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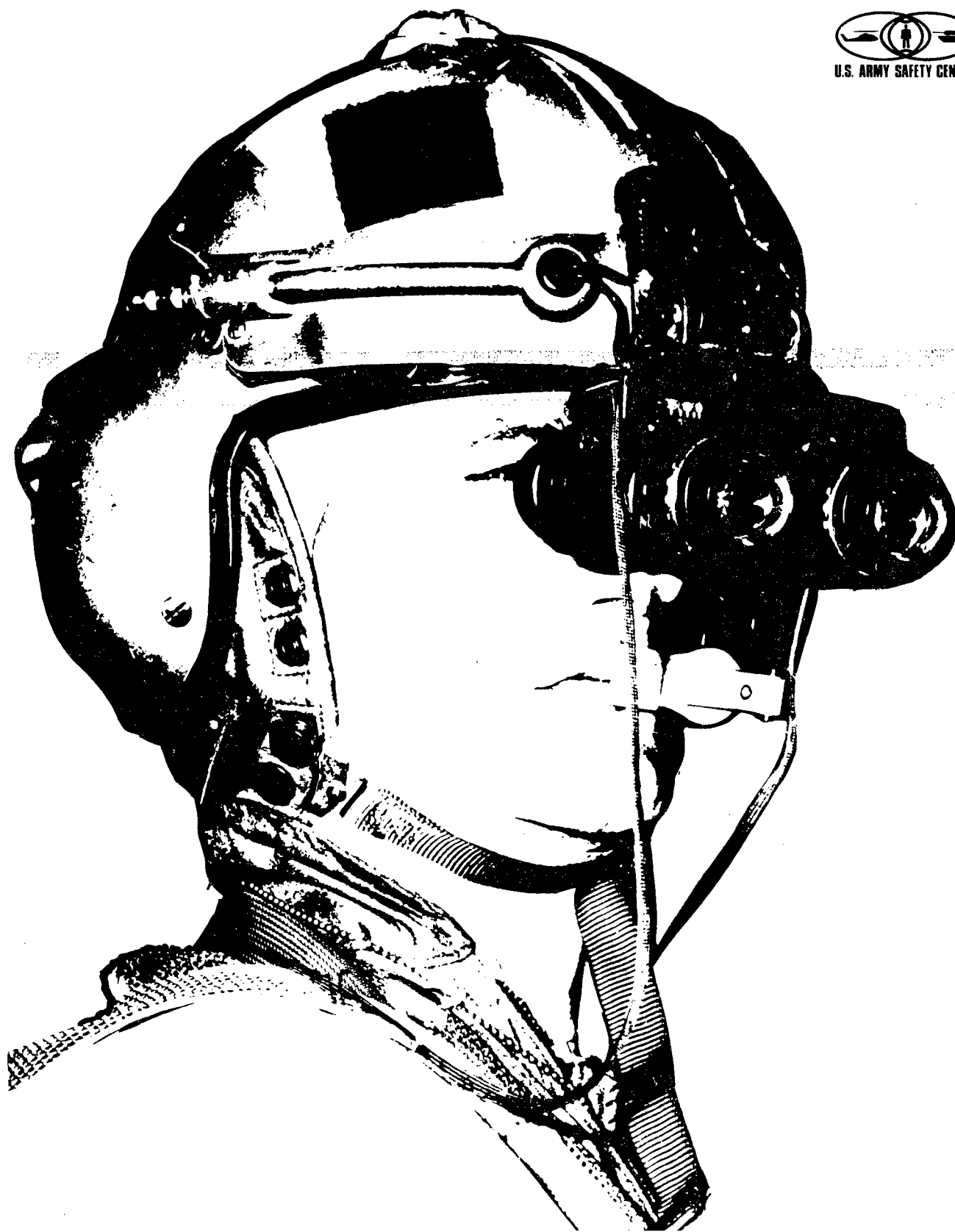
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NIGHT VISION FLYING

A SPECIAL REPORT TO THE FIELD

Foreword

This report was prepared to provide the aviator, crewmember, commander, and others involved in NVG operations, training, and development with information on night vision flying. It is not nor is it intended to be a "how to" report.

Without debating tactics, it is clear that for our aviation force to be effective on today's battlefield it needs to fly low and use the terrain to mask and protect itself. To do this at night, night vision devices are absolutely necessary.

We at the U.S. Army Safety Center believe that operations at night can be performed safely with night vision devices. The key, though, is to understand the limitations inherent in the night vision devices, in our aircraft, and in ourselves. We need to understand that night vision devices do not turn night into day. They greatly enhance our ability to fight at night, but there are limits.

What are these limits? We all know about the restricted field of view, varying levels of aircraft incompatibility, visual acuity reduction, and so forth. But what are your limits for any particular mission or operation? Only you can answer this question.

Only you can determine what your limits are after considering all of the variables involved in night vision flying. What is the ambient light? How is the aircraft equipped? Is there good contrast? How experienced are you? What is the terrain? The list goes on and on.

Commanders at every level need to ask questions concerning all the variables involved and get sound answers before expecting their subordinates to perform night vision flying. Commanders at all levels need to participate in night vision flying--not just with an IP at the airfield but out in the "boonies" with an operational aviator. They need to understand the inherent limitations of night vision devices and the inherent risks.

Flying at night with night vision devices is risky. But the risk can be managed and controlled by understanding the limitations of your equipment, your soldiers, and yourself, and by planning and performing night vision flying operations accordingly.

On 31 January 1987, the VCSA was briefed on night vision goggle related subjects to include 17 issues which were developed during a night vision flying accident prevention workshop held at the U.S. Army Safety Center 10 December 1986. The VCSA directed the ARSTAF to solve these issues, set the standards, and enforce them for NVG operations. The VCSA also issued other taskings related to NVG operations, training, and supportability. As a result, several corrective actions at HQDA and other levels have been initiated. As we receive information on the status of actions taken, you will be provided updates in Flightfax.

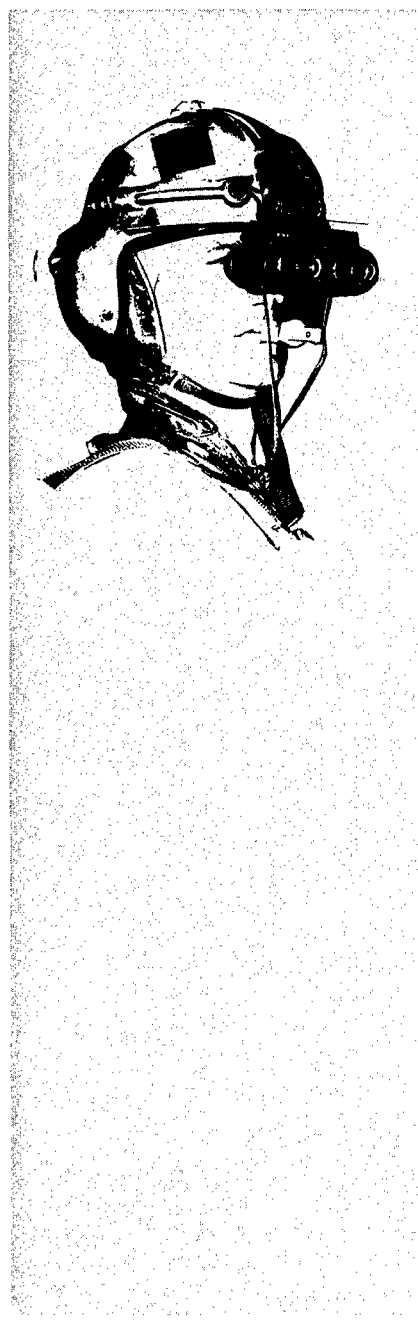
This report, portions of which were taken from a briefing prepared by CW4 Doug Joyce, AV 558-2442/6309, is by no means all encompassing. We need your input. POC at the Safety Center for NVG-related information is Major Ron Isbel, AV 558-4198/3901 or commercial 205-255-4198/3901. USAAVNC proponent for NVG doctrine and training is the Aviation Training Brigade, ATTN: ATZQ-ATB-O. POCs are Captain Snelling and CW3 Helmer, AV 558-2425/5691. After duty hours, use the existing Fort Rucker aviation hot line, AV 558-6487.

Share your ideas, successes, and problems with us so we can share them with the entire aviation community.



A. E. HERVEY, JR.
Colonel, Aviation
Commander, U.S. Army Safety Center

Night vision flying: A special report to the field



History of night vision flying

In 1969, the Army used a goggle-type device, on a limited basis, as a pilot's aid in night flying in Southeast Asia. In 1972, the U.S. Air Force used SU50 electronic binoculars for night search and rescue missions.

Tests conducted by the Land Warfare Laboratory and Combat Developments Experimental Command concluded that helicopters engaged in mid-intensity warfare must operate at nap-of-the-earth (NOE) altitudes during day and night. In 1973, the AN/PVS-5 was accepted as an interim—quick fix—pilot's night vision system.

In October 1976, AN/PVS-5 night vision goggles (NVG) entered the training and standardization field at the Aviation Center, Fort Rucker, Alabama. Four standardization instructor pilots (SIPs) began developing a flight and academic program to qualify rated aviators with the NVGs. The program consisted of 10 to 12 hours of unaided night hawk training and 10 hours of NVG flight.

In 1977 and 1978, the Aviation Center continued to train and qualify NVG instructor pilots for conducting a 4-hour NVG familiarization course with initial entry rotary wing (IERW) students.

In 1978, IERW students began to receive the 4 hours of NVG familiarization during their syllabus of training.

In 1983, based on a stated need from the field, the first IERW class graduates were NVG qualified. In November 1983, an NVG Instructor Pilots Course was established at the Aviation Center. Graduates of this course support field commands by conducting refresher, currency, sustainment, and mission training.

Early trials and errors

In 1976, the Night Vision Lab delivered four sets of AN/PVS-5 NVGs to the Aviation Center. It was an established fact that ability to see in the dark would enhance the aviation mission. However, without written doctrine on how the goggles would be used there were no procedures for training pilots. A program was established based on developing flying skills around the traffic pattern and emergency procedures. This would later prove to be a negative reinforcement in preparing aircrews to meet the demands of an NVG mission in the combat environment.

The inherent limitations of the NVGs, such as limited field of view, reduced visual acuity, and inability to quickly analyze emergency situations made the stagefield traffic pattern the logical arena for training. This controlled and sterile environment offered the best potential for numerous aircraft operations under near lights-out conditions.

Pattern altitudes were 500 feet agl and airspeeds were 90 to 100 knots. The tasks accomplished closely resembled day VFR contact maneuvers. Additional emphasis was placed on low-level autorotations and running landings. During this period, no tactical or terrain flight tasks were conducted with NVGs.

At this time, commands worldwide were beginning to receive NVGs and limited numbers of NVG instructor pilots. Commanders, recognizing the enhanced mission capability provided by NVGs, aggressively pursued establishing a program to perform NVG missions within their area of operation. The profile for these missions, when executed routinely, included multi-aircraft in tactical formations operating

Night vision flying

at contour and NOE altitudes. Airspeeds varied from 30 to 100 knots, and navigation was required by map interpretation. This mission profile, when coupled with external load operations, placed aircrews in an "alien environment."

The field missions in no way resembled the flight parameters taught during NVG qualification training. The traffic pattern had provided aircraft separation by ATC personnel, obstruction clearances by altitude, and orientation by familiar surrounding areas. Aircrews were now trying to navigate over unfamiliar terrain, fly as close to the earth's surface as vegetation permitted, and maintain the integrity of a formation. Capabilities gained during qualification training were quickly exceeded by mission task loading.

More recent experience

During the 18-month period from 1 October 1982 through 31 March 1984, NVG-related accidents resulted in 17 fatalities and the loss of more than \$20 million. Because of this, the Vice Chief of Staff of the Army reclassified NVG flight from a mission enhancement capability to a safety-of-flight issue.

Investigations indicated that 90 percent of the NVG accidents occurred during tactical terrain flight. Low ambient light and excessive airspeed for conditions were considered contributing factors. Accident reviews and staff studies conducted by experts in the training and standardization field indicated radical changes were needed in the qualification course.

In 1984, emphasis at the Aviation Center was shifted from the stagefield traffic pattern and its associated tasks to the terrain flight environment and tactical tasks. Aircrew preparation for NVG tactical missions required training in a similar mode of flight. Although some traffic pattern flight is still required during early training, it too is now accomplished at a much lower altitude and slower airspeeds. Currently, 85 percent of qualification training is conducted in the tactical terrain flight mode.

An NVG workshop symposium was hosted by the Army Aviation Center in

February 1984. Field users, combat and materiel developers, and manufacturers attended the symposium. A broad level of experience in NVG operations (SIPs, IPs, ASOs, operations officers, company and battalion commanders) was represented.

The purpose of the workshop was to address and rectify voids existing in NVG training guidance. The efforts of the group were oriented towards standardizing NVG tasks and missions, enhancing safety, and improving combat readiness. The results of the workshop and other coordinating meetings at HQDA were provided in message HQDA DAMO-TR/FD, R312016Z May 84. This message provided the Army's policy on NVG flight training and operations. It included qualification and currency requirements, NVG operation restrictions and definitions, and NVG PIC, unit trainer, and IP criteria.

As a follow-on to this message, the Aviation Center published FC 1-219, NVG Aircrew Training Manual, in December 1984. The manual contains information from the HQDA message and other NVG selected data.

In the "early days," there was a lot of experimentation with NVGs. Several different aircraft NVG compatibility modifications were developed. Some were adequate and some were not.

Often times, the users did not define exactly what was needed and, just as often, the developers did not listen. Also, as soon as a modification was developed, a "better idea" would come along. Units were developing NVG procedures and trying to maximize the mission capabilities provided by NVGs.

Mistakes were made, but there were also some successes. PVS-5s were modified by cutting away the face plates, eliminating the need to focus in/focus out. Information was provided in Aviation Center booklets on dual battery packs and counterbalance systems. Aircraft NVG compatibility modifications were improved and their application expedited. IERW students were being NVG qualified, and aviators night vision imaging system (ANVIS) goggles were beginning to be fielded. But problems still remain.

Rising trend in NVG-related accidents

In the last three fiscal years, there has been a rising trend in night vision device-related accidents because we are flying more in this high-risk environment (fig. 3).

Figure 1 shows the number of Class A accidents at night and those accidents which occurred while night vision devices were being used. In FY 84, 14 percent of these night accidents involved night vision devices. In FY 85,

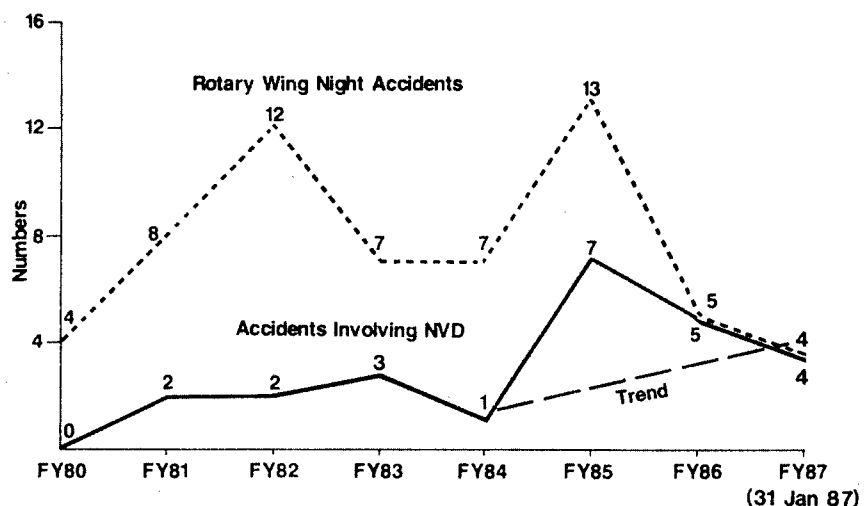


FIGURE 1. - Class A rotary wing night accidents and those involving use of night vision devices

53 percent involved night vision devices. In FY 86 and so far in FY 87, all of the night Class A accidents involved use of night vision devices.

Table 1 shows rotary wing Class A through C accidents involving night vision devices from FY 80 to 31 January 1987. Table 2 breaks out the Class A, B, and C night accidents by each type aircraft.

Increasing mission demands and training risks

Fifteen to 20 years ago when we flew observation missions at altitudes under VFR conditions, risks were relatively low. When the mission profile expanded to include tactical instrument flying, risks increased. As we gained proficiency in TAC instruments, the risk factor leveled off. But it was still greater than before TAC instruments.

Next came NOE flying. Again, the level of training risk rose in proportion to increased mission difficulty. The downward turn in risk associated with NOE operations shown in figure 2 may have been the result of new improved aircraft systems coming into the inventory. In any case, the overall risk level for sustained operations was still greater than before adopting NOE tactics.

TABLE 1. - Rotary wing Class A, B, C accidents involving use of night vision devices

FY 80 - 31 January 1987

ACFT	TOTAL A-C	FATALS	INJURIES	DAMAGE COST	INJURY COST	TOTAL COST
AH-1	19	4	4	\$6,843,689	\$1,362,090	\$8,205,779
AH-64	2	0	0	1,076,544	-0-	1,076,544
CH-47	3	12	0	10,048,642	2,254,000	12,302,642
OH-6	3	0	0	755,866	6,848	762,714
OH-58	14	8	3	1,191,637	1,708,520	2,900,157
UH-1	10	0	10	2,821,942	205,370	3,027,312
UH-60	28	8	17	38,668,415	1,765,220	40,433,635
TOTALS	79	32	34	\$61,406,735	\$7,302,048	\$68,708,783

TABLE 2. - Rotary wing accidents involving use of night vision devices by classification

FY 80 - 31 January 1987

AIRCRAFT	CLASS A	CLASS B	CLASS C	CLASS A-C
AH-1	5	1	13	19
AH-64	1	0	1	2
CH-47	2	1	0	3
OH-6	1	1	1	3
OH-58	6	0	8	14
UH-1	4	1	5	10
UH-60	8	1	19	28
TOTALS	27	5	47	79

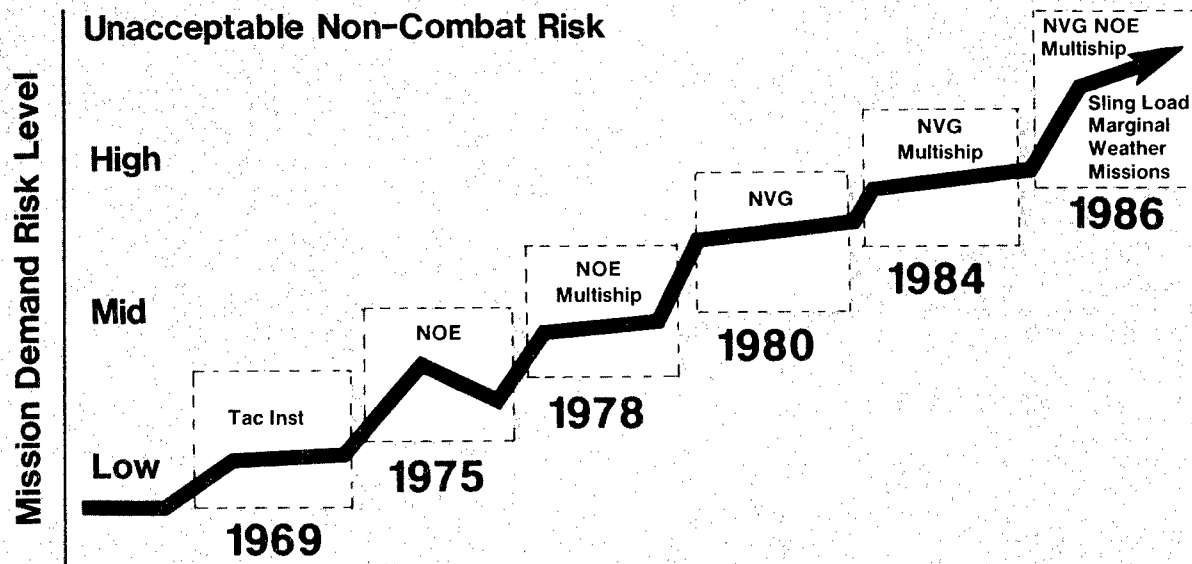


FIGURE 2. - Evolution of the Army aviation mission

Night vision flying

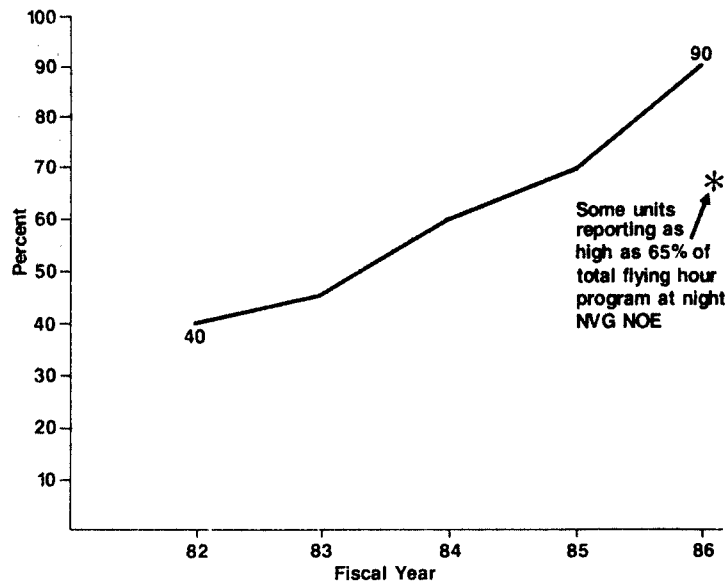


FIGURE 3. - Exposure to high risk environment (Percentage of total flying hour program)

The mission risks increased again as we began operating more in the night tactical environment. While night vision goggles expanded capability, they also increased demands placed on aircrews and equipment. These demands produced a corresponding increase in training risks. The inherent risk associated with NVG flying has continued to increase rather than leveling off, as in the case of tactical instruments, or decreasing, as in the case of NOE

flying. TAC instruments and NOE are oriented toward specific tasks, conditions, and standards. On the other hand, NVG flying applies to a much broader range of complex tasks, conditions, and standards. This broader range of application is the primary reason for the sustained increase in risk while using NVGs.

Army aviators are flying more and more in the high-risk environment. The percentage of exposure shown in

figure 3 is based on data from four of our combat-ready divisions. High-risk environment is defined as tactical, night, NVG, slingload, and hoist missions. Flight in this environment reduces the pilot's safety margin, increasing the chances that human error will result in an accident.

Because we are flying more in this high-risk night environment, we are having more accidents with night vision devices in use. A review of some of these accidents provides some insight into common trends.

Night vision device (NVD)-related accident briefs

- OH-58 No. 1 was cleared for south departure from lane 2 in west traffic. OH-58 No. 2 was cleared for takeoff from lane 3 in east traffic. No. 1 drifted left and No. 2 drifted right. The two aircraft collided 600 meters south of the lanes. The IP of OH-58 No. 2 failed to detect and correct for an incorrect ground track being flown by his student



Two OH-58s collided shortly after takeoff for NVG training flight.



During low-level NVG training flight, UH-60 struck a tree and crashed.

pilot because of one or more of the following: NVG visual limitations, lack of adequate ground references, loss of visual cues on the ground due to "shutting down" of the NVG as the moon was directly viewed, distraction of another aircraft making a go-around and climbing out overhead, significant change in wind direction and velocity encountered during climbout, and relative inexperience as an NVG IP. Result: four fatalities and cost of \$1,064,680.

- CH-47 flew into island during night overwater navigation training mission. CH-47 was lead aircraft in a flight of two conducting NVG training over a lake. Illumination was reported as being at or near zero percent. The lead aircraft was 75 feet above the water at 100 knots airspeed. The crew of the lead aircraft did not see the island in time to avoid impact. The crew thought the island was a fog bank and they were off course. Result: six fatalities and cost of \$5,480,478.

- UH-60 was No. 2 in a flight of three aircraft involved in a low-level NVG proficiency training flight. As the flight proceeded up a narrow valley, with the No. 2 aircraft to the right of the lead aircraft, at an airspeed of about 40 knots and an altitude of about 100 feet agl, the No. 2 aircraft's main rotor blade hit a 75-foot tree on rising terrain to the right of the aircraft. The UH-60 went into an immediate right

bank, yawed left, and crashed into trees, coming to rest on its right side. Moon illumination was 86 percent and 30 degrees, but the tree that was hit was in shadows. The day recon of the route was flown at 500 feet agl and the NVG mission was flown at 100 to 200 feet agl. Result: four fatalities and cost of \$6,208,700.

- A UH-60 crew was performing NVG training at an Army airfield in the traffic pattern because the conditions were not adequate to train in the training area. During the turn from

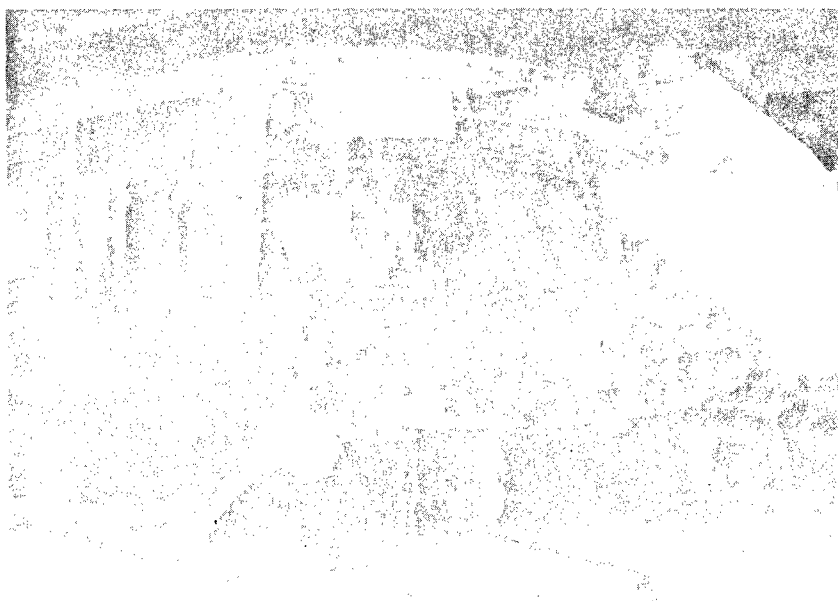
crosswind to downwind, a caution/master caution light came on and the aircraft was allowed to descend 200 feet and crash. As the aircraft flew crosswind to downwind, there was no visible horizon. The terrain was snow-covered fields. Result: \$4,650,820 in cost.

- While on training flight over lake, IP allowed UH-1 to descend into water at 80 knots. Crew became spatially disoriented. Result: \$967,075 in cost.

- CH-47 and AH-1 collided while flying low level along an "approved" terrain flight transition route. The route had not been surveyed for NVG use and adequacy. Neither aircrew initiated any evasive maneuver, and it is probable they never saw each other. A contributing factor was limited visual acuity, depth perception, and peripheral vision of the PVS-5. Result: eight fatalities and cost of \$8,762,356.

- AH-64, the No. 2 aircraft in a flight of six, hit a powerline support tower and wires and crashed. Crew was unable to detect support tower and wires with PNVIS at sufficient range to perform evasive maneuver. Result: \$1,022,476 in cost.

- UH-1 was making an approach to an unlighted sod area. The pilot was using, for a reference point, the position lights of a UH-60 that had just landed. The approach angle was too steep and



While on NVG training flight, IP allowed UH-1 to descend into lake.

Night vision flying



Two UH-60s collided during NVG formation flight.

the rate of closure excessive. The UH-1's tail rotor hit the UH-60. Result: \$4,703,682 in cost.

- Two UH-60s returning from separate NVG training flights joined up to practice NVG multi-helicopter/formation flight. During an attempt to change lead by using an "overtake" method, the aircraft collided. Result: three fatalities and cost of \$10,155,820.

- OH-58, with an IP and student pilot on board, was returning to an Army heliport as chalk 2 in a flight of five on a special VFR clearance at night with NVGs. The OH-58 was seen to enter clouds/fog at a greater than normal rate of descent and crashed. Result: two fatalities and cost of \$428,782.

Analysis of these NVG-related accidents and all other Class A through C NVG-related accidents from FY 80 to the present clearly reveals a costly learning curve in the use of NVGs in 1980 to 1983. With the full-face PVS-5 goggles, the need to focus in and out was a contributing factor in some accidents. In virtually every Class A accident, the crew was flying far too fast for conditions and ambient light. Slower airspeeds helped reduce risks. Modified aircraft with infrared lights also helped reduce risks. Improved night vision devices are in the future, and that will also reduce risks.

Analysis shows that most NVG accidents from FY 84 to the present have been caused by spatial disorientation, flying too fast based on the visual cues and conditions present, wire strikes, or

failure to see other aircraft. And the trend in Class A NVG-related accidents continues to increase.

Night vision flying workshop

Because of this increasing accident trend, the Army Safety Center conducted a night vision flying accident prevention workshop in December 1986. The purpose of the workshop was twofold: to gain a better understanding of how field units train and operate with NVGs in the high-risk night tactical environment and to define issues and develop lessons learned from operational experiences and NVG-related accident data.

Representatives from numerous Army commands, field units and agencies, the U.S. Navy, and U.S. Marine Corps attended the workshop. A broad range of NVG expertise was present. Lessons learned were developed, circumstances leading to the majority of NVG-related accidents were identified, and 17 issues were developed relating to NVG materiel, maintenance, supportability, safety, and operational concerns. These issues and other NVG-related subjects were briefed to the VCSA on 31 January 1987. As a result, the VCSA tasked the Army Staff to solve the issues. Additionally, the USAAVNC has established a night vision study group composed of subject matter experts to review the entire spectrum of night vision flying. The efforts of this study group and the results of a worldwide night vision users conference, scheduled for late

March/early April 1987, will result in corrections for issues defined and taskings to the appropriate Army agency to correct any which remain unresolved.

Lessons learned from the workshop

- Do not conduct NVG training in areas of good contrast only and then try to operate in areas of low contrast.

- Train progressively. Start with and master the basic skills before going on to the more difficult ones.

- Train as a total crew. Oftentimes the difference between avoiding an obstacle and hitting it are the NVG-trained and -equipped crewmembers in the rear of the aircraft providing clearance information to the pilots.

- PVS-5 NVGs cannot "see" wires because of the "frequencies" involved. ANVIS can "see" some wires that PVS-5 cannot.

- Adjustment of the NVG is critical. If the tubes are not adjusted properly to match the "spread" of a crewmember's eyes, optimum visual acuity and depth perception will be affected.

- One way to check the serviceability of the NVG is to set up a room with NVG-compatible lighting, a \$1.98 visual acuity chart, and a 20-foot viewing range. View the chart through the NVG first with one eye closed and then the opposite eye closed to determine what visual acuity is for each tube. If the tube acuity is different, then another set of goggles should be used.

- Well defined procedures must be developed and followed before operating with PVS-5-, ANVIS-, and PNVS-

equipped aircraft/crews in the same training area. Each has different capabilities and limitations which must be taken into consideration.

- NVG routes and operational procedures must be validated for adequacy. Checkpoints are often "choke" points. Ensure procedures clearly define where aircraft are to be and the required communication. Ensure everyone who uses the area knows the procedures and that non-NVG equipped aircraft stay out. Always plan and develop NVG areas and procedures based on the local conditions and environment. What worked at the last place will not necessarily work at the next place.

- If a problem with aircraft or NVG equipment develops, submit Quality Deficiency Reports. If there is a problem with doctrine or procedures, submit DA Form 2028. In both cases, send an information copy to the Army Safety Center.

- In most NVG-related accidents, the crew sensed/knew that everything was not right just before the accident occurred. The crew, or at least one member of the crew, was uncomfortable but, for some reason, did not let this be known or thought the other crewmembers had everything under control. Communicate as a crew. If any member of the crew is uncomfortable, he should make his feelings known, get out of the area, regroup, and try again if appropriate. If crews are unsure how close obstacles are or how close other aircraft are, they should assume they are too close and clearance is inadequate. Take corrective action.

- Most wires cannot be "seen" with NVGs. When aircraft suffered wire-strikes, crews were unsure or did not know the exact location of the wires.

- Low ambient light conditions create a high signal/noise ratio or graininess in the goggles. The definition of

objects viewed by the pilot loses sharpness or contrast. This results in inability to see some obstructions, depending on the backdrop of that object. This characteristic is still present in newer generations of NVGs, although greatly improved. NVG flights under overcast conditions away from populated areas have resulted in accidents due to this phenomenon.

- Visual contrast is the most critical factor during NVG flight. Contrast matters little if altitude permits obstruction clearance and flight instruments are available to prevent disorientation. However, flights into, out of, or around areas of minimal contrast are hazardous. Proper visual scan techniques will aid, although in some situations they cannot prevent, spatial disorientation. Areas void of visual cues require a combination of internal and external viewing for orientation purposes. Highly skilled and properly trained crews with artificial lighting and the latest generation NVGs can still become confused without adequate visual cues to relate movement.

- The 40-degree field of view tends to promote disorientation through tunneled vision. However, with proper visual cues, orientation can be maintained. Viewing outside references through the tubes is the only method for accomplishing most rotary wing tasks. If available, radar altimeters aid in determining altitude but can be unreliable, depending on aircraft attitude and terrain below. Stationary visual cues or breaks of contrast provide the only reliable information. Sometimes it's as simple as having ground crews walk around in the snow, providing contrast through footprints. At other times, a low approach and dropping a few chem-lights to provide a landing area will help. Seeking areas of contrast is a must during approach or hover work. Excessive hover height can also induce disorientation. Distant visual cues make it difficult to detect direction and rate of movement.

- Aircrew judgment in recognizing insufficient contrast and immediate execution of a takeoff or go-around is the best prevention for disorientation.

- Weather requirements for conducting NVG missions are directly related to mission profile, on-board equipment, and crew proficiency.

- Ceiling and visibility are not the primary factors in determining satisfactory conditions for NVG operations. Available ambient light, restrictions to visibility, and discernible contrast are the primary factors for safely employing NVGs.

- Flight with NVGs over water should be avoided if shoreline references are not available and the aircraft is not equipped with advanced flight stabilization equipment and radar altimeters and is not capable of instrument flight.

- Rolling, featureless desert/sand dunes provide hazardous NVG conditions requiring instrument flight.

- The urgency of certain emergencies while flying aided or unaided requires immediate and instinctive action by the pilot. The single most important consideration is aircraft control.

- Successful, safe NVG programs are generally those in which commanders at all levels are involved and participate.

Circumstances leading to most NVG-related accidents

- Lack of contrast and visual cues.
- Lack of crew communication/coordination and "total crew" training.
- Flying too fast based on visual cues and conditions present.
- Lack of recent NVG flight experience.
- Inability to determine distance to obstructions.
- "Invisibility" of wires.
- Sensing that things are about to turn bad and failing to take corrective action.