Saturn-V marked the beginning of the development of advanced technologies. But what would this project have looked like if it had been developed using modern algorithms? According to preliminary calculations, which need to be refined and verified, the Saturn-V launch vehicle could have carried a much larger payload. This is because the first and second stages of the launch vehicle would be lighter, keeping all their characteristics unchanged, and replacing the F-1 and J-2 engine sets with modern designs with the same fuel components. At the same time, the Lunar Programme would become more affordable.

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BASIC PRINCIPLES OF BEES` AND BUTTERFLIES` FLIGHT

For the movement of artificial devices there is a commonly used impulse, which is created by a path for expelling a part of the air into the opposite direction directly or behind the pulse of the reactive mass. At the same time, due to the run-up of the flow, control is carried out under the action of a force that compensates the force of gravity and ensures flight along a given trajectory.

Concerning insects, their flight is traditionally explained through Newtonian mechanics as the wings generate a downward flow of air, which propels the insect upwards. Nonetheless, a more accurate explanation of insect flight can be achieved by utilizing Newtonian mechanics that rely on the concept of mass flow rate [1].

In a hover, insect wings follow a symmetrical figure-of-eight pattern, moving back-and-forth from side-to-side. The wings maintain a positive angle of attack (AOA) on every stroke to pass through a mass of air each second (m/dt), which is accelerated to a velocity downwards (dv). The downward airflow can be assisted by leading edge vortices on the wings. This action creates a downward force ($Force_{DOWN}$ = ma = m/dt * dv) [4, p. 1]. See Fig 1. The inertia of the air generates a reactive equal and opposite upward force ($Force_{UP}$), which provides lift and pushes the insect upward. To generate lift, the wings transfer momentum and energy to the air [1].

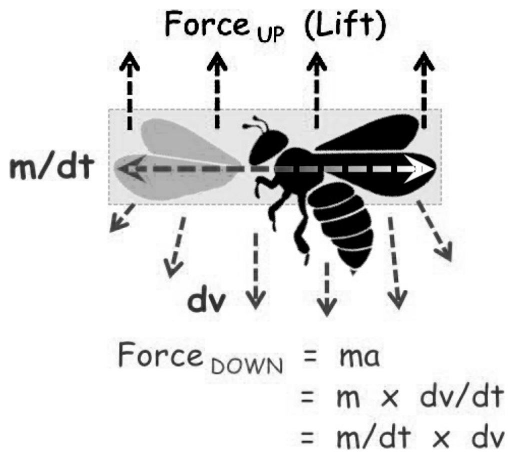

Fig. 1 – Insect hovering.

A key benefit of applying Newtonian mechanics based on the mass flow rate (lift = m/dt * dv), is that it enables the key components of lift to be analysed separately between: the mass of air flown through each second (m/dt) by the wings, and the velocity (dv) that this air is accelerated downward [4, p. 2].

It`s clear to see, that the total amount of lift generated by the different combinations of 'm/dt' and 'dv' can be shown graphically along a constant lift curve. 'm/dt' and 'dv' have an inverse relationship along a constant lift curve [4, p. 2]. See Fig. 2.

How lift is generated between 'm/dt' and 'dv' depends on things like aspect ratios, insect mass, and wing beat frequency.

The Newtonian approach can then be used to assess the energy-efficiency of lift generation for insects with different aspect ratios. The lower the aspect ratio, then the higher the proportion of lift generated from 'dv', as compared to 'm/dt'. Then the more energy-inefficient the lift generation process is, as kinetic energy is proportional to the velocity of the downwash (dv) squared (K.E. = $0.5\ mv^2$) [4, p. 2].

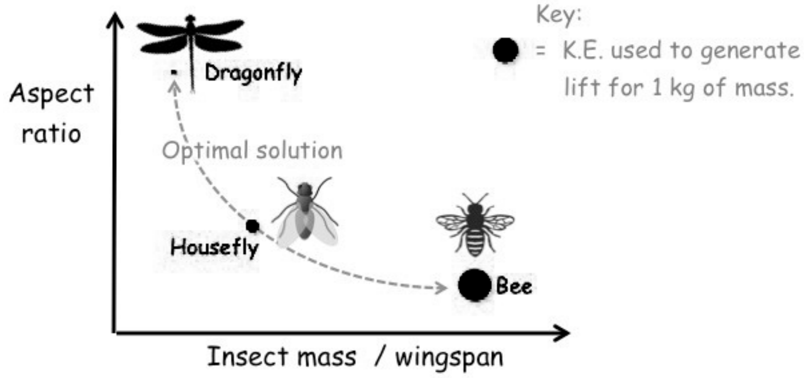

Fig. 2 – Graph of insect aspect ratio

For example, bees generate lift in a highly energy-inefficient manner because they rely heavily on accelerating a small mass of air (low m) downwards to a high velocity (high dv) to generate lift. A bee's short aspect ratio wings are optimal given its lifestyle collecting of nectar (high-energy food) from flowers and engaging in short, high-speed (high-energy) flight [2]. The Newtonian explanation for bees analyzes 'm/dt' and 'dv' separately:

- On each wing cycle, the bee's small wings pass through a small mass of air (small 'm')
- A high wing beat frequency means that the total mass of air pushed down each second is modest (modest 'm/dt'), compensating for its small wing area [3]
- A high wing beat frequency aggressively accelerates the air downwards to a high velocity (high 'dv'), to generate the required large amount of lift for their large mass [3]
- Overall, bees generate a large amount of lift, as shown by the equation: High lift = modest m/dt * high dv (see Fig. 3).

In contrast, the butterfly's large wings pass through a relatively large mass of air (large 'm') on each wing cycle. But the low wing beat frequency means produces a low 'm/dt' and a low downwash velocity (low dv) [1]. See Fig. 4.

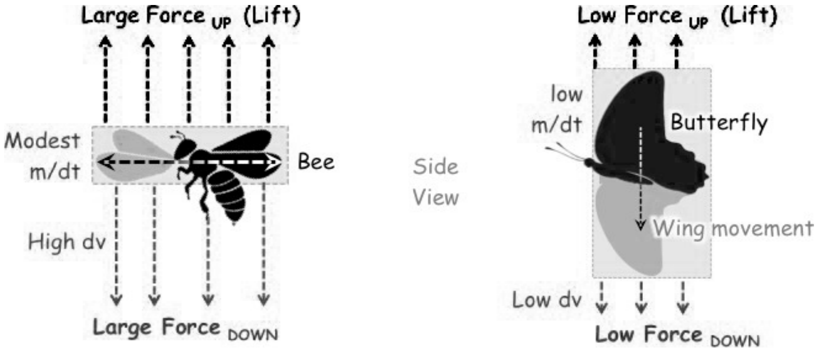

Fig. 3 – Bumblebee lift. 1

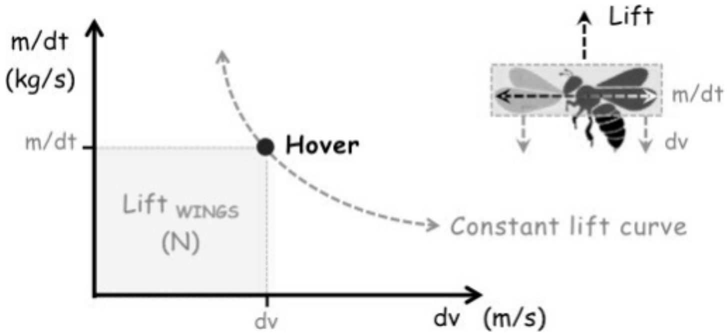

Fig. 4 – Graph of the constant lift curve 1

The wings can push air downwards by moving vertically up- and-down like a butterfly, or horizontally back-and-forth like a bumble bee; as long as a positive wing AOA is maintained [3].

In conclusion, Newtonian mechanics based on the mass flow rate can explain the physics of how insects generate lift to fly. This help to analyze the physics behind of lift between Newtonian and fluid mechanics. It should be possible to perform calculations and experiments that confirm the assertions above. For example, to prove that an insect in a hover accelerates a mass of air downwards each second to fly.

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