# Fixing Airplane Science

- If we would have only known

by
Galen Suppes
Adam B. Suppes

# Table of Contents


1. A Broken Foundation .......................................................3

2. The Broken Airplane Science ..........................................9

3. Generating of Aerodynamic Lift ....................................12

4. Cambered Airfoils and Cambered Wings ........................17

5. A Truly Transformational Technology .............................23

6. The Flying Railcar ..........................................................25

7. How the bogus Bernoulli's Theory of Lift Survived through the Decades ..........................................................29

8. The Greater Disruption ..................................................31

Additional Reading .............................................................33


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# 1. A Broken Foundation

Scientists have known for decades that “Theories of Flight” have been broken. What they did not know were the possibilities of accurate airplane science.

A Fixed Airplane Science allows concepts to be rapidly elevated to digital prototypes, which are quite accurate in predicting performances of physical prototypes and provide more information than can be readily obtained from physical prototypes. A broken science tradition disregards good alternatives that a fixed science fosters.

To put the problem and opportunity in perspective, an average passenger’s energy costs for a trip form Washington D.C. to New York City are $4.32 for high-speed rail and $13 for an airliner.[1] These costs are low; modern science has made great improvements on proven transportation technologies.

However, the first-mile/last-mile costs—of: a) commuting to and from ports, b) parking, c) building and maintaining the ports, and d) security—are considerably more than the rail/air transport energy costs. Fixing Airplane Science fosters new technological approaches like the Flying Railcar that can: a) eliminate the time/cost of connecting between separate modes of transit, b) bring the DC-NYC energy cost to less than $2, and c) reduce total transit time from more than 2 hours to less than 60 minutes.[1] New flying vehicle designs provide to a fast track to end global warming sources from transit and the electric power infrastructure, while improving lives and quality of life on planet Earth.

This book describes the fix to airplane science, the capabilities of new generations of vehicles, and the path

[1] See companion site https://hs-drone.com/ for details.

towards those innovations. The Fixed Airplane Science is not difficult to understand; it does not require a background in science or engineering.

In 2023, six heuristics were identified to design aircraft. Those six heuristics fall in three categories: a) generating lift forces, b) extending the impact of the generated lift forces, and c) reducing loss of the lift forces. Those six heuristics will be presented in Chapters 3 and 4.

The Fixed Airplane Science is a recent advance!

**An Improved Approach** - Fixing the science enables more efficient aircraft with more transit operating on fully renewable energy sources, including solar power. The advances will impact daily lives of people of all incomes, locations, and social status. Time spent in traffic slowdowns will be eliminated. Time spent in airport queues will be eliminated. The cost and time of airports will be eliminated. It will be faster than today's fastest trains and automobiles without intermediate stops.

The development path included many innovations on how not to build an airplane. Errors became fewer with progressively improved insight in January 2023 with the implementation of computational fluid dynamics (CFD) to determine what keeps airplanes in the sky. CFD simulation is the primary tool used by the world's leading aerospace corporations to build advanced planes and military weapons.

Modern aerospace and chemical engineering use simulation tools to refine and verify designs; however, the simulation tools are primarily used for refining base case designs rather than complete innovation. Innovation happens when the mind simultaneously considers a few practical Guidelines, referred to as engineering heuristics. Good engineering heuristics are both basic enough to be widely applicable but specific and simple enough to allow three to five relevant heuristics to be simultaneously considered by the human mind.

**The 2023 Path** – Advancing the science was performed hand-in-hand with pursuing innovative advances. Simply, a base case design was conceived and CFD was used to determine if it worked. This research and development (R&D) exercise included a continuous process of relating failures to underlying science which developed the heuristics to be used to improve the innovation towards new base case designs.

The path started with design of a lead aircraft pulling a solar panel. The application is an aircraft pulling a sequence of towed platforms which provide all the energy needed for flight, primarily 24/7 nonstop flight. The trillion-dollar telecommunications industry could benefit massively from a 24/7 high altitude platform station (HAPS) replacing all the satellites and cell towers needed for a city or region. The technology enables bifacial wings with solar power costs estimated at less than 1 ¢/kWh, which is lower than any current source of renewable electrical power.

That innovation led to the innovations applicable to a blended-wing-body aircraft (BWB), like the B2 bomber. Those innovations enable a BWB to have improved fuel economy, 24/7 flight capabilities, and the ability to routinely takeoff and land —a problematic endeavor for an aircraft consisting of a lead aircraft towing multiple solar panels. Also, the innovations enable lower cost small drones useful for a wide range of applications.

The innovations and development of heuristics continued, including a hyperloop tunnel system operating with open entries and exits—an intriguing concept enabling 500 mph corridors to be connected to guideways outside the tunnel network. A Transportation Research Board paper (conference proceeding) was published in January-2024 as the starting point of an emphasis on seamlessly connected land and air transit. Seamless connectivity avoids the costs and time associated with going to, through, and from airports. Today, many trips have larger costs associated with driving to, parking at, and going through airports than the flight itself. The first-mile/last-mile costs of air transit are about a trillion dollars per year.

Continuing these advancements, an additional innovation stands out as highly impactful: the Flying Railcar. Initial estimates place the per-passenger efficiency of the Flying Railcar at 2-4X the best alternatives. In addition, it can use existing railway tracks for both transit and takeoff, seamlessly connecting to free flight. The efficiency is estimated from both CFD results and the underlying physics.

The categories of heuristics for creating aerodynamic lift include "c) reducing loss of the lift forces". For Flying Railcars, both the rails and the ground between the rails block the loss of lift forces; this enables flight efficiencies greater than those attainable with other aircraft. Over the rail, electrical power can be directly transferred to the vehicle, enabling weight needed for fuel or batteries to be used for additional passengers/payload. The air cushion below a Flying Railcar allows tracks too bumpy and curvy for high-speed rail implementation to be compatible with high-speed Flying Railcars.

An interesting aspect of aerodynamic lift is that the generation of lift forces depend on pressures generated by the front of a vehicle. In technical terms, form drag is needed to generate aerodynamic lift, and a well-designed vehicle will create about 60 pounds of lift force for each pound of drag force. Flying Railcars do not need the heavy-duty undercarriage of a train car, and so, the form drag is about half that of a train. The result is a Flying Railcar with around twice the energy efficiency of a train.

High flight efficiency translates to lower noise, elimination of emissions, and lower energy costs. Initial applications of Flying Railcars could use under-utilized current rail infrastructures, such as subway tracks after hours; those Flying Railcars could provide passenger and payload transit. Once established and proven, the expansion and evolution of the Flying Railcar would be a results-driven overall infrastructure optimization.

**Extended Implications -** These innovations made possible by fixing airplane science enable:

- A unified seamless transit infrastructure that combines land and air transportation.
- Expansion of solar aircraft utility to encompass all subsonic aerodynamic flight.
- A new stratospheric frontier of 24/7 aerial platforms for energy production and manufacturing.
- Robust and low-cost high altitude platform stations (HAPS) where one HAPS replaces the satellites and cell towers for an entire city or region.
- A new generation of military weapons including airborne aircraft carriers.

The monetary value of these technologies is over a trillion dollars per year. The geopolitical value of these technologies is military and information dominance. The ecological value of these technologies includes a fast track to eliminating greenhouse gas emissions while improving standards of living. It is a technology for the rich and the poor, for the superpowers and the under-developed, for Earth.

A background in science or engineering is not needed to understand the innovations. Four Guidelines, heuristics, identify how pressures form on surfaces to create to aerodynamic lift. The fifth Guideline identifies how to convert those pressures to lift, drag, and flight efficiency; the fifth Guideline is best supplemented with engineering skills.

Major corporations use CFD to tweak proven aircraft designs, leading the world in aircraft design for decades. The Guidelines were developed using the same CFD tools as the major aerospace corporations.

Understanding the Guidelines and innovations starts with understanding how the vast majority of innovators were guided by prominent, incorrect aircraft science. Chapter 2 explains what was broken. Chapter 3 introduces the fix.

## 2. The Broken Airplane Science

Bernoulli's Theory of Lift has dominated the layman's explanation of aerodynamic lift for over half a century. The explanation is in error in every aspect, which is both a problem in itself and a problem with the educational infrastructure that propagates the errors.

The adverse impact of the erroneous teaching went undetected because mankind did not know what could be attained by "Fixing Airplane Science". No planes crashed because the pilot did not understand the details of the underlying science. Aircraft were tested to ensure they worked, not to ensure the science was correct. Large corporations maintained their status by tweaking proven designs with the same CFD tools used to develop the Guidelines in 2023.

Bernoulli was a great scientist who lived long before airplanes took flight. Bernoulli's equation is simply an application of an energy balance with simplifying assumptions that are usually reasonably accurate.

Bernoulli's Theory of Lift incorrectly applies the Bernoulli equation. Bernoulli was not responsible for the erroneous application.

Bernoulli's Theory of Lift starts by assuming air takes the same amount of time to travel from the leading edge to the trailing edge on both the upper and lower surfaces of the wing. The upper surface path is longer on most wings; this leads to the conclusion that air travels faster over the upper surface. Plugging velocities into the Bernoulli equation with this assumption identifies that pressure must be lower on the wing's upper surface than on the lower surface. Lower pressures on upper surfaces lead to aerodynamic lift.

The primary error is the initial assumption that "air takes the same amount of time to travel from leading to trailing edges on both upper and lower surfaces"; the assumption is simply not true.

In fact, the Bernoulli Theory of Lift is wrong in essentially every way:

1. The initial assumption that it takes the same amount of time for air to travel from leading to trailing edges over the upper and lower surfaces is incorrect.
2. Describing air as having one velocity above the wing, when in actuality air on the surface has zero velocity at the surface (i.e., the no-slip condition) with velocity increasing with increasing distance from the surface.
3. Assuming a simple relation between velocity and pressure on a wing's surface when air's pressure on the surface is primarily a function of whether the velocity is impacting or diverging from the surface.
4. Calculating a uniform, single pressure on a wing's upper surface is incorrect since the pressure varies from leading to trailing edge.
5. The suggestion that the theory has utility for designing a wing when there is no accurate link between the theory and a wing's shape.
6. The suggestion that a "wing" is needed to generate aerodynamic lift.

Through the decades, the errors of Bernoulli's Theory of Lift have been sidelined as a "school of thought" in contrast to other schools of thought, such as the momentum theory of lift. Big names in science like "Bernoulli" and "Newton" are improperly associated with erroneous "competing schools of thought".

Most of the aerospace community and those incredible fighter pilots were educated in these schools of thought, declaring the theories as bogus would be construed as synonymous with stepping on the toes of colleagues and heroes. To that end, the record needs to be corrected:

> *Bernoulli's Theory of Lift and the Momentum Theory of Lift are bogus, and most pilots really do not fundamentally understand the physics that keeps their planes in the sky. The failure of prominent entities like NASA, MIT, and AIAA for not setting the record straight are brutal failures and are indicative of a larger underlying problem.*

Their failures are opportunities for others. The door is open to make incredible advances in transportation that improve qualities of life and rapidly attain near-zero greenhouse gas emissions from transportation.

**Completing Book 1** – Chapter 3 presents four Guidelines, heuristics, that "Fix Airplane Science" in 50 words. The fifth Guideline is a statement of well-recognized physics. These 50 words do what several decades of aerospace engineering have failed to do; they enable innovation in aircraft design by the masses.

Chapter 4 provides examples of how the Guidelines explain aerodynamic lift for a range of complex shapes with complex pressure profiles. The remaining chapters discuss the transformative ramifications of the Flying Railcar. The past seven decades have been dominated by incremental advances in transportation. A Fixed Airplane Science enables multiple transformative advances.