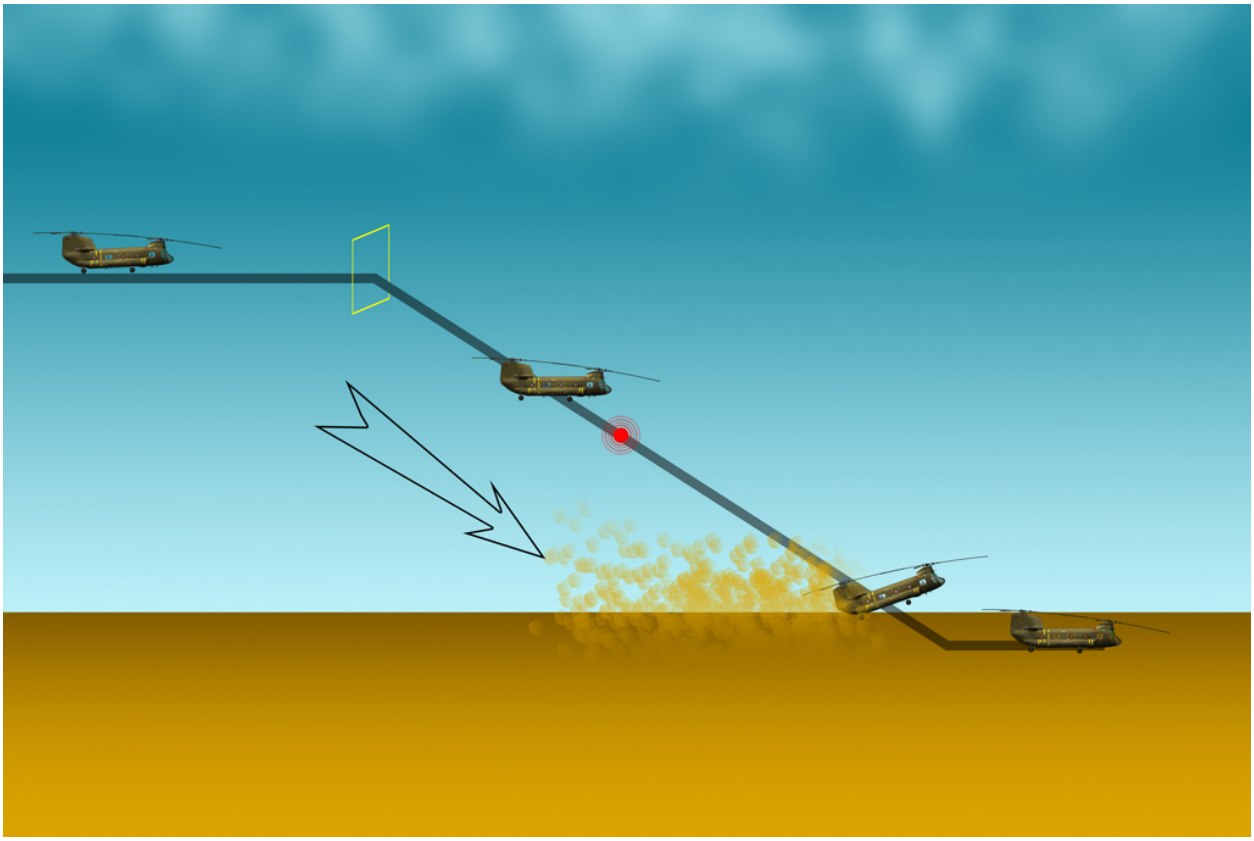

Figure 5-2: Short Running Landing.

Notable Risks: Unseen LZ obstructions, unseen slope, surface unevenness or a surface that gives way (e.g., crust or deep and soft) may cause sudden deceleration and undercarriage damage. Sudden deceleration also causes the disc to flap forward, which in turn may cause stones to be whipped up by the downdraft and induce windscreen damage. Excessive pitch up attitude may result in a tail or ramp strike.

5.4.3 Low Hover and Land

This approach is identical to the zero speed but culminates in a low hover over the intended landing point. The aircraft is then lowered under the guidance of rear crew directly visualizing the LZ. The selected hover height must be low enough to enable direct visualization of the ground but high enough to avoid a tail or ramp strike in the final flare. See Figure 5-3.

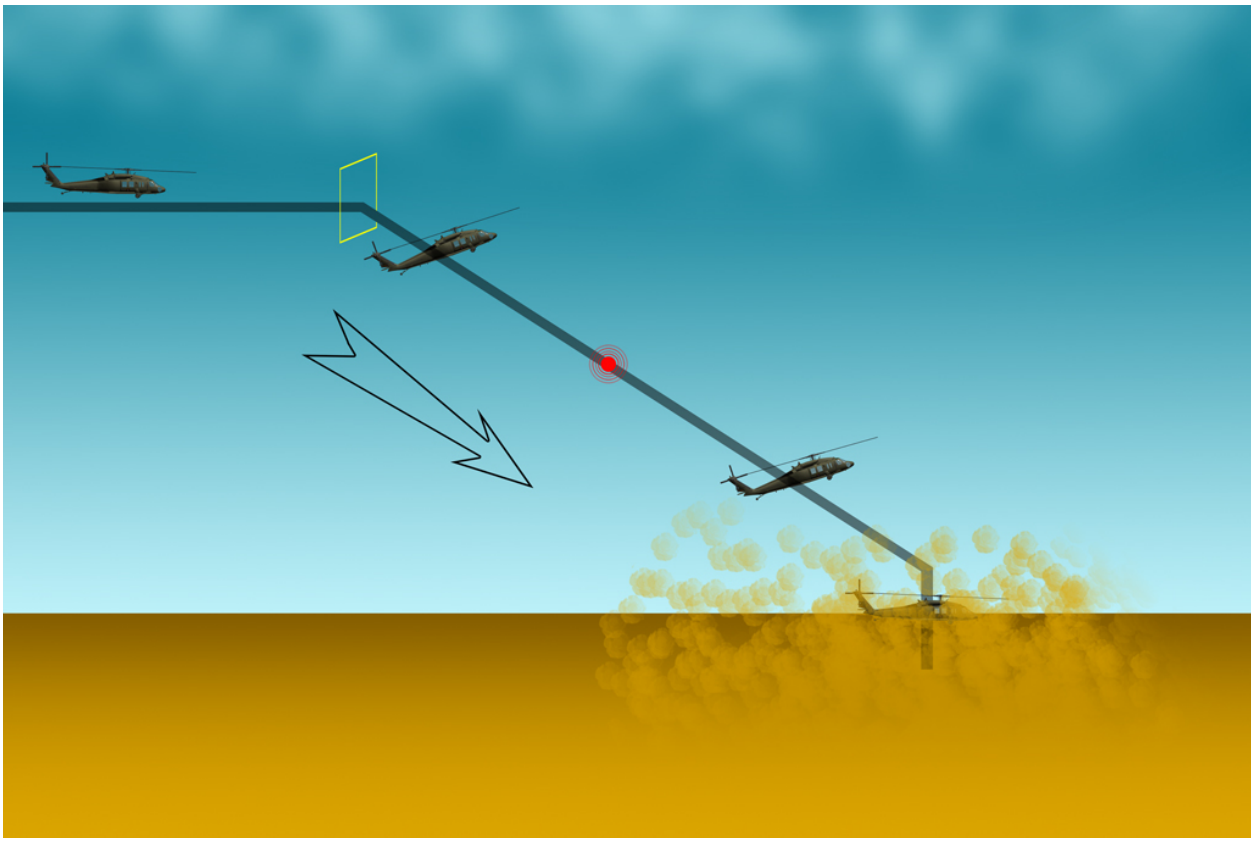

Figure 5-3: Low Hover and Land.

Notable Risks: Loss of HRM and ground contact with disorientation in the low hover.

5.4.4 High Hover and Vertical Descent

The approach to the high hover and vertical descent is best conducted using additional orientation cues or automation as HRM may be obscured or the aircraft may be engulfed within the recirculation cloud for significant periods of time. The HOGE normally starts at the upper limits of the recirculation – the height will vary between aircraft with different AUM. Once a stable hover has been established, height and position holds may be engaged prior to a stepwise descent to ground level. At each pause check for drift and allow the recirculation to moderate. The ROD is principally determined by the rate at which the obscurant is blown clear of the intended LZ. Any significant drift at the point of landing may induce aircraft roll-over and thus drift indication (usually in head-up symbology) is recommended. The procedure is ideally suited to hard surfaces where recirculation is anticipated to be slight. In this case one hover marker at 45 degrees to the HP may be sufficient for orientation throughout the controlled descent. The procedure may also be used for confined areas when constant angle approaches are impractical. See Figure 5-4.

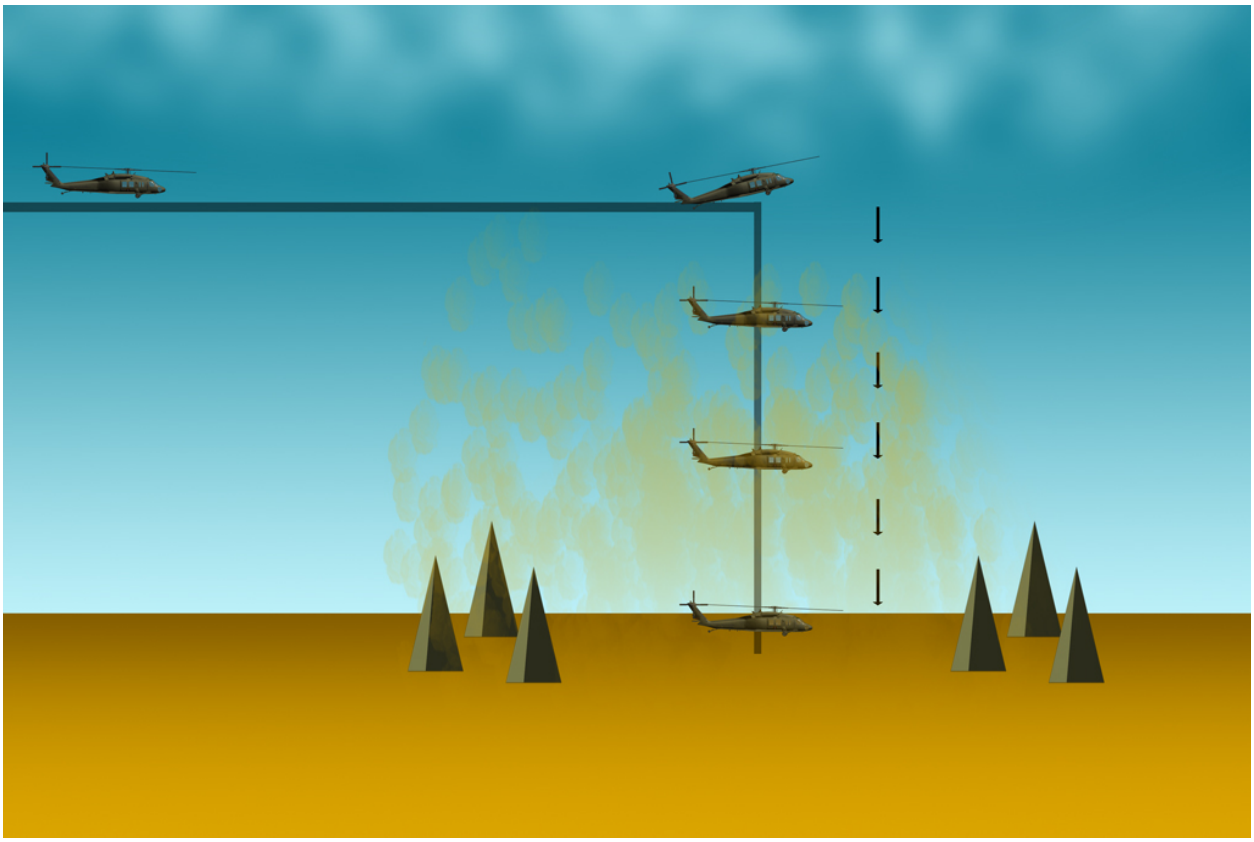

Figure 5-4: High Hover and Vertical Descent.

Notable Risks: Loss of HRM and disorientation in the hover and descent.

5.5 COMPARISON OF LANDING TECHNIQUES

Table 5-1 provides a summary and comparison of approach techniques, highlighting specific advantages/ disadvantages and factors that might influence the commander's selection.

Table 5-1: Comparison of Landing Techniques.

Approach	Advantages	Disadvantages	Requirements	Most Suited for
Zero Speed	↓ recirculation exposure. ↓ time in threat zone. No run on.	Nose up attitude. Risk of tail strike. High workload.	Accurate and controlled approach. Improved handling capability, needs adequate training.	LZ in high threat level environment. Precision LZ (e.g., FARP[1]). Tandem rotor or aircraft with good tail clearance.
Short Run-On	↓↓ recirculation exposure. ↑ stability in final approach. ↓ time in threat zone.	↑ risk from unseen obstructions, slope and poor surface. Risk of undercarriage damage. Risk of tail strike. High workload.	Surveyed LZ. Strong undercarriage.	Hostile LZ. LZ with few ground references. Tandem rotor or good tail clearance. Low CG.
Low Hover	Can visualize LZ. ↓ risk of tail strike.	Significant recirculation. Loss of HRM and drift.	Good HRM.	Indistinct surface. Poor tail clearance.
High Hover	Can visualize LZ. ↓ risk of tail strike.	Prolonged recirculation. Not suitable in threat environment. Loss of HRM and drift.	Benign tactical environment. Hover holds or orientation aids or good HRM. Light recirculation.	Confined areas. Prepared areas. Poor tail clearance.

5.6 CREW COORDINATION

Each crew-member has clearly demarcated responsibilities, uses standardized language and adheres to strict intercom discipline to reduce cognitive workload. An example of a height only talk down is illustrated below; this could be supplemented with ground speed information. Note the use of a call and response system using standardized phrases, and rotational patter to avoid the crew over-talking each other. The patter should be unhurried, although cadence can be used to express urgency when required. As the cloud approaches the tail of the aircraft, the crewmen's patter generally takes priority over that of the NHP.

NHP: "IN THE GATE, BUGGING ** FEET"(for RadAlt audio warning) and state direction of landing

[1] Forward Arming and Refuel Point.

HP:	"COMMENCING APPROACH"
NHP:	(height call)
HP:	"GOOD (references)"
**********	RadAlt Audio Warning **********
No 1 C'MAN:	"DUST CLOUD FORMING"
No 2 C'MAN:	(height call)
HP:	"GOOD (references)"
No 1 C'MAN:	"RAMP"
No 2 C'MAN:	(height call)
HP:	"GOOD (references)"
No 1 C'MAN:	"CENTRE"
No 2 C'MAN:	(height call)
HP:	"GOOD (references)"
No 1 C'MAN:	"DOOR"
No 2 C'MAN:	(height call)
No 1 C'MAN:	"COCKPIT"
No 2 C'MAN:	"AFT WHEELS ON"
No 2 C'MAN:	"FRONT WHEELS ON"
No 2 C'MAN:	"GOOD LINE" (if there is a run-on and the ground is suitable)

If the patter order breaks down, or a call is missed, a crew-member should prompt the appropriate crew position, e.g., "PILOT", who should then reply with the appropriate response. If the necessary information is still not forthcoming, an overshoot is mandatory. A silent pilot is likely to have exceeded his cognitive capacity and thereafter will be unable to devote sufficient attention to safe flight – hence the requirement for a mandatory overshoot.

Where HMD symbology is available to both pilots (day and night), critical flight data is continuously displayed, allowing both pilots to remain "eyes out". In these circumstances a briefer verbal talk-down may be utilized, thereby reducing the workload in the cockpit whilst maintaining a high level of crew-coordination. This method is particularly relevant for low-hover-and-land approaches. Crewmen are not as involved as with the previous concept (the windows and ramp may be closed, so visibility is limited in the dust).

HP:	"COMMENCING APPROACH"
**********	RadAlt Audio Warning **********
NHP:	"DUST CLOUD FORMING. HEAVY/MEDIUM CLOUD"
HP:	"STOPPING AT…..*landing point*" (including description of any obstacles around the LP.

NHP:	"EYE CONTACT" (meaning, I can take controls, if needed)
HP:	"EYE CONTACT"
HP:	"GOING DOWN" (HP must not descend below hover height before this call)
No 1 C'MAN:	"RIGHT CLEAR" (if visibility allows)
No 2 C'MAN:	"TAIL CLEAR" (if visibility allows)

If one of the pilots does not have sufficient ground references, a call out like "DON'T HAVE" is done. The NHP may take control at this stage, but must maintain a minimum of hover height, whilst the HP acquires sufficient visual references. Both pilots must have good ground visual references to descend below the predetermined hover height.

Operational experience has shown that pilots using this brief talk down patter are able to maintain high quality calls, with fewer omissions, whilst preserving reasonable workload levels.

5.6.1 Overshoot

An overshoot may be called by any member of the crew. It is usually executed by the HP immediately and unconditionally. When an overshoot is called the HP should:

- Transfer to instruments.
- Adopt a wings level, hover attitude and initiate a collective-led vertical climb.
- Transition into forward flight on the preselected overshoot track, but only once a positive rate of climb has been established.

5.7 TACTICAL CONSTRAINTS/VARIATIONS

There may be occasions when the approach must be conducted in difficult circumstances (e.g., low light or poor visibility) and perhaps without the benefit of an aerial inspection of the LZ. In these cases the operational imperative must justify the increased risk to the passengers and crew. Advance planning, including access to direct imagery of the LZ or a thermal scan of the LZ on the run-in, may offset some risk. Troops on the ground may have been able to survey the ground and mark out a standardized LZ; inter-operability between aviation crews and ground troops is vital to ensure the necessary standardization and trust. HRM may be ill defined as the approach starts; alternatively, the HRM that was deemed suitable at the start of the descent may transpire to be inappropriate. In these cases it is entirely appropriate to make fine adjustments during the descent provided the change in intent is conveyed to all the crew. If the approach is part of a multi-ship approach, the effect on other aircraft must also be considered. Occasionally no suitable HRM are present at all. Absence of clear visual cues considerably raises the risk of disorientation particularly where synthetic orientation cues are not available either. The aircraft commander must again balance risk against operational imperative and be prepared to modify the approach to match the environmental conditions, tactical situation and the competency of the crew.

5.8 TAKE-OFF TECHNIQUES

The technique used for take-off is primarily determined by power available and the characteristics of the LZ. There are three commonly used techniques:

- **Towering take-off** – a maximum power, vertical climb to break out of the recirculation cloud as quickly as possible.
- **Rotation about the nose** – the simultaneous application of power with forward transition allows the aircraft to clear the cloud earlier; the crew must be confident that the path ahead is clear and this should only be conducted into wind.
- **Rolling take-off** – the aircraft is accelerated along the ground for a normal rolling take-off once clear of the recirculation cloud; this technique is suitable for wheeled aircraft only, from areas with a suitable surface and length.

In the first two techniques the HP should expect to convert to an instrument scan once visual reference markers are lost and should utilize all additional orientation aids and stability systems where possible (e.g., hover meter, heading hold, symbology drift information). The NHP "bugs up" the RadAlt warning alert progressively, calls "CLEAR OF CLOUD" once the aircraft exits the cloud and monitors torque, especially when power margins are slight. The rolling take-off enables the pilots to retain visual contact with the ground throughout but is heavily dependent upon the LZ characteristics. It may also be useful for a power limited departure. If the surface is covered by only a light layer of dust, sand or snow, the pilot may elect to apply a limited amount of collective prior to take-off to disperse any loose material which in turn may enable a normal departure.

5.9 GROUND AND HOVER TAXI MANEUVERS

It is important to retain good ground definition throughout any taxi maneuvers. If the surface is suitable and a wheeled aircraft is used, ground taxiing may be appropriate. Ideally the speed is adjusted to keep the recirculation cloud aft of the cockpit. When moving short distances downwind it may be safer to transition out of the recirculation and conduct an into-wind approach to the new position. However, HOGE reduces available ground references and may increase the possibility of disorientation. Crews should also be alert to relative motion illusions (vection illusion) when operating close to the ground. Finally automation (e.g., UH-60M, CH-47D, Apache D model) or hover symbology may be used to augment orientation cues and stabilize the aircraft whilst maneuvering. The necessity of a take-off and go-around due to loss of orientation should always be considered.

5.10 NIGHT OPERATIONS

Night flying techniques are an extension of daylight procedures, but with the following considerations:

- Selection of good hover references with strong background contrast is highly desirable.
- Landing aids should be used where possible, e.g., a NATO T or Y, crossed vehicle headlights, cyalumes (light sticks dropped in the over-flight recce or deployed by ground troops).
- Slope and ground texture are very difficult to establish, particularly in low light conditions.

Night approaches are usually the last part of any environmental training syllabus, requiring sufficient competence in daylight transitions first. Most countries opt to restrict training and non-essential flight to

conditions above set minima (e.g., 10-20mLux). Whilst it may be necessary to operate at levels below set minima, these occasions should be confined to those crews with the necessary skill set and only when the operational imperative dictates. Some formations may have night enhancement packages to facilitate low light operations, e.g., TI, symbology, moving map displays.

5.11 SNOW OPERATIONS

Operations in cold and snowy environments are subject to some variations in the techniques discussed above due to differing environmental and aircraft performance factors:

- The cold air reduces the density altitude. Whilst this will increase aircraft performance, this may be partly offset by heavier troop loads and the use of demist.
- Snow provides a uniform and bright surface, often with few textural cues to aid the perception of height and speed.
  - Note: Doppler/INS and RadAlt are particularly important in transitions for their assessment of GROUND SPEED and height.
  - Note: A smoke canister may be useful as a high-contrast HRM as well as indicating wind direction.
- It is difficult to assess the surface snow condition from the air (e.g., hard packed/crusted or deep powder); it is also not possible to assess the surface conditions below the snow cover. Whilst the approach pattern may vary, only one landing configuration is deemed safe.
- Skis may be used on skids or wheels to reduce the depth the aircraft will sink in to the snow.

5.12 APPROACH TO LAND

Using a HRM the pilot typically flies a constant angle approach to a 10 ft stabilized hover. The hover reference marker is then held in the lateral chin bubble/quarter light whilst the HP lowers the aircraft to conduct a sloping ground landing. If there are no convenient HRM at the LZ or it is not possible to make a normal approach due to obstructions, then the high hover technique may be used. In this case the aircraft is brought to a hover outside of the recirculation and then descended in stages to allow recirculating snow to dissipate. Forward and lateral markers are essential to prevent drift in the hover. At the point of landing the aircraft may be rocked slightly as it settles into the snow to prevent any sudden lurches should the snow give way unevenly beneath the undercarriage.

Characteristic hazards associated with snow approaches:

- Wires and masts may be very difficult to see. Ensure the recce is meticulous.
- Flat, open areas devoid of shrubs and trees are probably frozen lakes so do not fully lower the lever once landed.
- Areas of tree felling will usually contain hidden stumps and therefore are not appropriate LZs.
- Use of the landing light at night causes dramatic reflection from recirculating snow and is not recommended (this includes taxiing manoeuvres). If light is used, the light beam should be aimed away from the pilot's direct field of view to minimise reflections.

5.13 TAKE OFF

The technique for whiteout conditions is not materially different from that used in other forms of recirculation. However crews should be aware that the skids, skis or wheels may be frozen to the surface and thus when initiating lift or any ground taxi, pressure and counter-pressure on the yaw pedals will help break any bond prior to movement.

5.14 UNDER SLUNG LOADS

The difficulties and hazards associated with Under Slung Load (USL) operations in recirculation are exacerbated by the need to operate in the hover for extended periods. However it is usually possible to continue to operate in all but the heaviest of recirculation, provided ground reference markers remain visible. The use of a longer strop may be considered as this enables a higher hover and in part ameliorates the severity of the recirculation; however HRM may be harder to determine and load control is affected. Careful planning with ground support troops enables a standardized operating template and the provision of suitable and robust HRM. Direct vision and feedback from the rear-crew considerably enhances orientation information when handling USL.

5.14.1 USL Techniques

Pre-mission planning is essential in predicting helicopter performance. When the load is first lifted the crew must accurately note the height at which the load first clears the ground. This information will enable the RadAlt to be accurately set (not below the “load clear” height) for the subsequent drop off. Drop off is normally conducted using the low hover approach technique (see above). A hovermeter, if available, provides additional orientation information and should be brought into the HP scan prior to the envelopment of the recirculation cloud. Once a stable hover is established over the drop-off point the load may be lowered under the guidance of the crewmen. The NHP’s duties are similar to those in normal transition but should also include monitoring the hovermeter.

5.15 FORMATION PROCEDURES

Formation landings onto a LZ with potential recirculation will raise more particulates and may create additional hazard for adjacent or successive aircraft. Careful consideration should be made of the composition of the crews, LZ size, prevailing wind and the likely conditions. The various options for the formation approaches, in order of ease of use, are as follows:

- Use individual, widely dispersed, LZs (at least 6 rotor spans separation, dependent upon the wind conditions).
- Stream for landing, allowing sufficient time between successive aircraft for the recirculation to disperse.
- Simultaneous arrivals with subordinate elements landing first (zero-speed landings) and in the downwind position. Careful assessment of the wind is essential. Run-on landings are not recommended for formation approaches due to the additional risk of collision with other aircraft. If space permits, aircraft may land on slightly divergent headings to aid avoidance of the recirculation generated by adjacent aircraft. If any aircraft overshoots, then all following aircraft must overshoot on predetermined vectors.

Formation departures should be well briefed and if necessary rehearsed. Aircraft should lift in sequence and following aircraft should only lift once the previous aircraft has called “CLEAR”. Once airborne, lead should fly a pre-briefed heading at a slower speed to allow the remainder to catch up.

5.16 PLATFORM SPECIFICS

5.16.1 Tilt Rotor

The highly loaded Prop Rotors of the CV-22 produce high downwash velocities that can result in partial or complete loss of visual references in recirculation, particularly in the forward quadrant as the aircraft slows; some visibility in the lateral quadrant and directly below is usually maintained throughout. Approaches are essentially a slower more methodical adaptation of the normal approaches. Two approaches are typically used: No-Hover Land (constant angle approach with a run on speed <5 kts ground speed) and the High Hover (for extreme conditions or where obstacles prohibit a constant angle approach).

5.16.2 Tandem Rotor

The tandem rotor as shown by the CH-47 Chinook has a specific downwash characteristic. Because of its stable and not retractable gear and the possibilities to tolerate high pitch positions during landing (there is no low tail) it is possible to maintain the high speed until it is close to the ground. This allows the aircrew to perform a thorough last minute check of the landing area and afford a good opportunity for a preferred low speed rolling landing to stay ahead of the dust cloud. When a zero speed landing is required the Pilot floor bulb and the first LM position (right hand side door) keep a relative good vision of the ground. This is because of the specific shape of the dust cloud (donut) and the position of the hole in the donut in relation of the position of the pilot and LM.

5.16.3 Single Main Rotor

It is difficult to provide a generic description about single main rotor aircraft. Most of them have a low vulnerable tail rotor. This defines the limits of forward speed reduction. This limitation in combination with an unstable landing gear (for example, the narrow wheel based tri landing gear of the super puma) makes it a very challenging situation.

The position of the pilot and the crew-member according to the blade position on the aircraft and the specific dust donut created by that blade configuration dictates if the pilot or crew-member keeps outside view during the last phase of landing and its type specific.

The **No-Hover Land** is not discernibly different from traditional rotary-wing platforms; the approach is orientated around a ground reference marker, which should end up abeam the pilot. There is a tendency to induce some lateral drift as the reference marker closes, particularly once the obscurant cloud passes the cockpit and the visual scan becomes more laterally orientated, but this effect is generally overcome with training. The HP has Head-Down Display (HDD) hover symbology for additional orientation cues although at night this cueing information may be displayed on the NVG HUD for reduced outside-inside scanning.

The **High Hover** approach is usually initiated outside the recirculation cloud (50 – 75 ft, 15 – 23 m) and the aircraft let-down in stages whilst utilizing groundspeed and position holds on the Hover Coupler. Again precise orientation symbology is available from the HDD or NVG HUD.

Visual references are temporarily lost in both approaches, particularly in close proximity to the ground; in this instance (dependent upon aircraft power margins) it may be safer to continue the approach to the ground rather than initiating an overshoot; pilots are taught to inform the crew when this point is passed. Crew roles are similar to conventional RW platforms with a high emphasis on a clear division of responsibility and concise communication (although typically less proscriptive than that described in the Crew Coordination section). The normal position of the cabin aircrew is on the ramp, whilst the flight engineer remains in the seat with the cockpit door closed (due to heavy ingress of particulates). The areas beneath the ramp and below the engine nacelles offer the best quarters for maintaining visual contact with the ground.

5.16.4 Undercarriage Factors

Aircraft with a **narrow wheelbase**, especially when coupled with a high CG are particularly vulnerable to roll-over should the aircraft land either with lateral drift or on an uneven surface. Thus running landings, unrecced LZs and approaches with limited orientation cues (natural or synthetic) present particular risk. A **single tail wheel** is particularly vulnerable on rough and uneven surfaces and thus a zero speed landing is preferred for tail wheel, tricycle aircraft. **Wheeled undercarriages** are generally more susceptible to damage when compared with skids. Front wheels in particular may bury on soft or uneven surfaces and thus a level or nose up attitude at the point of touchdown is important to reducing undercarriage stress and the development of dynamic roll-over.

5.17 TRAINING FOR TRANSITIONS IN DEGRADED VISUAL ENVIRONMENT

Undertaking transitions within reduced visual conditions, especially when close to the ground, requires a high level of skill and experience. This is a responsibility for not just pilots but for the whole aircrew. Training traditionally consists of a logical and progressive program that allows the whole aircrew to gain experience and develop skills, which maintain good situational awareness in safe flight configurations.

A progressive training structure normally consists of:

- Development of the procedure;
- Theoretical training;
- Synthetic training (simulator); and
- Actual flying.

5.17.1 Development of the Procedure

The procedures developed must allow for the efficient utilization of relevant visual and sensor information to the whole crew for each specific flight phase. The presentation of RELIABLE information is clearly crucial to this process. Information sources not only include the pilot's outside view and avionic data, but may also include information from the non-handling pilot and other aircrew (e.g., loadmasters). This clearly requires an efficient and effective CRM procedure for each DVE transition.

It is important that the workload of the entire crew and specifically the handling pilot is a concern during procedure development. There have been many reports illustrating reduced performance and decision making at times of cognitive overload. Thus a realistic distribution of workload (limited display information, prioritization of tasks and realistic task distribution) is important to ensure each crew-member is provided with relevant information only during each phase of the transition procedure. Information should be presented in a

standardized manner having eliminated as many variables from each situation to make scenarios instantly recognizable, thus allowing quick decisions on whether to continue the transition or abort.

5.17.2 Theoretical Training

Developed procedures must be grounded in Standard Operating Procedures (SOPs) to ensure intra-operability of all fleet crew-members. SOPs will require review whenever there are changes to aircraft configurations. For example if Head-Up Displays (HUDs) are installed, the availability of height information changes and the co-pilot may no longer need to call out periodic RadAlt information, but rather confine his calls to safety altitude calls only.

5.17.3 Synthetic Training

Simulators (fixed base and motion) are most commonly used for synthetic training and are capable of high quality training transfer particularly in developing the skills for risky procedures. Whilst simulators are capable of producing convincing DVE scenarios they lack some aspects of the real situation.

5.17.3.1 Vision

In most situations a brownout module is nothing more than a visual display that turns progressively brown, sometimes with additional effects (e.g., swirling of the dust cloud). However the vection illusion, conveying an incorrect assessment of motion and responsible for strong influences on crew behavior, is not usually part of the brownout representation. Many companies are now working on the development of more realistic visual representations for simulators, which will further enhance the synthetic experience; this development phase will require further integration prior to full implementation in training simulators.

5.17.3.2 Motion

Most motion simulators are of a hexapod design, while capable of some motion sensation cannot match reality. For example, sub-threshold acceleration and lateral drift, one of the most common errors for transitions in DVE, are poorly represented – this aspect is currently best demonstrated in actual flight. However we can expect some developments in the future as there are simulators with multiple axes of motion and with greater degrees of freedom (for example: device available to RNLAF).

5.17.3.3 Crew Concept

Most simulators allow for training of cockpit crews only as an attached crewman module is relatively uncommon. As a consequence, the synthetic training fails to mirror the standard informational inputs and SOPs of the actual flying task thus altering the patter of actual transitions.

5.17.3.4 Synthetic Training Conclusions

Synthetic training is rarely designed to wholly replicate the real environment but rather deliver a training effect in a safe and transferable manner. There are obvious shortfalls in realism some of which may not be apparent to aircrew. Trainers, however, must be aware of the gap between synthetic training and flight in actual DVE to ensure that the synthetic training has not engendered a false sense of security.

5.17.4 Actual Flying

Actual flying is the most realistic way of training in DVE but it is also the most hazardous and exerts additional wear and tear upon scant resources. Actual flying may be done in a progressive manner by choosing different landing areas with differing snow and dust characteristics thereby changing the severity of the obscuration. This allows aircrew to develop their performance and confidence in a controlled manner. However it is not always possible to find perfect environmental conditions and thus the benefits of well-constructed synthetic training prior to in flight training cannot be underestimated. If DVE conditions are not routinely experienced within national boundaries then the training may be done in supportive countries or within the actual operational theatre. A theatre qualification is normally awarded to verify the training. Finally it should be noted that there is no substitute for having undertaken transitions in real and demanding environmental conditions and thus some form of progressive actual training is necessary for confidence and competence prior to moving onto operational circumstances.

5.17.5 Continuation Training

The conduct of DVE transitions is a perishable skill and thus aircrew require a currency program to maintain competency. This may be achieved by conducting a minimum number of transitions over a period of time or by mandating periodic refresher training, or with a mix of the two; the operational experiences of differing countries and the frequency of DVE exposures will likely determine which modality is selected. A mandated and benchmarked standard is necessary to ensure competence across the fleet.

5.17.6 Training Conclusions

In the future we can expect new developments in simulators, which will make it easier to prepare our aircrew for operations in DVE. Until then it is important to recognize potential threats such as information overload and sub-threshold drift. This is initially managed by making the procedure as safe as possible by developing standardized procedures which are repeatable across a range of conditions and with manageable operator workload. Training exposure is thereafter incremental using a range of procedural synthetic trainers and actual flight. Ultimately aircrew should be confident in their collective ability developed through a system of progressive and maintenance training. Transitions in DVE are not without risk but can be made relatively safe through well-developed training programs.

5.18 CONCLUSIONS

Transitions in DVE are inherently dangerous maneuvers and therefore should only be carried out where operationally necessary. A range of procedures have been developed through operational experience; procedure selection is determined by the tactical and environmental conditions, platform capabilities, and aircrew experience and training. Workload, especially during DVE approaches, is high, hence the importance of using well rehearsed, standardized techniques and sharing the workload across the whole crew. The implementation of technical enablers in future aircraft will likely enhance situation awareness but the value of high quality procedures and aircrew training will remain paramount.