UAS 1010-51

sUAS Loading and Performance

Lesson 4: General loading and performance

Loading and Performance: Objectives

- To determine that the applicant is knowledgeable in the loading and performance of an sUAS.

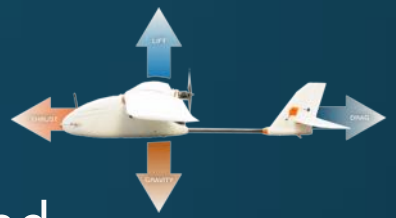
Flight Manual

Operational and performance information you will want to get from the manufacturer's manual:

- Takeoff
- Climb
- Range
- Endurance
- Descent
- Landing.

Flight Manual – Loading Performance

Understanding the Four Forces



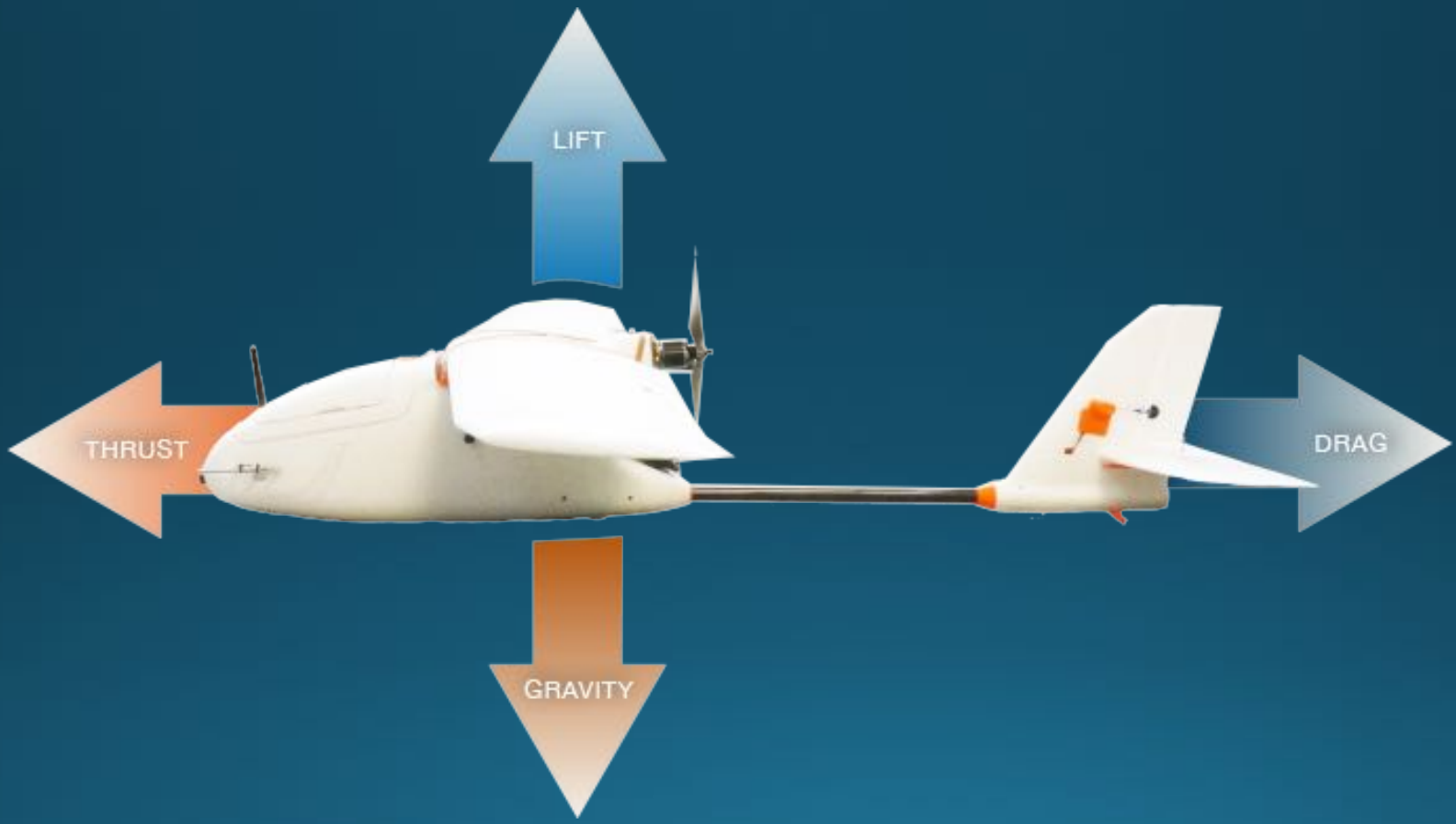
Thrust (Power) is the force that propels an unmanned aircraft in the direction of motion. Engines produce thrust. Propellers product thrust.

Drag (Friction) is the force that acts opposite to the direction of motion. Drag is caused by friction and differences in air pressure.

Weight (Gravity) is the force of gravity. It acts in a downward direction—toward the center of the Earth.

Lift is the force that acts at a right angle to the direction of motion through the air. Lift is created by differences in air pressure. In a turn, it is the horizontal component of lift which makes the aircraft turn.

Aerodynamic Forces



Effect of changes in the four forces.

- An increase in lift always results in an increase in drag.
- Whenever a force is out of balance with its opposite, the aircraft will accelerate or decelerate in the direction of the larger force.

- Examples:

  Lift > Weight, aircraft climbs.

  Thrust > Drag, aircraft speeds up.

- Equilibrium

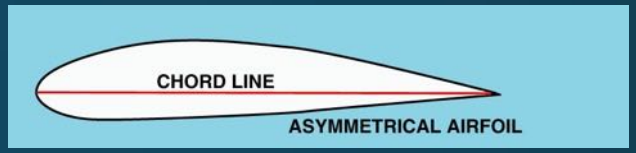
  A condition where lift equals weight and thrust equals drag.

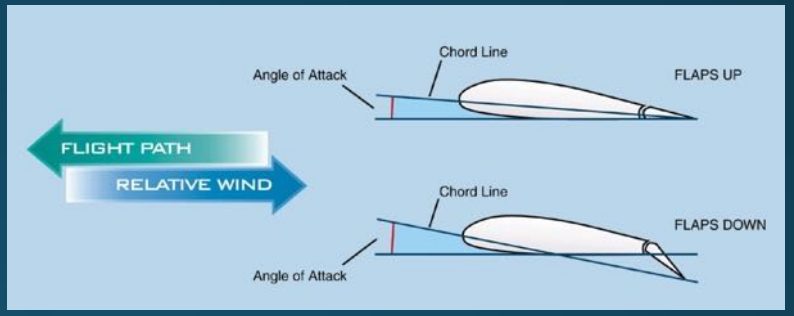
  Opposing forces are in balance.

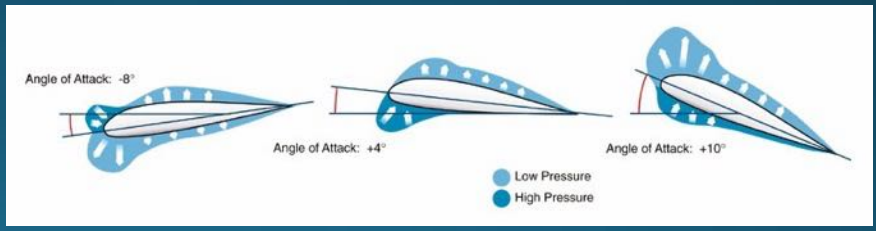
  When flying in a condition of equilibrium the aircraft will be in straight and level flight at a constant airspeed.

Aerodynamic Forces

- **Airfoil (wing or rotor):** A surface shape to produce an aerodynamic force or reaction.
- **Chord:** The straight line distance between the leading and trailing edges of an airfoil.
- **Relative Wind:** The oncoming airflow seen by an airfoil. It is always parallel to and in the opposite direction of the flight path.
- **Angle of Attack:** The acute angle formed between the chord line and the relative wind.

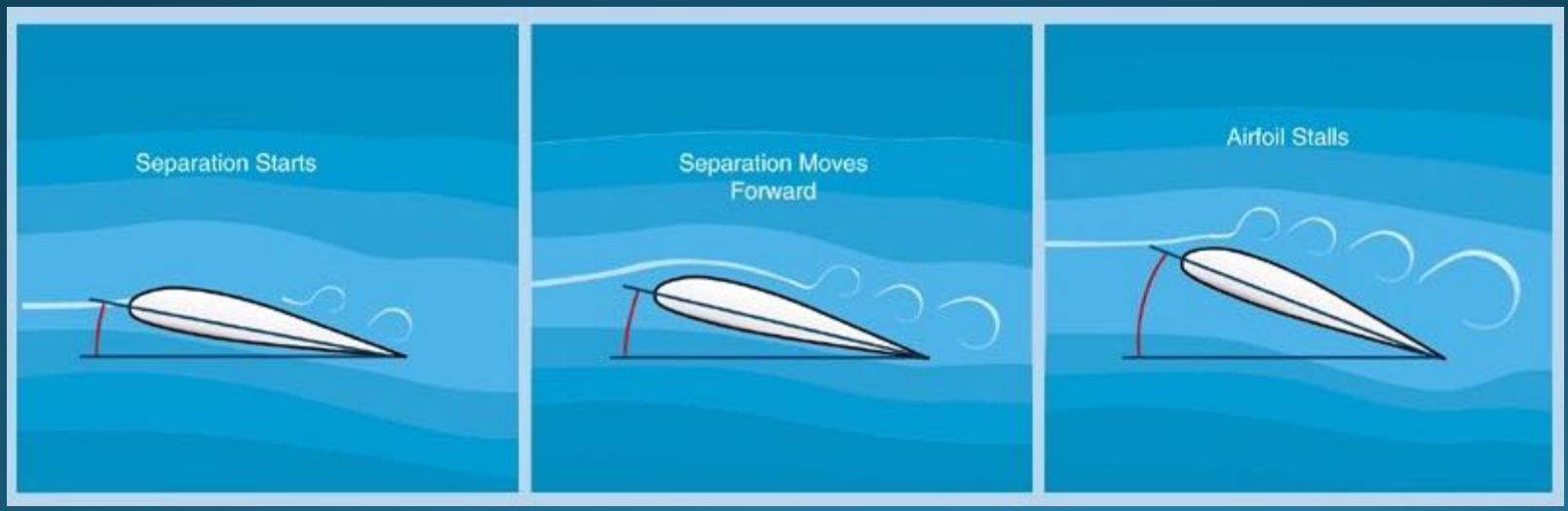






Stalls

- A stall occurs when the smooth airflow over the unmanned airplane's wing (propeller) is disrupted, and the lift degenerates rapidly, which can ultimately cause your aircraft to fall. In a stall, your wing cannot generate adequate lift to sustain level flight, and this happens when a pilot exceeds the critical angle of attack (AOA).
- The angle of attack is defined as "the angle between the chord of an airfoil and the direction of the surrounding undisturbed flow of gas or liquid". i.e. it is the angle formed by the wing (or propeller) and the relative wind, relative wind being the opposite of the direction of travel of the UA.



Loading and performance:
Effects of loading changes

Weight and Balance

- The Remote PIC must always determine:
  - Total Load – Maximum Gross Takeoff Weight
  - Balance of the aircraft – Center of Gravity
  - Ensure that they are within the manufacturer's specifications.
- Note that the manufacturer's specifications are for flying under "normal" conditions.

Effects of Loading Changes

- The acceptable Gross Takeoff Weight (GTW) must **always** be less than the manufacturer's specifications.
- Under specific circumstances it should be even less. Anything that affects the optimal flying conditions, i.e. other than "normal," must be taken into consideration when determinging the appropriate GTW, e.g.
  - Higher density altitudes - (higher elevations, temperatures, and humidity)
  - Runway/launch area length
  - Launch surface and slope
  - Surface wind
  - Obstacles.

Loading During Flight

- Any of these factors may require a reduction in weight prior to flight.
- The Remote PIC should consider that the load factor on the wings is increased any time the airplane is subjected to maneuvers other than straight-and-level flight. As during an emergency maneuver to avoid an obstacle.
- Excessive Weight Reduces:
  - Safety
  - The ability to respond to an emergency situation

Loading and Flight Performance

Excessive weight reduces the flight performance in almost every respect.

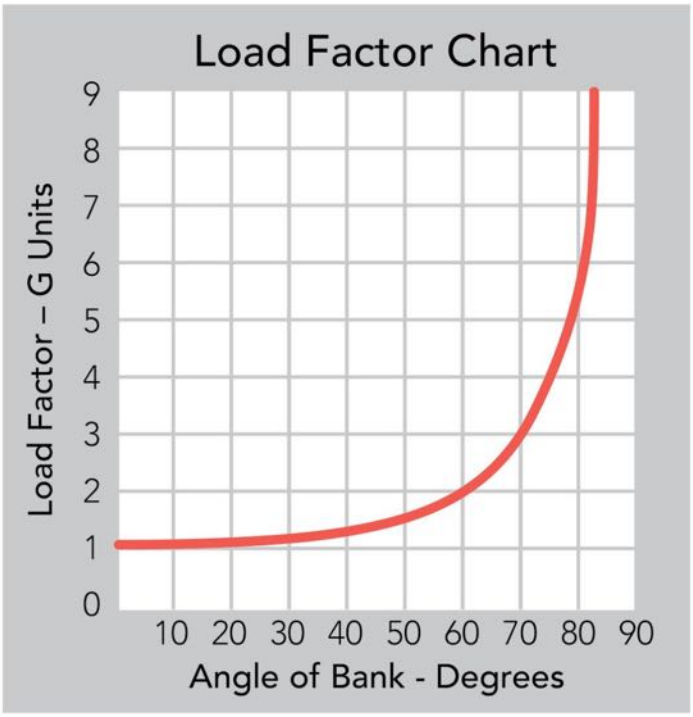
- Performance deficiencies of an overloaded aircraft are:

  - Higher takeoff speed
  - Longer takeoff run
  - Reduced rate and angle of climb
  - Lower maximum altitude
  - Shorter range
  - Reduced cruising speed
  - Reduced maneuverability
  - Higher stalling speed
  - Higher approach and landing speed
  - Longer landing roll

Load Factor Chart

- You may need to know how to read a Load Factor Chart for the Part 107 Exam.

Angle of Bank ϕ	Load Factor n
0°	1.000
10°	1.015
30°	1.154
45°	1.414
60°	2.000
70°	2.923
80°	5.747
85°	11.473
90°	∞



The Greater the bank angle the higher the load factor.

Under extreme turns (banks) the structural integrity of the aircraft may fail.

G Units – 1 G is a unit of force equal to the force exerted by gravity on a body at rest.

Load Factor Formula

- Load factor is the ratio of the total load supported by the aircraft's wings/airfoils (i.e., lift) to the actual weight of the aircraft and its contents:
- **Load Factor** =

$$\frac{\text{Total Load Supported by the Aircraft's Wings/Rotors}}{\text{Actual Weight of the Aircraft and contents}}$$

OR

Load Factor x Actual Weight of the Aircraft and its Contents = Total Load Supported by the Aircraft's Wings

The total weight of the aircraft and its contents is the

Gross Takeoff Weight (GTW)

Loading Example Calculation

sUAS GTW = 25 pounds,
While performing a 45° banked turn
AND maintaining altitude,
The aircraft would need to support a greater load, in this case, by a factor of 1.414. (See Loading Factor Chart)

To determine the Loading factor for a 45° banked turn:

Multiply the Weight of the aircraft and its contents by 1.414 (from the Loading Factor Chart).

25 lbs x 1.414 = 35.35 lbs

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60°	2.000
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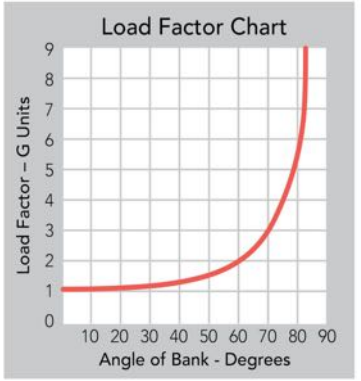

Loading and performance:
Balance, stability, and center of gravity

- Balance refers to the weight distribution of the sUAS relative to the the center of gravity (CG) that is usually determined by the design of the aircraft established by the manufacturer.
- Adverse balance conditions affect flight characteristics in much the same manner as excess weight.
- The CG is not a fixed point on the aircraft its location depends on the distribution of aircraft weight.
- As variable load items are shifted or expended, there may be a resultant shift in CG location.
- The remote PIC should determine how the CG will shift and the resultant effects on the aircraft.
- If the CG is not within the allowable limits after loading or does not remain within the allowable limits for safe flight, it will be necessary to relocate or shed some weight before flight.

Loading and performance:
Balance, stability, and center of gravity

- Stability is the inherent quality of an aircraft to correct for conditions that may disturb its equilibrium and to return to or to continue on the original flight path.

- Stability in an aircraft affects two areas:
  - **Maneuverability** - the quality of an aircraft that permits it to be maneuvered easily and to withstand the stresses imposed by maneuvers. It is governed by the aircraft's weight, inertia, size and location of flight controls, structural strength, and powerplant. It too is an aircraft design characteristic.
  - **Controllability** - the capability of an aircraft to respond to the pilot's control, especially with regard to flight path and attitude. It is the quality of the aircraft's response to the pilot's control application when maneuvering the aircraft, regardless of its stability characteristics.

Loading and performance:
Balance, stability, and center of gravity

- The center of gravity is (CG) the point at which your aircraft would perfectly balance if it were suspended at that point.
- The CG is determined by the distribution of the weight in the aircraft. (e.g. batteries, camera, radios, etc.)
- THE CG SHOULD BE CHECKED PRIOR TO ALL FLIGHTS.
- To ensure that the unmanned aircraft center of gravity (CG) limits are not exceeded, follow the aircraft loading instructions specified in the Pilot's Operating Handbook or UAS Flight Manual.