Subject Code & Name: **19AST302 FLIGHT DYNAMICS** **Date: 12.11.23**

DAY: **32** TOPIC: ***WEATHER COCKING EFFECT***

WEATHERVANE EFFECT.

Weathervaning or **weather cocking** is a phenomenon experienced by aircraft on the ground. As most of the side area of an aircraft will typically be behind this pivoting point, any crosswind will create a yawing moment tending to turn the nose of the aircraft into the wind.

WEATHERCOCK EFFECT

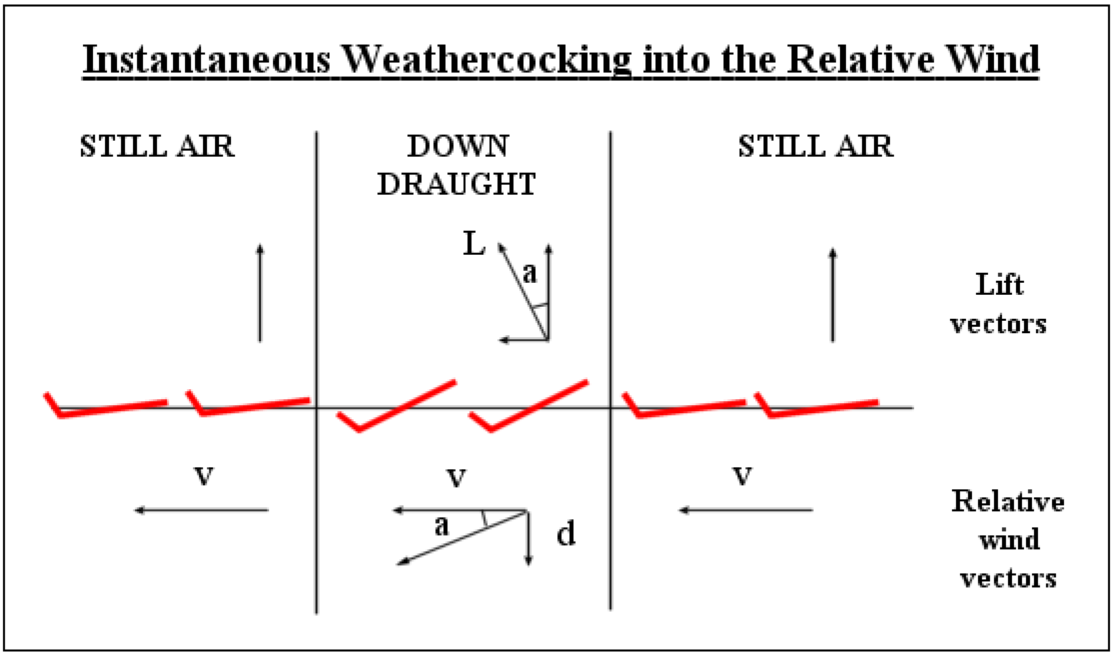
Whenever an airplane, originally flying with zero sideslip, develops a sideslip (β), the vertical tail tends to bring it back to the original position of zero sideslip. This effect is similar to that of the vane attached to the weathercock which is used to indicate the direction of wind and is located on top of buildings in meteorological departments and near airports When the vane is at an angle of attack, it produces lift on itself and consequently a moment about its hinge. This moment becomes zero only when the vane is aligned with the wind direction. Hence, the vane is always directed in a way that the arrow points in the direction opposite to that of the wind. The action of vertical tail on the airplane is also similar to that of the vane and helps in aligning the airplane axis with wind direction. Hence, the directional stability is also called weathercock stability.

TOPIC:***WEATHER COCKING EFFECT***

CASE STUDY:

The diagrams below depict an aircraft flying from left to right, first through still air, then through a down draught, then into still air again.

Case: 1 Instantaneous weather cocking into the relative wind

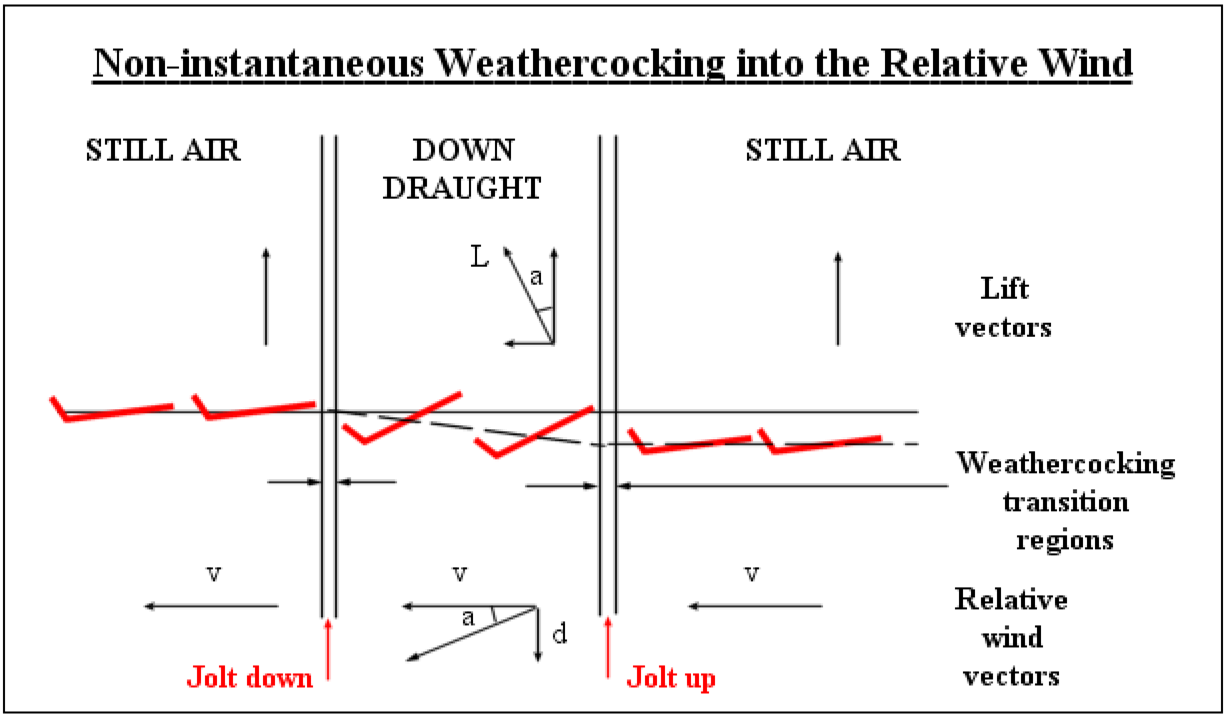


This diagram assumes that the aircraft weathercocks instantaneously to the new relative wind direction as soon as it enters the down draught by rotating about its center of gravity. If there is no change in engine thrust or trim, the lift vector, L, wil be greater than in stil air because the relative wind speed is greater, and it wil act at the angle "a" to the vertical adding to the induced drag. However I think that the increased lift and drag may be negligible and the aircraft wil effectively emerge again into stil air at the same altitude and speed that it started with.For example, the lift, L, in the down draught wil be increased over the stil air lift by the square of the increase in the relative wind, or by a factor of (v*2+ d*2)/v*2. The vertical component of this lift is [(v*2+ d*2)/v*2][v/((v*2+d*2)*0.5)] = (1+(d/v)*2)*0.5. We can get an idea of how big this factor (1+(d/v)*2)*0.5 is from some measurements made by NASA in 2000, when they flew an instrumented Boeing 757 through convective turbulence and in two encounters rated as "severe turbulence" measured maximum down draughts of 15.00 m/s and maximum up draughts of 18.41 m/s. However, these flights deliberately avoided direct entry into regions with the strongest radar returns.

If we assume a down draught twice as strong as the strongest measured by NASA, then d=30 m/s and the increased factor derived above (1+(d/v)*2)*0.5 = 1.02 if the aircraft is moving at 280 kts (as was NW 705), i.e. the vertical component of lift increases by only 2% with a down draught twice as strong as the strongest measured by NASA. So as I suggested above, these effects may be negligible and the aircraft may effectively emerge again into still air at the same altitude and speed that it started with.

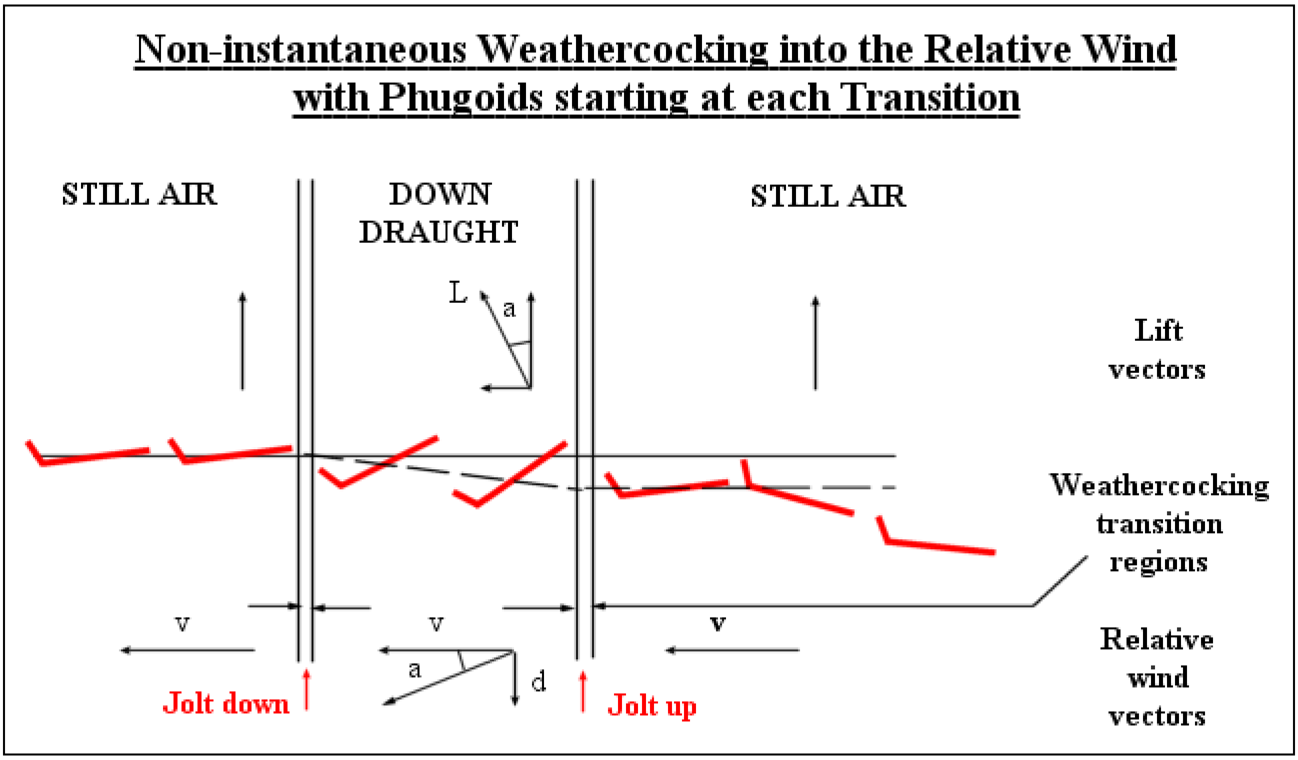
Case:2 **Non- Instantaneous weather cocking into the relative wind:**

This case assumes that the aircraft takes a finite time to weathercock into the new relative wind.



In the first transition region the plane wil experience a jolt downwards which will cause it to start to lose altitude, and during the second transition a very similar jolt upwards which will leave the aircraft flying about horizontal and at about the same speed but at a lower altitude. The wind and lift vectors are essentially the same as in Case 1. The difference betweenCase 1 and Case 2 is only that the jolt down initiates a loss in altitude which continues until the second, upward, jolt.

Case: 3 <u>Non-Instantaneous weather cocking into the relative wind with Phugoid staring at each transition</u>



This case assumes that in addition to everything that happens in Cases 1 and 2, each jolt will start a phugoid, the first initiating a pitch up rotation, while the second initiates a faster, potentially larger amplitude, pitch down rotation (assuming that there is no input from the pilot).This sequence in Case 3 is reminiscent of the words in the CAB report on the NW 705 incident quoted in an earlier post (but talking about an up draught rather than a down draught)Up draught causes an initial weather cocking pitch down into the relative wind followed “ultimately” by a pitch up and a gain in altitude. Down draught causes an initial weather cocking pitch up into the relative wind followed “ultimately” by a pitch down and a loss in altitude.

What is weather cocking?
Following the liftoff of a model rocket, it often turns into the wind. This maneuver is called weather cocking and it is caused by aerodynamic forces on the rocket. The term weather cocking is derived from the action of a weather vane which is shown in black at the top of the figure.

What is a Weathervaning?
Weathervaning or weather cocking is a phenomenon experienced by aircraft on the ground. Aircraft on the ground have a natural pivoting point on an axis through the main landing gear contact points [disregarding the effects of toe in/toe out of the main gear].

What is the definition of a weather vane?
A weather vane, wind vane, or weathercock is an instrument for showing the direction of the wind. They are typically used as an architectural ornament to the highest point of abuilding.