

Subpart H – Helicopter operations with night vision imaging systems

AMC1 SPA.NVIS.110(b) Equipment requirements for NVIS operations

RADIO ALTIMETER

- (a) The radio altimeter should:
 - (1) be of an analogue type display presentation that requires minimal interpretation for both an instantaneous impression of absolute height and rate of change of height;
 - (2) be positioned to be instantly visible and discernable from each cockpit crew station;
 - (3) have an integral audio and visual low height warning that operates at a height selectable by the pilot; and
 - (4) provide unambiguous warning to the crew of radio altimeter failure.
- (b) The visual warning should provide:
 - (1) clear visual warning at each cockpit crew station of height below the pilot-selectable height; and
 - (2) adequate attention-getting-capability for typical NVIS operations.
- (c) The audio warning should:
 - (1) be unambiguous and readily cancellable;
 - (2) not extinguish any visual low height warnings when cancelled; and
 - (3) operate at the same pilot-selectable height as the visual warning.

GM1 SPA.NVIS.110(b) Equipment requirements for NVIS operations

RADIO ALTIMETER

An analogue type display presentation may be, for example, a representation of a dial, ribbon or bar, but not a display that provides numbers only. An analogue type display may be embedded into an electronic flight instrumentation system (EFIS).

GM1 SPA.NVIS.110(f) Equipment requirements for NVIS operations

MODIFICATION OR MAINTENANCE TO THE HELICOPTER

It is important that the operator reviews and considers all modifications or maintenance to the helicopter with regard to the NVIS airworthiness approval. Special emphasis needs to be paid to modification and maintenance of equipment such as light emitting or reflecting devices, transparencies and avionics equipment, as the function of this equipment may interfere with the NVGs.

GM1 SPA.NVIS.130(e) Crew requirements for NVIS operations

UNDERLYING ACTIVITY

Examples of an underlying activity are:

- (a) commercial air transport;
- (b) helicopter emergency medical service (HEMS); and
- (c) helicopter hoist operation (HHO).

GM1 SPA.NVIS.130(e) Crew requirements for NVIS operations

OPERATIONAL APPROVAL

- (a) When determining the composition of the minimum crew, the competent authority should take account of the type of operation that is to be conducted. The minimum crew should be part of the operational approval.
- (b) If the operational use of NVIS is limited to the en-route phase of a commercial air transport flight, a single-pilot operation may be approved.
- (c) Where operations to/from a HEMS operating site are to be conducted, a crew of at least one pilot and one NVIS technical crew member would be necessary (this may be the suitably qualified HEMS technical crew member).
- (d) A similar assessment may be made for night HHO, when operating to unprepared sites.

AMC1 SPA.NVIS.130(f)(1) Crew requirements for NVIS operations

TRAINING AND CHECKING SYLLABUS

- (a) The flight crew training syllabus should include the following items:
 - (1) NVIS working principles, eye physiology, vision at night, limitations and techniques to overcome these limitations;
 - (2) preparation and testing of NVIS equipment;
 - (3) preparation of the helicopter for NVIS operations;
 - (4) normal and emergency procedures including all NVIS failure modes;
 - (5) maintenance of unaided night flying;
 - (6) crew coordination concept specific to NVIS operations;
 - (7) practice of the transition to and from NVG procedures;
 - (8) awareness of specific dangers relating to the operating environment; and
 - (9) risk analysis, mitigation and management.
- (b) The flight crew checking syllabus should include:
 - (1) night proficiency checks, including emergency procedures to be used on NVIS operations; and
 - (2) line checks with special emphasis on the following:

- (i) local area meteorology;
- (ii) NVIS flight planning;
- (iii) NVIS in-flight procedures;
- (iv) transitions to and from night vision goggles (NVG);
- (v) normal NVIS procedures; and
- (vi) crew coordination specific to NVIS operations.

(c) Whenever the crew is required to also consist of an NVIS technical crew member, he/she should be trained and checked in the following items:

- (1) NVIS working principles, eye physiology, vision at night, limitations, and techniques to overcome these limitations;
- (2) duties in the NVIS role, with and without NVGs;
- (3) the NVIS installation;
- (4) operation and use of the NVIS equipment;
- (5) preparing the helicopter and specialist equipment for NVIS operations;
- (6) normal and emergency procedures;
- (7) crew coordination concepts specific to NVIS operations;
- (8) awareness of specific dangers relating to the operating environment; and
- (9) risk analysis, mitigation and management.

AMC1 SPA.NVIS.130(f) Crew requirements

CHECKING OF NVIS CREW MEMBERS

The checks required in SPA.NVIS.130 (f) may be combined with those checks required for the underlying activity.

GM1 SPA.NVIS.130(f) Crew requirements

TRAINING GUIDELINES AND CONSIDERATIONS

(a) Purpose

The purpose of this GM is to recommend the minimum training guidelines and any associated considerations necessary for the safe operation of a helicopter while operating with night vision imaging systems (NVISs).

To provide an appropriate level of safety, training procedures should accommodate the capabilities and limitations of the NVIS and associated systems as well as the restraints of the operational environment.

(b) Assumptions

The following assumptions were used in the creation of this material:

- (1) Most civilian operators may not have the benefit of formal NVIS training, similar to that offered by the military. Therefore, the stated considerations are predicated on that individual who has no prior knowledge of NVIS or how to

use them in flight. The degree to which other applicants who have had previous formal training should be exempted from this training will be dependent on their prior NVIS experience.

(2) While NVIS are principally an aid to flying under VFR at night, the two-dimensional nature of the NVG image necessitates frequent reference to the flight instruments for spatial and situational awareness information. The reduction of peripheral vision and increased reliance on focal vision exacerbates this requirement to monitor flight instruments. Therefore, any basic NVIS training syllabus should include some instruction on basic instrument flight.

(c) Two-tiered approach: basic and advance training

To be effective, the NVIS training philosophy would be based on a two-tiered approach: basic and advanced NVIS training. The basic NVIS training would serve as the baseline standard for all individuals seeking an NVIS endorsement. The content of this initial training would not be dependent on any operational requirements. The training required for any individual pilot should take into account the previous NVIS flight experience. The advanced training would build on the basic training by focusing on developing specialised skills required to operate a helicopter during NVIS operations in a particular operational environment. Furthermore, while there is a need to stipulate minimum flight hour requirements for an NVIS endorsement, the training should also be event-based. This necessitates that operators be exposed to all of the relevant aspects, or events, of NVIS flight in addition to acquiring a minimum number of flight hours. NVIS training should include flight in a variety of actual ambient light and weather conditions.

(d) Training requirements

(1) Flight crew ground training

The ground training necessary to initially qualify a pilot to act as the pilot of a helicopter using NVGs should include at least the following subjects:

- (i) applicable aviation regulations that relate to NVIS limitations and flight operations;
- (ii) aero-medical factors relating to the use of NVGs to include how to protect night vision, how the eyes adapt to operate at night, self-imposed stresses that affect night vision, effects of lighting (internal and external) on night vision, cues utilized to estimate distance and depth perception at night, and visual illusions;
- (iii) NVG performance and scene interpretation;
- (iv) normal, abnormal, and emergency operations of NVGs; and
- (v) NVIS operations flight planning to include night terrain interpretation and factors affecting terrain interpretation.

The ground training should be the same for flight crew and crew members other than flight crew. An example of a ground training syllabus is presented in Table 1 of GM2 SPA.NVIS.130(f).

(2) Flight crew flight training

The flight training necessary to initially qualify a pilot to act as the pilot of a helicopter using NVGs may be performed in a helicopter or FSTD approved for the purpose, and should include at least the following subjects:

- (i) preparation and use of internal and external helicopter lighting systems for NVIS operations;
- (ii) pre-flight preparation of NVGs for NVIS operations;
- (iii) proper piloting techniques (during normal, abnormal, and emergency helicopter operations) when using NVGs during the take-off, climb, en-route, descent, and landing phases of flight that includes unaided flight and aided flight; and
- (iv) normal, abnormal, and emergency operations of the NVIS during flight.

Crew members other than flight crew should be involved in relevant parts of the flight training. An example of a flight training syllabus is presented in Table 1 of GM3 SPA.NVIS.130(f).

(3) Training crew members other than flight crew

Crew members other than flight crew (including the technical crew member) should be trained to operate around helicopters employing NVIS. These individuals should complete all phases of NVIS ground training that is given to flight crew. Due to the importance of crew coordination, it is imperative that all crew members are familiar with all aspects of NVIS flight. Furthermore, these crew members may have task qualifications specific to their position in the helicopter or areas of responsibility. To this end, they should demonstrate competency in those areas, both on the ground and in flight.

(4) Ground personnel training

Non-flying personnel who support NVIS operations should also receive adequate training in their areas of expertise. The purpose is to ensure, for example, that correct light discipline is used when helicopters are landing in a remote area.

(5) Instructor qualifications

An NVIS flight instructor should at least have the following licences and qualifications:

- (i) at least flight instructor (FI(H)) or type rating instructor (TRI(H)) with the applicable type rating on which NVIS training will be given; and
- (ii) logged at least 100 NVIS flights or 30 hours' flight time under NVIS as pilot-in-command/commander.

(6) NVIS equipment minimum requirements (training)

While minimum equipment lists and standard NVIS equipment requirements may be stipulated elsewhere, the following procedures and minimum equipment requirements should also be considered:

- (i) NVIS: the following is recommended for minimum NVIS equipment and procedural requirements:
 - (A) back-up power supply;

- (B) NVIS adjustment kit or eye lane;
- (C) use of helmet with the appropriate NVG attachment; and
- (D) both the instructor and student should wear the same NVG type, generation and model.

(ii) Helicopter NVIS compatible lighting, flight instruments and equipment: given the limited peripheral vision cues and the need to enhance situational awareness, the following is recommended for minimum compatible lighting requirements:

- (A) NVIS compatible instrument panel flood lighting that can illuminate all essential flight instruments;
- (B) NVIS compatible hand-held utility lights;
- (C) portable NVIS compatible flashlight;
- (D) a means for removing or extinguishing internal NVIS non-compatible lights;
- (E) NVIS pre-flight briefing/checklist (an example of an NVIS pre-flight briefing/checklist is in Table 1 of GM4-SPA.NVIS.130(f));
- (F) training references:
 - a number of training references are available, some of which are listed below:
 - DO 295 US CONOPS civil operator training guidelines for integrated NVIS equipment
 - United States Marine Corp MAWTS-1 Night Vision Device (NVD) Manual;
 - U.S. Army Night Flight (TC 1-204);
 - U.S. Army NVIS Operations, Exportable Training Package;
 - U.S. Army TM 11-5855-263-10;
 - Air Force TO 12S10-2AVS6-1;
 - Navy NAVAIR 16-35AVS-7; and
 - U.S. Border Patrol, Helicopter NVIS Ground and Flight Training Syllabus.

There may also be further documents available from European civil or military sources.

GM2 SPA.NVIS.130(f) Crew requirements

INSTRUCTION - GROUND TRAINING AREAS OF INSTRUCTION

A detailed example of possible subjects to be instructed in an NVIS ground instruction is included below. (The exact details may not always be applicable, e.g. due to goggle configuration differences.)

Table 1: Ground training areas of instruction

Item	Subject Area	Subject Details	Recommended Time
1	General anatomy and characteristics of the eye	<p>Anatomy:</p> <ul style="list-style-type: none"> • Overall structure of the eye • Cones • Rods <p>Visual deficiencies:</p> <ul style="list-style-type: none"> • myopia • hyperopia • astigmatism • presbyopia <p>Effects of light on night vision & NV protection physiology:</p> <ul style="list-style-type: none"> • Light levels <ul style="list-style-type: none"> - illumination - luminance - reflectance - contrast • Types of vision: <ul style="list-style-type: none"> - photopic - mesopic - scotopic • Day versus night vision • Dark adaptation process: <ul style="list-style-type: none"> - dark adaptation - pre-adaptive state • Purkinje shift • Ocular chromatic aberration • Photochromatic interval 	1 hour
2	Night vision human factors	<ul style="list-style-type: none"> • Night blind spot (as compared to day blind spot) • Field of view and peripheral vision • Distance estimation and depth perception: <ul style="list-style-type: none"> - monocular cues - motion parallax - geometric perspective - size constancy - overlapping contours or interposition of objects • Aerial perspective: <ul style="list-style-type: none"> - variations in colour or shade - loss of detail or texture - position of light source - direction of shadows • Binocular cues • Night vision techniques: 	1 hour

Item	Subject Area	Subject Details	Recommended Time
		<ul style="list-style-type: none"> - off-centre vision - scanning - shapes and silhouettes 	
		<ul style="list-style-type: none"> • Vestibular illusions • Somatogyral illusions: <ul style="list-style-type: none"> - leans - graveyard spin - coriolis illusion • Somatogravic illusions: <ul style="list-style-type: none"> - oculographic illusions - elevator illusion - oculoagravic illusions • Proprioceptive illusions • Dealing with spatial disorientation • Visual illusions: <ul style="list-style-type: none"> - auto kinetic illusion - confusion with ground lights - relative motion - reversible perspective illusion - false vertical and horizontal cues - altered planes of reference - height /depth perception illusion - flicker vertigo - fascination (fixation) - structural illusions - size-distance illusion • Helicopter design limitations: <ul style="list-style-type: none"> - windscreens condition - helicopter instrument design - helicopter structural obstruction - interior lights - exterior lights • Self-imposed stresses: <ul style="list-style-type: none"> - drugs - exhaustion - alcohol - tobacco - hypoglycaemia - injuries - physical fitness • Stress & fatigue: <ul style="list-style-type: none"> - acute vs. chronic - prevention • Hypoxia issues and night vision • Weather/environmental conditions: 	

Item	Subject Area	Subject Details	Recommended Time
		<ul style="list-style-type: none"> - snow (white-out) - dust (brown-out) - haze - fog - rain - light level • Astronomical lights (moon, star, northern lights) • Effects of cloud cover 	
3	NVIS general characteristics	<ul style="list-style-type: none"> • Definitions and types of NVIS: <ul style="list-style-type: none"> - light spectrum - types of NVIS • Thermal-imaging devices • Image-intensifier devices • Image-intensifier operational theory • Types of image intensifier systems: <ul style="list-style-type: none"> - generation 1 - generation 2 - generation 3 - generation 4 - type I / II - class A & B minus blue filter • NVIS equipment <ul style="list-style-type: none"> - shipping and storage case - carrying case - binocular assembly - lens caps - lens paper - operators manual - power pack (dual battery) - batteries • Characteristics of NVIS: <ul style="list-style-type: none"> - light amplification - light intensification - frequency sensitivity - visual range acuity - unaided peripheral vision - weight - flip-up device - break-away feature - neck cord - maintenance issues - human factor issues • Description and functions of NVIS components: 	1 hour

Item	Subject Area	Subject Details	Recommended Time
		<ul style="list-style-type: none"> - helmet visor cover and extension strap - helmet NVIS mount and attachment points - different mount options for various helmets - lock release button - vertical adjustment knob - low battery indicator - binocular assembly - monocular tubes - fore and aft adjustment knob - eye span knob - tilt adjustment lever - objective focus rings - eyepiece focus rings - battery pack 	
4	NVIS care & cleaning	<ul style="list-style-type: none"> • Handling procedures • NVIS operating instructions: <ul style="list-style-type: none"> - pre-mounting inspection - mounting procedures - focusing procedures - faults • Post-flight procedures; • Deficiencies: type and recognition of faults: <ul style="list-style-type: none"> - acceptable faults <ul style="list-style-type: none"> - black spots - chicken wire - fixed pattern noise (honeycomb effect) - output brightness variation - bright spots - image disparity - image distortion - emission points - unacceptable faults: <ul style="list-style-type: none"> - shading - edge glow - fashing, flickering or intermittent operation • Cleaning procedures • Care of batteries • Hazardous material considerations; 	1 hour
5	Pre- & post-	<ul style="list-style-type: none"> • Inspect NVIS 	1 hour

Item	Subject Area	Subject Details	Recommended Time
	flight procedures	<ul style="list-style-type: none"> • Carrying case condition • Nitrogen purge due date • Collimation test due date • Screens diagram(s) of any faults • NVIS kit: complete • NVIS binocular assembly condition • Battery pack and quick disconnect condition • Batteries life expended so far • Mount battery pack onto helmet: <ul style="list-style-type: none"> - verify no LED showing (good battery) - fail battery by opening cap and LED illuminates (both compartments) • Mount NVIS onto helmet • Adjust and focus NVIS • Eye-span to known inter-pupillary distance • Eye piece focus ring to zero • Adjustments: <ul style="list-style-type: none"> - vertical - fore and aft - tilt - eye-span (fine-tuning) • Focus (one eye at a time at 20 ft, then at 30 ft from an eye chart) <ul style="list-style-type: none"> - objective focus ring - eye piece focus ring - verify both images are harmonised - read eye-chart 20/40 line from 20 ft • NVIS mission planning • NVIS light level planning • NVIS risk assessment 	
6	NVIS terrain interpretation and environmental factors	<ul style="list-style-type: none"> • Night terrain interpretation • Light sources: <ul style="list-style-type: none"> - natural - lunar - solar - starlight - northern lights - artificial - cultural - infra-red • Meteorological conditions: <ul style="list-style-type: none"> - clouds/fog - indications of restriction to visibility: <ul style="list-style-type: none"> - loss of celestial lights 	1 hour

Item	Subject Area	Subject Details	Recommended Time
		<ul style="list-style-type: none"> - loss of ground lights - reduced ambient light levels - reduced visual acuity - increase in video noise - increase in halo effect • Cues for visual recognition: <ul style="list-style-type: none"> - object size - object shape - contrast - ambient light - colour - texture - background - reflectivity • Factors affecting terrain interpretation: <ul style="list-style-type: none"> - ambient light - flight altitudes - terrain type • Seasons • Night navigation cues: <ul style="list-style-type: none"> - terrain relief - vegetation - hydrographical features - cultural features 	
7	NVIS training & equipment requirements	<p>Cover the relevant regulations and guidelines that pertain to night and NVIS flight to include as a minimum:</p> <ul style="list-style-type: none"> • Crew experience requirements; • Crew training requirements; • Airspace requirements; • Night / NVIS MEL; • NVIS / night weather limits; • NVIS equipment minimum standard requirements. 	1 hour
8	NVIS emergency procedures	<p>Cover relevant emergency procedures:</p> <ul style="list-style-type: none"> • Inadvertent IMC procedures • NVIS goggle failure • Helicopter emergencies: <ul style="list-style-type: none"> - with goggles - transition from goggles 	1 hour
9	NVIS flight techniques	<p>Respective flight techniques for each phase of flight for the type and class of helicopter used for NVIS training</p>	1 hour
10	Basic instrument	<p>Present and confirm understanding of basic instrument flight techniques:</p>	1 hour

Item	Subject Area	Subject Details	Recommended Time
	techniques	<ul style="list-style-type: none"> Instrument scan Role of instruments in NVIS flight Unusual attitude recovery procedures 	
11	Blind cockpit drills	<p>Perform blind cockpit drills:</p> <ul style="list-style-type: none"> Switches Circuit breakers Exit mechanisms External / internal lighting Avionics 	1 hour

GM3 SPA.NVIS.130(f) Crew requirements

FLIGHT TRAINING - AREAS OF INSTRUCTION

A detailed example of possible subjects to be instructed in a NVIS flight instruction is included below.

Table 1: Flight training areas of instruction

Item	Subject Area	Subject Details	Recommended Time
1	Ground operations	<ul style="list-style-type: none"> NVIS equipment assembly Pre-flight inspection of NVISs Helicopter pre-flight NVIS flight planning: <ul style="list-style-type: none"> light level planning meteorology obstacles and known hazards risk analysis matrix CRM concerns NVIS emergency procedures review Start-up/shut down Goggling and degoggling 	1 hour
2	General handling	<ul style="list-style-type: none"> Level turns, climbs, and descents For helicopters, confined areas and sloped landings Operation specific flight tasks Transition from aided to unaided flight Demonstration of NVIS related ambient and cultural effects 	1 hour

Item	Subject Area	Subject Details	Recommended Time
3	Take-offs & landings	<ul style="list-style-type: none"> At both improved illuminated areas such as airports/airfields and unimproved unlit areas such as open fields Traffic pattern Low speed manoeuvres for helicopters 	1 hour
4	Navigation	<ul style="list-style-type: none"> Navigation over variety of terrain and under different cultural lighting conditions 	1 hour
5	Emergency procedures	<ul style="list-style-type: none"> Goggle failure Helicopter emergencies Inadvertent IMC Unusual attitude recovery 	1 hour

GM4 SPA.NVIS.130(f) Crew requirements

NVIS PRE-FLIGHT BRIEFING/CHECKLIST

A detailed example of a pre-flight briefing/checklist is included below.

Table 1: NVIS pre-flight briefing/checklist

Item	Subject
1	<p>Weather:</p> <ul style="list-style-type: none"> METAR/forecast Cloud cover/dew point spread/precipitation
2	<p>OPS items:</p> <ul style="list-style-type: none"> NOTAMs IFR publications backup/maps Goggles adjusted using test set (RTCA Document DO-275 [NVIS MOPS], Appendices G & H give suggested NVG pre-flight and adjustment procedures and a ground test checklist)
3	<p>Ambient light:</p> <ul style="list-style-type: none"> Moon rise/set/phase/position/elevation % illumination and millilux (MLX) for duration of flight Recommended minimum MLX: 1.5

Item	Subject
4	<p>Mission:</p> <ul style="list-style-type: none"> • Mission outline • Terrain appreciation • Detailed manoeuvres • Flight timings • Start/airborne/debrief • Airspace coordination for NVIS • Obstacles/minimum safe altitude • NVIS goggle up/degoggle location/procedure • Instrument IFR checks
5	<p>Crew:</p> <ul style="list-style-type: none"> • Crew day/experience • Crew position • Equipment: NVIS, case, video, flashlights • Lookout duties: left hand seat (LHS) – from 90° left to 45° right, RHS – from 90° right to 45° left; • Calling of hazards/movements landing light • Transfer of control terminology • Below 100 ft AGL – pilot monitoring (PM) ready to assume control
6	<p>Helicopter:</p> <ul style="list-style-type: none"> • Helicopter configuration • Fuel and CG
7	<p>Emergencies:</p> <ul style="list-style-type: none"> • NVIS failure: cruise and low level flight • Inadvertent IMC/IFR recovery • Helicopter emergency: critical & non-critical

AMC1 SPA.NVIS.140 Information and documentation

OPERATIONS MANUAL

The operations manual should include:

- (a) equipment to be carried and its limitations;
- (b) the minimum equipment list (MEL) entry covering the equipment specified;
- (c) risk analysis, mitigation and management;
- (d) pre- and post-flight procedures and documentation;
- (e) selection and composition of crew;
- (f) crew coordination procedures, including:
 - (1) flight briefing;

- (2) procedures when one crew member is wearing NVG and/or procedures when two or more crew members are wearing NVGs;
- (3) procedures for the transition to and from NVIS flight;
- (4) use of the radio altimeter on an NVIS flight; and
- (5) inadvertent instrument meteorological conditions (IMC) and helicopter recovery procedures, including unusual attitude recovery procedures;
- (g) the NVIS training syllabus;
- (h) in-flight procedures for assessing visibility, to ensure that operations are not conducted below the minima stipulated for non-assisted night VFR operations;
- (i) weather minima, taking the underlying activity into account; and
- (j) the minimum transition heights to/from an NVIS flight.

GM1 SPA.NVIS.140 Information and documentation

CONCEPT OF OPERATIONS

Night Vision Imaging System for Civil Operators

Foreword

This document, initially incorporated in JAA TGL-34, prepared by a Sub-Group of EUROCAE Working Group 57 "Night Vision Imaging System (NVIS) Standardisation" is an abbreviated and modified version of the RTCA Report DO-268 "Concept Of Operations – Night Vision Imaging Systems For Civil Operators" which was prepared in the USA by RTCA Special Committee 196 (SC-196) and approved by the RTCA Technical Management Committee in March 2001.

The EUROCAE Working Group 57 (WG-57) Terms of Reference included a task to prepare a Concept of Operations (CONOPS) document describing the use of NVIS in Europe. To complete this task, a Sub-Group of WG-57 reviewed the RTCA SC-196 CONOPS (DO-268) to assess its applicability for use in Europe. Whilst the RTCA document was considered generally applicable, some of its content, such as crew eligibility and qualifications and the detail of the training requirements, was considered to be material more appropriately addressed in Europe by at that time other Joint Aviation Requirements (JAR) documents such as JAR-OPS and JAR-FCL. Consequently, WG-57 condensed the RTCA CONOPS document by removing this material which is either already addressed by other JAR documents or will be covered by the Agency's documents in the future.

In addition, many of the technical standards already covered in the Minimum Operational Performance Standards (MOPS) for Integrated Night Vision Imaging System Equipment (DO-275) have been deleted in this European CONOPS.

Executive summary

The hours of darkness add to a pilot's workload by decreasing those visual cues commonly used during daylight operations. The decreased ability of a pilot to see and avoid obstructions at night has been a subject of discussion since aviators first attempted to operate at night. Technology advancements in the late 1960s and early 1970s

provided military aviators some limited ability to see at night and therein changed the scope of military night operations. Continuing technological improvements have advanced the capability and reliability of night vision imaging systems to the point that they are receiving increasing scrutiny are generally accepted by the public and are viewed by many as a tool for night flight.

Simply stated, night vision imaging systems are an aid to night VFR flight. Currently, such systems consist of a set of night vision goggles and normally a complimentary array of cockpit lighting modifications. The specifications of these two sub-system elements are interdependent and, as technology advances, the characteristics associated with each element are expected to evolve. The complete description and performance standards of the night vision goggles and cockpit lighting modifications appropriate to civil aviation are contained in the Minimum Operational Performance Standards for Integrated Night Vision Imaging System Equipment.

An increasing interest on the part of civil operators to conduct night operations has brought a corresponding increased level of interest in employing night vision imaging systems. However, the night vision imaging systems do have performance limitations. Therefore, it is incumbent on the operator to employ proper training methods and operating procedures to minimise these limitations to ensure safe operations. In turn, operators employing night vision imaging systems must have the guidance and support of their regulatory agency in order to safely train and operate with these systems.

The role of the regulatory agencies in this matter is to develop the technical standard orders for the hardware as well as the advisory material and inspector handbook materials for the operations and training aspect. In addition, those agencies charged with providing flight weather information should modify their products to include the night vision imaging systems flight data elements not currently provided.

An FAA study (DOT/FAA/RD-94/21, 1994) best summarised the need for night vision imaging systems by stating, "When properly used, NVGs can increase safety, enhance situational awareness, and reduce pilot workload and stress that are typically associated with night operations."

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2 Terminology

2.1 Night vision goggles

An NVG is a binocular appliance that amplifies ambient light and is worn by a pilot. The NVG enhances the wearer's ability to maintain visual surface reference at night.

2.1.1 Type

Type refers to the design of the NVG with regards to the manner in which the image is relayed to the pilot. A Type 1 NVG is one in which the image is viewed directly in-line with the image intensification process. A Type 1 NVG is also referred to as "direct view" goggle. A Type 2 NVG is one in which the image intensifier is not in-line with the image viewed by the pilot. In this design, the image may be reflected several times before being projected onto a combiner in front of the pilot's eyes. A Type 2 NVG is also referred to as an "indirect view" goggle.

2.1.2 Class

Class is a terminology used to describe the filter present on the NVG objective lens. The filter restricts the transmission of light below a determined frequency. This allows the cockpit lighting to be designed and installed in a manner that does not adversely affect NVG performance.

2.1.2.1 Class A

Class A or "minus blue" NVGs incorporate a filter, which generally imposes a 625 nanometercutoff. Thus, the use of colours in the cockpit (e.g., colour displays, colour warning lights, etc.) may be limited. The blue green region of the light spectrum is allowed through the filter.

2.1.2.2 Class B

Class B NVGs incorporate a filter that generally imposes a 665 nanometercutoff. Thus, the cockpit lighting design may incorporate more colours since the filter eliminates some yellows and oranges from entering the intensification process.

2.1.2.3 Modified class B

Modified Class B NVGs incorporate a variation of a Class B filter but also incorporates a notch filter in the green spectrum that allows a small percentage of light into the image intensification process. Therefore, a Modified Class B NVG allows pilots to view fixed head-up display (HUD) symbology through the NVG without the HUD energy adversely affecting NVG performance.

2.1.3 Generation

Generation refers to the technological design of an image intensifier. Systems incorporating these light-amplifying image intensifiers were first used during WWII and were operationally fielded by the US military during the Vietnam era. These systems were large, heavy and poorly performing devices that were unsuitable for aviation use,

and were termed Generation I (Gen I). Gen II devices represented a significant technological advancement and provided a system that could be head-mounted for use in ground vehicles. Gen III devices represented another significant technological advancement in image intensification, and provided a system that was designed for aviation use. Although not yet fielded, there are prototype NVGs that include technological advances that may necessitate a Gen IV designation if placed into production. Because of the variations in interpretations as to generation, NVGs will not be referred to by the generation designation.

2.1.4 OMNIBUS

The term OMNIBUS refers to a US Army contract vehicle that has been used over the years to procure NVGs. Each successive OMNIBUS contract included NVGs that demonstrated improved performance. There have been five contracts since the mid 1980s, the most current being OMNIBUS V. There may be several variations of NVGs within a single OMNIBUS purchase, and some NVGs from previous OMNIBUS contracts have been upgraded in performance to match the performance of goggles from later contracts. Because of these variations, NVGs will not be referred to by the OMNIBUS designation.

2.1.5 Resolution and visual acuity

Resolution refers to the capability of the NVG to present an image that makes clear and distinguishable the separate components of a scene or object.

Visual acuity is the relative ability of the human eye to resolve detail and interpret an image.

2.2 Aviation night vision imaging system (NVIS)

The Night Vision Imaging System is the integration of all elements required to successfully and safely operate an aircraft with night vision goggles. The system includes at a minimum NVGs, NVIS lighting, other aircraft components, training, and continuing airworthiness.

2.2.1 Look under (under view)

Look under is the ability of pilots to look under or around the NVG to view inside and outside the aircraft.

2.3 NVIS lighting

An aircraft lighting system that has been modified or designed for use with NVGs and which does not degrade the performance of the NVG beyond acceptable standards, is designated as NVIS lighting. This can apply to both interior and exterior lighting.

2.3.1 Design considerations

As the choice of NVG filter drives the cockpit lighting design, it is important to know which goggle will be used in which cockpit. Since the filter in a Class A NVG allows wavelengths above 625 nanometers into the intensification process, it should not be used in a cockpit designed for Class B or Modified Class B NVGs. However, since the filter in a

Class B and Modified Class B NVGs is more restrictive than that in a Class ANVG, the Class B or Modified Class B NVG can be used with either Class A or Class B cockpit lighting designs.

2.3.2 Compatible

Compatibility, with respect to an NVIS system, includes a number of different factors: compatibility of internal and external lighting with the NVG, compatibility of the NVG with the crew station design (e.g., proximity of the canopy or windows, proximity of overhead panels, operability of controls, etc.), compatibility of crew equipment with the NVG and compatibility with respect to colour discrimination and identification (e.g., caution and warning lights still maintain amber and red colours). The purpose of this paragraph is to discuss compatibility with respect to aircraft lighting. An NVIS lighting system, internal and external, is considered compatible if it adheres to the following requirements:

1. the internal and external lighting does not adversely affect the operation of the NVG during any phase of the NVIS operation;
2. the internal lighting provides adequate illumination of aircraft cockpit instruments, displays and controls for unaided operations and for "look-under" viewing during aided operations; and
3. The external lighting aids in the detection and separation by other aircraft.

NVIS lighting compatibility can be achieved in a variety of ways that can include, but is not limited to, modification of light sources, light filters or by virtue of location. Once aircraft lighting is modified for using NVGs, it is important to keep in mind that changes in the crew station (e.g., addition of new display) must be assessed relative to the effect on NVIS compatibility.

2.4. NVIS operation

A night flight wherein the pilot maintains visual surface reference using NVGs in an aircraft that is NVIS approved

2.4.1 Aided

Aided flight is flight with NVGs in an operational position.

2.4.2 Unaided

Unaided flight is a flight without NVGs or a flight with NVGs in a non-operational position.

3 System description

3.1 NVIS capabilities

NVIS generally provides the pilot an image of the outside scene that is enhanced compared to that provided by the unaided, dark-adapted eye. However, NVIS may not provide the user an image equal to that observed during daylight. Since the user has an enhanced visual capability, situational awareness is generally improved.

3.1.1 Critical elements

The following critical elements are the underlying assumptions in the system description for NVIS:

1. aircraft internal lighting has been modified or initially designed to be compatible;
2. environmental conditions are adequate for the use of NVIS (e.g. enough illumination is present, weather conditions are favourable, etc.);
3. the NVIS has been properly maintained in accordance with the minimum operational performance standards;
4. a proper pre-flight has been performed on the NVIS confirming operation in accordance with the continued airworthiness standards and training guidelines; and
5. the pilot(s) has been properly trained and meets recency of experience requirements.

Even when insuring that these conditions are met, there still are many variables that can adversely affect the safe and effective use of NVIS (e.g., flying towards a low angle moon, flying in a shadowed area, flying near extensive cultural lighting, flying over low contrast terrain, etc.). It is important to understand these assumptions and limitations when discussing the capabilities provided by the use of NVIS.

3.1.2 Situation awareness

Situation awareness, being defined as the degree of perceptual accuracy achieved in the comprehension of all factors affecting an aircraft and crew at a given time, is improved at night when using NVG during NVIS operations. This is achieved by providing the pilot with more visual cues than is normally available under most conditions when operating an aircraft unaided at night. However, it is but one source of the factors necessary for maintaining an acceptable level of situational awareness.

3.1.2.1 Environment detection and identification

An advantage of using NVIS is the enhanced ability to detect, identify, and avoid terrain and/or obstacles that present a hazard to night operations. Correspondingly, NVIS aid in night navigation by allowing the aircrew to view waypoints and features.

Being able to visually locate and then (in some cases) identify objects or areas critical to operational success will also enhance operational effectiveness. Finally, use of NVIS may allow pilots to detect other aircraft more easily.

3.1.3 Emergency situations

NVIS generally improve situational awareness, facilitating the pilot's workload during emergencies. Should an emergency arise that requires an immediate landing, NVIS may provide the pilot with a means of locating a suitable landing area and conducting a landing. The pilot must determine if the use of NVIS during emergencies is appropriate. In certain instances, it may be more advantageous for the pilot to remove the NVG during the performance of an emergency procedure.

3.2.1 NVG design characteristics

There are limitations inherent in the current NVG design.

3.2.1.1 Visual acuity

The pilot's visual acuity with NVGs is less than normal daytime visual acuity.

3.2.1.2 Field of view

Unaided field of view (FOV) covers an elliptical area that is approximately 120° lateral by 80° vertical, whereas the field of view of current Type I NVG systems is nominally 40° and is circular. Both the reduced field of view of the image and the resultant decrease in peripheral vision can increase the pilot's susceptibility to misperceptions and illusions. Proper scanning techniques must be employed to reduce the susceptibility to misperception and illusions.

3.2.1.3 Field of regard

The NVG has a limited FOV but, because it is head-mounted, that FOV can be scanned when viewing the outside scene. The total area that the FOV can be scanned is called the field of regard (FOR). The FOR will vary depending on several factors: physiological limit of head movement, NVG design (e.g., protrusion of the binocular assembly, etc.) and cockpit design issues (e.g., proximity of canopy or window, seat location, canopy bow, etc.).

3.2.1.4 NVG weight & centre of gravity

The increased weight and forward CG projection of head supported devices may have detrimental effects on pilot performance due to neck muscle strain and fatigue. There also maybe an increased risk of neck injury in crashes.

3.2.1.5 Monochromatic image

The NVG image currently appears in shades of green. Since there is only one colour, the image is said to be "monochromatic". This colour was chosen mostly because the human eye can see more detail at lower brightness levels when viewing shades of green. Colour differences between components in a scene helps one discriminate between objects and aids in object recognition, depth perception and distance estimation. The lack of colour variation in the NVG image will degrade these capabilities to varying degrees.

3.2.1.6 Ambient or artificial light

The NVG requires some degree of light (energy) in order to function. Low light levels, non-compatible aircraft lighting and poor windshield/window light transmissibility, diminish the performance capability of the NVG. It is the pilot's responsibility to determine when to transition from aided to unaided due to unacceptable NVG performance.

3.2.2 Physiological and other conditions

3.2.2.1 Cockpit resource management

Due to the inherent limitations of NVIS operations, there is a requirement to place emphasis on NVIS related cockpit resource management (CRM). This applies to both single and multi-pilot cockpit environments. Consequently, NVIS flight requires effective CRM between the pilot(s), controlling agencies and other supporting personnel. An appropriate venue for addressing this issue is the pre-flight NVIS mission brief.

3.2.2.2 Fatigue

Physiological limitations that are prevalent during the hours of darkness along with the limitations associated with NVGs, may have a significant impact on NVIS operations. Some of these limitations are the effects of fatigue (both acute and chronic), stress, eyestrain, working outside the pilot's normal circadian rhythm envelope, increased helmet weight, aggressive scanning techniques associated with NVIS, and various human factors engineering concerns that may have a direct influence on how the pilot works in the aircraft while wearing NVGs. These limitations may be mitigated through proper training and recognition, experience, adaptation, rest, risk management, and proper crew rest/duty cycles.

3.2.2.3 Over-confidence

Compared to other types of flight operations, there may be an increased tendency by the pilot to over-estimate the capabilities of the NVIS.

3.2.2.4 Spatial orientation

There are two types of vision used in maintaining spatial orientation: central (focal) vision and peripheral (ambient) vision. Focal vision requires conscious processing and is slow, whereas peripheral information is processed subconsciously at a very fast rate. During daytime, spatial orientation is maintained by inputs from both focal vision and peripheral vision, with peripheral vision providing the great majority of the information. When using NVGs, peripheral vision can be significantly degraded if not completely absent. In this case, the pilot must rely on focal vision to interpret the NVG image as well as the information from flight instruments in order to maintain spatial orientation and situation awareness. Even though maintaining spatial orientation requires more effort when using NVGs than during daytime, it is much improved over night unaided operations where the only information is obtained through flight instruments. However, anything that degrades the NVG image to a point where the horizon is not visualised and/or ground reference is lost or significantly degraded will necessitate a reversion to flight on instruments until adequate external visual references can be established. Making this transition quickly and effectively is vital in order to avoid spatial disorientation. Additionally, added focal task loading during the operation (e.g., communications, looking at displays, processing navigational information, etc.) will compete with the focal requirement for interpreting the NVG image and flight instruments. Spatial disorientation can result when the task loading increases to a point where the outside scene and/or the flight instruments are not properly scanned. This potential can be mitigated to some extent through effective training and experience.

3.2.2.5 Depth perception & distance estimation

When flying, it is important for pilots to be able to accurately employ depth perception and distance estimation techniques. To accomplish this, pilots use both binocular and monocular vision. Binocular vision requires the use of both eyes working together, and, practically speaking, is useful only out to approximately 100 ft.

Binocular vision is particularly useful when flying close to the ground and/or near objects (e.g. landing a helicopter in a small landing zone). Monocular vision can be accomplished with either eye alone, and is the type of vision used for depth perception and distance estimation when viewing beyond approximately 100 ft. Monocular vision is the predominant type of vision used when flying fixed wing aircraft, and also when flying helicopters and using cues beyond 100 ft. When viewing an NVG image, the two eyes can no longer provide accurate binocular information, even though the NVG used when flying is a binocular system. This has to do with the way the eyes function physiologically (e.g. accommodation, stereopsis, etc.) and the design of the NVG (i.e. a binocular system with a fixed channel for each eye). Therefore, binocular depth perception and distance estimation tasking when viewing terrain or objects with an NVG within 100 ft is significantly degraded. Since monocular vision does not require both eyes working together, the adverse impact on depth perception and distance estimation is much less, and is mostly dependent on the quality of the NVG image. If the image is very good and there are objects in the scene to use for monocular cueing (especially objects with which the pilot is familiar), then distance estimation and depth perception tasking will remain accurate. However, if the image is degraded (e.g., low illumination, airborne obscurants, etc.) and/or there are few or unfamiliar objects in the scene, depth perception and distance estimation will be degraded to some extent. In summary, pilots using NVG will maintain the ability to accurately perceive depth and estimate distances, but it will depend on the distances used and the quality of the NVG image.

Pilots maintain some ability to perceive depth and distance when using NVGs by employing monocular cues. However, these capabilities may be degraded to varying degrees.

3.2.2.6 Instrument lighting brightness considerations

When viewing the NVG image, the brightness of the image will affect the amount of time it takes to adapt to the brightness level of the instrument lighting, thereby affecting the time it takes to interpret information provided by the instruments. For example, if the instrument lighting is fairly bright, the time it takes to interpret information provided by the instruments may be instantaneous. However, if the brightness of the lighting is set to a very low level, it may take several seconds to interpret the information, thus increasing the heads-down time and increasing the risk of spatial disorientation. It is important to ensure that instrument lighting is kept at a brightness level that makes it easy to rapidly interpret the information. This will likely be brighter than one is used to during unaided operations.

3.2.2.7 Dark adaptation time from NVG to unaided operations

When viewing an NVG image, both rods and cones are being stimulated (i.e., mesopic vision), but the brightness of the image is reducing the effectiveness of rod cells. If the outside scene is bright enough (e.g., urban area, bright landing pad, etc.), both rods and cones will continue to be stimulated. In this case there will be no improvement in acuity

over time and the best acuity is essentially instantaneous. In some cases (e.g., rural area with scattered cultural lights), the outside scene will not be bright enough to stimulate the cones and some amount of time will be required for the rods to fully adapt. In this case it may take the rods one to two minutes to fully adapt for the best acuity to be realised. If the outside scene is very dark (e.g., no cultural lights and no moon), it may take up to five minutes to fully adapt to the outside scene after removing the NVGs. The preceding are general guidelines and the time required to fully adapt to the outside scene once removing the NVG depends on many variables: the length of time the NVG has been used, whether or not the pilot was dark adapted prior to flight, the brightness of the outside scene, the brightness of cockpit lighting, and variability in visual function among the population. It is important to understand the concept and to note the time requirements for the given operation.

3.2.2.8 Complacency

Pilots must understand the importance of avoiding complacency during NVG flights. Similar to other specialised flight operations, complacency may lead to an acceptance of situations that would normally not be permitted. Attention span and vigilance are reduced, important elements in a task series are overlooked, and scanning patterns, which are essential for situational awareness, break down (usually due to fixation on a single instrument, object or task). Critical but routine tasks are often skipped.

3.2.2.9 Experience

High levels of NVIS proficiency, along with a well-balanced NVIS experience base, will help to offset many of the visual performance degradations associated with night operations. NVIS experience is a result of proper training coupled with numerous NVIS operations. An experienced NVIS pilot is acutely aware of the NVIS operational envelope and its correlation to various operational effects, visual illusions and performance limitations. This experience base is gained (and maintained) over time through a continual, holistic NVIS training programme that exposes the pilot to NVIS operations conducted under various moon angles, percentage of available illumination, contrast levels, visibility levels, and varying degrees of cloud coverage. A pilot should be exposed to as many of these variations as practicable during the initial NVIS qualification programme. Continued exposure during the NVIS recurrent training will help strengthen and solidify this experience base.

4 Operations

Operations procedures should accommodate the capabilities and limitations of the systems described in Section 3 of this GM as well as the restraints of the operational environment.

All NVG operations should fulfil all applicable requirements in accordance with Regulation (EC) No 216/2008.

4.1 Pilot eligibility

About 54% of the civil pilot population wears some sort of ophthalmic device to correct vision necessary to safely operate an aircraft. The use of inappropriate ophthalmic devices with NVGs may result in vision performance decrement, fatigue, and other

human factor problems, which could result in increased risk for aviation accidents and incidents.

4.2 Operating environment considerations

4.2.1 Weather and atmospheric obscurants

Any atmospheric condition, which absorbs, scatters, or refracts illumination, either before or after it strikes terrain, may reduce the usable energy available to the NVG.

4.2.1.1 Weather

During NVIS operations, pilots can see areas of moisture that are dense (e.g., clouds, thick fog, etc.) but may not see areas that are less dense (e.g., thin fog, light rain showers, etc.). The inability to see some areas of moisture may lead to hazardous flight conditions during NVIS operations and will be discussed separately in the next section.

The different types of moisture will have varying effects and it is important to understand these effects and how they apply to NVIS operations. For example:

1. It is important to know when and where fog may form in the flying area. Typically, coastal, low-lying river, and mountainous areas are most susceptible.
2. Light rain or mist may not be observed with NVIS but will affect contrast, distance estimation, and depth perception. Heavy rain is more easily perceived due to large droplet size and energy attenuation.
3. Snow occurs in a wide range of particle sizes, shapes, and densities. As with clouds, rain, and fog, the denser the airborne snow, the greater the effect on NVG performance. On the ground, snow has mixed effect depending on terrain type and the illumination level. In mountainous terrain, snow may add contrast, especially if trees and rocks protrude through the snow. In flatter terrain, snow may cover high contrast areas, reducing them to areas of low contrast. On low illumination nights, snow may reflect the available energy better than the terrain it covers and thus increase the level of illumination.

All atmospheric conditions reduce the illumination level to some degree and recognition of this reduction with NVGs can be difficult. Thus, a good weather briefing, familiarity with the local weather patterns and understanding the effects on NVG performance are important for a successful NVIS flight.

4.2.1.2 Deteriorating weather

It is important to remain cognizant of changes in the weather when using NVGs. It is possible to “see through” areas of light moisture when using NVGs, thus increasing the risk of inadvertently entering IMC. Some ways to help reduce this possibility include the following:

1. Be attentive to changes in the NVG image. Halos may become larger and more diffuse due to diffraction of light in moisture. Scintillation in the image may increase due to a lowering of the illumination level caused by the increased atmospheric moisture. Loss of scene detail may be secondary to the lowering illumination caused by the changing moisture conditions.

2. Obtain a thorough weather brief with emphasis on NVG effects prior to flight.
3. Be familiar with weather patterns in the flying area.
4. Occasionally scan the outside scene. The unaided eye may detect weather conditions that are not detectable to the NVG.

Despite the many methods of inadvertent instrument meteorological conditions (IMC) prevention, one should have established IMC recovery procedures and be familiar with them.

4.2.1.3 Airborne obscurants

In addition to weather, there may be other obscurants in the atmosphere that could block energy from reaching the NVG, such as haze, dust, sand, or smoke. As with moisture, the size and concentration of the particles will determine the degree of impact. Examples of these effects include the following:

1. high winds during the day can place a lot of dust in the air that will still be present at night when the wind may have reduced in intensity;
2. forest fires produce heavy volumes of smoke that may cover areas well away from the fire itself;
3. the effects of rotor wash may be more pronounced when using NVGs depending on the material (e.g. sand, snow, dust, etc.); and
4. pollution in and around major cultural areas may have an adverse effect on NVG performance.

4.2.1.4 Winter operations

Using NVGs during winter conditions provide unique issues and challenges to pilots.

4.2.1.4.1 Snow

Due to the reflective nature of snow, it presents pilots with significant visual challenges both en-route and in the terminal area. During the en-route phase of a flight the snow may cause distractions to the flying pilot if any aircraft external lights (e.g., anti-collision beacons/strobes, position lights, landing lights, etc.) are not compatible with NVGs. In the terminal area, whiteout landings can create the greatest hazard to unaided night operations. With NVGs the hazard is not lessened, and can be more disorienting due to lights reflecting from the snow that is swirling around the aircraft during the landing phase. Any emergency vehicle lighting or other airport lighting in the terminal area may exaggerate the effects.

4.2.1.4.2 Ice fog

Ice fog presents the pilot with hazards normally associated with IMC in addition to problems associated with snow operations. The highly reflective nature of ice fog will further aggravate any lighting problems. Ice fog conditions can be generated by aircraft operations under extremely cold temperatures and the right environmental conditions.

4.2.1.4.3 Icing

Airframe ice is difficult to detect while looking through NVGs. The pilot will need to develop a proper crosscheck to ensure airframe icing does not exceed operating limits for that aircraft. Pilots should already be aware of icing indicator points on their aircraft. These areas require consistent oversight to properly determine environmental conditions.

4.2.1.4.4 Low ambient temperatures

Depending on the cockpit heating system, fogging of the NVGs can be a problem and this will significantly reduce the goggle effectiveness. Another issue with cockpit temperatures is the reduced battery duration. Operations in a cold environment may require additional battery resources.

4.2.2 Illumination

NVGs require illumination, either natural or artificial, to produce an image. Although current NVG technology has significantly improved low light level performance, some illumination, whether natural or artificial, is still required to provide the best possible image.

4.2.2.1 Natural illumination

The main sources of natural illumination include the moon and stars. Other sources can include sky glow, the aurora borealis, and ionisation processes that take place in the upper atmosphere.

4.2.2.1.1 Moon phase

The moon provides the greatest source of natural illumination during night time. Moon phase and elevation determines how much moonlight will be available, while moonrise and moonset times determine when it will be available. Lunar illumination is reported in terms of percent illumination, 100% illumination being full moon. It should be noted that this is different from the moon phase (e.g., 25% illumination does not mean the same thing as a quarter moon). Currently, percent lunar illumination can only be obtained from sources on the Internet, military weather facilities and some publications (e.g. Farmers Almanac).

4.2.2.1.2 Lunar azimuth and elevation

The moon can have a detrimental effect on night operations depending on its relationship to the flight path. When the moon is on the same azimuth as the flight path, and low enough to be within or near the NVG field of view, the effect on NVG performance will be similar to that caused by the sun on the unaided eye during daytime. The brightness of the moon drives the NVG gain down, thus reducing image detail. This can also occur with the moon at relatively high elevations. For example, it is possible to bring the moon near the NVG field of view when climbing to cross a ridgeline or other obstacle, even when the moon is at a relatively high elevation. It is important to consider lunar azimuth and elevation during pre-flight planning. Shadowing, another effect of lunar azimuth and elevation, will be discussed separately.

4.2.2.1.3 Shadowing

Moonlight creates shadows during night time just as sunlight creates shadows during daytime. However, night time shadows contain very little energy for the NVG to use in forming an image. Consequently, image quality within a shadow will be degraded relative to that obtained outside the shadowed area. Shadows can be beneficial or can be a disadvantage to operations depending on the situation.

4.2.2.1.3.1 Benefits of shadows

Shadows alert aircrew to subtle terrain features that may not otherwise be noted due to the reduced resolution in the NVG image. This may be particularly important in areas where there is little contrast differentiation; such as flat featureless deserts, where large dry washes and high sand dunes may go unnoticed if there is no contrast to note their presence. The contrast provided by shadows helps make the NVG scene appear more natural.

4.2.2.1.3.2 Disadvantages due to shadows

When within a shadow, terrain detail can be significantly degraded, and objects can be regarded as being lost. The potential for loss of terrain detail during flight in or around shadowed areas is the pilot's response to loss of terrain detail. During flight under good illumination conditions, a pilot expects to see a certain level of detail. If flight into a shadow occurs while the pilot is preoccupied with other matters (e.g., communication, radar, etc.), it is possible that the loss in terrain detail may not have been immediately noted. Once looking outside again, the pilot may think the reduced detail is due to an increase in flight altitude and thus begin a descent - even though already at a low altitude. Consideration should be given during mission planning to such factors as lunar azimuth and elevation, terrain type (e.g., mountainous, flat, etc.), and the location of items significant to operation success (e.g., ridgelines, pylons, targets, waypoints, etc.). Consideration of these factors will help predict the location of shadows and the potential adverse effects.

4.2.2.1.4 Sky glow

Sky glow is an effect caused by solar light and continues until the sun is approximately 18 degrees below the horizon. When viewing in the direction of sky glow there may be enough energy present to adversely affect the NVG image (i.e., reduce image quality). For the middle latitudes the effect on NVG performance may last up to an hour after official sunset. For more northern and southern latitudes the effect may last for extended periods of times (e.g., days to weeks) during seasons when the sun does not travel far below the horizon. This is an important point to remember if planning NVG operations in those areas. Unlike sky glow after sunset, the sky glow associated with sunrise does not have an obvious effect on NVG performance until fairly close to official sunrise. The difference has to do with the length of time the atmosphere is exposed to the sun's irradiation, which causes ionisation processes that release near-IR energy. It is important to know the difference in these effects for planning purposes.

4.2.2.2 Artificial illumination

Since the NVGs are sensitive to any source of energy in the visible and near infrared spectrums, there are also many types of artificial illumination sources (e.g., flares, IR searchlights, cultural lighting, etc.). As with any illumination source, these can have both

positive and detrimental effects on NVG utilisation. For example, viewing a scene indirectly illuminated by a searchlight can enable the pilot to more clearly view the scene; conversely, viewing the same scene with the searchlight near or within the NVG field of view will reduce the available visual cues. It is important to be familiar with the effects of cultural lighting in the flying area in order to be able to avoid the associated problems and to be able to use the advantages provided. Also, it is important to know how to properly use artificial light sources (e.g., aircraft IR spotlight). It should be noted that artificial light sources may not always be available or dependable, and this should be taken into consideration during flight planning.

4.2.3 Terrain contrast

Contrast is one of the more important influences on the ability to correctly interpret the NVG image, particularly in areas where there are few cultural features. Any terrain that contains varying albedos (e.g., forests, cultivated fields, etc.) will likely increase the level of contrast in a NVG image, thus enhancing detail. The more detail in the image, the more visual information aircrews have for manoeuvring and navigating. Low contrast terrain (e.g., flat featureless desert, snow-covered fields, water, etc.) contains few albedo variations, thus the NVG image will contain fewer levels of contrast and less detail.

4.3 Aircraft considerations

4.3.1 Lighting

Factors such as aircraft internal and external lighting have the potential to adversely impact NVG gain and thus image quality. How well the windshield, canopy, or window panels transmit near infrared energy can also affect the image. Cleanliness of the windshield directly impacts this issue.

4.3.2 Cockpit ergonomics

While wearing NVGs, the pilot may have limited range of head movement in the aircraft. For example, switches on the overhead console may be difficult to read while wearing NVGs. Instruments, controls, and switches that are ordinarily accessible, may now be more difficult to access due to the extended mass (fore/aft) associated with NVGs.

In addition, scanning may require a more concentrated effort due to limited field of view. Lateral viewing motion can be hindered by cockpit obstructions (i.e. door post or seat back design).

4.3.3 Windshield reflectivity

Consideration within the cockpit and cabin should be given to the reflectivity of materials and equipment upon the windshield. Light that is reflected may interfere with a clear and unobstructed view. Items such as flight suits, helmets, and charts, if of a light colour such as white, yellow, and orange, can produce significant reflections. Colours that impart the least reflection are black, purple, and blue. This phenomena is not limited to windshields but may include side windows, chin bubbles, canopies, etc.

4.4 Generic operating considerations

This section lists operating topics and procedures, which should be considered when employing NVIS. The list and associated comments are not to be considered all inclusive. NVIS operations vary in scope widely and this section is not intended to instruct a prospective operator on how to implement an NVIS programme.

4.4.1 Normal procedures

4.4.1.1 Scanning

When using NVGs there are three different scan patterns to consider and each is used for different reasons: instrument scan, aided scan outside, and unaided scan outside. Normally, all three are integrated and there is a continuous transition from one to the other depending on the mission, environmental conditions, immediate tasking, flight altitude and many other variables. For example, scanning with the NVG will allow early detection of external lights. However, the bloom caused by the lights will mask the aircraft until fairly close or until the lighting scheme is changed. Once close to the aircraft (e.g., approximately one-half mile for smaller aircraft), visual acquisition can possibly be made unaided or with the NVG. Whether to use the NVG or unaided vision depends on many variables (e.g., external lighting configuration, distance to aircraft, size of aircraft, environmental conditions, etc.). The points to be made are that a proper scan depends on the situation and variables present, and that scanning outside is critical when close to another aircraft. Additionally, for a multi-crew environment, coordination of scan responsibilities is vital.

4.4.1.1.1 Instrument crosscheck scan

In order to effect a proper and effective instrument scan, it is important to predict when it will be important. A start can be made during pre-flight planning when critical phases of flight can be identified and prepared for. For example, it may be possible when flying over water or featureless terrain to employ a good instrument crosscheck. However, the most important task is to make the appropriate decision during flight as conditions and events change. In this case, experience, training and constant attention to the situation are vital contributors to the pilot's assessment of the situation.

4.4.1.1.2 NVG scan

To counteract the limited field of view, pilots should continually scan throughout the field of regard. This allows aircrew to build a mental image of the surrounding environment. How quickly the outside scene is scanned to update the mental image is determined by many variables. For example, when flying over flat terrain where the highest obstacle is below the flight path, the scan may be fairly slow. However, if flying low altitude in mountainous terrain, the scan will be more aggressive and rapid due to the presence of more information and the increased risk. How much of the field of regard to scan is also determined by many variables. For example, if a pilot is anticipating a turn, more attention may be placed in the area around the turn point, or in the direction of the new heading. In this situation, the scan will be limited briefly to only a portion of the field of regard.

As with the instrument scan, it is very important to plan ahead. It may, for example, be possible to determine when the scan may be interrupted due to other tasks, when it may be possible to become fixated on a specific task, or when it is important to maximise the outside scan. An important lesson to learn regarding the NVG scan is when not to rely on visual information. It is easy to overestimate how well one can see with NVGs, especially on high illumination nights, and it is vital to maintain a constant awareness regarding their limitations. This should be pointed out often during training and, as a reminder, should be included as a briefing item for NVG flights.

4.4.1.1.3 Unaided scan

Under certain conditions, this scan can be as important as the others can. For example, it may be possible to detect distance and/or closure to another aircraft more easily using unaided vision, especially if the halo caused by the external lights is masking aircraft detail on the NVG image. Additionally, there are other times when unaided information can be used in lieu of or can augment NVG and instrument information.

4.4.1.1.4 Scan patterns

Environmental factors will influence scan by limiting what may be seen in specific directions or by degrading the overall image. If the image is degraded, aircrew may scan more aggressively in a subconscious attempt to obtain more information, or to avoid the chance of missing information that suddenly appears and/or disappears. The operation itself may influence the scan pattern. For example, looking for another aircraft, landing zone, or airport may require focusing the scan in a particular direction. In some cases, the operation may require aircrew in a multi place aircraft to assign particular pilots responsibility for scanning specific sectors.

The restrictions to scan and the variables affecting the scan pattern are not specific to night operations or the use of NVGs, but, due to the NVG's limited field of view, the degree of impact is magnified.

4.4.1.2 Pre-flight planning

4.4.1.2.1 Illumination criteria

The pilot should provide a means for forecasting the illumination levels in the operational area. The pilot should make the effort to request at least the following information in addition to that normally requested for night VFR: cloud cover and visibility during all phases of flight, sunset, civil and nautical twilight, moon phase, moonrise and moonset, and moon and/or lux illumination levels, and unlit tower NOTAMS.

4.4.1.2.2 NVIS operations

An inspection of the power pack, visor, mount, power cable and the binocular assembly should be performed in accordance with the operations manual.

To ensure maximum performance of the NVGs, proper alignment and focus must be accomplished following the equipment inspection. Improper alignment and focus may degrade NVIS performance.

4.4.1.2.3 Aircraft pre-flight

A normal pre-flight inspection should be conducted prior to an NVIS flight with emphasis on proper operation of the NVIS lighting. The aircraft windshield must also be clean and free of major defects, which might degrade NVIS performance.

4.4.1.2.4 Equipment

The basic equipment required for NVIS operations should be those instruments and equipment specified within the current applicable regulations for VFR night operations. Additional equipment required for NVIS operations, e.g. NVIS lighting system and a radio altimeter must be installed and operational. All NVIS equipment, including any subsequent modifications, shall be approved.

4.4.1.2.5 Risk assessment

A risk assessment is suggested prior to any NVIS operation. The risk assessment should include as a minimum:

1. illumination level
2. weather
3. pilot recency of experience
4. pilot experience with NVG operations
5. pilot vision
6. pilot rest condition and health
7. windshield/window condition
8. NVG tube performance
9. NVG battery condition
10. types of operations allowed
11. external lighting environment.

4.4.1.3 Flight operations

4.4.1.3.1 Elevated terrain

Safety may be enhanced by NVGs during operations near elevated terrain at night. The obscuration of elevated terrain is more easily detected with NVGs thereby allowing the pilot to make alternate flight path decisions.

4.4.1.3.2 Over-water

Flying over large bodies of water with NVGs is difficult because of the lack of contrast in terrain features. Reflections of the moon or starlight may cause disorientation with the natural horizon. The radio altimeter must be used as a reference to maintain altitude.

4.4.1.4 Remote area considerations

A remote area is a site that does not qualify as an aerodrome as defined by the applicable regulations. Remote area landing sites do not have the same features as an

aerodrome, so extra care must be given to locating any obstacles that may be in the approach/departure path.

A reconnaissance must be made prior to descending at an unlighted remote site. Some features or objects may be easy to detect and interpret with the unaided eye. Other objects will be invisible to the unaided eye, yet easily detected and evaluated with NVGs.

4.4.1.5 Reconnaissance

The reconnaissance phase should involve the coordinated use of NVGs and white lights. The aircraft's external white lights such as landing lights, searchlights, and floodlights, should be used during this phase of flight. The pilot should select and evaluate approach and departure paths to the site considering wind speed and direction, and obstacles or signs of obstacles.

4.4.1.6 Sources of high illumination

Sources of direct high illumination may have the potential to reduce the effectiveness of the NVGs. In addition, certain colour lights, such as red, will appear brighter, closer and may display large halos.

4.4.2 Emergency procedures

No modification for NVG operations is necessary to the aircraft emergency procedures as approved in the operations manual or approved checklist. Special training may be required to accomplish the appropriate procedures.

4.4.3 Inadvertent IMC

Some ways to help reduce the potential for inadvertent flight into IMC conditions are:

1. obtaining a thorough weather brief (including pilot reports);
2. being familiar with weather patterns in the local flying area; and
3. by looking beneath the NVG at the outside scene.

However, even with thorough planning a risk still exists. To help mitigate this risk it is important to know how to recognise subtle changes to the NVG image that occur during entry into IMC conditions. Some of these include the onset of scintillation, loss of scene detail, and changes in the appearance of halos.

5 Training

To provide an appropriate level of safety, training procedures must accommodate the capabilities and limitations of the systems described in Section 3 of this GM as well as the restraints of the operational environment.

To be effective, the NVIS training philosophy would be based on a two-tiered approach: basic and advanced NVIS training. The basic NVIS training would serve as the baseline standard for all individuals seeking an NVIS endorsement. The content of this initial training would not be dependent on any operational requirements. The advanced training would build on the basic training by focusing on developing specialised skills required to operate an aircraft during NVIS operations in a particular operational environment.

Furthermore, while there is a need to stipulate minimum flight hour requirements for an NVIS endorsement, the training must also be event based. This necessitates that pilots be exposed to all of the relevant aspects, or events, of NVIS flight in addition to acquiring a minimum number of flight hours.

6. Continuing airworthiness

The reliability of the NVIS and safety of operations are dependent on the pilots adhering to the instructions for continuing airworthiness. Personnel who conduct the maintenance and inspection on the NVIS must be qualified and possess the appropriate tools and facilities to perform the maintenance.

Acronyms used in this GM

AC	Advisory Circular
AGL	above ground level
ATC	air traffic control
CONOPs	concept of operations
CG	centre of gravity
CRM	cockpit resource management
DOD	Department of Defence
DOT	Department of Transportation
EFIS	electronic flight instrumentation systems
EMS	emergency medical service
FAA	Federal Aviation Administration
FLIR	forward looking infrared radar
FOR	field of regard
FOV	field of view
GEN	generation
HUD	head-up display
IFR	instrument flight rules
IMC	instrument meteorological conditions
IR	infrared
JAA	Joint Aviation Authorities
MOPS	Minimum Operational Performance Standard
NAS	national airspace system
NOTAMS	Notices to Airmen
NVD	night vision device

NVED	night vision enhancement device
NVG	night vision goggles
NVIS	night vision imaging system
SC	special committee
TFR	temporary flight restrictions
VA	visual acuity
VFR	visual flight rules
VMC	visual meteorological conditions

Glossary of terms used in this GM

1. 'Absorptance': the ratio of the radiant energy absorbed by a body to that incident upon it.
2. 'Albedo': the ratio of the amount of light reflected from a surface to the amount of incident light.
3. 'Automatic brightness control (ABC)': one of the automatic gain control circuits found in second and third generation NVG devices. It attempts to provide consistent image output brightness by automatic control of the micro channel plate voltage.
4. 'Automatic gain control (AGC)': comprised of the automatic brightness control and bright source protection circuits. Is designed to maintain image brightness and protect the user and the image tube from excessive light levels. This is accomplished by controlling the gain of the intensifier tube.
5. 'Blackbody': an ideal body of surface that completely absorbs all radiant energy falling upon with no reflection.
6. 'Blooming': common term used to denote the "washing out" of all or part of the NVG image due to de-gaining of the image intensifier tube when a bright light source is in or near the NVG field of view.
7. 'Bright source protection (BSP)': protective feature associated with second and third generation NVGs that protects the intensifier tube and the user by controlling the voltage at the photo cathode.
8. 'Brownout': condition created by blowing sand, dust, etc., which can cause the pilots to lose sight of the ground. This is most commonly associated with landings in the desert or in dusty LZs.
9. 'Civil nautical twilight': the time when the true altitude of the centre of the sun is six degrees below the horizon. Illuminance level is approximately 3.40 lux and is above the usable level for NVG operations.
10. 'Diopter': a measure of the refractive (light bending) power of a lens.
11. 'Electro-optics (EO)': the term used to describe the interaction between optics and electronics, leading to transformation of electrical energy into light or vice versa.

12. 'Electroluminescent (EL)': referring to light emission that occurs from application of an alternating current to a layer of phosphor.
13. 'Foot-candle': a measure of illuminance; specifically, the illuminance of a surface upon which one lumen is falling per square foot.
14. 'Foot-Lambert': a measure of luminance; specifically the luminance of a surface that is receiving an illuminance of one foot-candle.
15. 'Gain': when referring to an image intensification tube, the ratio of the brightness of the output in units of foot-lambert, compared to the illumination of the input in foot-candles. A typical value for a GEN III tube is 25,000 to 30,000 Fl/fc. A "tube gain" of 30,000 Fl/fc provides an approximate "system gain" of 3,000. This means that the intensified NVG image is 3,000 times brighter to the aided eye than that of the unaided eye.
16. 'Illuminance': also referred to as illumination. The amount, ratio or density of light that strikes a surface at any given point.
17. 'Image intensifier': an electro-optic device used to detect and intensify optical images in the visible and near infrared region of the electromagnetic spectrum for the purpose of providing visible images. The component that actually performs the intensification process in a NVG. This component is composed of the photo cathode, MCP, screen optic, and power supply. It does not include the objective and eyepiece lenses.
18. 'Incandescent': refers to a source that emits light based on thermal excitation, i.e., heating by an electrical current, resulting in a very broad spectrum of energy that is dependent primarily on the temperature of the filament.
19. 'Infrared': that portion of the electromagnetic spectrum in which wavelengths range from 0.7 microns to 1 mm. This segment is further divided into near infrared (0.7-3.0 microns), mid infrared (3.0-6.0 microns), far infrared (6.0-15 microns), and extreme infrared (15 microns-1 mm). A NVG is sensitive to near infrared wavelengths approaching 0.9 microns.
20. 'Irradiance': the radiant flux density incident on a surface. For the purpose of this document the terms irradiance and illuminance shall be interchangeable.
21. 'Lumen': a measurement of luminous flux equal to the light emitted in a unit solid angle by a uniform point source of one candle intensity.
22. 'Luminance': the luminous intensity (reflected light) of a surface in a given direction per unit of projected area. This is the energy used by NVGs.
23. 'Lux': a unit measurement of illumination. The illuminance produced on a surface that is one-meter square, from a uniform point source of one candle intensity, or one lumen per square meter.
24. 'Microchannel plate': a wafer containing between 3 and 6 million specially treated microscopic glass tubes designed to multiply electrons passing from the photo cathode to the phosphor screen in second and third generation intensifier tubes.
25. 'Micron': a unit of measure commonly used to express wavelength in the infrared region; equal to one millionth of a meter.

26. 'Nanometer (nm)': a unit of measure commonly used to express wavelength in the visible and near infrared region; equal to one billionth of a meter.
27. 'Night vision device (NVD)': an electro-optical device used to provide a visible image using the electromagnetic energy available at night.
28. 'Photon': a quantum (basic unit) of radiant energy (light).
29. 'Photopic vision': vision produced as a result of the response of the cones in the retina as the eye achieves a light adapted state (commonly referred to as day vision).
30. 'Radiance': the flux density of radiant energy reflected from a surface. For the purposes of this manual the terms radiance and luminance shall be interchangeable.
31. 'Reflectivity': the fraction of energy reflected from a surface.
32. 'Scotopic vision': that vision produced as a result of the response of the rods in the retina as the eye achieves a dark-adapted state (commonly referred to as night vision).
33. 'Situational awareness (SA)': degree of perceptual accuracy achieved in the comprehension of all factors affecting an aircraft and crew at a given time.
34. 'Starlight': the illuminance provided by the available (observable) stars in a subject hemisphere. The stars provide approximately 0.00022 lux ground illuminance on a clear night. This illuminance is equivalent to about one-quarter of the actual light from the night sky with no moon.
35. 'Stereopsis': visual system binocular cues that are used for distance estimation and depth perception. Three dimensional visual perception of objects. The use of NVGs seriously degrades this aspect of near-depth perception.
36. 'Transmittance': the fraction of radiant energy that is transmitted through a layer of absorbing material placed in its path.
37. 'Ultraviolet': that portion of the electromagnetic spectrum in which wavelengths range between 0.1 and 0.4 microns.
38. 'Wavelength': the distance in the line of advance of a wave from any one point to the next point of corresponding phase; is used to express electromagnetic energy including IR and visible light.
39. 'Whiteout': a condition similar to brownout but caused by blowing snow.

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Subpart I – Helicopter hoist operations

AMC1 SPA.HHO.110(a) Equipment requirements for HHO

AIRWORTHINESS APPROVAL FOR HUMAN EXTERNAL CARGO

- (a) Hoist installations that have been certificated according to any of the following standards should be considered to satisfy the airworthiness criteria for human external cargo (HEC) operations:
 - (1) CS 27.865 or CS 29.865;
 - (2) JAR 27 Amendment 2 (27.865) or JAR 29 Amendment 2 (29.865) or later;
 - (3) FAR 27 Amendment 36 (27.865) or later - including compliance with CS 27.865(c)(6); or
 - (4) FAR 29 Amendment 43 (29.865) or later.
- (b) Hoist installations that have been certified prior to the issuance of the airworthiness criteria for HEC as defined in (a) may be considered as eligible for HHO provided that following a risk assessment either:
 - (1) the service history of the hoist installation is found satisfactory to the competent authority; or
 - (2) for hoist installations with an unsatisfactory service history, additional substantiation to allow acceptance by the competent authority should be provided by the hoist installation certificate holder (type certificate (TC) or supplemental type certificate (STC)) on the basis of the following requirements:
 - (i) The hoist installation should withstand a force equal to a limit static load factor of 3.5, or some lower load factor, not less than 2.5, demonstrated to be the maximum load factor expected during hoist operations, multiplied by the maximum authorised external load.
 - (ii) The reliability of the primary and back-up quick release systems at helicopter level should be established and failure mode and effect analysis at equipment level should be available. The assessment of the design of the primary and back-up quick release systems should consider any failure that could be induced by a failure mode of any other electrical or mechanical rotorcraft system.
 - (iii) The operations or flight manual contains one-engine-inoperative (OEI) hover performance data and procedures for the weights, altitudes, and temperatures throughout the flight envelope for which hoist operations are accepted.
 - (iv) Information concerning the inspection intervals and retirement life of the hoist cable should be provided in the instructions for continued airworthiness.

- (v) Any airworthiness issue reported from incidents or accidents and not addressed by (i), (ii), (iii) and (iv) should be addressed.

AMC1 SPA.HHO.130(b)(2)(ii) Crew requirements for HHO

RELEVANT EXPERIENCE

The experience considered should take into account the geographical characteristics (sea, mountain, big cities with heavy traffic, etc.).

AMC1 SPA.HHO.130(e) Crew requirements for HHO

CRITERIA FOR TWO PILOT HHO

A crew of two pilots should be used when:

- (a) the weather conditions are below VFR minima at the offshore vessel or structure;
- (b) there are adverse weather conditions at the HHO site (i.e. turbulence, vessel movement, visibility); and
- (c) the type of helicopter requires a second pilot to be carried because of:
 - (1) cockpit visibility;
 - (2) handling characteristics; or
 - (3) lack of automatic flight control systems.

AMC1 SPA.HHO.130(f)(1) Crew requirements for HHO

TRAINING AND CHECKING SYLLABUS

- (a) The flight crew training syllabus should include the following items:
 - (1) fitting and use of the hoist;
 - (2) preparing the helicopter and hoist equipment for HHO;
 - (3) normal and emergency hoist procedures by day and, when required, by night;
 - (4) crew coordination concepts specific to HHO;
 - (5) practice of HHO procedures; and
 - (6) the dangers of static electricity discharge.
- (b) The flight crew checking syllabus should include:
 - (1) proficiency checks, which should include procedures likely to be used at HHO sites with special emphasis on:
 - (i) local area meteorology;
 - (ii) HHO flight planning;
 - (iii) HHO departures;
 - (iv) a transition to and from the hover at the HHO site;
 - (v) normal and simulated emergency HHO procedures; and

(vi) crew coordination.

(c) HHO technical crew members should be trained and checked in the following items:

- (1) duties in the HHO role;
- (2) fitting and use of the hoist;
- (3) operation of hoist equipment;
- (4) preparing the helicopter and specialist equipment for HHO;
- (5) normal and emergency procedures;
- (6) crew coordination concepts specific to HHO;
- (7) operation of inter-communication and radio equipment;
- (8) knowledge of emergency hoist equipment;
- (9) techniques for handling HHO passengers;
- (10) effect of the movement of personnel on the centre of gravity and mass during HHO;
- (11) effect of the movement of personnel on performance during normal and emergency flight conditions;
- (12) techniques for guiding pilots over HHO sites;
- (13) awareness of specific dangers relating to the operating environment; and
- (14) the dangers of static electricity discharge.

AMC1 SPA.HHO.140 Information and documentation

OPERATIONS MANUAL

The operations manual should include:

- (a) performance criteria;
- (b) if applicable, the conditions under which offshore HHO transfer may be conducted including the relevant limitations on vessel movement and wind speed;
- (c) the weather limitations for HHO;
- (d) the criteria for determining the minimum size of the HHO site, appropriate to the task;
- (e) the procedures for determining minimum crew; and
- (f) the method by which crew members record hoist cycles.

Subpart J - Helicopter emergency medical service operations

GM1 SPA.HEMS.100(a) Helicopter emergency medical service (HEMS) operations

THE HEMS PHILOSOPHY

(a) Introduction

This GM outlines the HEMS philosophy. Starting with a description of acceptable risk and introducing a taxonomy used in other industries, it describes how risk has been addressed in this Subpart to provide a system of safety to the appropriate standard. It discusses the difference between HEMS and air ambulance - in regulatory terms. It also discusses the application of operations to public interest sites in the HEMS context.

(b) Acceptable risk

The broad aim of any aviation legislation is to permit the widest spectrum of operations with the minimum risk. In fact it may be worth considering who/what is at risk and who/what is being protected. In this view three groups are being protected:

- (1) third parties (including property) - highest protection;
- (2) passengers (including patients); and
- (3) crew members (including technical crew members) – lowest.

It is for the Legislator to facilitate a method for the assessment of risk - or as it is more commonly known, safety management (refer to Part-ORO).

(c) Risk management

Safety management textbooks² describe four different approaches to the management of risk. All but the first have been used in the production of this section and, if it is considered that the engine failure accountability of performance class 1 equates to zero risk, then all four are used (this of course is not strictly true as there are a number of helicopter parts - such as the tail rotor which, due to a lack of redundancy, cannot satisfy the criteria):

(1) Applying the taxonomy to HEMS gives:

- (i) zero risk; no risk of accident with a harmful consequence – performance class 1 (within the qualification stated above) - the HEMS operating base;
- (ii) de minimis; minimised to an acceptable safety target - for example the exposure time concept where the target is less than 5×10^{-8} (in the case of elevated final approach and take-off areas (elevated FATOs) at hospitals in a congested hostile environment the risk is contained to

² Reason, J., 1997. Managing the Risks of Organizational Accidents. Ashgate, Farnham.

- the deck edge strike case - and so in effect minimised to an exposure of seconds);
- (iii) comparative risk; comparison to other exposure - the carriage of a patient with a spinal injury in an ambulance that is subject to ground effect compared to the risk of a HEMS flight (consequential and comparative risk);
- (iv) as low as reasonably practicable; where additional controls are not economically or reasonably practicable - operations at the HEMS operating site (the accident site).

(2) HEMS operations are conducted in accordance with the requirements contained in Annex IV (Part-CAT) and Annex III (Part-ORO), except for the variations contained in SPA.HEMS, for which a specific approval is required. In simple terms there are three areas in HEMS operations where risk, beyond that allowed in Part-CAT and Part-ORO, are identified and related risks accepted:

- (i) in the en-route phase, where alleviation is given from height and visibility rules;
- (ii) at the accident site, where alleviation is given from the performance and size requirement; and
- (iii) at an elevated hospital site in a congested hostile environment, where alleviation is given from the deck edge strike - providing elements of the CAT.POL.H.305 are satisfied.

In mitigation against these additional and considered risks, experience levels are set, specialist training is required (such as instrument training to compensate for the increased risk of inadvertent entry into cloud) and operation with two crew (two pilots, or one pilot and a HEMS technical crew member) is mandated. (HEMS crews and medical passengers are also expected to operate in accordance with good crew resource management (CRM) principles.)

(d) Air ambulance

In regulatory terms, air ambulance is considered to be a normal transport task where the risk is no higher than for operations to the full OPS.CAT and Part-ORO compliance. This is not intended to contradict/complement medical terminology but is simply a statement of policy; none of the risk elements of HEMS should be extant and therefore none of the additional requirements of HEMS need be applied.

To provide a road ambulance analogy:

- (1) if called to an emergency: an ambulance would proceed at great speed, sounding its siren and proceeding against traffic lights - thus matching the risk of operation to the risk of a potential death (= HEMS operations);
- (2) for a transfer of a patient (or equipment) where life and death (or consequential injury of ground transport) is not an issue: the journey would be conducted without sirens and within normal rules of motoring - once again matching the risk to the task (= air ambulance operations).

The underlying principle is that the aviation risk should be proportionate to the task.

It is for the medical professional to decide between HEMS or air ambulance - not the pilot. For that reason, medical staff who undertake to task medical sorties should be fully aware of the additional risks that are (potentially) present under HEMS operations (and the pre-requisite for the operator to hold a HEMS approval). (For example in some countries, hospitals have principal and alternative sites. The patient may be landed at the safer alternative site (usually in the grounds of the hospital) thus eliminating risk - against the small inconvenience of a short ambulance transfer from the site to the hospital.)

Once the decision between HEMS or air ambulance has been taken by the medical professional, the commander makes an operational judgement over the conduct of the flight.

Simplistically, the above type of air ambulance operations could be conducted by any operator holding an AOC (HEMS operators hold an AOC) - and usually are when the carriage of medical supplies (equipment, blood, organs, drugs etc.) is undertaken and when urgency is not an issue.

(e) Operating under a HEMS approval

There are only two possibilities: transportation as passengers or cargo under the full auspices of OPS.CAT and Part-ORO (this does not permit any of the alleviations of SPA.EMS - landing and take-off performance should be in compliance with the performance Subparts of Part-CAT), or operations under a HEMS approval as contained in this Subpart.

(f) HEMS operational sites

The HEMS philosophy attributes the appropriate levels of risk for each operational site; this is derived from practical considerations and in consideration of the probability of use. The risk is expected to be inversely proportional to the amount of use of the site. The types of site are as follows:

- (1) HEMS operating base: from which all operations will start and finish. There is a high probability of a large number of take-offs and landings at this HEMS operating base and for that reason no alleviation from operating procedures or performance rules are contained in this Subpart.
- (2) HEMS operating site: because this is the primary pick-up site related to an incident or accident, its use can never be pre-planned and therefore attracts alleviations from operating procedures and performance rules, when appropriate.
- (3) The hospital site: is usually at ground level in hospital grounds or, if elevated, on a hospital building. It may have been established during a period when performance criteria were not a consideration. The amount of use of such sites depends on their location and their facilities; normally, it will be greater than that of the HEMS operating site but less than for a HEMS operating base. Such sites attract some alleviation under this Subpart.

(g) Problems with hospital sites

During implementation of the original HEMS rules contained in JAR-OPS 3, it was established that a number of States had encountered problems with the impact of performance rules where helicopters were operated for HEMS. Although States accept that progress should be made towards operations where risks associated

with a critical engine failure are eliminated, or limited by the exposure time concept, a number of landing sites exist that do not (or never can) allow operations to performance class 1 or 2 requirements.

These sites are generally found in a congested hostile environment:

- (1) in the grounds of hospitals; or
- (2) on hospital buildings.

The problem of hospital sites is mainly historical and, whilst the authority could insist that such sites are not used - or used at such a low weight that critical engine failure performance is assured - it would seriously curtail a number of existing operations.

Even though the rule for the use of such sites in hospital grounds for HEMS operations attracts alleviation, it is only partial and will still impact upon present operations.

Because such operations are performed in the public interest, it was felt that the authority should be able to exercise its discretion so as to allow continued use of such sites provided that it is satisfied that an adequate level of safety can be maintained - notwithstanding that the site does not allow operations to performance class 1 or 2 standards. However, it is in the interest of continuing improvements in safety that the alleviation of such operations be constrained to existing sites, and for a limited period.

It is felt that the use of public interest sites should be controlled. This will require that a State directory of sites be kept and approval given only when the operator has an entry in the route manual section of the operations manual.

The directory (and the entry in the operations manual) should contain for each approved site:

- (i) the dimensions;
- (ii) any non-conformance with ICAO Annex 14;
- (iii) the main risks; and
- (iv) the contingency plan should an incident occur.

Each entry should also contain a diagram (or annotated photograph) showing the main aspects of the site.

(h) Summary

In summary, the following points are considered to be pertinent to the HEMS philosophy and HEMS regulations:

- (1) absolute levels of safety are conditioned by society;
- (2) potential risk must only be to a level proportionate to the task;
- (3) protection is afforded at levels appropriate to the occupants;
- (4) this Subpart addresses a number of risk areas and mitigation is built in;
- (5) only HEMS operations are dealt with by this Subpart;

- (6) there are three main categories of HEMS sites and each is addressed appropriately; and
- (7) State alleviation from the requirement at a hospital site is available but such alleviations should be strictly controlled by a system of registration.

GM1 SPA.HEMS.120 HEMS operating minima

REDUCED VISIBILITY

- (a) In the rule the ability to reduce the visibility for short periods has been included. This will allow the commander to assess the risk of flying temporarily into reduced visibility against the need to provide emergency medical service, taking into account the advisory speeds included in Table 1. Since every situation is different it was not felt appropriate to define the short period in terms of absolute figures. It is for the commander to assess the aviation risk to third parties, the crew and the aircraft such that it is proportionate to the task, using the principles of GM1 SPA.HEMS.100(a).
- (b) When flight with a visibility of less than 5 km is permitted, the forward visibility should not be less than the distance travelled by the helicopter in 30 seconds so as to allow adequate opportunity to see and avoid obstacles (see table below).

Table 1: Operating minima – reduced visibility

Visibility (m)	Advisory speed (kt)
800	50
1 500	100
2 000	120

GM1 SPA.HEMS.125(b)(3) Performance requirements for HEMS operations

PERFORMANCE CLASS 2 OPERATIONS AT A HEMS OPERATING SITE

As the risk profile at a HEMS operating site is already well known, operations without an assured safe forced landing capability do not need a separate approval and the requirements does not call for the additional risk assessment that is specified in CAT.POL.H.305 (b)(1).

AMC1 SPA.HEMS.125(b)(4) Performance requirements for HEMS operations

HEMS OPERATING SITE DIMENSIONS

- (a) When selecting a HEMS operating site it should have a minimum dimension of at least 2 x D (the largest dimensions of the helicopter when the rotors are turning). For night operations, unsurveyed HEMS operating sites should have dimensions of at least 4 x D in length and 2 x D in width.

- (b) For night operations, the illumination may be either from the ground or from the helicopter.

AMC1 SPA.HEMS.130(b)(2) Crew requirements

EXPERIENCE

The minimum experience level for a commander conducting HEMS flights should take into account the geographical characteristics of the operation (sea, mountain, big cities with heavy traffic, etc.).

AMC1 SPA.HEMS.130(d) Crew requirements

RECENCY

This recency may be obtained in a visual flight rules (VFR) helicopter using vision limiting devices such as goggles or screens, or in an FSTD.

AMC1 SPA.HEMS.130(e) Crew requirements

HEMS TECHNICAL CREW MEMBER

- (a) When the crew is composed of one pilot and one HEMS technical crew member, the latter should be seated in the front seat (co-pilot seat) during the flight, so as to be able to carry out his/her primary task of assisting the commander in:
 - (1) collision avoidance;
 - (2) the selection of the landing site; and
 - (3) the detection of obstacles during approach and take-off phases.
- (b) The commander may delegate other aviation tasks to the HEMS technical crew member, as necessary:
 - (1) assistance in navigation;
 - (2) assistance in radio communication/radio navigation means selection;
 - (3) reading of checklists; and
 - (4) monitoring of parameters.
- (c) The commander may also delegate to the HEMS technical crew member tasks on the ground:
 - (1) assistance in preparing the helicopter and dedicated medical specialist equipment for subsequent HEMS departure; or
 - (2) assistance in the application of safety measures during ground operations with rotors turning (including: crowd control, embarking and disembarking of passengers, refuelling etc.).
- (d) There may be exceptional circumstances when it is not possible for the HEMS technical crew member to carry out his/her primary task as defined under (a).

This is to be regarded as exceptional and is only to be conducted at the discretion of the commander, taking into account the dimensions and environment of the HEMS operating site.)

- (e) When two pilots are carried, there is no requirement for a HEMS technical crew member, provided that the pilot monitoring performs the aviation tasks of a technical crew member.

GM1 SPA.HEMS.130(e)(2)(ii) Crew requirements

SPECIFIC GEOGRAPHICAL AREAS

In defining those specific geographical areas, the operator should take account of the cultural lighting and topography. In those areas where the cultural lighting and topography make it unlikely that the visual cues would degrade sufficiently to make flying of the aircraft problematical, the HEMS technical crew member is assumed to be able to sufficiently assist the pilot, since under such circumstances instrument and control monitoring would not be required. In those cases where instrument and control monitoring would be required the operations should be conducted with two pilots.

AMC1 SPA.HEMS.130(e)(2)(ii)(B) Crew requirements

FLIGHT FOLLOWING SYSTEM

A flight following system is a system providing contact with the helicopter throughout its operational area.

AMC1 SPA.HEMS.130(f)(1) Crew requirements

TRAINING AND CHECKING SYLLABUS

- (a) The flight crew training syllabus should include the following items:
 - (1) meteorological training concentrating on the understanding and interpretation of available weather information;
 - (2) preparing the helicopter and specialist medical equipment for subsequent HEMS departure;
 - (3) practice of HEMS departures;
 - (4) the assessment from the air of the suitability of HEMS operating sites; and
 - (5) the medical effects air transport may have on the patient.
- (b) The flight crew checking syllabus should include:
 - (1) proficiency checks, which should include landing and take-off profiles likely to be used at HEMS operating sites; and
 - (2) line checks, with special emphasis on the following:
 - (i) local area meteorology;
 - (ii) HEMS flight planning;
 - (iii) HEMS departures;

- (iv) the selection from the air of HEMS operating sites;
- (v) low level flight in poor weather; and
- (vi) familiarity with established HEMS operating sites in the operator's local area register.

(c) HEMS technical crew members should be trained and checked in the following items:

- (1) duties in the HEMS role;
- (2) map reading, navigation aid principles and use;
- (3) operation of radio equipment;
- (4) use of on-board medical equipment;
- (5) preparing the helicopter and specialist medical equipment for subsequent HEMS departure;
- (6) instrument reading, warnings, use of normal and emergency checklists in assistance of the pilot as required;
- (7) basic understanding of the helicopter type in terms of location and design of normal and emergency systems and equipment;
- (8) crew coordination;
- (9) practice of response to HEMS call out;
- (10) conducting refuelling and rotors running refuelling;
- (11) HEMS operating site selection and use;
- (12) techniques for handling patients, the medical consequences of air transport and some knowledge of hospital casualty reception;
- (13) marshalling signals;
- (14) underslung load operations as appropriate;
- (15) winch operations as appropriate;
- (16) the dangers to self and others of rotor running helicopters including loading of patients; and
- (17) the use of the helicopter inter-communications system.

AMC1 SPA.EMS.130(f)(2)(ii)(B) Crew requirements

LINE CHECKS

Where due to the size, the configuration, or the performance of the helicopter, the line check cannot be conducted on an operational flight, it may be conducted on a specially arranged representative flight. This flight may be immediately adjacent to, but not simultaneous with, one of the biannual proficiency checks.

AMC1 SPA.HEMS.135(a) HEMS medical passenger and other personnel briefing

HEMS MEDICAL PASSENGER BRIEFING

The briefing should ensure that the medical passenger understands his/her role in the operation, which includes:

- (a) familiarisation with the helicopter type(s) operated;
- (b) entry and exit under normal and emergency conditions both for self and patients;
- (c) use of the relevant on-board specialist medical equipment;
- (d) the need for the commander's approval prior to use of specialised equipment;
- (e) method of supervision of other medical staff;
- (f) the use of helicopter inter-communication systems; and
- (g) location and use of on board fire extinguishers.

AMC1.1 SPA.HEMS.135(a) HEMS medical passenger and other personnel briefing

HEMS MEDICAL PASSENGER BRIEFING

Another means of complying with the rule as compared to that contained in AMC1-SPA.HEMS.135(a) is to make use of a training programme as mentioned in AMC1.1 CAT.OP.MPA.170.

AMC1 SPA.HEMS.135(b) HEMS medical passenger and other personnel briefing

GROUND EMERGENCY SERVICE PERSONNEL

- (a) The task of training large numbers of emergency service personnel is formidable. Wherever possible, helicopter operators should afford every assistance to those persons responsible for training emergency service personnel in HEMS support. This can be achieved by various means, such as, but not limited to, the production of flyers, publication of relevant information on the operator's web site and provision of extracts from the operations manual.
- (b) The elements that should be covered include:
 - (1) two-way radio communication procedures with helicopters;
 - (2) the selection of suitable HEMS operating sites for HEMS flights;
 - (3) the physical danger areas of helicopters;
 - (4) crowd control in respect of helicopter operations; and
 - (5) the evacuation of helicopter occupants following an on-site helicopter accident.

AMC1 SPA.HEMS.140 Information and documentation

OPERATIONS MANUAL

The operations manual should include:

- (a) the use of portable equipment on board;
- (b) guidance on take-off and landing procedures at previously unsurveyed HEMS operating sites;
- (c) the final reserve fuel, in accordance with SPA.HEMS.150;
- (d) operating minima;
- (e) recommended routes for regular flights to surveyed sites, including the minimum flight altitude;
- (f) guidance for the selection of the HEMS operating site in case of a flight to an unsurveyed site;
- (g) the safety altitude for the area overflown; and
- (h) procedures to be followed in case of inadvertent entry into cloud.