**How to shop for aeroplanes**

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We go shopping every day to buy necessary goods. We consider the quality of the product, the company that made it, and maybe even look at online reviews. When it comes to electronics or mechanical items, we always check the performance parameters.

**Rahim and his family**

Consider a particular case here. Rahim's family decides to get a 4-wheeler for general transportation. There are 5 members, and they live in a crowded city. Rahim is the earner for the family, and he is not that rich. They choose to select a vehicle based on its performance. They consider three four-wheeler types: 1. bus, 2. truck, and 3. car, and pick three performance features: 1. Horsepower (how much load the vehicle can pull), 2. Fuel consumption, and 3. Turning radius (mimimum radius of curvature needed to make a turn). While a bus and truck has more power (about 200 HP), it uses more fuel per litre (it travels less than 10 km per litre while a car gives 15) and requires a large turning radius (more than 6 m, while a car needs less than 5 m). You can see that a bus or truck is not useful. Rahim is left with only the car, based on the performance parameters that he had selected.

**Shopping for aeroplanes**

While going to shop for aeroplanes, one has to note some exciting performance parameters before purchasing. In fact, those different parameters result in a wide range of aeroplane configurations being in existence. Like the Rahim family, if a country decides to get an aeroplane to transport their citizens from one place to another or defend their airspace from enemy intrusion, it has to carefully monitor: 1. *Thrust to weight ratio*, and 2. *Lift to drag ratio*. There are many other important performance parameters that one must consider while shopping for planes. Still, we seek the ones mentioned above to determine the vehicle's overall shape, structural limit, and propulsion requirements in a global sense.

**Level flight**

In a level flight, when the aircraft reaches the necessary speed and holds its speed, being horizontal to the ground, the net forces acting on the body are zero. Consider the figure where the plane is in level flight. The **drag** and **thrust** force balance each other horizontally, whereas the **lift** and **gravity** balance each other in the vertical direction.

BOX on **Forces on an aeroplane**

**Thrust** is the force which moves an aircraft through the air.

The aeroplane gains **lift** using the wings. However, there should be air flow around the wings to produce lift, so the wing needs to be traveling at high speed. The high-speed comes from the *propulsion unit* available in the aircraft, like an engine in a car. But a moving vehicle will always produce a **drag** force that acts against the direction of motion. Thrust overcomes both the drag as well as the **weight** of the plane (coming from the action of **gravity**).

**END OF BOX**

Drag can be reduced by altering the shape of the vehicle. You may have seen sports cars which are aerodynamically shaped. Fast trains have long “noses”. Reducing drag also increases the speed.

You have to also look at the payload weight. If you carry a heavy payload, you need to produce sufficiently enormous lift to keep the vehicle airborne. This is one of the primary reasons why a housefly and an eagle do not have the same wingspan (that is, the distance from tip to tip of the two wings). The body weight of an eagle is relatively more than a housefly. Thus, the four forces mentioned above and their ratio in a leveled flight determine the aeroplane's behavior.

**Thrust to weight ratio, T/W**

Thrust and weight determine the vehicle's ability to climb high really quickly. Look at the figure that explains the climbing flight. Here the thrust force balances the drag force and the entire vehicle's weight. For a passenger aircraft, climbing almost instantly is not a requirement. It imparts serious 'g-forces' and causes severe discomfort to the passengers.

On the other hand, during war-time, the fighter aircraft on the ground should go to the necessary altitude as quickly as possible to neutralize the threat of a bomber enemy aircraft. Similarly, for interplanetary missions or for launching satellites, one has to reach space and cross the dense atmosphere as soon as possible. It will help to save fuel and reduce severe aerodynamic loads on the vehicle during rapid acceleration. This is only possible by gaining altitude almost through a vertical climb. Hence, for the passenger plane, T/W is lesser than the fighter plane.

Similarly, for a space shuttle, T/W is larger than the fighter plane. Look at the following table for a brief summary of T/W values in different aircraft. Note: The jet exhaust is entirely different for different T/W, as the propulsion systems are diverse for each of the cases.

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| --- | --- | --- |
| **Airbus A380** (passenger plane) | T/W = 0.227 | L/D = 20 |
| **MD F-15** (fighter plane) | T/W = 1.04 | L/D = 4 |
| **Space shuttle** | T/W=1.5 -3 | L/D = 1 |

**The lift to drag ratio, L/D**

The second parameter we would like to discuss is the lift to drag ratio or L/D. If the body is aerodynamically shaped, then the drag forces are less. It means that the vehicle can travel at high speeds—High-speeds help produce significant lift. We can also achieve lift increment by having a more enormous wingspan. A fighter aircraft with a small wingspan needs to move at a considerable velocity to generate a high lift which puts a high demand on the propulsive requirements.

On the other hand, look at the glider. A hand-operated glider achieves lift at a running speed itself. The energy expenditure in gaining speed is much much less than the fighter plane. Thus, the L/D signifies the aerodynamic and power aspects of the flying vehicle.

**Birds and their wing span**

Consider the following case, a *house sparrow* with an L/D of 4 and a wingspan of 0.25 m flies at a top speed of 45.5 km/hr. On the contrary, an *albatross* with an L/D of 20 and a wingspan of about 3 m outpaces the house sparrow while flying at 107.8 km/hr.

**Planes and their wing span**

Higher L/D reduces the power requirements to overcome the drag, and the excess energy can be used to gain speed. Another exciting feature of L/D can be put to use for getting good endurance from a plane. Flyers like the Virgin Atlantic Global Flyer can cover a longer distance by consuming less fuel with an L/D of 10. It can be pushed to an extent such that the plane can cover the globe at least once without refueling.

Similarly, reconnaissance flights like Lancer U2 need to take pictures of the enemy territory without being spotted by the enemy flights or radars. Hence, it has to fly at a high altitude. At high-altitude, air density is less, and the vehicle needs to fly at high speed to maintain the lift. A large wingspan will increase the L/D, and in the U2 plane, one could see that the wingspan extends to 31 m tip-to-tip, which generates an L/D of 20 at a top speed of 880 km/hr. To summarize, just like the examples in the previous case, a passenger aircraft possesses a high L/D of 20 to save fuel, whereas a highly maneuverable fighter has only an L/D of 4. A space shuttle that relies on its sheer thrust-producing capability possesses only an L/D of 1.

There are many design and performance parameters to consider for a specific aeroplane mission. Next time when you see an aeroplane picture or a bird or a glider, try comparing the outlook through these parameters.