VI. HIGH LIFT DEVICES

1) Introduction

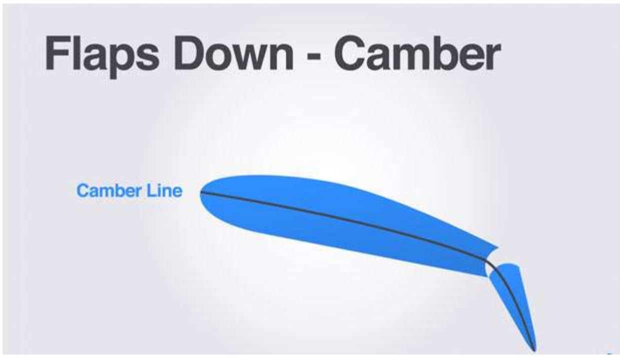
It has been seen that there is always a compromise between the lift and the drag when an aerofoil is made. Lift is very essential for flight, and the drag is an undesired force that unfortunately exist. An aerofoil that increases the lift will increase the drag and an aerofoil that reduces the drag will reduce the lift. Therefore the solution is to have an aerofoil that changes the camber and/or surface, in order to operate the aircraft with the highest performances.

To do that, we fit devices to the wings operated by the pilot, which will either extend to camber the aerofoil to increase the LIFT when the aircraft is required to fly a lower speed, and retract to reduce the camber to reduce the DRAG when the aircraft is required to fly a high speed.

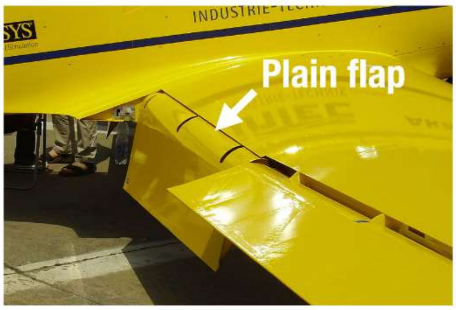
2) Trailing Edge High Lift Devices

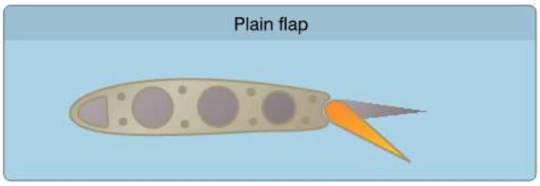
As stated in the name, the Trailing Edge High Lift Devices are part of the wing trailing edge operated by the pilot, and that will change the camber of the aerofoil by extending or retracting.

Those devices are called **FLAPS**, and they are located at the inboard wing.

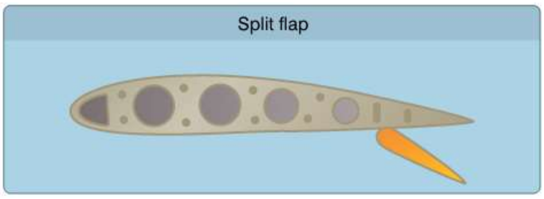


Many type of FLAPS exist and each one will change the aerofoil characteristics.

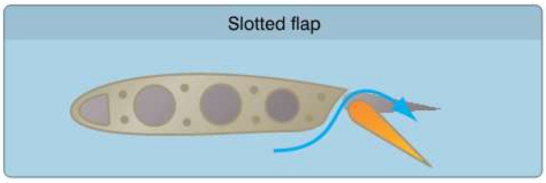




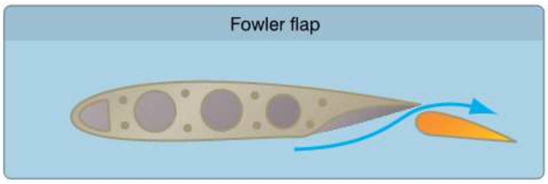
The rear portion of aerofoil rotates downwards on a simple hinge mounted at the front of the flap. Simply the camber is increased, C_{Lmax} increases however C_D increases significantly. Due to the greater efficiency of other flap types, the plain flap is normally only used where simplicity is required.



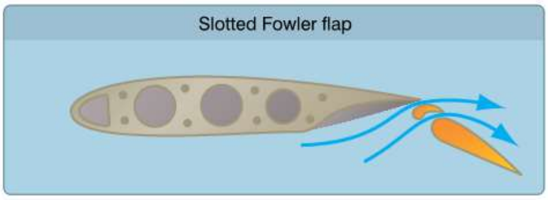
The rear portion of the lower surface of the aerofoil hinges downwards from the leading edge of the flap, while the upper surface stays immobile. A split flap has slightly better C_{Lmax} than a plain flap, but more drag, and at full deflection, it acts much like a spoiler.



A gap between the flap and the wing allowing the PGF to accelerate the high pressure air from below the wing over the flap helping the airflow remain attached by to the flap by increasing its kinetic energy. This will reenergize the boundary layer and generates more lift and less drag compared to a split flap.

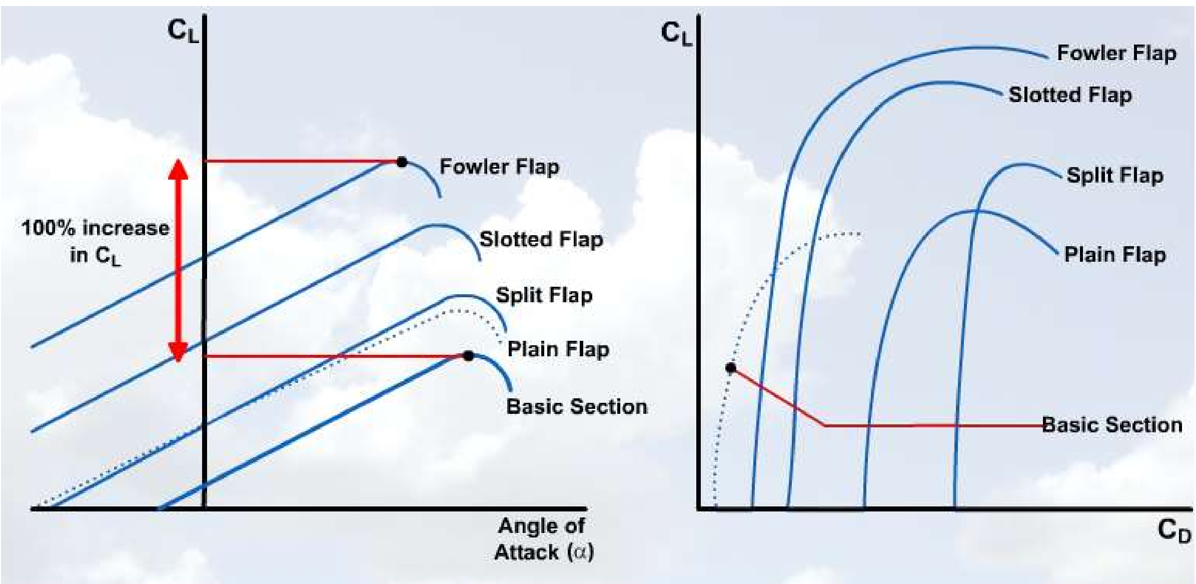


When you need serious lift, you need serious flaps, and Fowlers are there to make it happen. Fowler flaps increase the area of your wing by extending out on rails or tracks. Fowler flaps often have a series of slots to add energy to the airflow as well - they're called slotted-Fowler flaps



In the first stages of a Fowler flap's extension, there's a large increase in lift, but little increase in drag. As they continue to extend, the flaps move downward more and more, creating a little more lift, but a lot more drag. By increasing the area and the camber, and reenergizing the boundary layer, they significantly increase C_{Lmax} while the drag increases less.

Since the flaps increase the camber, **C_{Lmax} will increase**. However it will be more cambered at the rear of the aerofoil, which mean the adverse pressure gradient at the rear is significant and the aerofoil will stall at a lower AoA; **AoA_{CRIT} decreases.**



Comparison of Trailing Edge Flaps.

Take-off and Landing

As it can be seen on the graphs, the flaps will increase the C_L significantly compared to the C_D, however at a higher angle, the C_L increases at a lower rate and the C_D increases significantly.

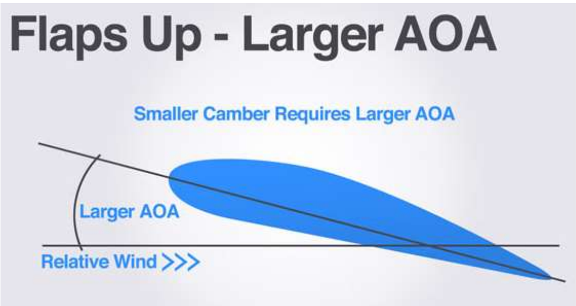
The flaps are very helpful for take-off. They shorten the take-off distance, since they increase the C_L, it means that a lower airspeed is required to be built up to generate the sufficient lift to take-off. However, excessive flaps angle will certainly provide more lift, but also too much drag, and now the aircraft is not accelerating less to reach the required speed to take-off, meaning that the drag penalty will now increase the take-off distance. So only a low flaps angle setting will be selected for take-off. Each aircraft has its own optimum flaps setting for take-off, but it will never be full flaps setting.

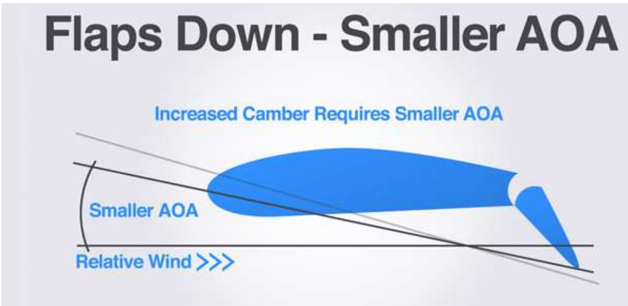
The full flaps angle setting can be selecting for landing. Indeed they will increase C_L higher allows the aircraft to maintain a lower airspeed for approach and decelerate on a shorter distance, but also they will increase significantly the drag which will the aircraft to decelerate more during landing and shorten further the landing distance.

Flaps operation

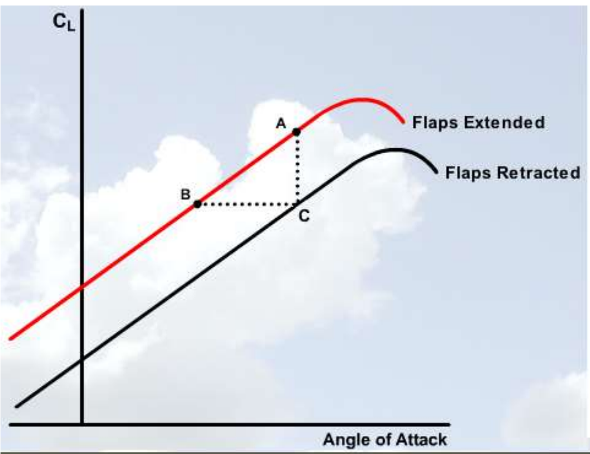
When the flaps are extended, in order a straight and level flight, the lift has to remain constant.

For the same airspeed, since the flaps increase C_L, so the AoA must be reduce to bring back CL to its initial value. So actually C_L is constant but the AoA is lower.

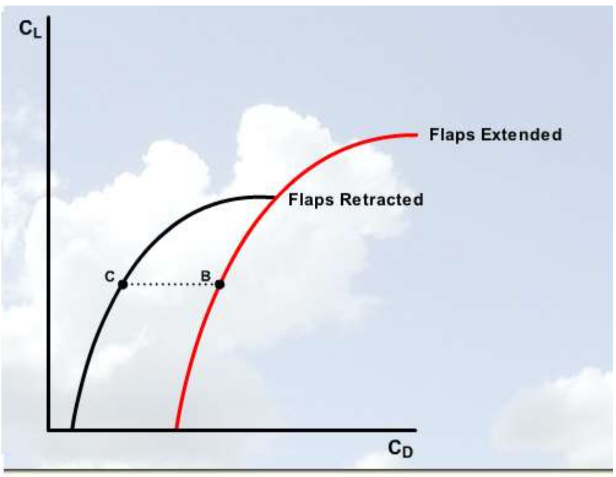




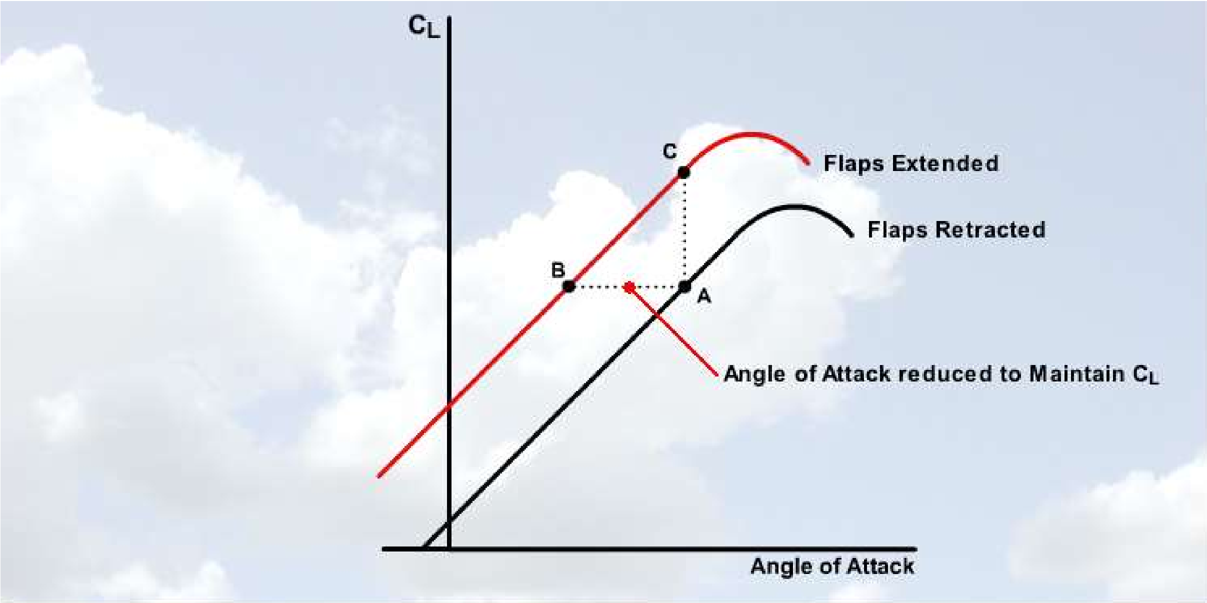
After take-off, when retracting the flaps, the pilot must increase the AoA (from B to A) to maintain the same C_L (at C) otherwise the lift will drop if the AoA isn't increase (sometimes after take-off, it can be felt that the aircraft is falling when retracting the flaps). This will also allow the aircraft to go faster by lowering the drag.



Flap Retraction After Take Off.



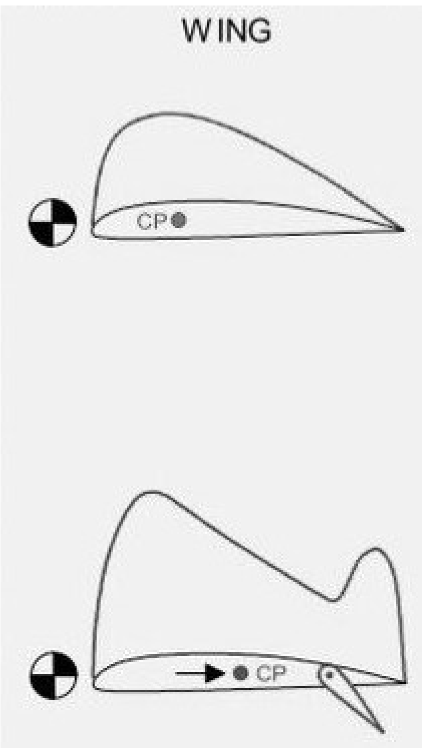
During the approach, when the flaps are lowered, to keep the same C_L will increase (from A to C), to keep it constant the AoA must be lowered (from A to B) otherwise the lift will increase and the aircraft will gain height.

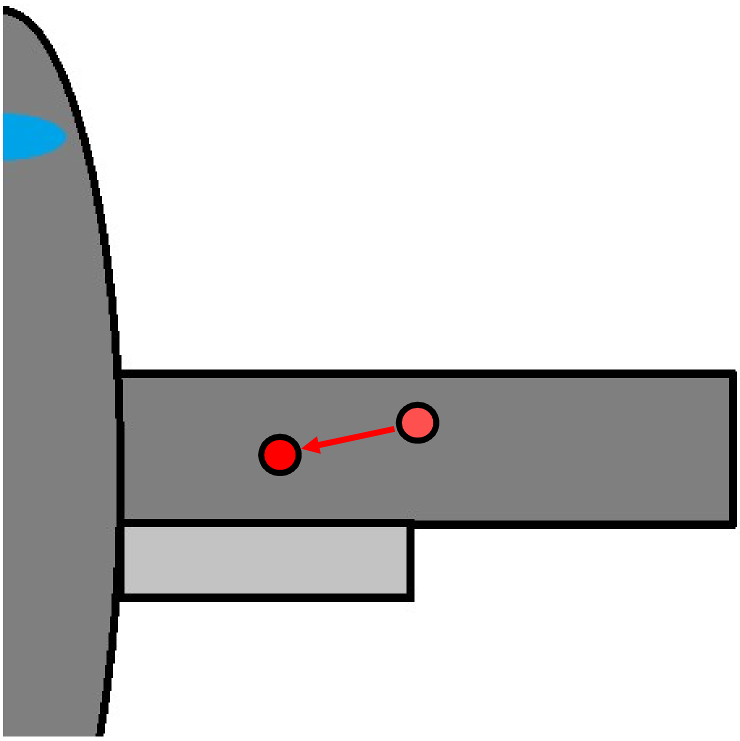


Flap Selection for Approach and Landing.

CP movement

When the flaps are extended, since the rear part of the aerofoil generate more lift, the CP will move afterward. As well, since the flaps are located at the inboard wings, the inboard wings will generate more lift, so the CP will move toward the inboard wing.

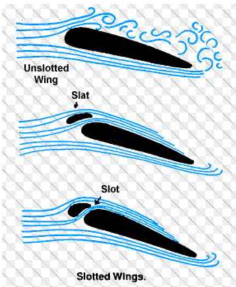


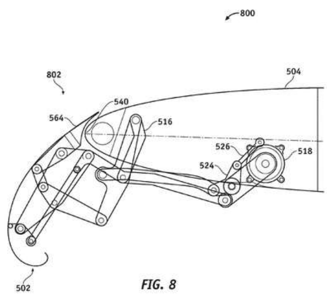


3) Leading Edge High Lift Devices

As stated in the name, the Leading Edge High Lift Devices are part of the wing leading edge operated automatically. They are either coupled to the flaps system or extended and retract movement of the stagnation point, and that will change the camber of the aerofoil by extending or retracting.

Two types of Leading Edge High Lift Devices exist: the **Slats** or the **Krueger Flaps**.





SLAT/SLOT **KRUEGER FLAPS**

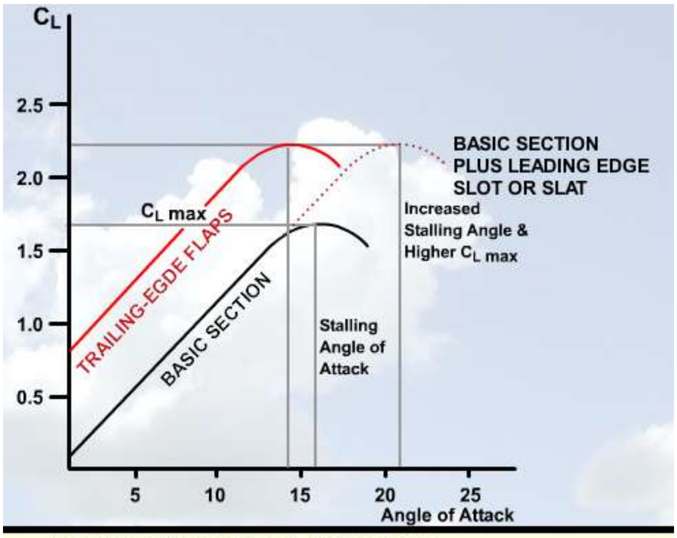
The **Slats** and **the Krueger Flaps**, when extending they will camber the aerofoil at the front which increases C_{Lmax} and increase the surface. However the slats form a **slot** which will reenergize the boundary layer and delay separation which increase C_{Lmax} more than the Krueger flaps, however they are more complex during production.

Since the Leading Edge High Lift Devices increase the camber, **C_{Lmax} will increase**. Also, it will be more cambered at the front of the aerofoil, which mean the airflow will be more accelerated and has a higher kinetic energy, this means that the airflow separation is delayed and the aerofoil will stall at a higher AoA; **AoA_{CRIT} increases.**

Simply remember:

<u>Trailing Edge High Lift Devices:</u>
Increases C_{Lmax} and **decreases AoA_{CRIT}**

<u>Leading Edge High Lift Devices:</u>
Increases C_{Lmax} and **increases AoA_{CRIT}**



Leading-Edge High-Lift Devices.