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Methodology of VFR Night Flying

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Abstract
Night is defined, for aviation purposes, as the period of darkness from the end of evening civil twilight to the beginning of morning civil twilight. Night flying is risky and more dangerous, comparing with flying during daylight, so it is essential to seek training with a flight instructor specifically for night flying. This article looks briefly at some underlying principles and practices, including: illusions, planning considerations, and handling emergencies.

Keywords
Aviation safety — Flying — Illusions — Night flying — Pilot training

1. Introduction

There are numerous and different internet sources, which aviator was the first one to make night flight, but identical is year 1910. During World War I and World War II, armies started to use dark to hide their attacking airplanes. In modern age, with the increasing need to fly as often, as possible, flying during night time has started to be essential [1]. Flying through dark night brings new dangers and requirements for pilot's training. The goal of this training is to understand given flight environment for safer flying [2].

2. Night vision

To improve your night vision you need to know, how your eye works, see Fig. 1. In the back of an eye there is retina, which consists of light-sensitive nerves, called the rods and the cones.
The cones are located in the centre of the retina, and the rods are concentrated in a ring around the cones. The function of the cones is to detect colour, details, and faraway objects. The rods purpose is for peripheral vision. They detect objects, particularly those that are moving, but do not give detail or colour – only black and white. Both the cones and the rods are used for vision during daylight and moonlight. The rods, however, make night vision possible. Because the rods are distributed in a band around the cones and do not lie directly behind the pupil, off-centre viewing (looking to one side of an object) is important during night flight. During daylight we rely on our central vision to see fine details, and use our peripheral vision to see general features, and to be aware of changes in movement or brightness. In low light, our central vision does not work as well, so we rely more on our peripheral vision to see things in the dark [4].

To improve your night vision [3]:

- Maintain good general health – especially important for night flying.
- Avoid activities that impair vision performance – e.g., cigarette smoking or medications.
- Allow time for your eyes to dark adapt.

- Avoid bright light even when using your central vision – keep cockpit lights and torches as dim as you can without losing your ability to read instruments and documents.
- Use a practiced scanning motion when looking outside the aircraft.

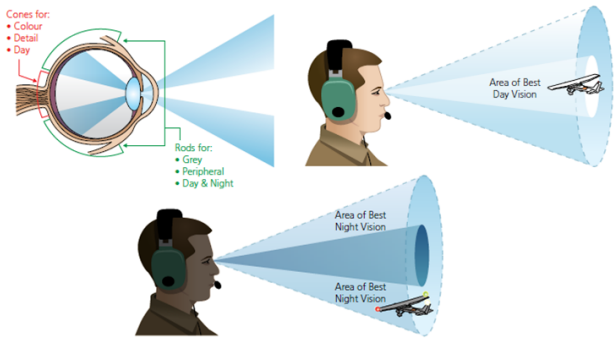

Figure 1. Rods and cones [3].

3. Dark adaptation

Dark Adaptation is adjusting to low intensity light. It takes quite some time to adjust from bright light to low light – but when going from dark light to bright light the effect is rapid and removes any dark adaptation that has taken place. You can meet with this for example when entering and leaving a cinema. You need to plan for dark adaptation when preparing for night flight. Allow time to adjust to low light after completing any tasks that need to take place in bright light, such as the pre - flight inspection. The rods become fully effective approximately after 30 minutes. Watch out for any bright light, if you have already started with adapting to the dark. Consider instrument lighting levels, especially if large multi - colored LCD screens are used. Use caution with mobile phones too, as they can have very bright displays. If you do use red light in the cockpit, avoid having it at too high a level, reduce the intensity as you adapt, and be aware that it will distort the colors on navigation charts [5].

If a pilot watches only instruments for a longer period of time, because there are no objects visible in the outside of the aircraft, and once some visual objects become visible, a problem to focus onto these objects occurs. This is called empty visual field myopia. To avoid this problem a pilot needs to focus periodically after few minutes onto any object, further than 6 meters away (wing tip, if nothing else is visible) [3].

4. Illusions

In some flight situations it is necessary to fly with reference to the instruments, even in the case, when external sources of light gives particular information of spatial position. Basic knowledge about illusions is needed to be aware of conditions, which may lead to illusions [6].

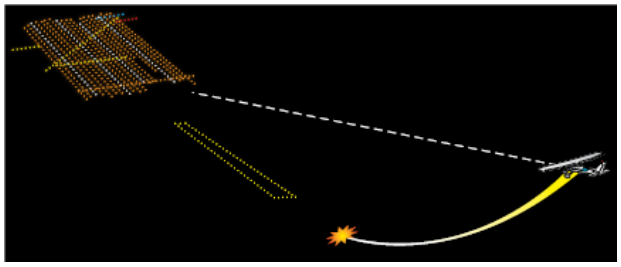

Figure 2. The black hole [3].

Charts placed on the top of the instrument panel can cause reflections that have a disorienting effect. Flashing lights or flicker effects from propellers and helicopter rotor blades can also cause disorientation [3, 7].

Judgement of distance could be impaired, because there can be insufficient visual information [3, 7].

Auto-kinesis, or self-movement, can occur when looking at a fixed light source against a dark sky, with no surrounding lights or other visual cues. For example, a star, or a single light source in a remote area. After a while, the light may appear to be moving or oscillating, and could be mistaken for an aircraft light. To prevent this illusion, avoid prolonged focusing on any one light, and look to one side to use the peripheral vision provided by the rods [8, 7].

At night, ground lights can be confused with stars. This can lead pilots to maneuver the aircraft into an unusual attitude in an effort to put the ground lights above them. In areas with sparse ground lighting, isolated lights can also be mistaken for stars, which can make the aircraft appear to be in a nose-high attitude, or have one wing low [3, 7].

During landing, when a terrain in front of the airport does not give a pilot enough lighted points, runway may appear as up-sloping, or down-sloping. This illusion is referred as the black hole. Pilot may not recognize this illusion and it may lead to land short of the runway (see Fig. 2) [3, 8, 7].

In a situation, where a steady turn has been established for longer, than 20 seconds, the body compensates this turn, and incorrectly perceives the turn as being level flight. On rolling out of the turn, the sensation is of banking in the opposite direction, even though the wings are level. This illusion is named as The leans [3, 7].

When an aircraft accelerates in level flight, or during take-off, our vestibular organs are not able to distinguish between the acceleration and gravity. This can result in an illusion that the aircraft's attitude is more nose-high than it is (Fig. 3). The pilot can incorrectly apply nose down control inputs until the flight feels right – and the aircraft descends and impacts the ground [3, 8, 7].

To reduce the appearance of these illusions [3]:

- **Prepare yourself pre-flight**
  What situations in this flight What situations in this flight are likely to lead to illusions? What will I do if I have a problem? Am I in good health and okay for this flight?

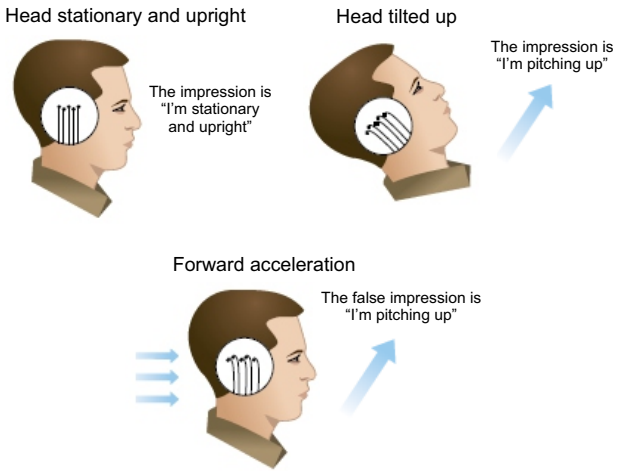

Figure 3. Somatogravic illusion [3].

- **Minimize head movements**
  During the scanning of your instruments, and outside, try to keep head movements to a minimum and move your eyes instead. Don't make big head movements while turning.
- **Use the visual horizon where it is available and reliable**
  Vision is the most powerful sense for orientation.
- **Get onto your instruments, and rely on them**
  Whenever you don't have a reliable visual horizon, whenever you're doing maneuvers that can lead to illusions, and whenever you've recognized any sort of illusion or possible disorientation.

When experiencing any of described illusions, scan all the flight instruments at first. If the aircraft is really in improper attitude: level the wings, make engine power inputs to not reach critical airspeeds, establish horizontal flight [3].

5. Equipment and flight planning

An airplane has to be equipped for night flying with flight instruments and lighting system, given by regulations. Aircraft lights are given like this: left wing position light is red, right wing position light is green, tail position light is white, see Fig. 4. This configuration gives a pilot basic imagination about approximate heading of the other aircraft, flying in the vicinity. Landing light and taxi light serves for runway, or taxiway lighting [9, 10].

A torch (and reserve batteries) for every flight crew member is a requirement. A torch is useful in the cockpit for checking a chart detail, or an unlit gauge, etc. It is a good idea to have two torches, or at least a second set of batteries. Your choice of torch should take into account that you may need to use it in an emergency situation, such as an electrical failure [9].

If possible, carry a hand-held VHF transceiver for backup. If you have a radio failure, this will enable you to communicate and also to switch on aerodrome lights. Some pilots will carry a hand-held GPS receiver as a backup too. A pilot should know to find any control elements literally blindfolded [9].

Figure 4. Aircraft position lights [11].

During night preflight check, some items, which are found easily by day, could be hidden in dark night. Better idea is to check the aircraft during day light, if possible. Maintain the aircraft in clean state, especially the windscreen [10].

Good flight planning is the key to safe flight. Good idea is to plan flight altitude the same, as for IFR flight. Carefully watch meteorological situation and forecasts. Clouds are hard to discover in total dark. Consider increased fuel reserves. For alternate airports you can count only with those, equipped with airport lighting [3, 10].

6. Night flights

Make sure, that everything you will need during flight, you have by hand. After startup is important to check electrical system of the aircraft, because electricity is essential for night flying. For taxiing, taxi slower, because speed estimate will not be as exact, as during the day. After lining up on the runway, remember optical picture of runway lights.

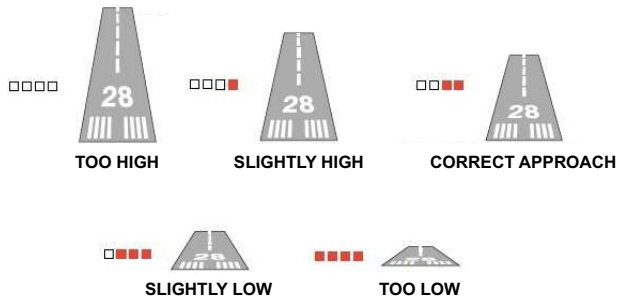

Figure 5. Precision approach path indicator (PAPI) [11].

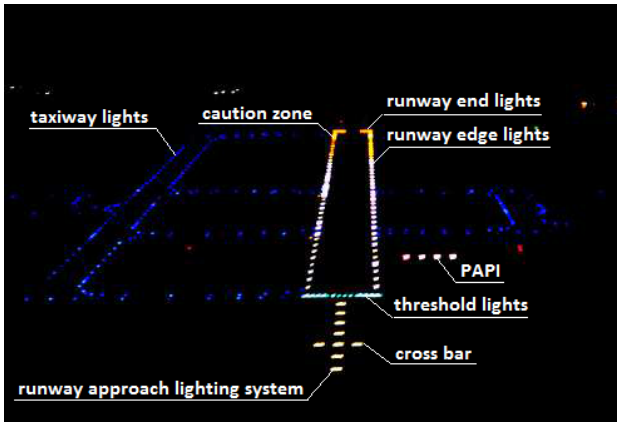

Figure 6. Airport lights [11].

Figure 7. Final approach, PAPI are clearly visible [11].

This will be the view, which you will use for altitude estimate during landing. After takeoff it is needed to scan the instruments for better picture of flight. Turns are recommended to perform at 15° of bank. Unless absolutely necessary, do not use higher vertical speed as 500ft/min for descent. For an orientation in the vicinity of the airport use airport lights, or ground lights around the airport. For landing, use PAPI (Precision approach path indicator) for descent guidance, see Fig. 5. Those are the most commonly 4 lights with gradual white/red filtering, which transmit optical beams (Fig. 6 and Fig. 7) [12, 13].

7. Emergencies at night

Solutions of emergencies at night are generally more difficult, than during the day. Always remember: aviate, navigate, communicate. Radio failure could be serious, so standby, or hand – held radio could be advantage. Do not forget, that squawk code for radio failure is 7600. Regularly check ammeter, if the alternator is working correctly. If not, reduce electrical load to as low, as possible and land as soon, as possible. If total electrical failure occurs, you will loss some instruments, internal and external lights and all the other electrical systems (flaps, trim, gear standard extension, if operated electrically). Use hand – held radio, or mobile phone to communicate with appropriate air traffic control to request assistance [10].

During inadvertent flight into clouds, make a 180° degrees turn immediately. If equipped, use autopilot. Turn off the beacon and strobes to avoid illusions. Monitor the vacuum pump to detect its failure as soon, as possible. If failed, maintain control by using the other instruments (turn coordinator, skid/slip indicator) [10].

Engine failure, when flying with single engine aircraft, could be very dangerous situation. If possible, try to find cause of failure (check fuel selector, mixture, magnetos). If you are not within gliding distance to any airport available, choose landing area somewhere close to lights. Consider landing on a highway, but keep in mind, that columns, trees, power lines will not be visible. Within unlighted terrain you will not be able to distinguish between straight field and hills with forests. Help with landing light to illuminate ground. Turn off master switch after final stop to ensure needed lighting for movement. If not possible to use landing, or taxi light, or to ensure any visual references for altitude estimate at all, maintain the aircraft in landing configuration at minimum safe airspeed until the aircraft hits the ground [12, 10].

8. Conclusion

Night flying provides less visual references, than flying during day time.

Pilot simply has few light points to catch on (in some cases none). This could cause in – flight illusions and pilot has to know, how to prevent these illusions and how to react, if they already occurred. This is the main purpose of training for night flying and this methodology serves as theoretical preparation for flights during night darkness.

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