Visual Scanning and Collision Avoidance

Objective

To ensure the applicant learns the purpose of and can exhibit a clear understanding of visual scanning and collision avoidance procedures.

Purpose

Although the sky is a big place, mid-air collisions are unfortunately common occurrences, particularly around airports or in practice areas. This lesson introduces pilots to the concepts behind proper visual scanning and collision avoidance procedures, which will make them safer pilots.

Schedule

- **Ground Lesson**: 15 minutes
- **During Flight:** *Continuously*
- **Student Q&A**: 5 minutes

Equipment

- Whiteboard / Markers (optional)

Student Actions

- Ask any questions, receive study material for the next lesson.
- Watch linked video.
- Review listed references.

Instructor Actions

- Deliver the ground lesson (below).
- Answer student questions.

Completion Standards

- Student can explain the following concepts:
  - The human visual system and its limitations
  - The “see and avoid” concept
  - Proper visual scanning and clearing procedures
  - Barriers to visual scanning
  - Tools for reducing collision risks
  - Situations that create a higher risk of collisions

References

- ERAU SpecialVFR - “Collision Avoidance Precautions”
  - YouTube - https://www.youtube.com/watch?v=j3WOrhHBDMA
- FAA-H-8083-3C (Airplane Flying Handbook) - Chapter 8, Page 5-6 [Airport Traffic Patterns/Safety Considerations]
- FAA-H-8083-25C (Pilot’s Handbook of Aeronautical Knowledge) - Chapter 14, Page 28-30 [Clearing Procedures], Chapter 14, Page 31-33 [Runway Incursion Avoidance], Chapter 17, Page 19-29 [Vision in Flight]
- AIM-2024-03-21 (Aeronautical Information Manual) - Chapter 4, Section 4-14 [Visual Separation], Chapter 4, Section 4-15 [Use of Visual Clearing Procedures], Chapter 5, Section 5-8 [See and Avoid], Chapter 5, Section 5-10 [Traffic Advisories], Chapter 8, Section 1-6 [Vision in Flight], Chapter 8, Section 1-8 [Judgement Aspects of Collision Avoidance]
- FAA AC 90-48E (Pilot’s Role in Collision Avoidance)
- FAA AC 90-66C (Non-Towered Airport Flight Operations)
- FAA-S-ACS-25 (CFI ACS) - Area II Task B

Ground Lesson Outline

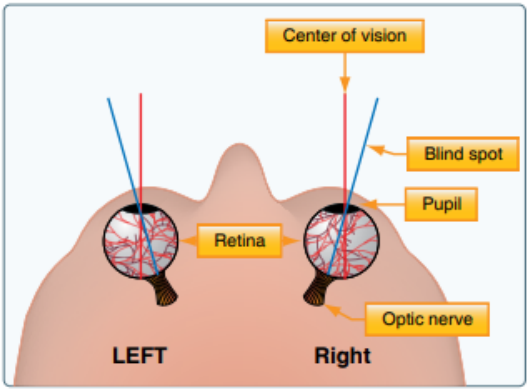
- Vision
  - Relationship of Physical Condition and Vision
  - Types of Vision - Photopic, Mesopic, Scotopic
  - Limitations of Vision - Fovea / Blind Spot
    - Day vs Night Vision - Rods, Cones, Night Blind Spot, Relaxed Intermediate Focal Distance
    - Environmental Conditions - Smoke, Haze, Dust, Fog
  - Vestibular and Visual Illusions
- “See and Avoid” Concept
  - Visual Cues of an Impending mid-air collision
  - Proper Visual Scanning Procedure - Distractions / Poor Scanning Habits -> Increased Collision Risk
  - Proper Clearing Procedures
  - Barriers To Visual Scanning
    - Limitations of Vision, Aircraft Blind Spots - High Wing vs Low Wing
    - Glareshield Reflections, Dirty Windshields
  - Tools for Reducing Collision Risks
    - Sunglasses, Crew Resource Management (ask for help)
    - Aircraft Lighting - § 91.209
    - CTAF/Practice Area Radio Calls
    - Right of Way Rules - § 91.113
    - Proper Non-Towered Procedures - § 91.126 (Class G), § 91.127 (Class E)
    - TIS-B (ADS-B In)
    - ATC and Flight Following
    - Traffic Calls - Nose Position (Clock System), Based on Ground Track
    - Synthetic Vision Systems
    - Knowing Minimum Safe Altitudes
- Mid-Air Collision Risk Factors
  - Relationship between aircraft speed differential and collision risk
  - Situations that involve the greatest collision risk - Non-towered airports, most accidents during daytime!

Common Errors

- Improper visual scanning techniques
- **Failure to scan outside cockpit**

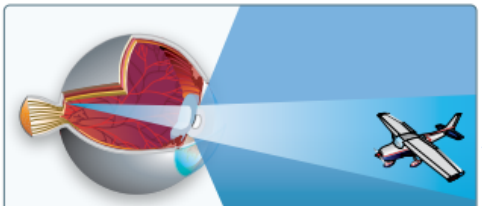
Ground Lesson Content

- **Vision** - The primary tool pilots have for reducing the risk of collisions with terrain or other aircraft is their vision, however human vision has some important limitations.
    - **Relationship of Physical Condition and Vision** - Vision is dependent on being in proper physiological condition. Fatigue can reduce visual acuity. One of the most important factors, however, is *hypoxia*. Human vision is significantly degraded when at high altitude, and **at night, human vision is significantly degraded above only 5,000 feet without supplemental oxygen**.
    - **Types of Vision** - There are 3 types of vision, which are active in different light levels:
        - **Photopic** - Active in well-lit situations only, best visual acuity, color vision.
        - **Mesopic** - Active in medium-low light situations, dawk/dusk/moonlight. Mixture of color and non-color vision. **Considered the most dangerous lighting condition for collision avoidance**, acuity varies, both day and night blind spots are present at times.
        - **Scotopic** - Used in low-light situations only, low visual acuity, no color vision.
    - **Limitations of Vision**
        - **Fovea** - Most of the human retina does not sense high-detail images. There is, however, a small section at the center of the visual field that during *daylight or well-lit scenes* resolves detail quite well. This area is called the *fovea*. The fovea contains both rods and cones, allowing it to sense color as well as intensity.



            - **Blind Spot** - There is also an area for each eye where the optic nerve attaches to the retina and where there are no rods and cones. The eye is completely blind in this section of the retina, however the human brain generally 'covers' this deficiency such that it is difficult to notice. **In the image below, if one eye is closed and the other eye focuses on the X, at a certain focal length the airplane on the left will cease to be visible.**

        - **Day vs Night Vision** - There are two types of



cells in the retina, *rods*, and *cones*. Cones are responsible for all color vision, but have poor low-light capability. Rods are extremely sensitive to low-light situations, but do not sense color. During night situations, only the rods are active. Because the rods are extremely sensitive, it is easy for them to be overwhelmed. Pilots must take care to let their eyes adapt to the dark, avoiding bright light sources.

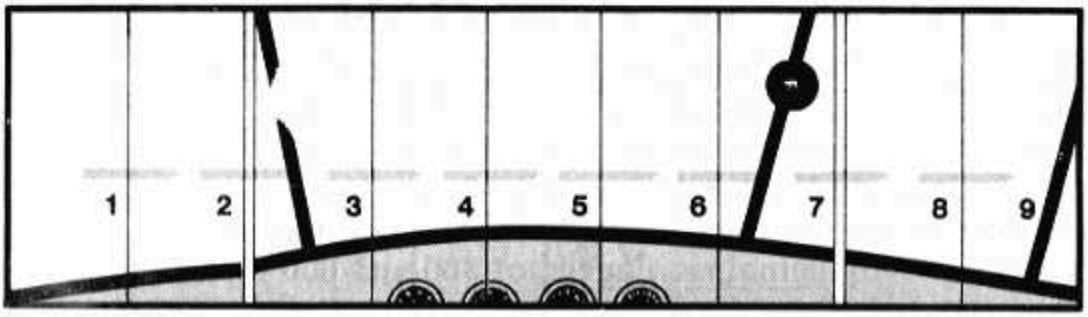
- **Night Blind Spot** - Because the fovea is populated primarily with cones, the center of the visual field is only usable during well-lit situations. At night, when the vision provided by rods dominates, there is effectively a *night blind spot*, where the lack of rods in the fovea create an area of low-light blindness. To account for this deficiency, pilots must use off-center viewing at night.

- **Relaxed Intermediate Focal Distance (Empty Field Myopia)** - There is another visual system limitation called *empty field myopia*. When there is nothing definite for the eyes to focus on (as in hazy or foggy conditions), the eyes naturally relax to a very short focal distance, called the *relaxed intermediate focal distance* (10 to 30 feet). This effectively eliminates forward visual acuity entirely. Pilots must concentrate on the scene outside and force their eyes to focus on distant light sources in order to see properly.
- **Environmental Conditions -** Smoke, Haze, Dust, and Fog all dramatically reduce the contrast of the visual scene and by causing empty-field myopia, make it difficult to focus on distant objects. Additionally, the visual system relies on haze as a sort of visual clue for distance, and objects in hazy scenes may seem further away than they actually are.

- **Vestibular and Visual Illusions** - The human brain is highly dependent on the visual and vestibular systems for determining orientation and position. These systems are subject to several kinds of illusions that can cause spatial disorientation and increase the risk of collisions with terrain.
  - See related lesson on *Aeromedical Factors* (Area II, Task A).

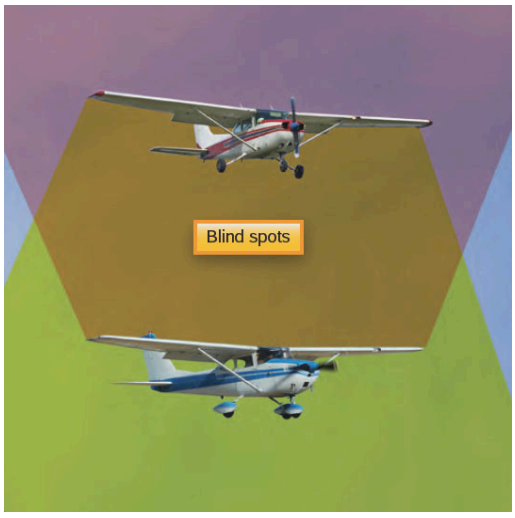
- **“See and Avoid” Concept** - VFR flying provides an exceptional degree of freedom to pilots, but at the cost that, since there is no requirement to be on a flight plan or be receiving ATC services, pilots are solely responsible for avoiding collisions with other aircraft and terrain. This concept is referred to as “see and avoid”, and it requires pilots to maintain vigilance at all times during flight to prevent collisions.
  - **Visual Cues of an Impending Collision** - Unfortunately, two aircraft on a collision course will appear to have no relative motion, and therefore they may be hard to notice. However, as an object approaches an observer's eye, it enlarges rapidly in the field of view. There is evidence that humans are able to distinguish the relative expansion rate of the object's image on the retina, and approximate the time to collision (TTC). This may subconsciously draw your

attention, but **prompt action will be required to avoid a collision!**
    - See: https://jov.arvojournals.org/article.aspx?articleid=2121255
- **Proper Visual Scanning Procedure** - Because of the limitations in the human visual system, namely that visual acuity is sharpest only at the very center of the visual field, pilots must employ a procedure that uses brief pauses to visually scan segments of the sky, as shown below. Note that at night, pilots should intentionally look off-center to avoid the night blind spot.

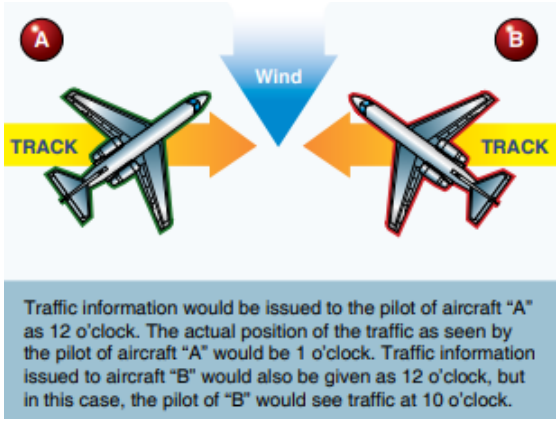


Side-to-Side scanning method. Start at the far left of your visual area and make a methodical sweep to the right, pausing in each block of viewing area to focus your eyes. At the end of the scan, return to the panel.

- **Distractions and Poor Visual scanning Habits -> Increased Collision Risk** - Failure to adequately scan outside the cockpit (sometimes due to distractions) creates a large risk of a mid-air collision.
- **Proper Clearing Procedures** - Before performing certain maneuvers, it is crucial for pilots to visually ensure that the area is clear of other traffic and obstacles.
    - **Before Entering Runways** - Before entering any runway, even when cleared by ATC, pilots should visually scan the final approach path *at both ends* of the runway.
    - **Climbs/Descents** - It may be necessary to momentarily level off at intervals to scan for traffic.
    - **Straight and Level, Before Turns** - The normal visual scan should be used during cruise flight. In high wing airplanes especially, pilots should raise a wing to ensure the area is clear before beginning a turn.
    - **Before Maneuvering** - Before doing any maneuvers or air work, pilots must clear the area by performing at least 2 90 degree turns left and right, while looking for other traffic.
    - **Before Landing** - Before landing, even when cleared by ATC, pilots should visually confirm the runway environment is clear.
- **Barriers To Visual Scanning**
    - **Limitations of Vision** - Human visual system limitations described above.
    - **Aircraft Blind Spots - High Wing vs Low Wing** - High wing airplanes tend to be blind to the sides and above the airplane. Low wing airplanes are blind to the side and below the airplane. This can lead to extremely dangerous situations. There have been many accidents involving a low-wing airplane descending on top of a high-wing airplane on a simultaneous final approach at an uncontrolled airfield. To avoid this, pilots can make gentle S-turns to gain some visibility above and below, and exercising vigilance in airport traffic patterns.



    - **Glareshield Reflections, Dirty Windshields** - If the windshield is not properly cleaned, reflections, dirt, and oil residue can make it difficult to scan properly.
- **Tools for Reducing Collision Risks** - Pilots have a few important tools for reducing collision risks:
    - **Sunglasses, Crew Resource Management (ask for help)** - Wear sunglasses, employ proper scanning procedures, and ask passengers to help scan for traffic. (Divide the scanning responsibilities)
    - **Aircraft Lighting - § 91.209** - Flying with landing lights and strobes on at all times can reduce collision risk. Flying with nav lights on at night is required.
    - **CTAF/Practice Area Radio Calls** - Proper radio calls can supplement visual scanning to make other pilots aware of where they should be looking.
    - **Right of Way Rules - § 91.113** - Obey proper right-of-way rules, which create predictable behavior that minimizes collision risks when used properly.
    - **Proper Non-Towered Procedures - § 91.126 (Class G), § 91.127 (Class E)** - Proper pattern entries, and flying proper patterns (e.g. no right-hand patterns when not authorized by A/FD or ATC)
    - **TIS-B (ADS-B In)** - Traffic data from ADS-B can greatly assist maintaining situational awareness.
    - **ATC and Flight Following** - Use ATC services to assist with traffic avoidance.
        - **Traffic Calls** - ATC will call out traffic using their position relative to the nose, e.g. **"Traffic, 1 o'clock, 1 mile, 3,000 feet indicated"**
            - **Note:** ATC does not know your actual heading, and so clock positions are based on your ground track!



    - **Synthetic Vision Systems** - Synthetic vision systems can help with terrain avoidance.
    - **Knowing Minimum Safe Altitudes** - Know the minimum safe altitude for each area and maintain it.

- **Mid-Air Collision Risk Factors**
  - **Relationship between aircraft speed differential and collision risk** - Faster moving airplanes converge much more rapidly, and create a higher collision risk.
  - **Situations that involve the greatest collision risk** - Anywhere many airplanes are converging is a high risk area for collisions. Airport traffic areas, particular the final approach leg, are dangerous because many other pilots commonly use non-standard pattern entries. Practice areas are also highly dangerous, with many airplanes maneuvering in a small area across a wide range of altitudes.
    - **The vast majority of mid-air collisions occur at non-towered airports during daytime, clear conditions!**