Planetary Aerodynamics: Lift and Stability of Disc-Shaped Aircraft on Earth, Venus, Mars, and Titan

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Introduction

People have been curious about flying disc-shaped machines for over 100 years. From old experimental planes to today's drones, engineers have always had the same problems: keeping them steady, making them lift off, and controlling air resistance [1].

Early Experiments (1910s)
Chance Vought "Umbrella Plane" (1911) - round wing, lift possible, but very unstable.

Fig. 1: Disc-shaped experimental plane. [2]

Post-WWII Projects
Avro Canada VZ-9 Avrocar (1950s–1960s)

Fig. 2: The Avrocar S/N 58-7055 [3]

Fig. 3: Avrocar 59-4975 [4]

VTOL disc aircraft, unstable above 3 ft ("hubcapping"), project cancelled 1961.

Fig. 4: Avrocar at the USAF Museum [5]

Fig. 5: Avrocar at the Air Force Museum, Dayton [6]

Modern Concepts (2000s-Present)
Small UAVs using Coanda effect for lift.
Still face issues: drag, stability, and control.

Fig. 6: UAV prototype [7]

Fig. 7: UAV prototype [7]

It would be interesting to further explore new disc shapes and rotation strategies to improve flight stability in different planetary atmospheres.

Objective and Hypothesis

Objective:
To study how disc-shaped aircraft behave in the atmospheres of Earth, Venus, Mars, and Titan, and to understand how their shape affects lift, drag, and stability.

Hypothesis:
The aerodynamic stability of a disc-shaped aircraft depends on its shape and the density of the atmosphere. Using stabilization methods, such as spinning discs, can improve stability, especially in dense atmospheres.

Methods

- Designed three disc-shaped sizes with different mass and area [8].
- Calculated lift for each disc using the lift formula [9].
- Compared lift in four atmospheres: Earth, Venus, Mars, and Titan.
- Variables used in lift calculations: air density (ρ), flight speed (V), lift coefficient (C_l), and disc area (S); weight calculations: weight (W), mass (m), gravitational acceleration (g) [1].
- Analyzed how disc-shaped size and atmospheric density affect lift and stability.

Lift formula:

$$L = \frac{1}{2}\rho V^2 C_l S \quad [9]$$

Weight formula:

$$W = mg \quad [1]$$

Parameters

Goal: disc aircraft designed to carry 2 people, fuel, and cargo.
Three disc sizes tested: radius 4 m, radius 4.5 m, radius 6 m.
Flight speeds analyzed: 20, 30, 40 and 100 m/s.

Atmospheric density used in calculations:
Earth (ρ = 1.225 kg/m³)
Venus (ρ ≈ 1.5 kg/m³, ≈50 km altitude)
Mars (ρ ≈ 0.020 kg/m³)
Titan (ρ ≈ 5.3 kg/m³)

Lift coefficient values tested:
C_l = 0.1 – flat disc, very low lift (historical simple designs)
C_l = 0.5 – moderate aerodynamic efficiency
C_l = 0.8 – optimized curved disc profile
C_l = 1.2 – high-lift design with advanced airflow control

Mass scaled with disc area to keep realistic structure and weight.

Results

Table 1: Lift and flight conditions for disc-shaped aircraft on different planets. Table created by student using Excel, 2026.

Planet	Radius (m)	Speed (m/s)	C	Lift (N)	Weight (N)
Earth	4	30	0.8	22,154	11,770
Earth	4	40	0.8	39,435	11,770
Earth	4.5	30	0.8	28,018	14,900
Earth	4.5	40	0.8	49,862	14,900
Earth	6	20	0.5	13,842	26,487
Earth	6	30	0.8	88,598	26,487
Mars	4	40	1.2	966	4,452
Mars	4.5	30	0.8	5,088	5,635
Mars	4.5	40	1.2	7,632	5,635
Mars	6	40	1.2	13,572	10,017
Mars	6	100	1.2	135,720	10,017
Venus	4	30	0.8	27,160	13,460
Venus	4.5	30	0.8	34,344	13,460
Venus	4.5	40	1.2	91,584	13,460
Venus	6	20	0.8	61,064	23,950
Venus	6	40	1.2	162,864	23,950
Titan	4	20	0.1	5,323	2,050
Titan	4	20	0.8	42,585	2,050
Titan	4.5	20	0.5	33,705	2,050
Titan	6	20	0.8	383,632	3,645

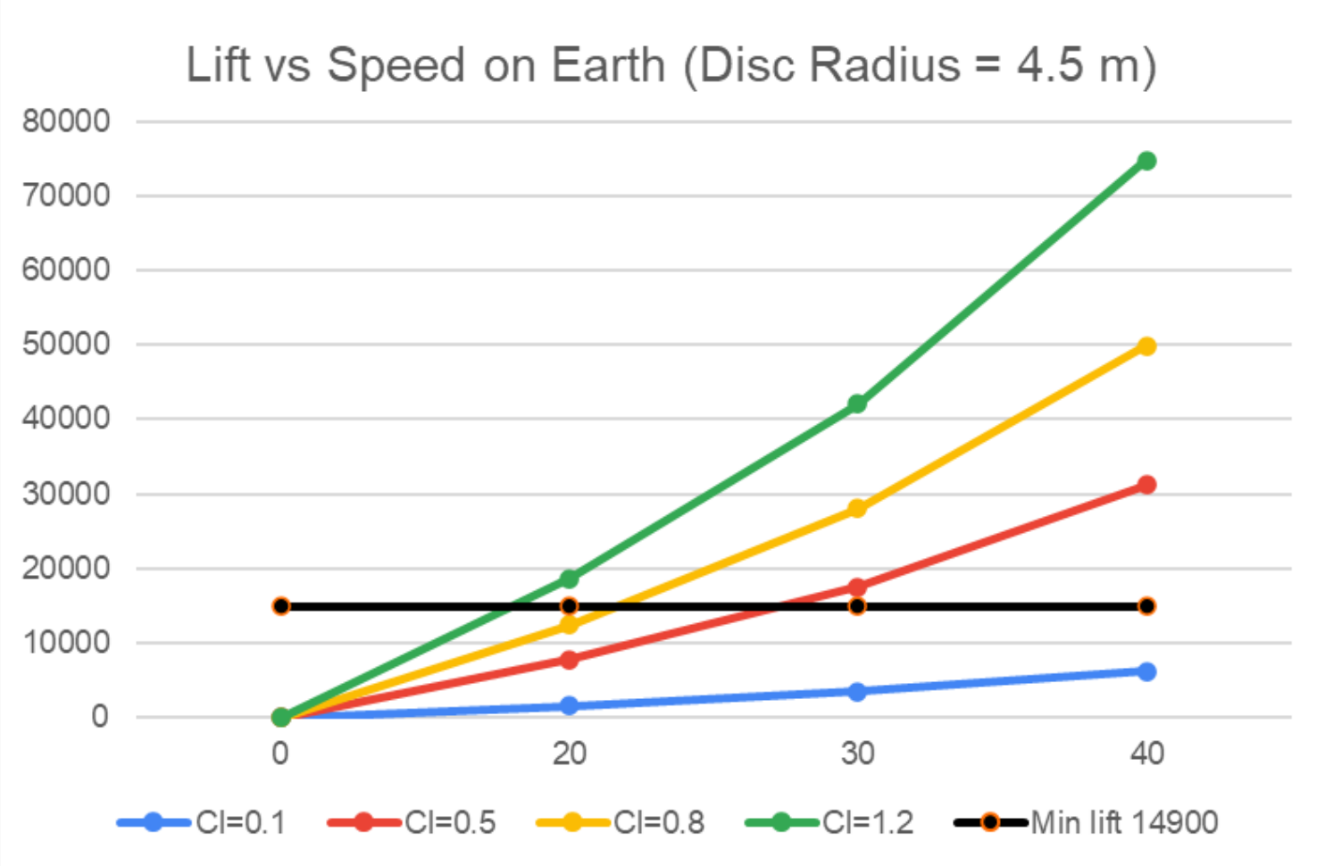

Fig. 8: Lift vs Speed on Earth (Disc Radius = 4.5 m). Graph created by student using Excel, 2026.

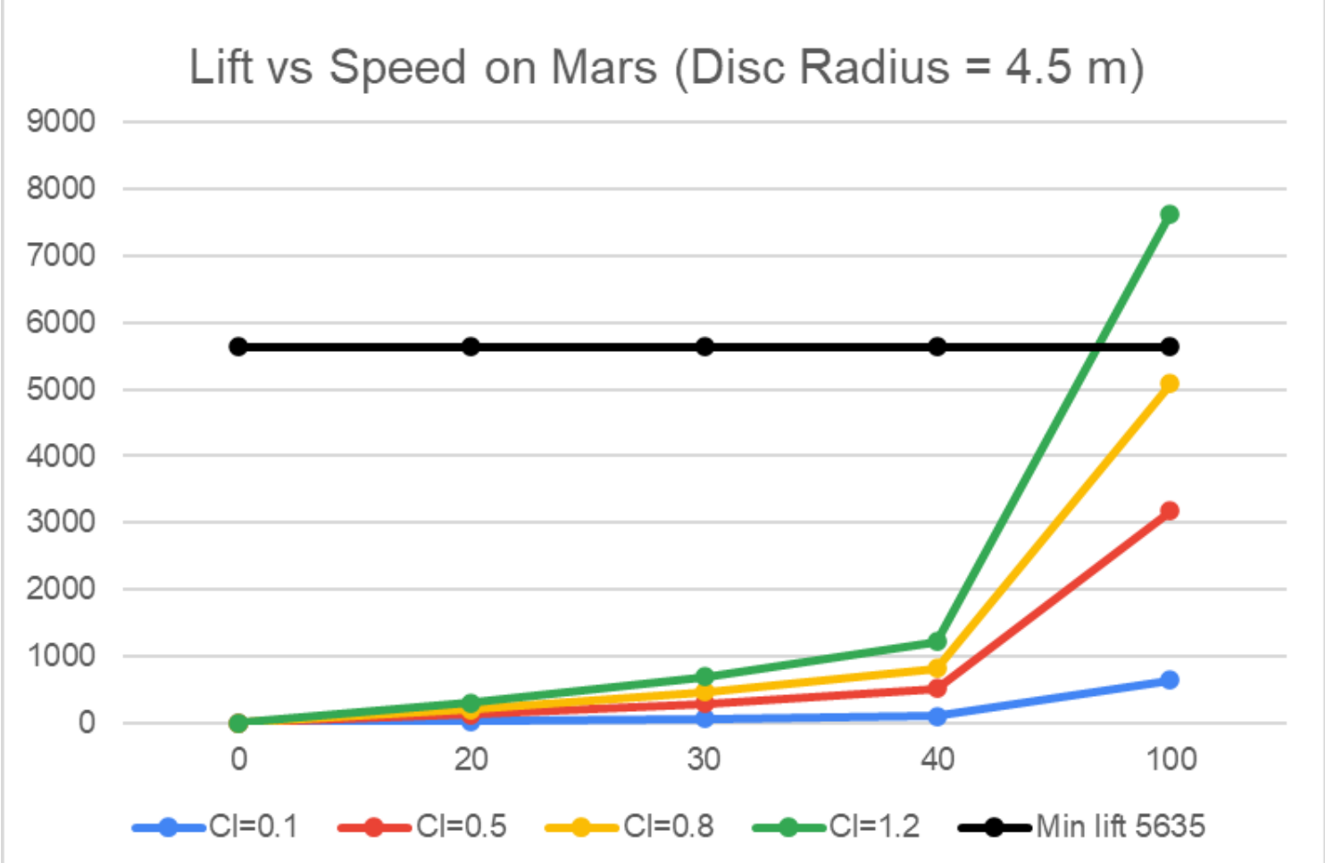

Fig. 9: Lift vs Speed on Mars (Disc Radius = 4.5 m). Graph created by student using Excel, 2026.

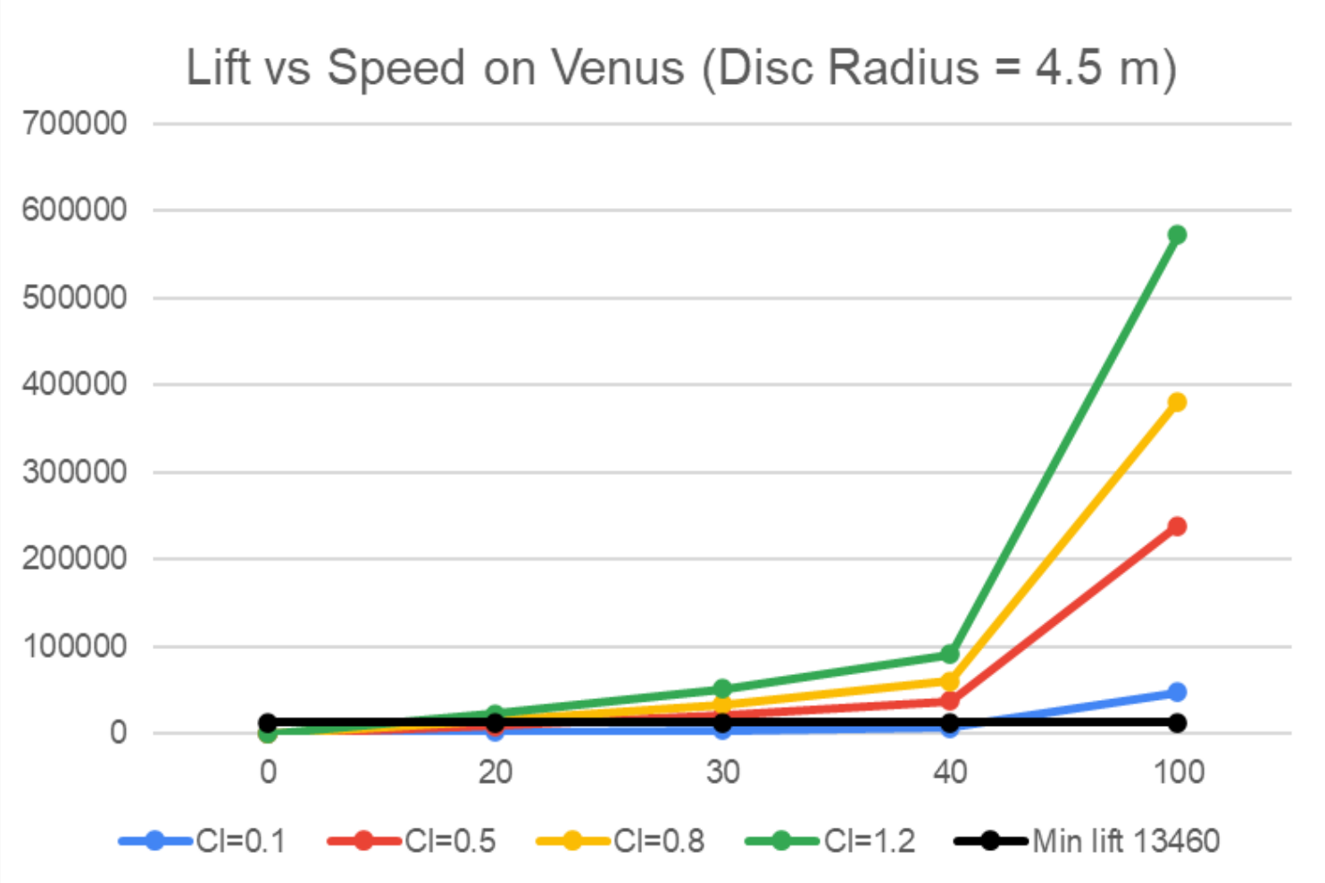

Fig. 10: Lift vs Speed on Venus (Disc Radius = 4.5 m). Graph created by student using Excel, 2026.

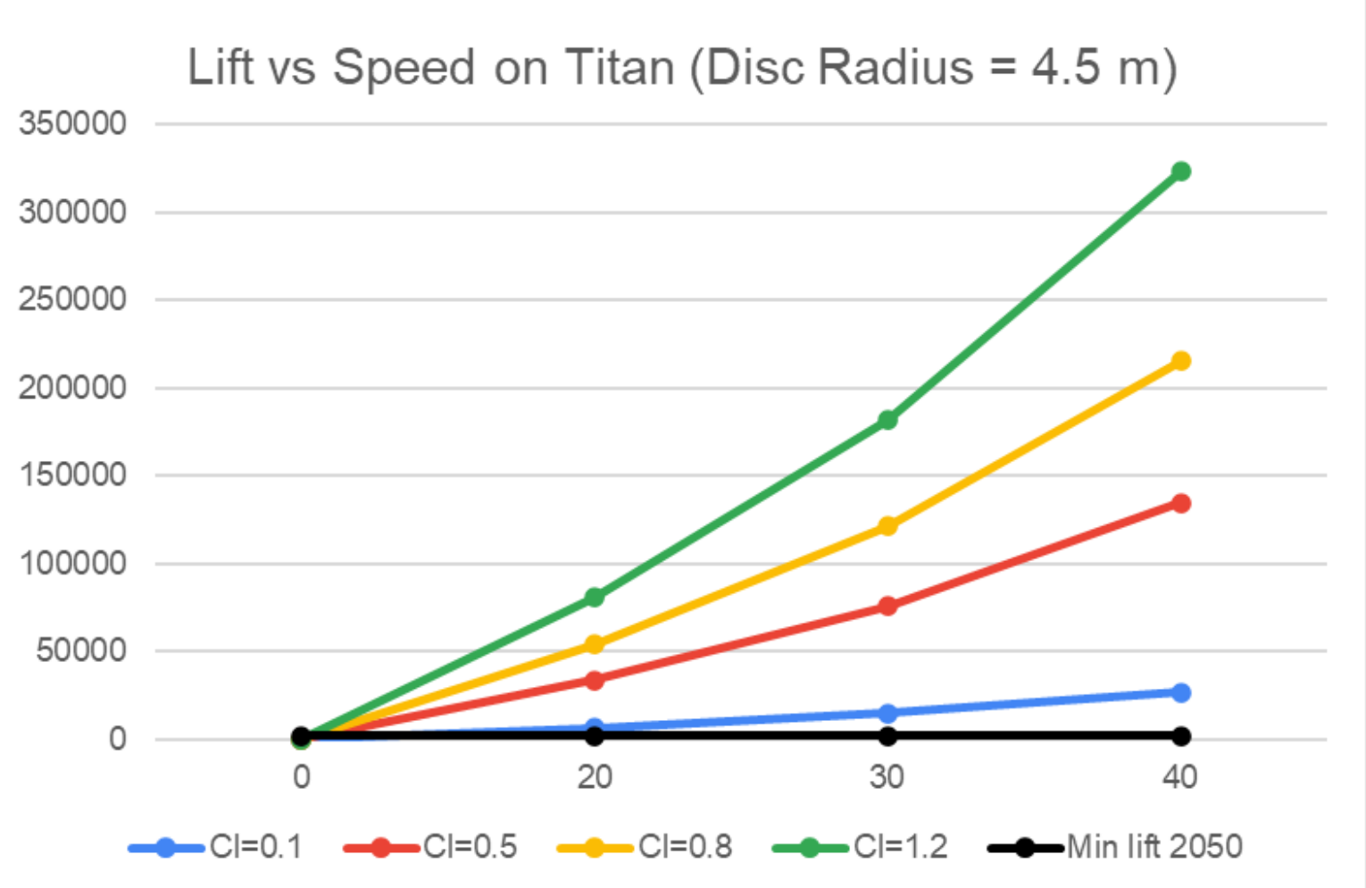

Fig. 11: Lift vs Speed on Titan (Disc Radius = 4.5 m). Graph created by student using Excel, 2026.

Discussion

- Flight performance of a disc-shaped aircraft depends on shape, speed, and atmospheric density.
- Flat discs produce low lift and high drag, needing very high speed or large size to fly.
- Dome-shaped discs improve airflow, reduce drag, and increase lift at the same speed.
- Atmosphere matters: Venus and Titan allow easy lift; Earth works with a medium dome at 30–40 m/s; Mars is very challenging.
- Stability is difficult because discs have no wings or tail. Spinning like a Frisbee creates a gyroscopic effect that helps balance and reduces wobbling, especially in dense atmospheres.

Conclusions

The hypothesis was supported: the stability and flight performance of disc-shaped aircraft depend on both the disc shape and the atmospheric density.

Dome-shaped discs perform better than flat discs, producing more lift and less turbulence, and spinning the disc adds stability through the gyroscopic effect, keeping it balanced during flight.

A medium dome-shaped disc with a radius of about 4.5 m appears practical for Earth-like conditions, while dense atmospheres such as Venus and Titan make flight easier, and Mars remains very challenging due to its thin atmosphere.

These results show that disc-shaped aircraft, particularly dome-shaped and rotating designs, can provide stable and efficient flight in dense planetary atmospheres, making them suitable for future planetary drones and probes.

Future Directions

In the future, I will use CFD (computer air simulations) to test different disc shapes, sizes, and spins. CFD shows how air moves, where turbulence forms, and how lift and drag change, helping me find the most stable discs and test extreme atmospheres like Mars, Venus, and Titan.

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