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Why fly at night?

Night flying is a very complex and varied reality. It has been developed through numerous steps, both technical, cognitive and legislative, and has now become a reality that modern and efficient emergency systems can no longer stay without.

The evolution of night flight can be compared to one of man's great discoveries. For just as the human being, born on dry land, decided to venture into the seas and even the skies, in the same way, it was impossible not to think that he himself would sooner or later attempt to operate at night, in an environment far from his usual one. To remain in the class of mammals, the nightlife is certainly not the prerogative of man but of those animals that have marked out their existence in the hours of scarce light. For evolutionary reasons, these animals have adapted adequately to nightlife, achieving the ability to move easily in the dark. One only has to think of the development of the peculiarity of the eye, which in nocturnal mammals (some ungulates, or felines, to give examples), is characterised by the typical *tapetum lucidum*. This is a reflective membrane located behind the retina, which favors the reflection of light, however scarce, through the retina itself, creating greater efficiency of visual acuity in dark conditions and providing a greater visual impression in the transformation of the image from light stimulus to chemical-nervous-sensory stimulus. *Tapetum lucidum, therefore,* acts as a kind of visual efficiency multiplier, although it differs considerably from the operating principle of technological systems with luminosity amplification, such as the so-called Night Vision Goggles (NVG).

In the Lombardy Region, out of the five bases that provide helicopter assistance (Bergamo, Brescia, Como, Milan and Sondrio), only two (Brescia and Como) are also authorised to fly at night. However, there are some differences in terms of the possibility of carrying out any operational mission, including the so-called special operations, which are currently only possible at the Como base. The aircraft used for this type of mission are also different: the

AW-139 for Como and the EC-145 T2 for the Brescia base. These are very different machines, and probably difficult to compare, because they are very different in terms of efficiency or readiness for rescue missions. It is perhaps true that the AW-139, heavier but with a higher maximum speed and range, is better suited to those missions that require longer flight distances and times.

But why fly at night? It would perhaps be more correct to answer this other question: why not fly at night?

The demand for health care in an urgency-emergency regime is certainly greater during daylight hours, i.e. at times of the day when the main economic activities take place, when work and tourism are mobile, when schools are open, when sports centres are open, etc. But it is also true that ‘illness’, unfortunately, knows no hours or holidays, and that the reduction in the incidence of the occurrence of medical and/or traumatic events at night is directly proportional to the reduction in the supply in terms of territorial and hospital health resources that can potentially be used to deal with them.

It is, therefore, necessary that the Emergency and Urgency systems be structured in such a way as to guarantee the best possible service, regardless of the time of occurrence. There are, therefore a number of critical objectives that contribute to enhancing the night-time activity of medical helicopters in a precise design that must necessarily aim for maximum integration between local and hospital rescue activities, all the more so in critical situations where there is a shortage of light.

In the area managed by the Sala Operativa Emergenza Urgenza dei Laghi (SOREU, covering the Lombardy provinces of Varese, Como and Lecco), many places are not always easy to reach by road. In absolute terms, the number of interventions in these areas is certainly limited; but, in percentage terms, the arrival of emergency vehicles is sometimes significantly higher than the average standards constantly recorded. Therefore, it is essential to implement helicopter rescue services in these areas, too, and even more so in these very areas, on a 24/7 basis, all year round. The demand for medical assistance becomes even more urgent when we have to manage events related to the so-called “time-dependent” pathologies (myocardial infarction, ischemic or haemorrhagic stroke, severe trauma, maternal and child emergencies), where both the arrival time of advanced assistance at the scene of the event and the subsequent hospitalisation to a HUB hospital, which is able to respond adequately, in terms of knowledge, practice and technology, to the global clinical needs of the patient, must be kept to a minimum. In the cases envisaged, “centralisation” then becomes a mandatory requirement for the Emergency-Urgency systems, so much so that it must also be guaranteed at night. Hence the development of the necessary technology, knowledge and training, and therefore of appropriate legislation that favours, permits, and even encourages night-time medical flights.

The development of night flying in Como

Night flying has evolved significantly over the years, reaching the high level of quality currently achieved, made possible by both the technology now available and the legislation currently in force.

The development of a night flight system has, of necessity, gone hand in hand with the gradual adaptation of the relevant legislation.

Night operations began in August 2008 for the Como base, which at the time was located in the municipality of Erba (CO), while it is now located at the Villaguardia helibase. Operations were strictly and exclusively linked to the use of the so-called HLS (Helicopter Landing Site) Standard mode. Therefore, night flights could only take place at surfaces (Helipads) that were certified for night operations, thus making rescue activities more typically represented by so-called Secondary Flights and, sporadically, deferred Primary Flights. The regulatory period mainly concerned the transition phase between JAR (Joint Aviation Requirements) Operations and European Operations, i.e. the same regulations carried out by EASA (European Aviation Safety Agency), the current control body of the aviation sector in the European Union.

In the case of primary operations, as the aircraft could only use certified nightstands, the medical team was accompanied to the scene of the event by third parties such as MSBs (Basic Rescue Vehicles), Public Safety Forces, or even by users with private vehicles. In the recovery phase, the patient was transported below deck to be subsequently accompanied to the receiving hospital most suited to the clinical case represented.

At the end of 2013, with the transposition and entry into force of EU Regulation 965 (2012), the possibility of operating on “non-standard HLS”, but illuminated, such as sports fields duly surveyed and included in the Company Route Manual, was thus extended. The lighting of these fields could, in some cases, be directly activated by the technical operator from the operations room console, using special software connected by GSM telephone to the field in question. The opening of these fields took place after alerting the local access holders, duly informed during the previous reconnaissance carried out by the flight personnel, and/or thanks to the safety boxes installed at the fields and containing the access/exit keys.

Among the first camps to be surveyed were those of Brebbia, Sesto Calende and Lavena Ponte Tresa, located in the Province of Varese and situated in orographically complex areas, mostly from the point of view of distance from HUB hospitals. The "non-standard HLS" network obviously expanded rapidly, thanks to the interaction between the Sala Operativa Regionale Emergenza Urgenza dei Laghi (SOREU), which manages emergency-emergency conditions in the three provinces of Varese, Como and Lecco, and the municipalities themselves affected by the development of the system. The Azienda Regionale Emergenza Urgenza (AREU), of which the SOREUs are the operational explication, signed special agreements with the municipalities owning HLS fields surveyed from the ground by the flight personnel and duly included in the relevant Company Route Manual.

The characteristics of areas potentially suitable for landing at night were defined in detail by Regulation 965/2012 – SPA.HEMS.125 which stated that "The HEMS operational site must be large enough to provide adequate separation from all obstacles. For night operations, it must be illuminated to allow identification of the site itself and all obstacles".

The European Aviation Safety Agency (EASA) then stated that 'the dimensions of the HEMS operational site for landing at night must be at least 4D x 2D, with D referring to the maximum footprint with the helicopter in motion'. For example, applying this formula to the AW-139 the site had to be sized as follows: 66.6m long and 33.3m wide. Lighting could be provided by ground-based equipment or directly from the aircraft. As stated, the aircraft operator had to inspect (survey) the indicated areas in order to certify their suitability for use.

In the Lombardy Region, the Regional Emergency-Urgency Agency (AREU, now the Regional Emergency-Urgency Agency), in 2014, implementing the opportunities introduced by EU regulation 965/2012, launched a project that can be divided into the following phases:

- Identification of locations of strategic interest
- Identification of landing sites
- Defining the operational strategy
- Involvement of local administrations
- Definition of administrative aspects
- Definition of activity monitoring indicators

The sustainability of the development of night-time operations was and is closely linked to the distribution of expected cases, the level of operation of the various territorial rescue resources and the response capacity of the hospital structures. Therefore, a number of aspects have been analysed for each location, such as those listed below:

- Expected distribution of events by severity and type
- Average time of arrival of the first rescue vehicle on site
- Average time of arrival of advanced rescue equipment at the scene
- Average time for the helicopter to arrive on site
- Average hospitalisation times at the nearest or most suitable health facility
- Distribution of helipads proper used for night flying

In this sense, it becomes logical to think that the multiplication of landing possibilities would significantly increase the advantages of using helicopter resources, even in night flights.

At the beginning of 2017, the first NVIS (Night Vision Imaging System) endorsements began, i.e. the first training for flight crews and technicians (TCM) rotating on the Como base, with the accompanying technical certification of the helicopters deployed.

Basically, the development of night flight possibilities unfolded through the advancement of legislative opportunities, flight crew training and technical adaptation of the machines. From a so-called Phase 1, in which flight was only permitted, as today with two pilots on board (multicrew), with landings on illuminated HLS, a transition was made to Phase 2. First, landings in both illuminated and non-illuminated HLSs were authorised, then landings in so-called Night HEMS Operating Sites, to move on to any surface without terrestrial lighting support. In the operational and training organisation, subject as usual to the approval of the competent authorities, the phases of training and growth of the personnel involved are outlined, outlining a detailed and complex development programme, which is not the case here.

Phase 2 presented an Initial Operational Capability, finally moving towards a Full Operational Capability. Having thus reached the appropriate skills/certifications required by current regulations, in May 2019, the first training for special operations (HHO-Hovering) began, thus enabling the aircraft to reach the envisaged final phase, called Phase 3 Full Operational Capability – HOIST Operations at Night, allowing crews to conduct rescue operations even with a winch, without any limitations. The operational management of the aircraft is now guaranteed by the dual presence of the pilots and the onboard technician, all equipped with NVG (Night Vision Goggles) technology. All this has led to a consequent adaptation of the technological aspects of the helicopter, including instrumentation that conforms to the use of NVG devices and an increase in the external lighting of the aircraft itself, with the recent installation of a searchlight, installed on the left-hand side and usable in night-time Search and Rescue (SAR) operations. This equipment is also indispensable for operating outside the ‘Local Area’, in order to guarantee coverage of the entire regional context.

As a result, from 2019 to 2021, high levels of effectiveness in night-time rescue operations were achieved, resulting in the following interventions, updated to 19 May 2021:

- No. 150 off-site activities (Not Presurveyed Site)
- No. 3 Hovering
- No. 169 Helicopter Hoist Operations

This is a significant number of interventions, which is likely to increase even more, and which extends to secondary and primary interventions, the latter also conducted in impervious environments.

(Not) seeing in the dark

The ability to see more or less defined objects in conditions of darkness, as already stated, is not a specific property of human beings. However, from their ancestors of prehistoric memory, human beings have inherited a capacity that remains, albeit limited, for visual adaptation to conditions of darkness. The ability to see one’s surroundings is guaranteed by the human eye’s ability to perceive a certain wavelength of the electromagnetic spectrum, known as ‘light’. But what happens to light during the darkest hours? The total absence of any light is almost impossible because during the night, there are two other sources of natural light: the stars and the moon (as well as light produced by forms of light pollution). The light of the Moon is typologically identical to that of the Sun, the ‘forge’ of daylight, although it tends to be much less intense. Stars, on the other hand, produce a different type of light, which is greatly affected by the great distance at which they are located and which is expressed in their magnitude.

The human eye has qualities that make it an organ capable, within certain parameters of course, of adapting to darkness. In general, at least half an hour (or even 45 minutes) is required for it to become accustomed to night vision. However, the night very often accentuates ophthalmic pathologies that are already present during the day, such as myopia (night myopia). Day vision is called ‘photopic’, twilight vision ‘mesopic’ and night vision ‘scotopic’. It is conventionally believed that the 24-hour period can be divided into a number of parameters, called thresholds, depending on its brightness:

- The aeronautical or civil threshold of twilight and dawn is considered to be when the sun is about 6° below the horizon. At this stage, which corresponds to about 30 minutes before sunrise and after sunset, daylight vision begins to be inhibited. The aforementioned 30 minutes are also the time when the so-called ephemeris for daytime flight expires. Aeroplanes that are only approved for visual flight by day can therefore only fly from sunrise to sunset plus or minus the aforementioned half hour.

- The nautical threshold positions the sun 12° below the horizon and corresponds to the last visually appreciable light. The coastline, for example, and the brightest stars are visible
- The astronomical threshold is present when the sun is at least 18° below the horizon: all stars are visible at this stage.

Visibility at night is also divided into four levels:

1. Moonlight: landscape details can be distinguished even at great distances
2. Stellar clarity: allowing contours to be seen at around 100 metres
3. Very overcast sky: allows objects to be distinguished at no more than 20 metres
4. Zero visibility

At our latitudes, even in the darkest hours, level 4 is rare, but the coexistence of level 3 and dark terrain can significantly mimic level 4. Finally, during the night, most of the time (55%) is accounted for by the so-called dark hours, while 30% is accounted for by the semi-dark hours and only 15% by the hours defined as light.

The human organ responsible for collecting light stimuli (photons) is obviously the eye, through the anatomical surface of the retina. On the retina, a portion of tissue is extremely sensitive to daylight, known as the fovea. Here are arranged nerve structures called 'cones', which are adapted to daylight and effective in transmitting the luminous visual impulse. The cones, active in daylight, allow us to distinguish colours (chromatic vision) but also shades of grey (achromatic vision). There are also other structures, distributed mainly in the more marginal areas of the retina, known as 'rods', which are activated in reduced light conditions and are only effective in achromatic vision. The cones provide more accurate images, but only under good lighting conditions.

On the other hand, the rods make vision possible in low light conditions, but offer achromatism and less visual definition. The arrangement of the rods (their concentration) is such that during the night, marginal vision is favoured, i.e. at the sides of the visual field, which is therefore more sensitive in receiving low light signals. In the rods, a substance known as rhodopsin degrades when affected by even low light intensities, favouring the chemical processes that produce the transmission of the visual impulse. When looking at an object in low light the rhodopsin is consumed, so the object will tend to fade. This means that the eye has to be shifted several times, avoiding staring at dark objects for more than two or three seconds, performing what is known in military (but also aviation) jargon as a *visual scan*. The dark-adapted eye produces a lot of rhodopsin, which is why a continuous transition from dark to light is not recommended during a night flight. This condition is made possible by the opportunity, in certain cases, to isolate the aircraft cockpit from the rear medical compartment, where it is often necessary to ensure at least a minimum of light in order to allow medical operations on the patient.

Night Vision Goggles in brief

NVGs are the fundamental tool with which pilots and the technical crew member/HHO operator of the Como helicopter base (as well as all the crews of HEMS bases carrying out helicopter rescue operations) carry out night flights in safety. The peculiarity of helicopters lies in the fact that they often move in unfamiliar or even inaccessible environments, operating at low altitudes or near obstacles, navigating by relying directly on terrain recognition in order to move. The helicopter crew, in this context, is always responsible for navigation, separation from obstacles and the suitability of the chosen airspace to carry out the operations required by a HEMS mission.

The Night Vision Goggles (NVG) are military-derived devices that exploit the principle of light amplification (Image Intensification). The human eye can perceive electromagnetic energy between 0.4 and 0.7 microns in length, while NVGs can ‘see’ the same energy, but between 0.6 and 0.9 microns. NVGs are therefore incapable of capturing ‘light that is not there’, but they fulfil their function of amplifying residual or artificial light in the environment. At the heart of NVGs is the Image Intensifier Tube (IIT). Photons are captured by the front lens of the IIT and reach a photocathode (which ‘converts’ light energy into electrical energy). The photocathode converts each photon into an electron, which is accelerated by an electric field and directed to a Micro Channel Plate (MCP). Each electron thrown into the MCP cell repeatedly hits its surface, releasing other electrons in a ‘cascade’ effect, thus enhancing the amount of light energy collected by the NVGs. At the exit of the MCP disc is a phosphor screen which, when struck by electrons, releases photons, reconstituting the image entering the IIT, amplified by the number of electrons multiplied by the cascade effect.

NVGs began to appear on the military market around the 1970s. However, the first devices failed to meet some basic standards: mainly difficulty in simultaneously focusing on near (instruments, maps) and far objects, and poor performance at low ambient light levels. The first problem was conveniently solved by “cutting” the lower part of the NVG mask, thus allowing pilots to "peek" underneath it at both instruments and charts, a system that is still used today: the NVGs do not adhere to the eyes, but are positioned at a certain distance from them, so that the pilot, by lowering his gaze, can see the onboard instruments. The latter must also have a brightness of radiation that does not create the need for light-darkness readjustment of the eyes, nor disturb the vision apparatus itself, creating a disturbance in the field of view of the NVGs. Helicopters equipped with night vision devices must therefore have a cockpit with adequate lighting and therefore compatible with the use of NVGs.

The transition from visual flight to NVG flight is a very delicate phase of HEMS operations. This is the reason why personnel wearing the devices declare, at a specific stage of the flight, that they must wear (and have worn) the goggles themselves. This is normally referred to as cabin 'conditioning' and 'conditioning' each operator to use NVGs. When the commander, pilot and flight engineer have 'conditioned' themselves, then it means that the entire flight crew is flying in night mode, wearing NVGs. In this sense, and once again, it clearly emerges the need for decisive coordination and harmony in the performance of night operations that, obviously even more than those conducted in daylight, require perfect and careful teamwork.

Life onboard and in training

It is very curious and impressive to fly, as a rescue team member, onboard a helicopter on a night HEMS mission. The pilots, seated in the front cockpit, can completely separate themselves from the rear compartment, which houses the flight engineer (technical crew member/HHO operator), the helicopter rescue technician (belonging to the Corpo Nazionale del Soccorso Alpino e Speleologico, CNSAS), the doctor and the nurse, as well as the patient of course. The isolation of the pilots is achieved by closing a special curtain, which is, however, only fitted to the AW-139 aircraft, but is not present on the EC-145 T2. The isolation allows the mission to be carried out in NVG mode, without any interference from any light coming from the rear cabin. The latter can be illuminated with a special green light, which has the peculiarity of maintaining a more solid adaptation of the eye to the darkness, while creating a very special atmosphere in the medical compartment. It should not be forgotten that the flight engineer can also wear NVGs. This is the reason why, during special operations, the medical team is advised not to switch on their headlamps (which each person carries on their protective helmet) before leaving the aircraft. The winch hook is made identifiable, due to its dark colouring which is not at all visible in darkness or semi-darkness, using a special chalume stick attached underneath it.

It is very interesting to carry out special manoeuvres such as descending with a winch. On the ground, especially if the mission takes place in an inaccessible environment, there is no illumination other than that provided by the two onboard lights or by the "TrakkaBeam-A800" lighting system. However, these illuminations only allow the pilots to view areas of interest, while the medical personnel make a real "leap in the dark". It is precisely for this reason that, generally, the first to descend is the CNSAS Technician, who can prepare the appropriate safety measures (preparation of the area, creation of anchorages) for the doctor and the nurse, who will then follow. Experience, shrewdness and, above all, harmony with the flight team obviously favour the safe execution of these manoeuvres which, as can be imagined, are far more complex than those that can be carried out during the day.

Once on the ground, the doctor, nurse and T.E. (Helicopter Rescue Technician, belonging as we said to the CNSAS) use their own light sources to move around on the ground, which requires an increase in the attentional phase both during descent and when approaching the helicopter, perhaps with stretcher and patient. The typical terrain of a remote environment, which is often uneven, requires an increase in concentration and in handling and proprioception skills.

This is why there is a special training phase for medical staff, in addition to the normal training in the use of personal protective equipment and special manoeuvres (winching, hovering). Night work essentially requires all personnel to be specifically trained to move in a dark, often unknown and unlit environment. Specific training is therefore provided during the training phase:

- Single and double winches, in a known environment (Como helibase) and in an impervious environment. The latter is generally developed at the heights of Mount Bolettone, located in the Larian Triangle, or at Sasso Gordona, in the southern portion of the Upper Intelvi Valley (located between the western shore of Lake Como and the Italian-Swiss border);
- Ascent with a stretcher, carried out in a known area (helicopter base in Como), indifferently by the doctor and the nurse, using, as always, the anti-rotation lanyard held on the ground by the T.E;
- Night hike, near mountain areas, characterised by a walk with self-generated lighting from one's own headlamps, to accustom the sanitary person to moving appropriately over impervious terrain in conditions of lack of natural light
- Technical handling on impervious terrain, at night, using abseiling on a rope and steep terrain and ascending on fixed ropes always on complex terrain (rocky, grassy)
- Walking with the E.T. in short preserve conditions, i.e. using a tie-down rope between members of the rescue team

Thanks to the skills it has acquired, the Como helicopter base is ready to carry out any type of HEMS mission, whether this involves a “primary” mission (with intervention conducted directly at the patient’s home or at the scene of the event, The helicopter and the team are activated for “secondary” activities (in the latter case, the patient will be transferred between different types of hospitals, generally from a SPOKE to a HUB).

Conclusions

The night flight was the completion of a long and fruitful journey to develop the HEMS capabilities of the Como base. Started in August 2008, it has gradually evolved to the multiple possibilities that are now offered by knowledge, skills and modern technology. Through the application of regulations, which are constantly evolving and often meet the needs of a modern helicopter rescue service, the updating of flight crews and the training of medical personnel, today night flying has become an indispensable reality, towards which the Como base has been able to invest, with profit, commitment, perseverance and dedication. This has led to qualified and qualifying results in patient care and the performance of the missions entrusted to it.

Alongside the more common form of daytime flying, the development of night-time capabilities has made it possible to achieve an indispensable objective, which must be, and is, the foundation of any integrated emergency-urgency system: to always provide, at all times and in all conditions, highly qualified assistance to the people who require our care and assistance. This indispensable value has also been made possible by the parallel evolution of systems for alerting, managing and coordinating assistance, represented in the Lombardy Region by the Urgent Emergency Operations Rooms (SOREU), which have also been able to adapt to the changes faced by the HEMS service in Como and throughout the Region.

Training, harmony and resource management of the rescue teams and the flight team have enabled and encouraged this great achievement, making the pilots, technicians, doctors and nurses who today have the good fortune to carry out their profession at the Como base justifiably proud.