Night Operations

KATHERINE WILCOXSON

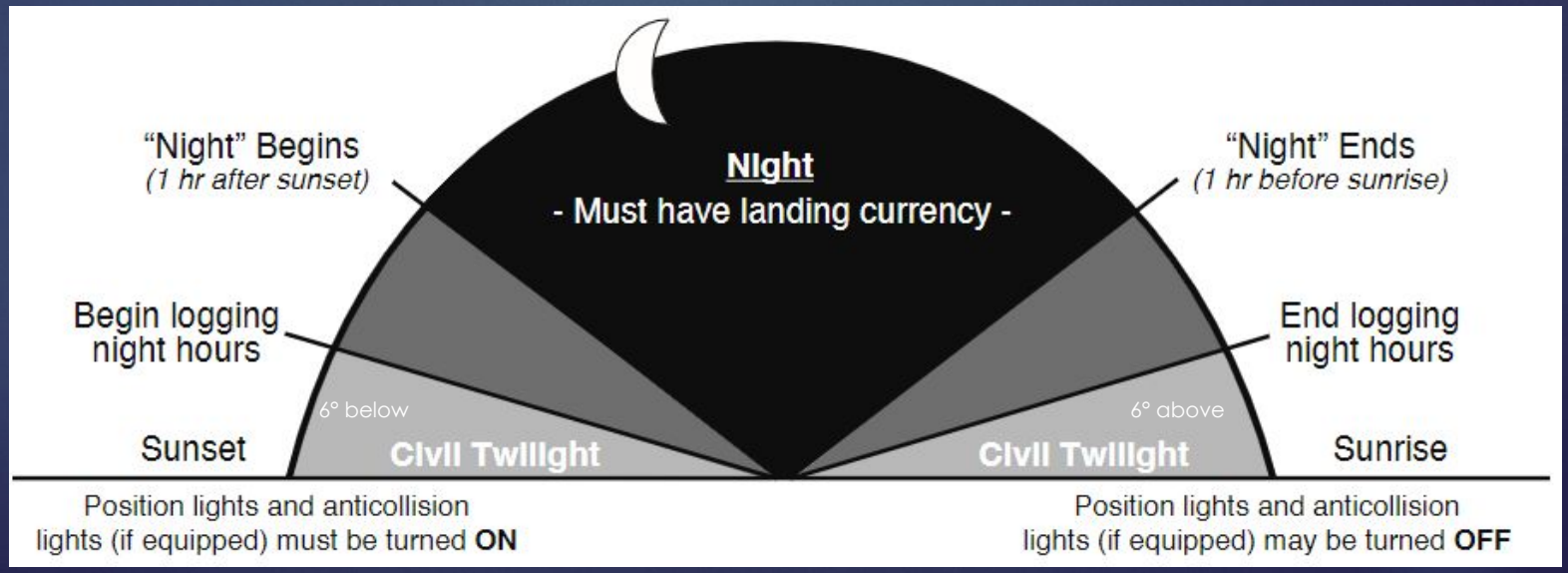
Factors related to night vision

The same hazards apply to night flying during the day, but there are additional hazards that are unique to night flying that pilots must be aware of like:

- Eye function at night vs. day
- Day references are not longer available at night
- Night illusions

According to Title 14 of the Code of Federal Regulations (14 CFR) part 1, Definitions and Abbreviations, night is defined as the time between the end of evening civil twilight and the beginning of morning civil twilight.

- Morning civil twilight begins when the geometric center of the sun is 6° below the horizon and ends at sunrise.
- Evening civil twilight begins at sunset and ends when the geometric center of the sun reaches 6° below the horizon.
- Sunset to Sunrise – position and anticollision lights must be turned on



Factors related to night vision cont.

Eye function

- Rods & Cones
  - Cones – Located in the center of the retina, and responsible for color, detail and far away objects
  - Rods – Located in a ring around the cones, and used for peripherals and vision in dim light
  - Both are used for vision in the day
  - Rods are almost exclusively used for vision at night
- Night vision is based on Rods
  - Off-center viewing is necessary
  - Protect night vision (long time to adapt, quick to lose)

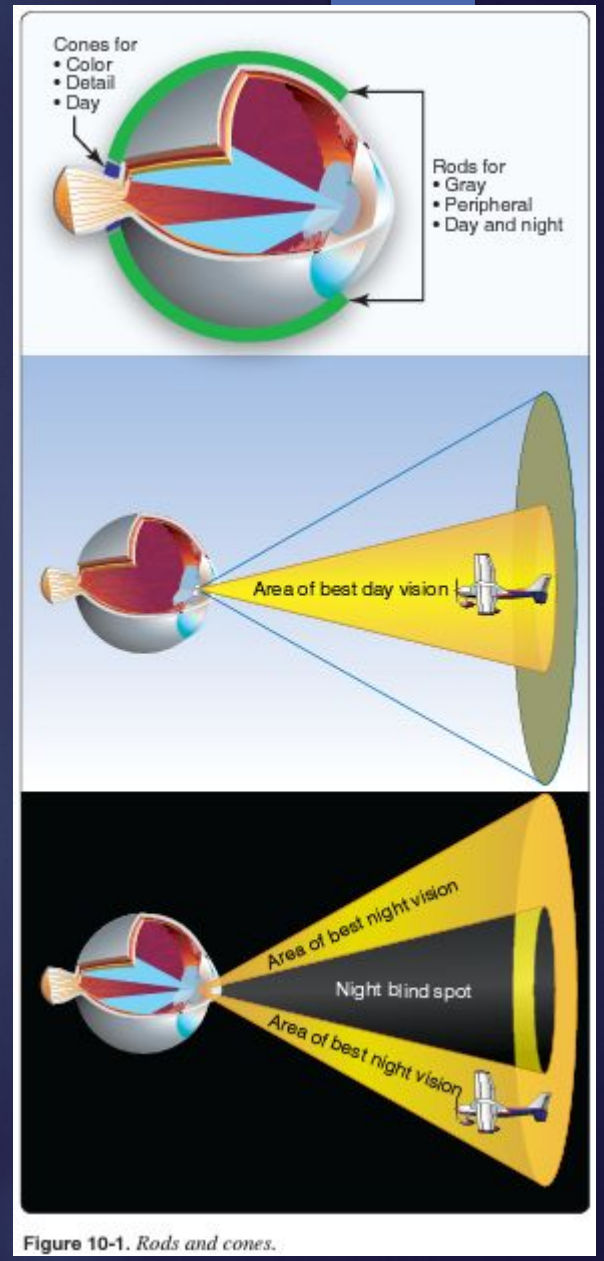
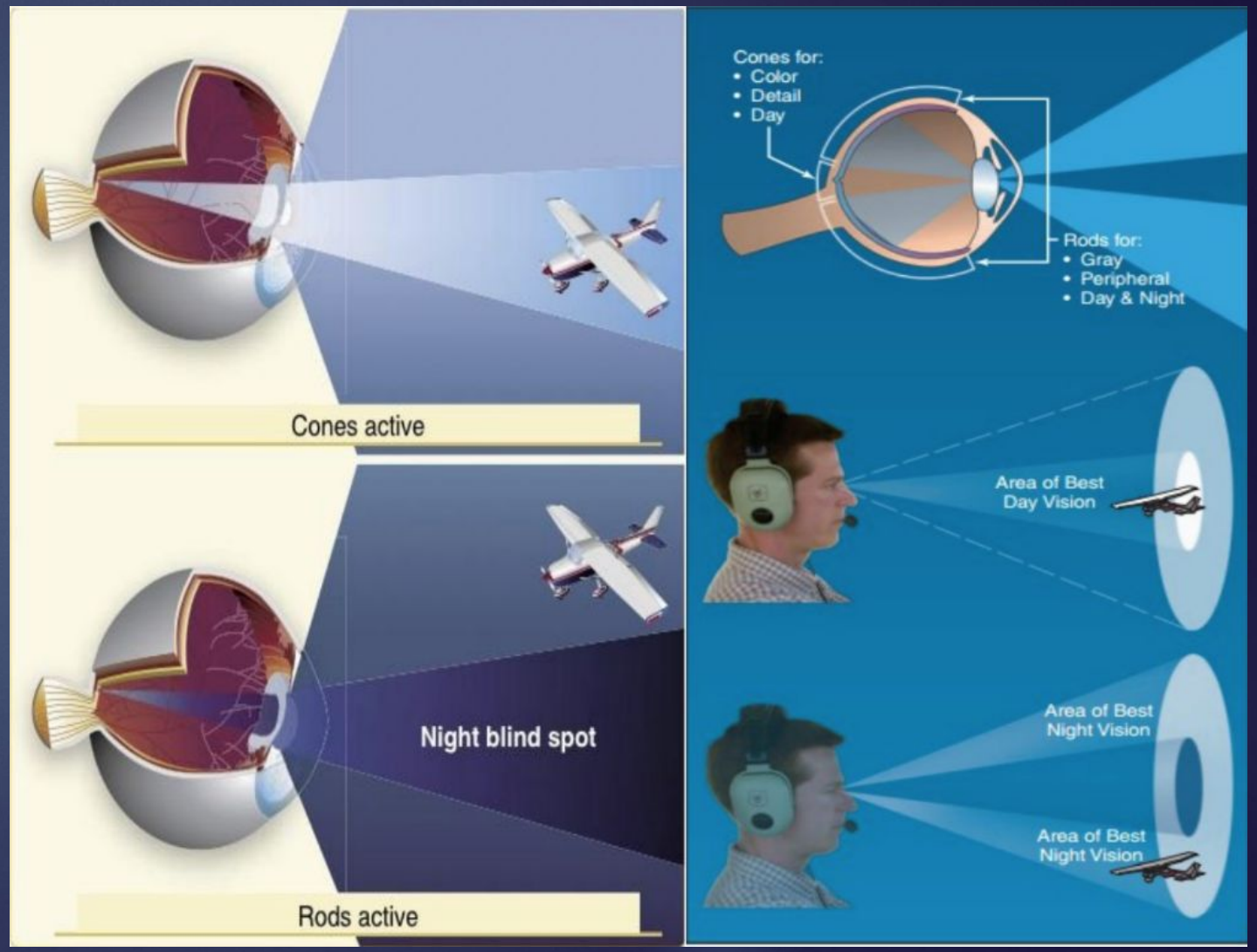


Figure 10-1. *Rods and cones.*

Visual in Flight: Rods and Cones

- Cones
  - Color
  - Center of eye
  - Details
  - Effective in day

- Rods
  - Grey
  - Periphery of eye
  - Movement
  - 10,000x more light sensitive than cones
  - 30 minutes to adapt to darkness



Types of Vision

Types of Vision						
Types of vision used	**Light level**	**Technique of viewing**	**Color perception**	**Receptors used**	**Acuity best**	**Blind spot**
Photopic	High	Central	Good	Cones	20/20	Day
Mesopic	Medium/Low	Both	Some	Cones/Rods	Varies	Day/Night
Scotopic	Low	Scanning	None	Rods	20/200	Day/Night

Types of Vision

Photopic

Mesopic

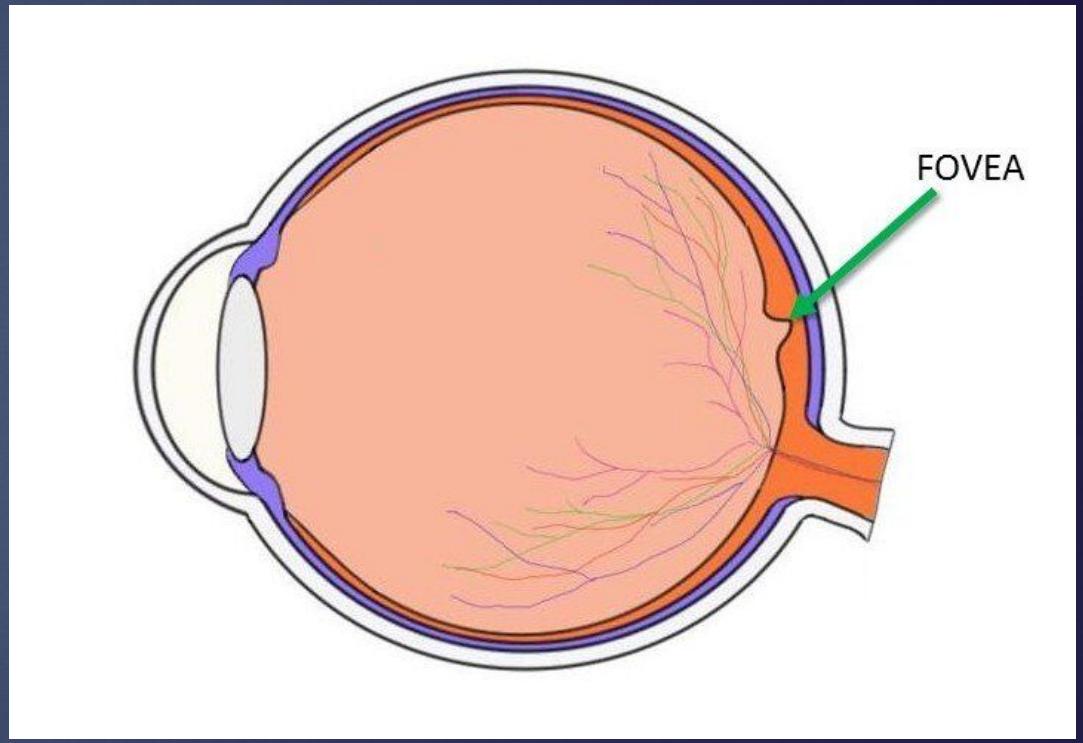
Scotopic

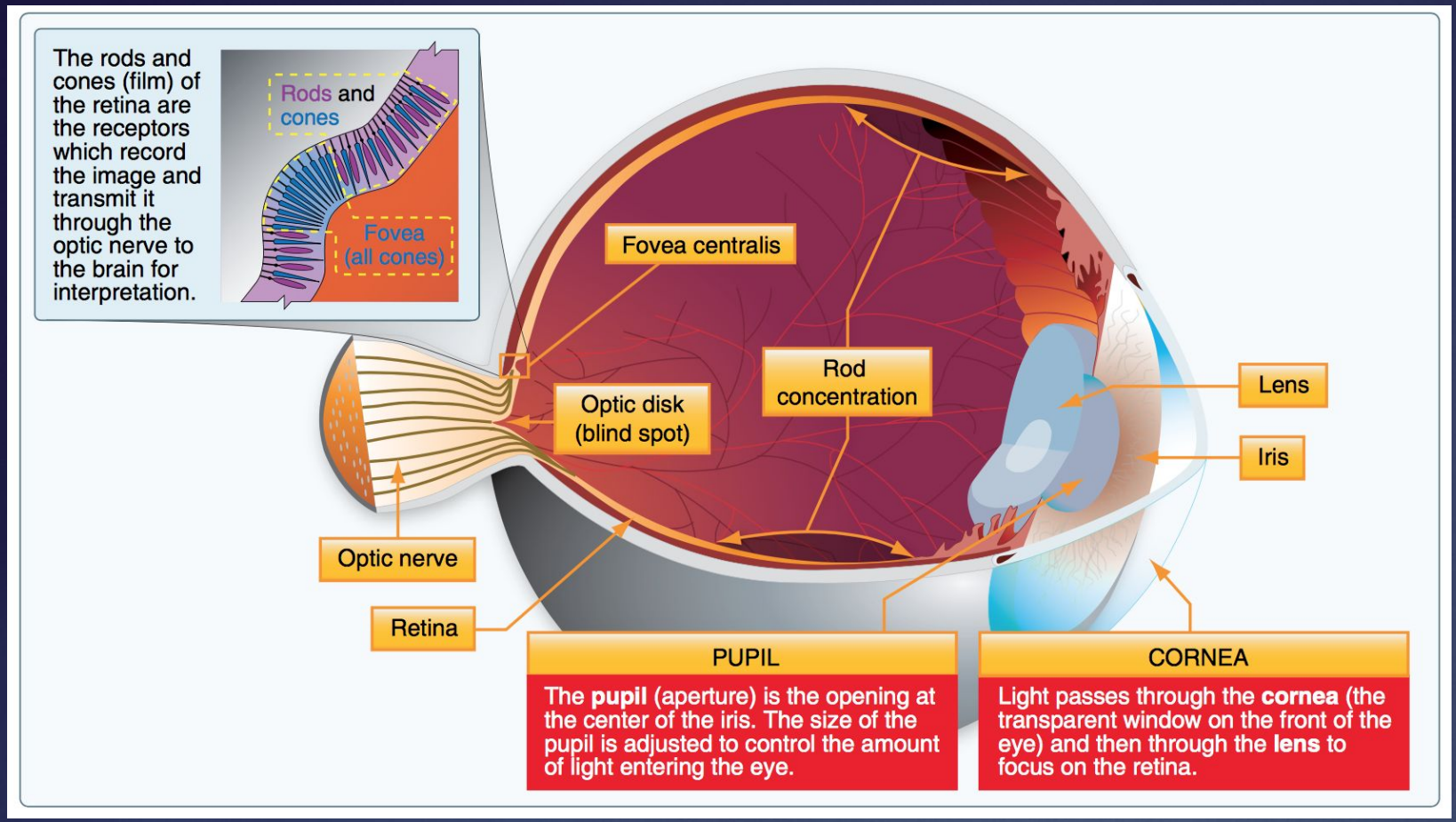
Limitations of Vision- Fovea

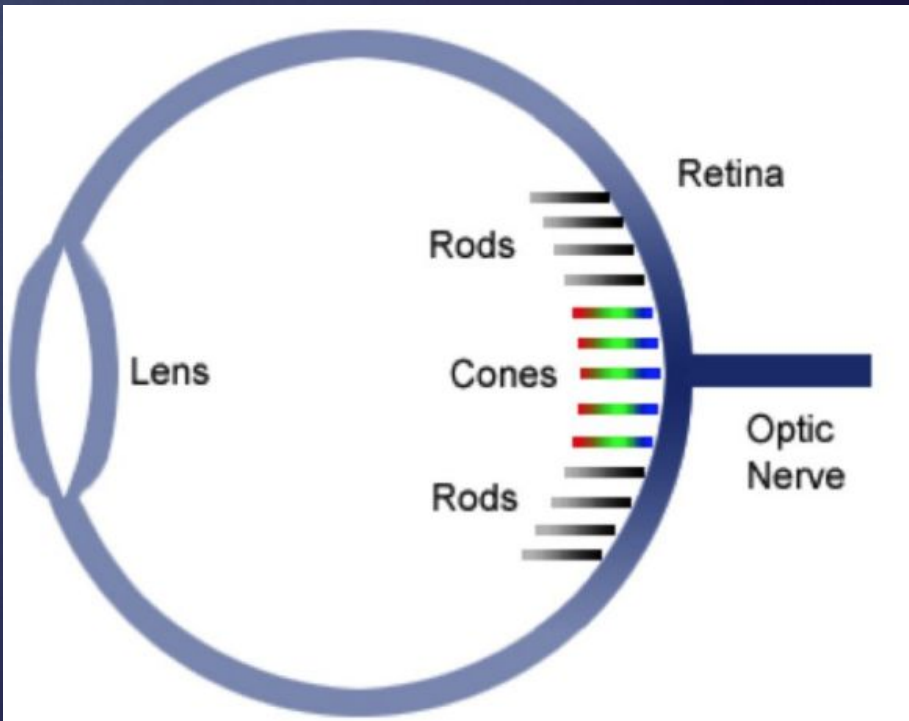
Most of the human retina does not sense high-detail images

Small section at the center of the visual field called the **Fovea**

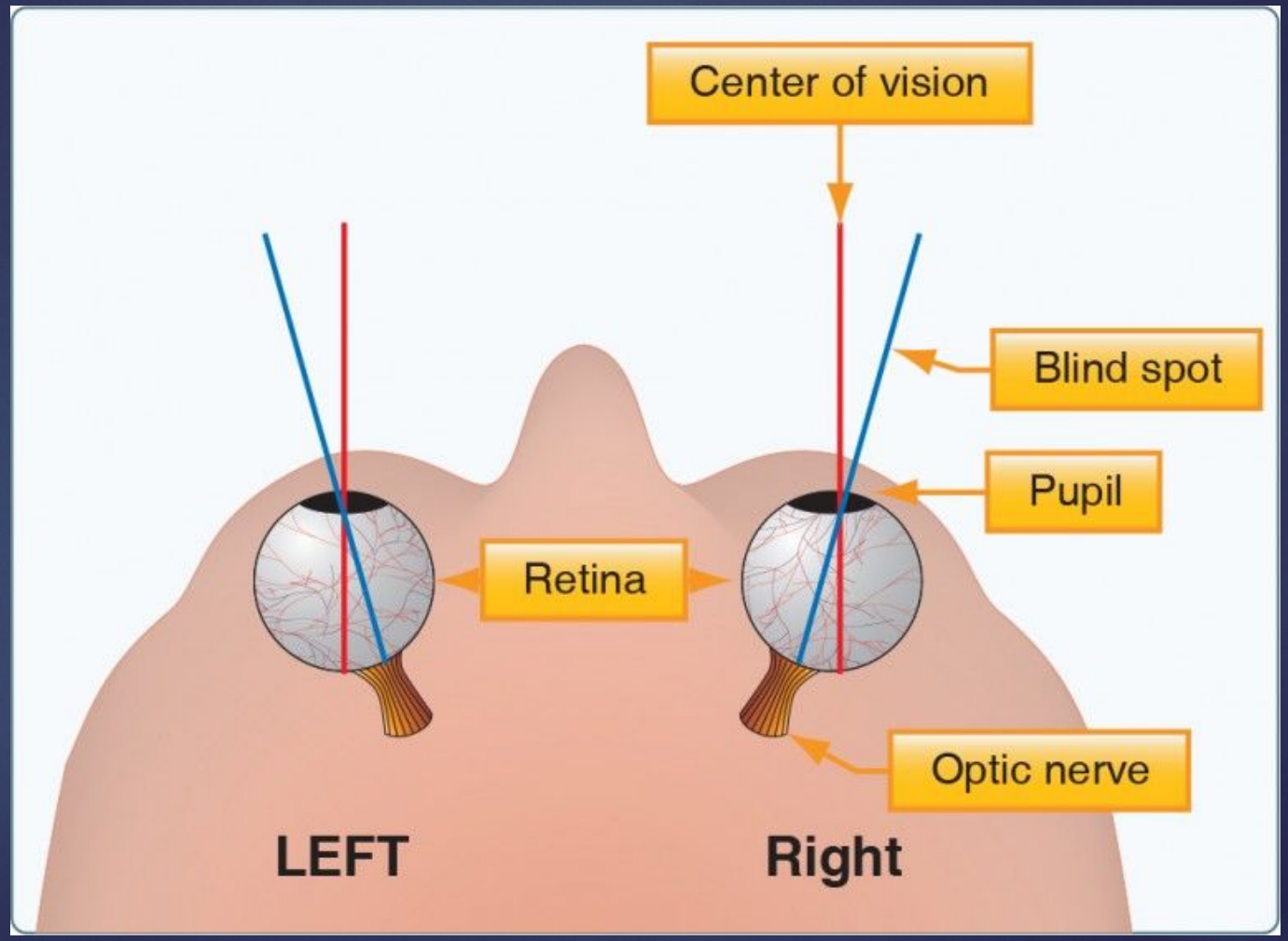
- Sees detail well during daylight or well lit area
- Contains both cones and rods
  - Senses color as well as intensity




The rods and cones (film) of the retina are the receptors which record the image and transmit it through the optic nerve to the brain for interpretation.
Rods and cones
Fovea (all cones)
Fovea centralis
Rod concentration
Optic disk (blind spot)
Lens
Iris
Optic nerve
Retina
PUPIL
The pupil (aperture) is the opening at the center of the iris. The size of the pupil is adjusted to control the amount of light entering the eye.
CORNEA
Light passes through the cornea (the transparent window on the front of the eye) and then through the lens to focus on the retina.


Retina
Rods
Lens
Cones
Optic Nerve
Rods

Blind Spot

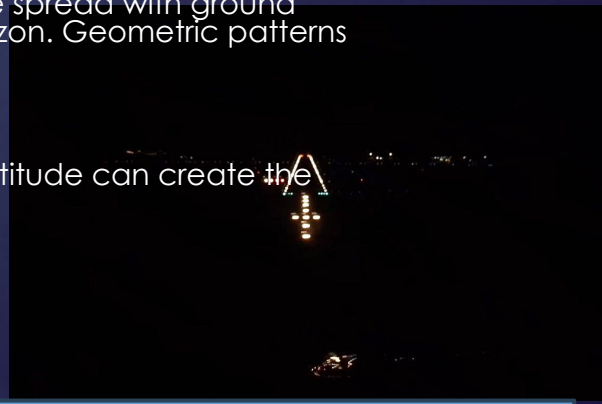

Center of vision
Blind spot
Pupil
Retina
Optic nerve
LEFT
Right

Prepping for Night Operations

- Dark Adaptation - To adapt to the darkness: About 30 minutes is needed to adjust the eyes to maximum efficiency after exposure to a bright light.
- Visual Hypoxia - If oxygen is available, use it during night flying. The FAA recommends oxygen usage beginning as low as 5,000 ft to prevent significant deterioration in night vision (PHAK 10-3).
- When staring into the darkness of night — an empty visual field — the eyes do not focus on optical infinity but at their resting state of about 2 ft (0.6 m) to 6 ft (2 m) ahead. This empty-field (or night) myopia blurs objects in the distance, making them appear smaller and farther away, and less detectable.
- Visual Acuity - Force the eyes to view off center using scanning techniques. Maintain good physical condition.
- Close one eye when exposed to bright light to help avoid the blinding effe
- Do not wear sunglasses after sunset as this impairs night vision.
- Move the eyes more slowly than in daylight.
- Blink the eyes if they become blurred.
- Avoid smoking, drinking, and using drugs that may be harmful

Disorientation and night optical illusions

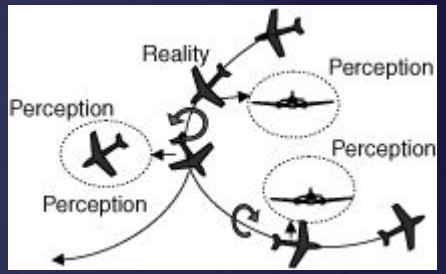
- Spatial disorientation is the main culprit of illusions we may experience as pilots. We utilize the ICEFLAGS acronym to describe a variety of illusions. There are additional illusions that we will cover as well. These illusions can occur at night, in low light conditions, hazy conditions, or even IMC.
- Inversion
  - Abrupt change from climb to straight and level will make the pilot feel like he is tumbling backward. The disoriented pilot will push the nose forward (low) and possibly intensify the illusion
- Coriolis
  - Occurs when a pilot has been in a turn long enough for the fluid in the ear canal to move at the same speed as the canal, which is then followed by an abrupt head movement. A movement of the head in a different plane, such as looking at something in a different part of the flight deck or grabbing a chart, may set the fluid moving and create the illusion of turning or accelerating on an entirely different axis. The disoriented pilot may maneuver the aircraft into a dangerous attitude to correct the aircraft's perceived attitude
- Elevator
  - Abrupt upward vertical acceleration, as can occur in an updraft, can stimulate the otolith organs to create the illusion of being in a climb. The disoriented pilot may push the aircraft into a nose-low attitude
- <u>False Horizon</u>
  - Dark nights tend to eliminate reference to a visual horizon. Sloping cloud formations, an obscured horizon, a dark scene spread with ground lights and stars, and specific geometric patterns of ground light can make the illusion of not being aligned with the horizon. Geometric patterns of ground light can create illusions of not being aligned correctly with the actual horizon
- Leans
  - If entering a turn too slowly to stimulate the motion sensing system in the inner ear, an abrupt correction of a banked attitude can create the illusion of banking in the opposite direction

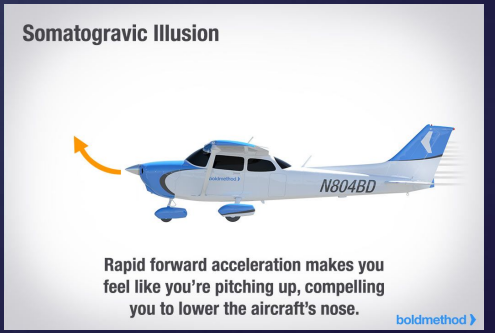


Antidote: Trust your instruments. Maintain your instrument scan. Utilize NAVAIDS

Disorientation and night optical illusions Cont.

- Autokinesis
  - Caused by staring at a single point of light against a dark background for more than a few seconds. After a few moments, the light appears to move on its own. The disoriented pilot will lose control of the aircraft in attempting to align it with the light
- Graveyard Spin/Spiral
  - a pilot in a prolonged coordinated, constant rate turn will have the illusion of not turning
  - An observed loss of altitude during a coordinated constant-rate turn that has ceased stimulating the motion sensing system can create the illusion of being in a descent with the wings level
  - During the recovery to level flight, the pilot will experience the sensation of turning in the opposite direction (leans).
  - Spin Recovery: PARE – Power Idle, Aileron's Neutral, Rudder Opposite, Elevator Forward
- Somatogravic
  - A rapid acceleration, like during takeoff, stimulates the otolith organs in the same way as tilting the head backward. This action creates the illusion of being in a nose-up attitude, especially in situations without good visual references – night. The disoriented pilot may push the aircraft into a nose-low or dive attitude
  - A rapid deceleration by quick reduction of the throttle(s) can have the opposite effect, with the disoriented pilot pulling the aircraft into a nose-up or stall attitude





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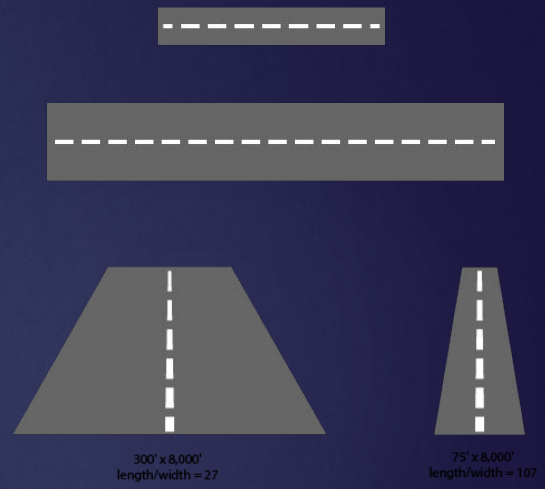
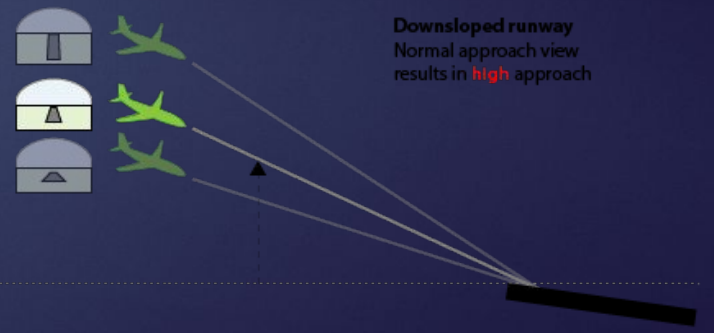
Disorientation and night optical illusions Cont.

- Reversible Perspective Illusion
  - Another aircraft appears to be moving away when it is acutally approaching
  - Observe their lights and position
    - Increasing intensity is getting closer / Dimming is getting farther
- Size-Distance Illusion
  - Light getting brighter or dimmer can be mistaken for getting closer or farther away
- Runway Illusions
  - Downslope - A downsloping runway can create the illusion that the aircraft is lower than it is, leading to a higher approach
  - Upslope - An upsloping runway can create the illusion that the aircraft is higher than it is, leading to a lower approach. The same is true for flying around sloping terrain.
  - Narrow – A narrower-than-usual runway can create an illusion that the aircraft is higher than it actually is, leading to a lower approach.
  - Wide – A wider-than-usual runway can create an illusion that the aircraft is lower than it is, leading to a higher approach.
  - More info: https://flightsafety.org/asw-article/in-the-dark/





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Inversion Illusion

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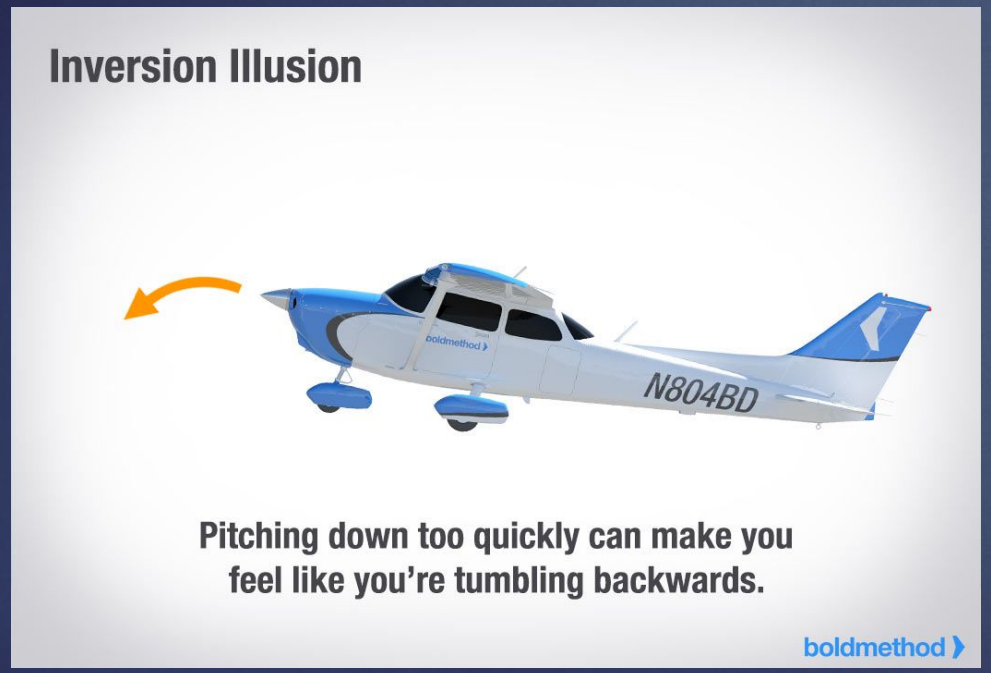

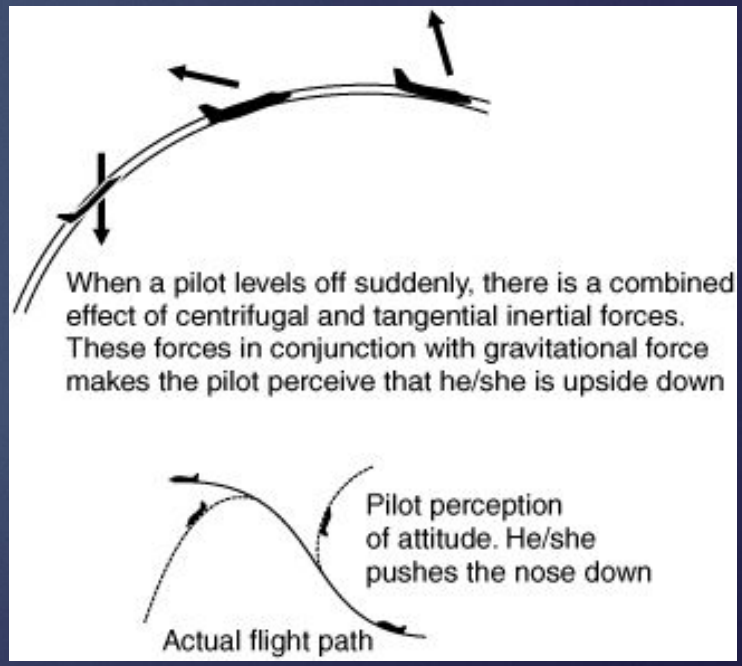

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Coriolis Illusion

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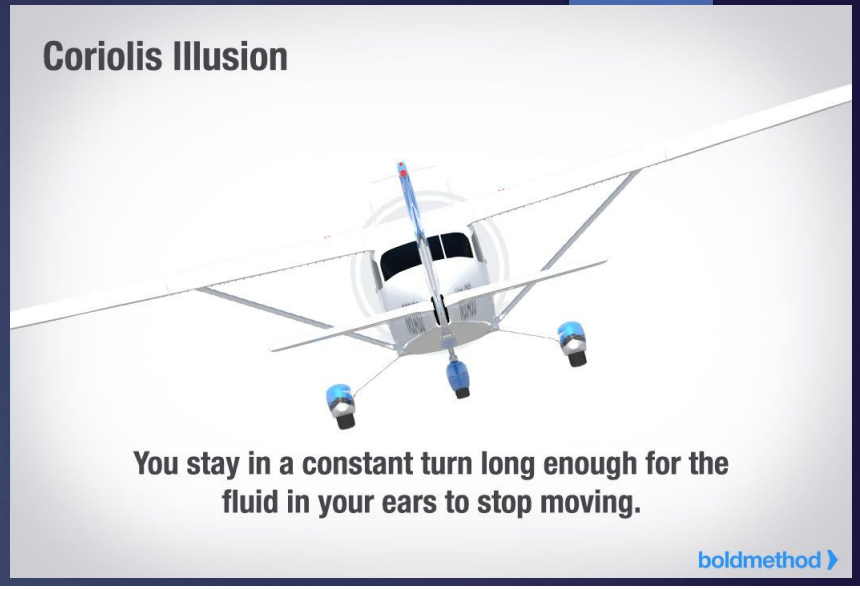

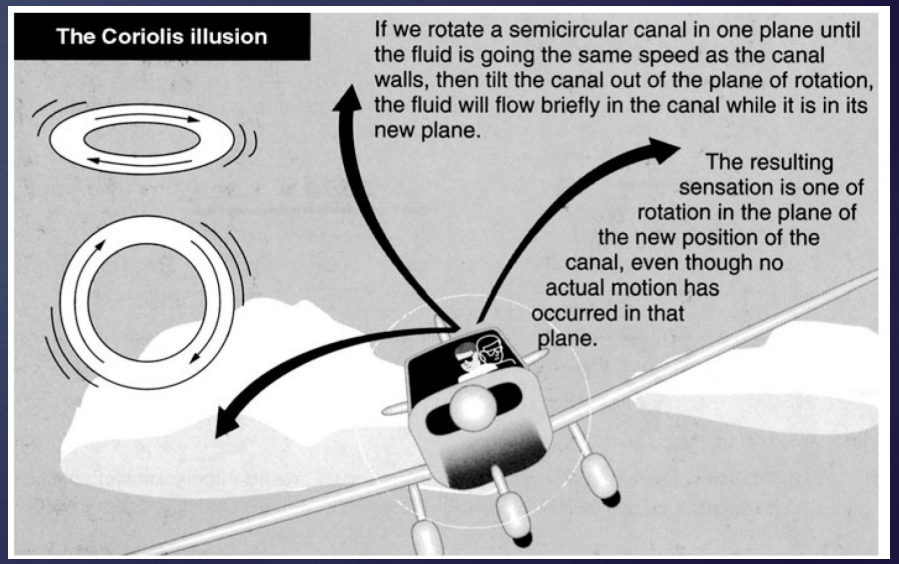

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Elevator Illusion

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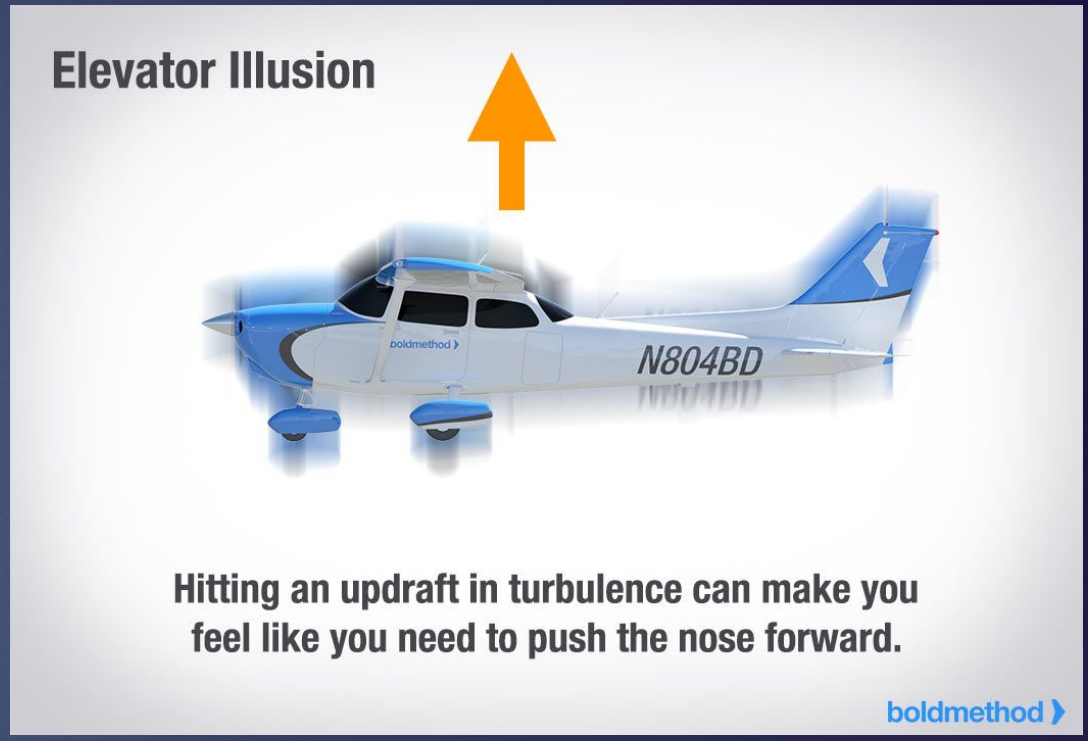

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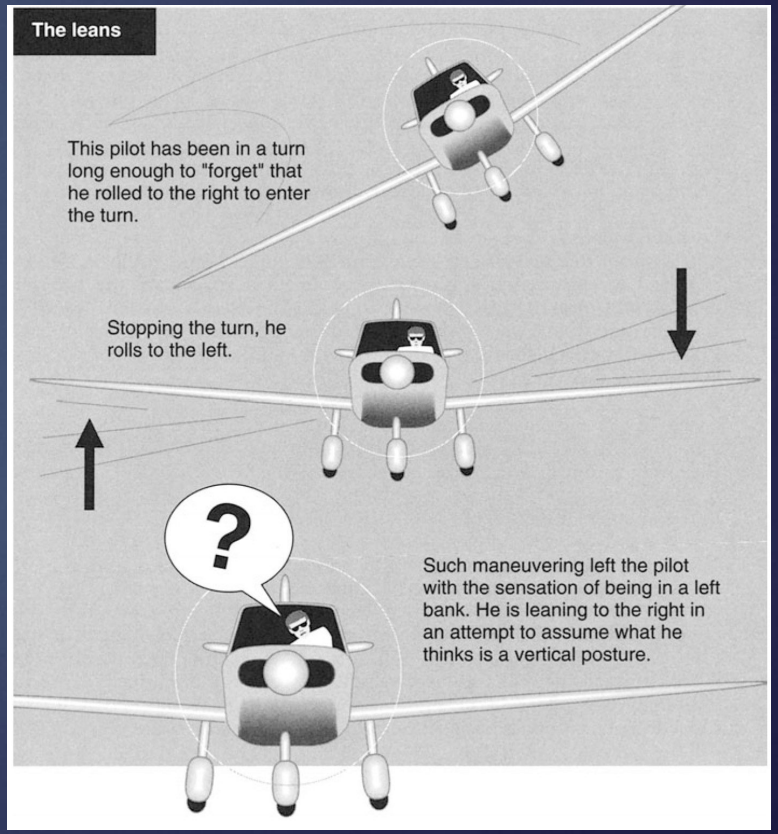

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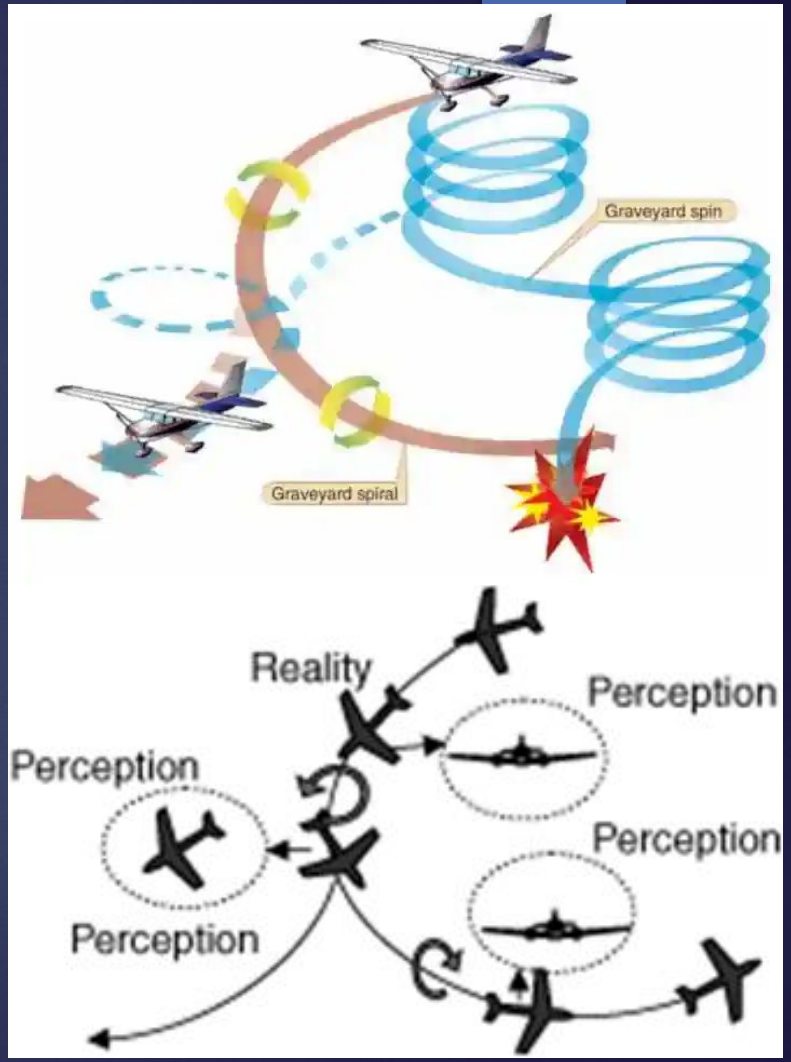
Spin Recovery: PARE – Power Idle, Aileron's Neutral, Rudder Opposite, Elevator Forward



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Somatogravic Illusion

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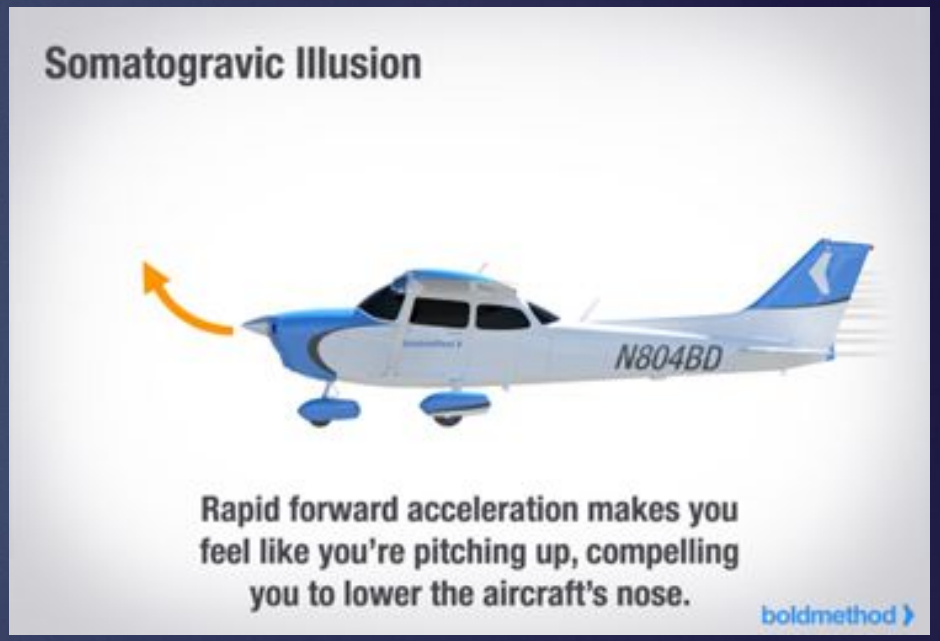

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Black Hole

A nighttime aviation landing illusion that occurs when only the runway is visible to pilots. With this illusion, pilots overestimate their descent angle, which causes them to overestimate their height, compensate by flying lower, and crash into the ground.

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Featureless Terrain (aka Daytime Black hole)

Flight over featureless terrain (such as still water, smooth snow, etc.) creates an illusion of being higher than the actual altitude.

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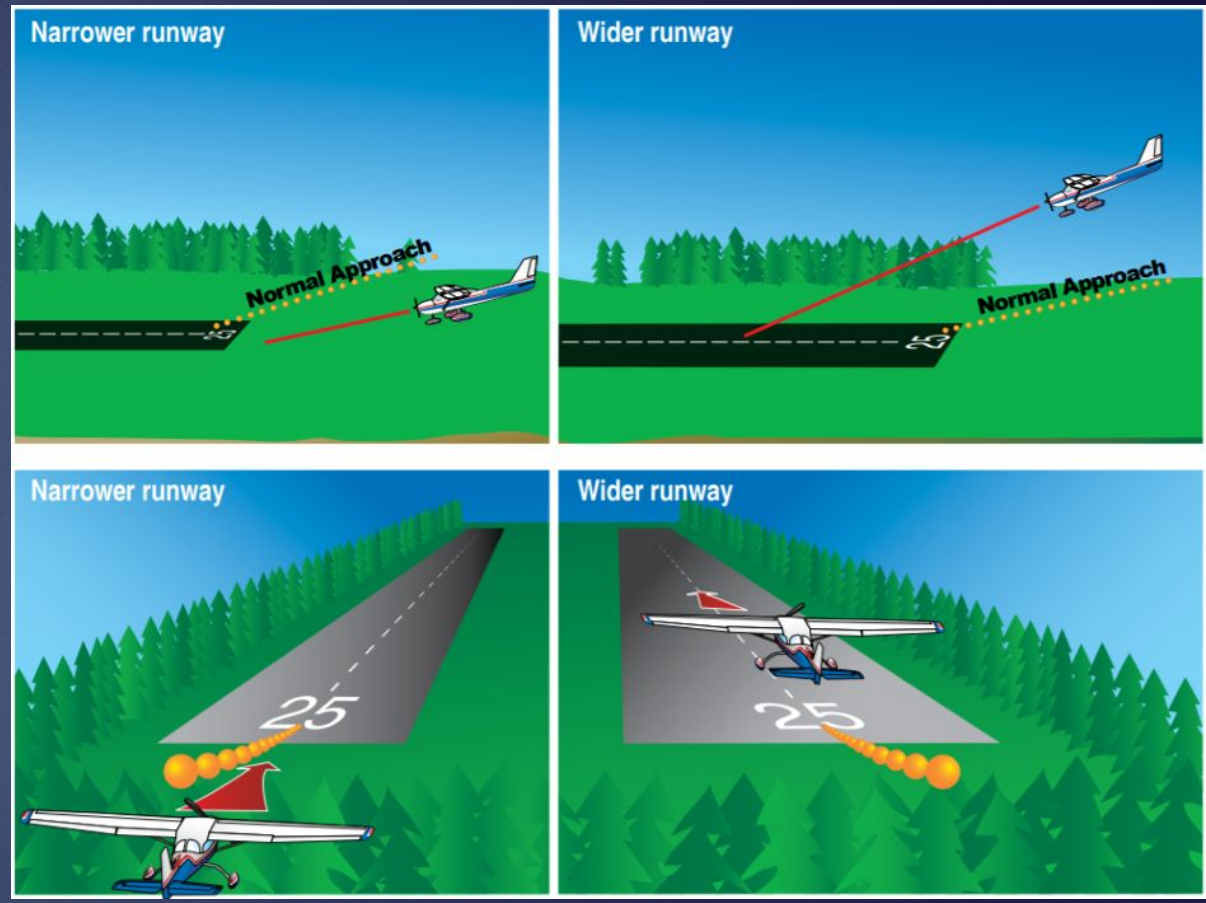
Runway Width Illusions

A narrower than usual runway can cause the appearance of being above glideslope, causing the pilot to fly excessively low on approach.



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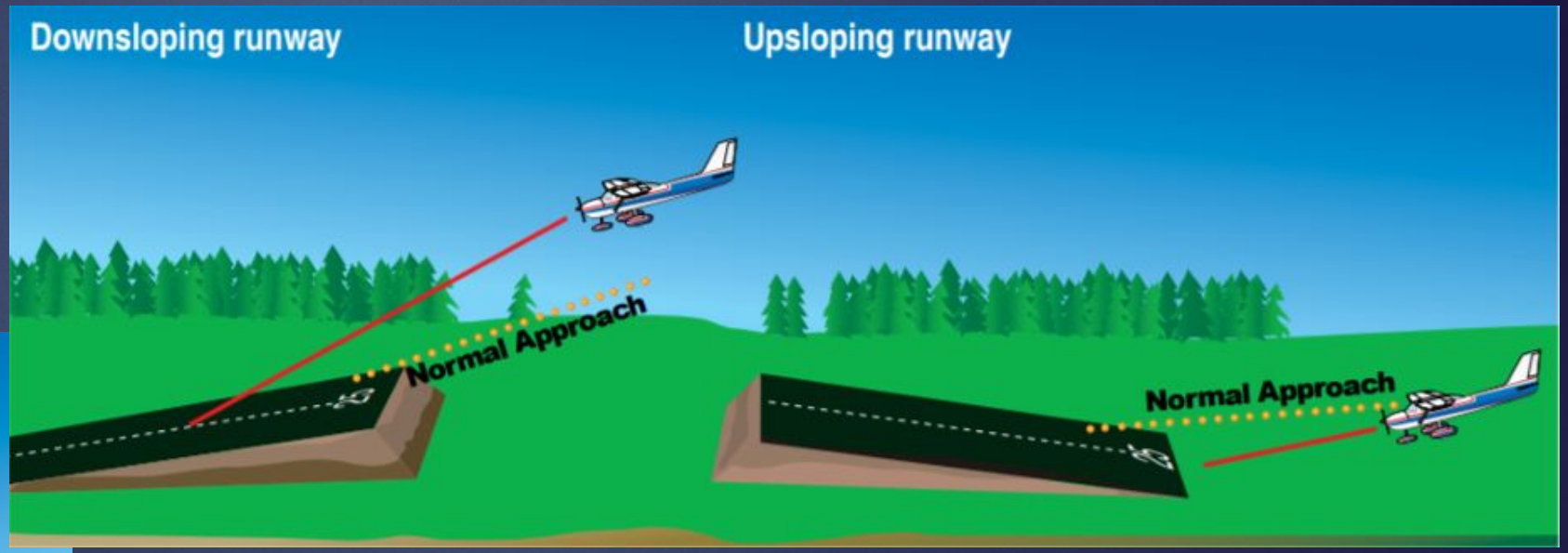
Runway Slope Illusions

An upsloping runway creates the illusion of being higher than normal, and vice-versa.



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Disorientation and night optical illusions Cont.

- Vertigo
  - A feeling of dizziness and disorientation caused by doubt in visual interpretation
  - Distractions and problems can result from a flickering light in the cockpit, anti-collision light, strobe lights, or other aircraft lights and can cause flicker vertigo
  - Often experienced from a lack of a well-defined horizon (common at night)
  - Also experienced leaving a well-lit area (a runway) into darkness
  - Possible physical reactions include nausea, dizziness, grogginess, unconsciousness, headaches, or confusion

Antidote: Trust your instruments. Maintain your instrument scan.

Disorientation and night optical illusions Cont.

- Black Hole Approach / Featureless Terrain
  - When landing at night from over water or non-lighted terrain (featureless terrain), the runway lights are the only source of light
  - Without peripheral visual cues to help, pilots will have trouble orientating themselves relative to Earth (horizon)
  - The runway can seem out of position (down-sloping or up-sloping) and, in the worse case, results in landing short of the runway
  - Utilize visual glide-slope indicators, if available
  - If navigation aids (NAVAIDs) are unavailable, pilots should pay careful attention to using the flight instruments to assist in maintaining orientation and a normal approach
  - Featureless terrain may give the impression that the aircraft is lower than it is

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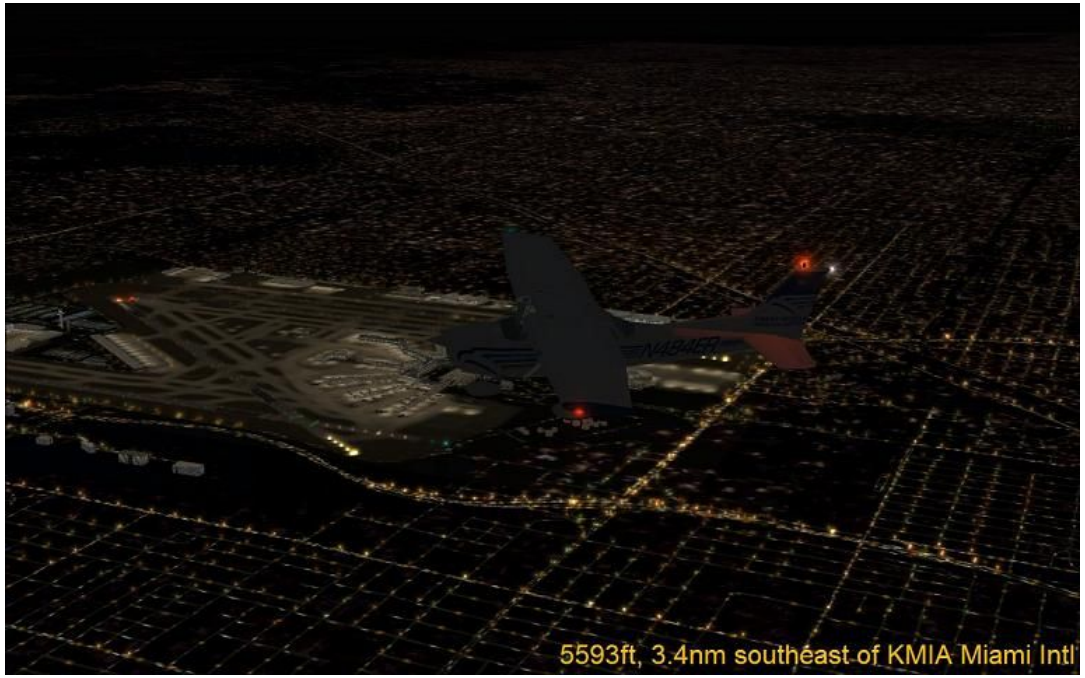
Disorientation and night optical illusions Cont.

- Ground Lighting Illusions
  - Ground lights like roadways can be mistaken for runways.
  - Few lights in the area may create the illusion of less distance to the runway
  - Bright lights may make them appear closer than they are.
  - For example, when a double row of approach lights joins the boundary lights of the runway, there can be confusion as to where the approach lights terminate, and runway lights begin. Under certain conditions, approach lights can make the aircraft seem higher in a turn to final, than when its wings are level (AFH 11-5).



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Proper adjustment of interior lights

- Dim the cockpit lighting so the instruments are readable, without hindering night vision
- Set the interior light settings to a dim setting that still allows you to conduct your flight safely
- Dim the GPS, PFD, MFD, EFIS and etc, so the instruments are readable, without hindering night vision

Importance of having a flashlight with a red lens / LED

- Used to help pre-flight – but white is primarily used
  - Read charts - Be aware: Red light will wash out red colors on the map
  - Perform operations that require light
  - (White light can be used during preflight, however be cautious of brightness and ensure your eyes are properly adjusted for night flying)
- Does not interfere with night vision – Non glaring

- Additional Pilot Equipment
  - Ensure the proper aeronautical charts are on board
  - Use city light depictions on charts to assist in navigation
  - Keep charts organized and easy to access

Night preflight inspection

- Required Equipment (FAR 91.205)
  - TOMATO FLAMES (day VFR)
  - FLAPS (additional night VFR requirements)
    - Fuses (if applicable)
    - Landing Light
    - Anti-Collision Lights
    - Position Lights
    - Source of Power
  - Instrument required equipment doesn't hurt (safer is smarter)
- Walk Around
- White & red flashlight(s) for the inspection
- Normal walk around but with extra focus on night equipment / environment
- Check all lights
- Check the ramp for obstructions
- Ensure that your phone and ipad are adjusted to a reduced brightness setting

Engine starting procedures, including use of position and anti-collision lights prior to start

- Take extra precaution to be sure the propeller area is clear
- Turn on position and anti-collision lights prior to start
- Announce “Clear Prop”
- To avoid excessive battery drain, leave all unnecessary electrical equipment off until after engine start

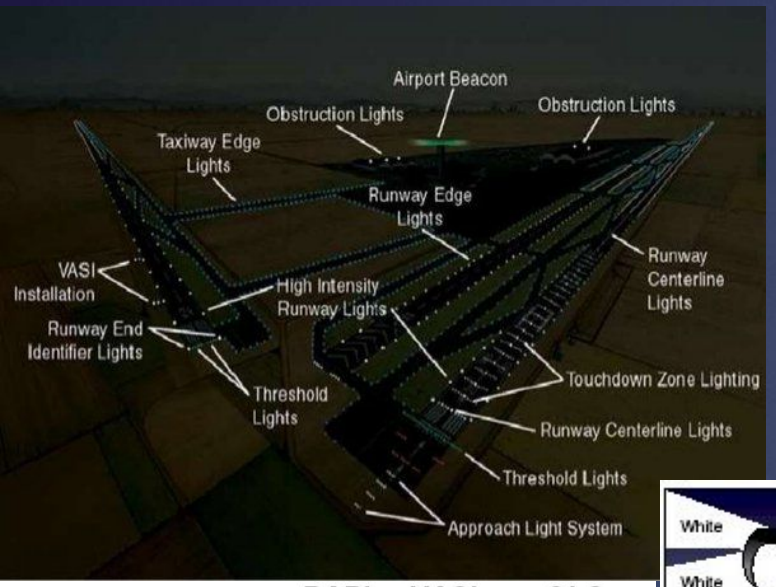
Taxiing and orientation on an airport

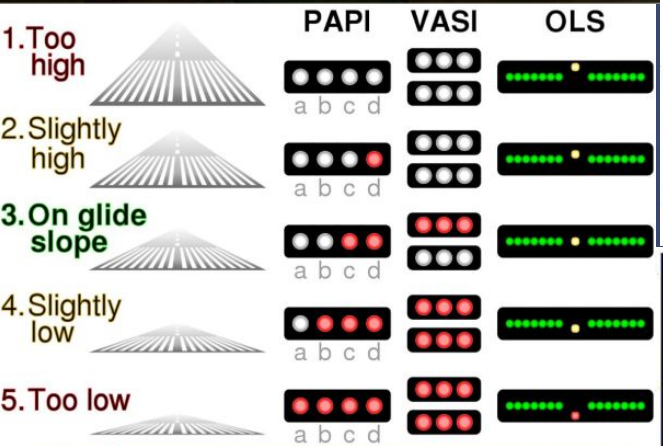
- Turn on the taxi and / or landing light (be cautious as to not blind other aircraft on the airport or on final)
- Taxi slowly, particularly in congested areas (speed of a fast walk)
- Orientation
- Airport Diagram - Be familiar with taxiway markings, lights, and signs
- Maintain slow taxi for situational awareness

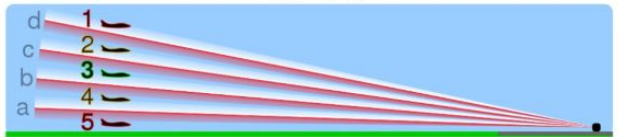
Run Up

- Airplane movement is harder to detect at night
- Be extra cautious for other people, aircraft, equipment

What does an airport at night look like?

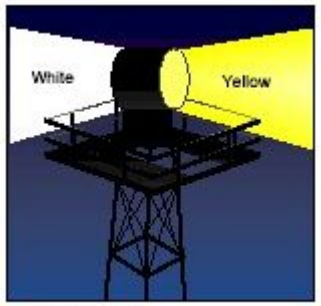




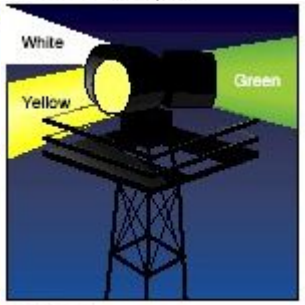


Military airport

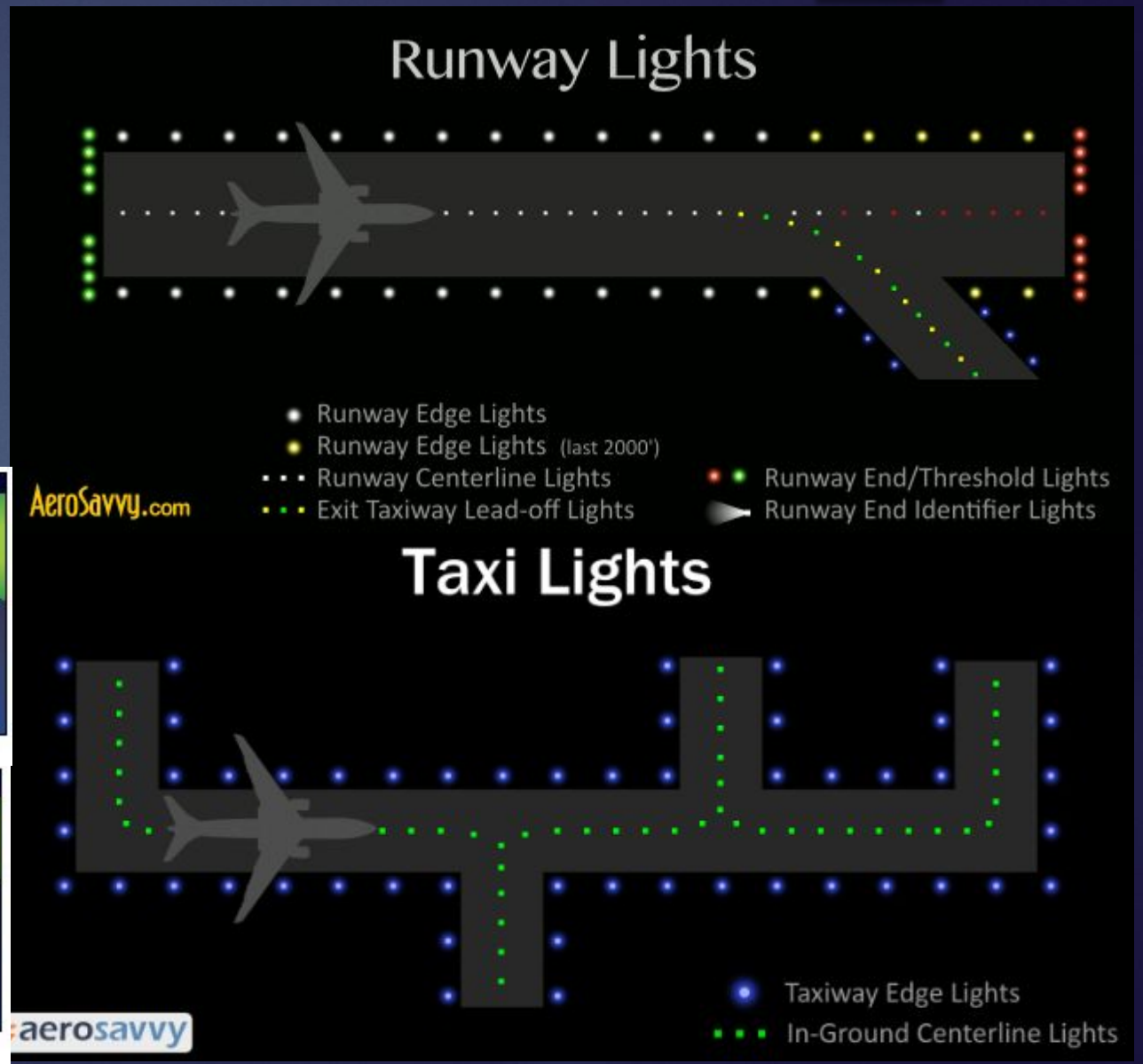
Civilian land airport



Water airport

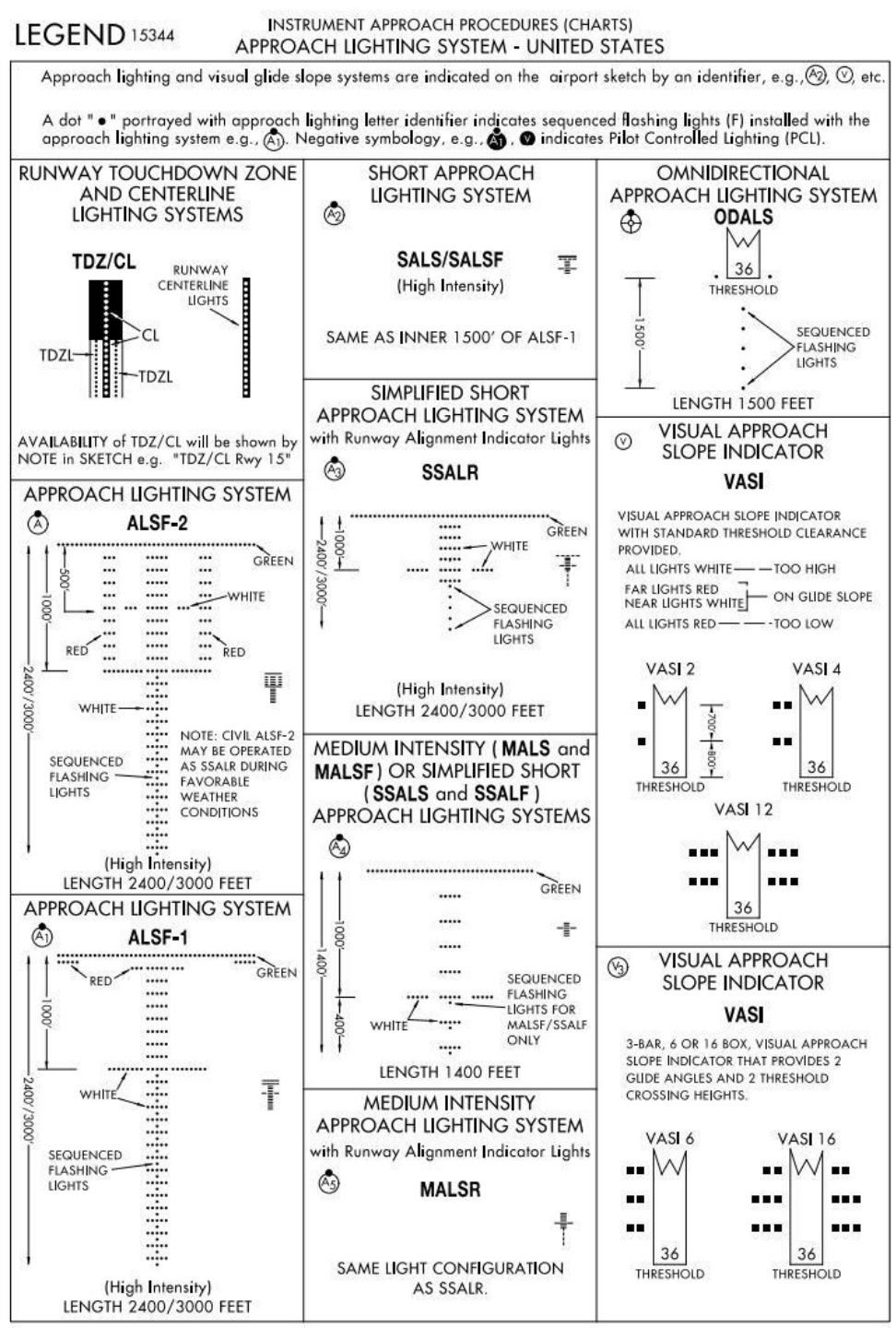


Heliport



What does an airport at night look like? Cont.

See AIM Chapter 2, PHAK Chapter 14, AFM Chapter 11 for further descriptions



Symbol and color letters	Description
G R	Runway threshold / End lights Green (G) / Red (R)
Y W	Runway edge light (see note 3) Yellow (Y) / White (W)
W	Runway edge light White (W)
W	Runway edge light (in-pavement) White (W)
R	Runway threshold / End light Red (R)
B	Taxiway edge light Blue (B)
Y R	Runway edge light at displaced threshold Yellow (Y) / Red (R)
G Y	Threshold / Runway edge lights at displaced threshold Green (G) / Yellow (Y)
G UNI	Runway threshold light with a unidirectional green (G UNI)

Takeoff and climb-out

- General
  - Same procedures as during the day, but with reduced visual references
  - Flight instruments are used to a greater degree
- Clear final approach & the runway
- Uncontrolled airport: Radios are not required, just because you don't hear anyone doesn't mean they aren't there, you should still make all radio calls
- Entering the runway
  - Turn on all lights and lineup approximately 3' off centerline to prevent blending in with the runway lights
  - Verify the proper runway (runway signs, heading, ground markings, lights, etc.)
- Takeoff Roll
  - Same as a day takeoff, but with less visual references
  - Check the flight instruments more frequently
- Climb
  - Darkness can make it difficult to tell if the airplane is climbing
    - Verify with the instruments (altimeter, VSI, airspeed)
  - Attitude and heading indicators for pitch and bank adjustments

In-flight orientation

Navigating

- Numerous night references can be easier to see than some day references
- Large concentrations of lights (cities, highways), bright lights (airports), patterned lights (airports, street grids)
- Combine with radio navigation

Nav Lights

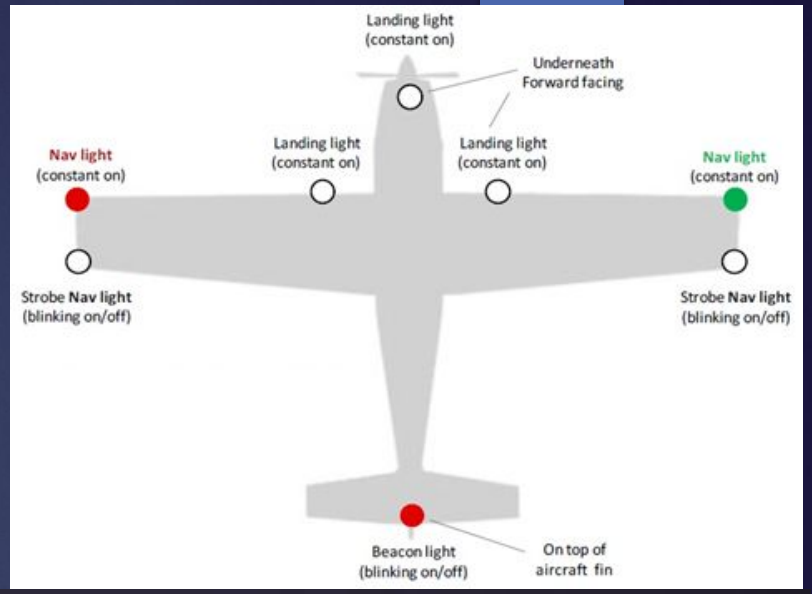
- Orientation with other traffic – Red light on left wing, Green light on right wing

Clouds and Low Visibility

- Difficult to see at night – be cautious to avoid flying into IMC conditions
- Indications: gradual disappearance of the ground, glowing / halo around ground lights, reflection of strobe light
- Do not attempt to fly through poor visibility, turn around and return to VMC conditions

Large Bodies of Water

- Very easy to become disoriented with little to no horizon
- Rely more heavily on the instruments and radio navigation



Importance of verifying the airplane's attitude by reference to flight instruments

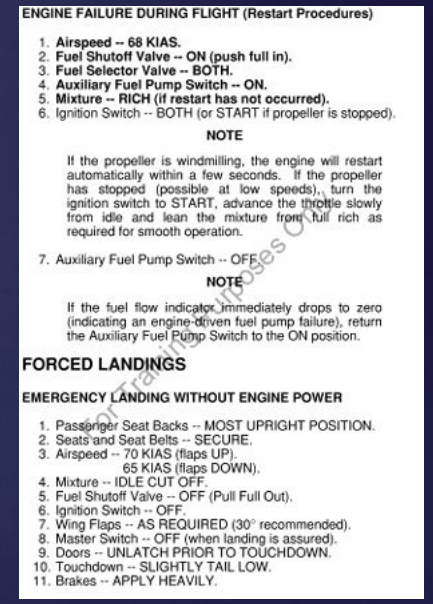
Night flying demands more attention of the pilot than day flying

The most noticeable difference is the limited availability of outside visual references. Therefore, flight instruments should be used to a greater degree at night than in the day

Again, dim the cockpit lighting so the instruments are readable, without hindering night vision

Night emergencies procedures

- Don't Panic: Aviate Navigate Communicate
- Maintain positive control of the airplane and establish the best glide configuration and airspeed. Turn the airplane towards an airport or away from congested areas.
- Check to determine the cause of the engine malfunction, such as the position of fuel selectors, magneto switch, or primer. If possible, the cause of the malfunction should be corrected immediately, and the engine restarted.
- Announce the emergency to air traffic control (ATC) or Universal Communications (UNICOM). If already in radio contact with a facility, do not change frequencies unless instructed to change.
- If the condition of the nearby terrain is known and is suitable for a forced landing, turn towards an unlighted portion of the area and plan an emergency forced landing to an unlighted portion.
- Consider an emergency landing area close to public access if possible. This may facilitate rescue or help, if needed.
- Maintain orientation with the wind to avoid a downwind landing.
- Complete the emergency checklist, before landing checklist and check the landing lights for operation at altitude and turn ON in sufficient time to illuminate the terrain or obstacles along the flightpath. Follow all POH procedures.
- The landing should be completed in the normal landing attitude at the slowest possible airspeed. If the landing lights are unusable and outside visual references are not available, the airplane should be held in level-landing attitude until the ground is contacted.
- After landing, turn off all switches and evacuate the airplane as quickly as possible.



ENGINE FAILURE DURING FLIGHT (Restart Procedures)

1. **Airspeed -- 68 KIAS.**
2. **Fuel Shutoff Valve -- ON (push full in).**
3. **Fuel Selector Valve -- BOTH.**
4. **Auxiliary Fuel Pump Switch -- ON.**
5. **Mixture -- RICH (if restart has not occurred).**
6. Ignition Switch -- BOTH (or START if propeller is stopped).

NOTE

If the propeller is windmilling, the engine will restart automatically within a few seconds. If the propeller has stopped (possible at low speeds), turn the ignition switch to START, advance the throttle slowly from idle and lean the mixture from full rich as required for smooth operation.

7. Auxiliary Fuel Pump Switch -- OFF.

NOTE

If the fuel flow indicator immediately drops to zero (indicating an engine-driven fuel pump failure), return the Auxiliary Fuel Pump Switch to the ON position.

FORCED LANDINGS

EMERGENCY LANDING WITHOUT ENGINE POWER

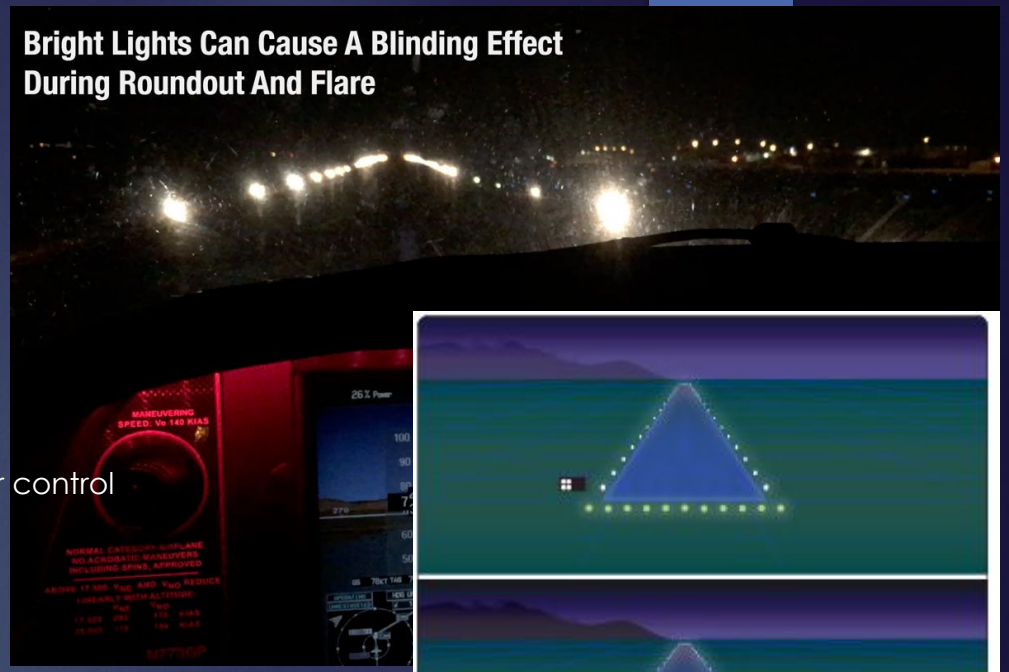
1. Passenger Seat Backs -- MOST UPRIGHT POSITION.
2. Seats and Seat Belts -- SECURE.
3. Airspeed -- 70 KIAS (flaps UP).
   65 KIAS (flaps DOWN).
4. Mixture -- IDLE CUT OFF.
5. Fuel Shutoff Valve -- OFF (Pull Full Out).
6. Ignition Switch -- OFF.
7. Wing Flaps -- AS REQUIRED (30° recommended).
8. Master Switch -- OFF (when landing is assured).
9. Doors -- UNLATCH PRIOR TO TOUCHDOWN.
10. Touchdown -- SLIGHTLY TAIL LOW.
11. Brakes -- APPLY HEAVILY.

Traffic patterns

- Identify runway/airport lights as soon as possible
  - It may be difficult to find the airport or runways (especially if they're buried within a city)
  - Fly towards the beacon until you identify runway lights
  - Compare the runway lights with heading indicator to ensure you are in the right place
  - If possible, tune the localizer for course guidance to the runway and/or use the OBS function of a GPS to view an extended runway centerline
  - Use any additional means available to help orient yourself and maintain situational awareness
- Distance may be deceptive at night due to limited light conditions
  - A lack of references on the ground and the inability to compare their location and size causes this
  - Altitude and airspeed are also difficult to estimate
  - More trust must be put on the instruments (particularly the altimeter and airspeed indicator)
- Ensure appropriate lights are on for collision avoidance
- Fly a normal traffic pattern (don't fly a wider pattern)
  - Always know the location of the runway/threshold lights
  - When entering, allow for plenty of time to complete the before landing checklist. Use your heading bug to set the runway heading
  - Execute the approach in the same manner as during the day

Figure 10-4. *Use light patterns for orientation.*

Night Landings



- A stabilized approach should be made in the same manner as during the day
- Use flight instruments more often (especially altimeter/airspeed indicator)
  - Distance, height, etc. may be deceptive
  - Maintain specified airspeeds on each leg and watch the VSI to keep the approach under control
  - A low, shallow approach is definitely not appropriate during a night landing
- Final Approach
  - If there are no centerline lights, align the airplane between the edge lights
  - Note and correct any wind drift
  - Apply power and pitch corrections to maintain a stabilized approach
  - Use any visual aids to assist in maintaining a proper glideslope (vasi, papi, etc.)
  - Tune the glideslope if available for additional guidance
- Round out/Touchdown
  - A smooth, controlled roundout and touchdown should be made in the same manner as in the day
  - Judgment of height, speed, and sink rate may be impaired due to lack of visual references
  - There is often a tendency to round out too high
  - A good rule is to start the roundout when the landing lights reflect on the tire marks on the runway
  - In the case you have no landing light/can't see tire marks, start the roundout when the runway lights at the far end appear to be rising higher than the nose of the airplane

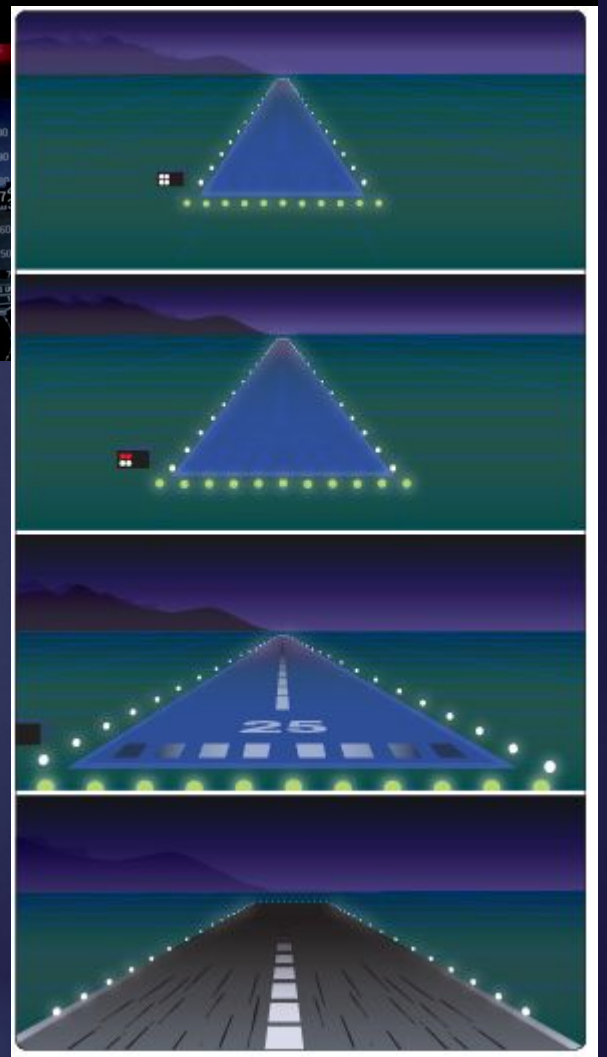


Figure 10-6. *Roundout when tire marks are visible.*

Approaches and landings with and without landing lights

- Locate the airport's rotating beacons
- The runway lights must be identified prior to an approach
- The tendency at night is to fly a wider pattern
- Setting a heading bug to the runway direction will help gain and maintain situational awareness
- Distance can be deceptive so you must be vigilant and paying attention to your instruments
- Fly at or above a glide slope if you have one
- At night, the judgment of height, speed, and sink rate is impaired by the scarcity of observable objects in the landing area
- The inexperienced pilot may tend to flare too high until attaining familiarity with the proper height for the correct round-out
- To aid in determining the proper round-out point, continue a constant approach descent until the landing lights reflect on the runway and tire marks on the runway can be seen clearly
- "Blackout landings" (landings without runway lights) should always be included in night pilot training as an emergency procedure

- Runway lights are not a requirement for landing at night; pilots may utilize lighted, and non-lighted runways all the same
- If there is no tower and the airport is unlit:
  - 3 clicks = low intensity
  - 5 clicks = medium intensity
  - 7 clicks = high intensity
  - If unable to located the airport, consider high intensity

Go-arounds

- Remember, you can always go-around
- If something doesn't look or feel right – go around
- Making this decision at night should be prompt
- Fly a normal go-around with more emphasis on your instruments
- Aviate Navigate Communicate