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12th March 2009

Dear Sir,
This letter is to certify that the essay written by Edric San Miguel is his original work.
He completed the essay under my supervision.

Joy W Young

(Joy W. Young, NORSTAR Instructor, Norfolk Technical Center)

The Silent Airliner

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Abstract

For many decades, supersonic travel has been the ultimate dream of air travelers. Now, we are only a few years away from perfecting such travel. High demand for air travel is a major issue that we now face. As this demand increases at an exponential rate every year, we will need an aircraft that will transport us at supersonic speeds. However, there are several factors that prevent us from flying supersonic aircraft. Such factors involve sonic boom, environmental issues, lack of efficiency and insufficient technology. By the year 2020, supersonic aircraft will soar the skies, addressing the innumerable demands for air travel around the globe. My design for the future supersonic aircraft, called the Silent Airliner, will utilize low boom supersonic travel. It will be structured to reshape the sound waves generated by a supersonic aircraft. The structure will prevent sharp "N-shaped" sound waves which produces sonic boom. The sharp N-shaped wave is generated from pressure spikes from the front and the rear of a supersonic aircraft. Therefore, the Silent Airliner will have a quiet spike and an inverted V-shaped tail to mitigate the intense sound-wave.

The keyword to future air travel is "green". In order to be successful, futuristic aircraft must exhibit clean emissions. The Silent Airliner will produce carbon neutral emissions, despite its use of algae biofuel. The fuel and engine efficiency of my aircraft will be made possible through a combination of aerodynamics, effective flight trajectories, and light weight materials.

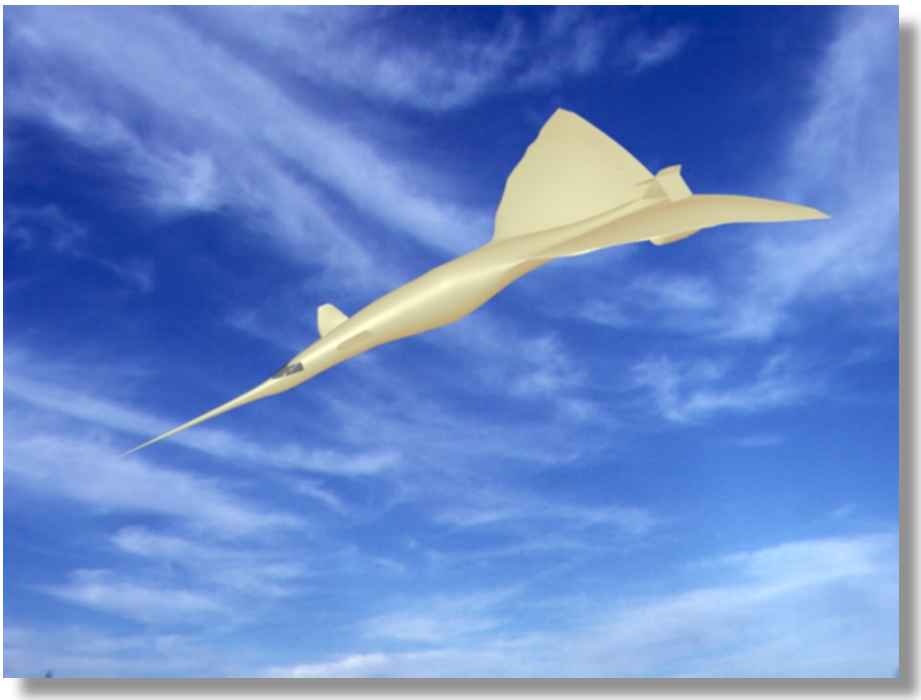
My aircraft design will use a mixture of both future and present-day technologies to achieve maximum flight efficiency. These technologies will enable the pilot to control the aircraft in a more proficient manner. The Silent Airliner will utilize maneuverable canards, winglets, an external vision system, GPS-based navigation and other advantageous technologies.

The Silent Airliner will revolutionize the National Aerospace System (NAS). Bans on supersonic transcontinental flight will be lifted and the use of supersonic aircraft will be common. Furthermore, airports will no longer need long, extended runways because my aircraft will take off in less than 10,000 feet. Finally, communication between airports and aircraft will be much more efficient compared with today's aircraft.

The overall lower cost will be beneficial to both passengers and airline companies. It will also be lessened by cheap algae biofuel production and extreme fuel efficiency.

II. Introduction

Supersonic speeds are vital to future aircraft travel. In 1969, the Concorde proved that aircraft are capable of such speeds, however, there were still several issues that the Concorde did not address which eventually led to its withdrawal from service. First and foremost, doubts existed at the government level regarding the commercial viability of the aircraft due to its high cost of maintenance. Not only did it have high fuel consumption; it also had small tanks for the fuel, which greatly decreased the range of the aircraft and added to its financial issues ("1969: Concorde Flies…"). Furthermore, the Concorde's fuel emissions negatively impacted the environment as it emitted carbon into the atmosphere. The aircraft also created an intense sonic boom which prohibited it from flying supersonically over land (Kruszelnicki). My design for the future supersonic aircraft, the Silent Airliner, will address all these issues and become the next and improved generation of the Concorde.



The Silent Airliner

Credits: Howard Sherburne Jr.

III. Design Structure and Capacity

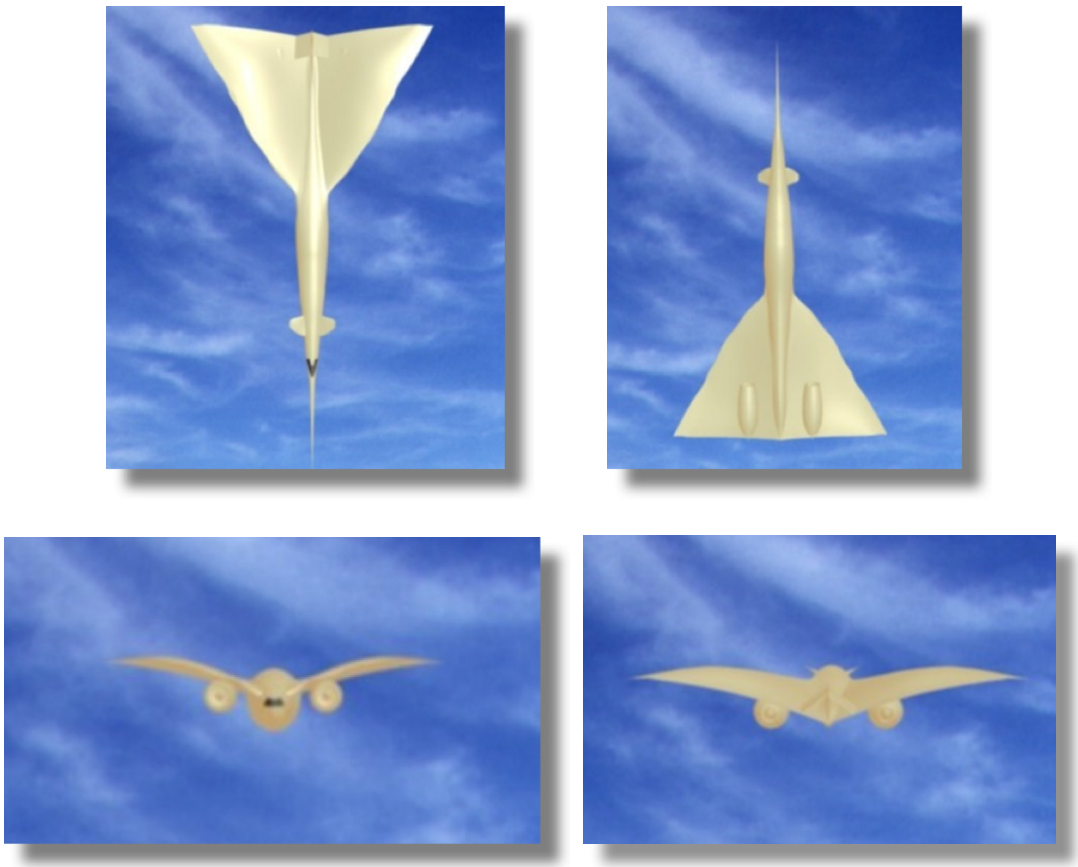
Sonic boom is a major factor to consider in the design of supersonic aircraft. Other factors to consider when designing future supersonic aircraft include aerodynamics, easier takeoffs and controlling airflow.

The sonic boom, generated by a supersonic aircraft, is a result of overpressure around the wings and engines of the aircraft (Hagerman). The forward and backward movement of this pressure creates pressure spikes at the front and rear of the aircraft, thus creating a sharp N-shaped sound wave. This sound wave is what produces a sonic boom. An aircraft's weight, size, and altitude all contribute to the intensity of its sonic boom as well. For example, a large aircraft will create a loud sonic boom because it displaces more air along its path, resulting in stronger air turbulence (Wiley).

The Silent Airliner's structural design is similar to that of the Quiet Supersonic Transport (QSST) and will carry up to 70 passengers. The design aims to mitigate the sonic boom generated by a supersonic aircraft by reshaping the sharp N-shaped sound wave. By broadening this sound wave, booms will be spread out over larger areas, making them weaker ("NASA plans to reduce sonic…"). The Silent Airliner will have a retractable quiet spike at the front of the aircraft which not only increases the overall length of the aircraft, but also reduces the sonic boom signature generated from the front of the aircraft (Knight). This quiet spike will break down large shockwaves into smaller and weaker shockwaves ("Concorde's Successor"). These small shockwaves travel parallel to each other until they reach the ground, which muffles the noise ("Supersonic Jousting"). The Silent Airliner will also have an inverted V-tail which will reshape the sonic boom signature at the rear of the aircraft ("QSST FAQ"). I have placed the engines far aft and widely separated on the wing to separate the pressure waves caused by the engines so preventing them from colliding with one another to generate sonic boom ("All Sonic, No Boom"). Although overpressure cannot be completely eliminated, we can still minimize aircraft noise to acceptable levels. Designers will use Multi-disciplinary Optimization (MDO) methods to reduce overpressure and perceived volume. High-fidelity MDO along with Computational Fluid Dynamics (CFD) methods will be used to design the aircraft shape for optimal low-boom. They will also enhance cruise performance of supersonic aircraft (Magee).

The Silent Airliner's design is lighter, longer, and more slender than the Concorde. These traits will allow the aircraft to generate less shock compared to larger aircraft. The wings themselves will offer a wide variety of features that will be beneficial to the aircraft in terms of aerodynamics, control and noise. There will be winglets at the tip of the gull wings, where high and low air pressures meet. These winglets will prevent wing tip vortices and reduce aerodynamic drag (Dunbar). The Silent Airliner will also use maneuverable canards in order to control the aircraft easily. The canards also prevent pressure changes which usually occur in larger and wider winged aircraft and cause a sharp sonic boom ("All Sonic, No Boom"). In addition, both the canards and the gull wings will demonstrate a "perfect" laminar airflow across their surfaces.

Both will have microscopic holes on their surfaces with an internal suction system that will regulate the airflow on the surface of the wing, thus eliminating turbulent airflow. There will be sensors built into the wings of the aircraft that will feed the pilot information about the airflow. The pilot will then use these data to control the airflow through the suction. Furthermore, laminar flow can be increased by simply contouring the wing's surface.



The Silent Airliner Different Views

Credits: Howard Sherburne Jr.

IV. Aircraft Technologies and Service Operation

Ever since the Concorde took flight in 1969, technology has flourished and is still growing. Technological advancements are major necessities to futuristic aircraft. They are especially crucial when they are needed to compensate for changes in the structural design of the aircraft. There are always added benefits to both passengers and airliners as we find ways to streamline an aircraft's operation. In the future, we will rely on technology to adapt to environmental uncertainties in the atmosphere. Currently, we do not have access to all necessary

technologies for my design. However, by the year 2020, technology would have already developed far enough to be incorporated into supersonic aircraft.

The Silent Airliner will take advantage of the availability of both present and future technologies. The aircraft will have a "central nervous system" composed of intelligent systems such as sensors, actuators, microprocessors, and adaptive controls. This system will enhance the capability of the aircraft to monitor its own performance throughout the entire travel experience, and will assist the pilot in ensuring a safe and efficient flight (Schultz 171).

The use of a quiet spike decreases visibility from the cockpit because it eliminates the usual raised cockpit windows ("Concorde's Successor"); therefore, the Silent Airliner will use an External Vision System (XVS), to compensate for reduced visibility. The XVS will provide the pilot with high-definition feed from outside the aircraft ("Flying in High Def"). Synthetic vision will also be used to get additional views from the exterior of the plane and allow the pilot to map the terrain below (Rincon). This type of system will be composed of sensors and imaging systems which will feed high-resolution images and computer graphics to both the pilot and passengers ("Concorde's Successor"). Furthermore, the Silent Airliner will use the Automatic Dependent Surveillance Broadcast (ADS-B) technology. This technology will replace antiquated radars by the year 2020. It will give the pilot exceptional views of what is happening within a given radius. Together with Global Positioning Software (GPS) technology, pilots will not only be able to monitor their position, but that of other aircraft in the area as well. This would mean the aircraft could safely change altitudes and speed when necessary. Replacing radar-based navigation with GPS will help prevent flight delays in the future (Demerjian).

The Silent Airliner design also includes active noise control inside the cabin. There will be panels in the aircraft that will respond to the noise generated by the airframe. These panels will work together to cancel out the noise using smart actuators which will sense the noise and create an opposite wave vibration to cancel it out (Skena).

Means of communication between aircraft and airport will be revolutionized by the year 2020. Highly advanced computers such as quantum and light computers will be used to communicate in a faster and more efficient manner. Also, cell phones will no longer be banned during flight because the current aircraft wiring will be replaced with fiber optic "fly-by-light" control systems (qtd. in "The Future of Flight").

V. Materials

Supersonic aircraft must be light weight in order to minimize the sonic boom. Most of our current commercial aircraft use aluminum for their external structure. An advantage of

aluminum is the fact that it is easily replaceable. However, aluminum is too heavy and would make low sonic boom impossible. In addition, aluminum would not be able to withstand the heat generated from friction as it travels at speeds exceeding the speed of sound.

The Silent Airliner will use carbon fiber composites for its external surface. These composite materials are not only light, but also strong. They can withstand high temperatures and pressures. Kevlar polymer fiber will also be used to further reinforce these carbon composites and ensure the toughness of the material ("Composite Materials"). Under the composite material, there will be a layer of actively cooled internal screen. This screen will absorb the heat generated by friction on the outer shell of the aircraft ("LAPCAT"). The winglets, canards, and sections of the wings will also have "smart" materials that respond to flight control commands.

The engines will be composed of titanium aluminide, acoustic absorber materials, polymer, and ceramic composites. The performance of the engines is affected by the heat tolerance of their material; therefore, it is necessary to utilize materials with higher specific stiffness and damage tolerance at high operating temperatures. Titanium aluminide is half as dense as today's existing engine materials; which mean that it can perform at higher temperatures without affecting its performance, resulting in a more efficient engine (Campbell). Acoustic absorber materials will be used for the nacelle, which houses the engines. This will help reduce the sound emitted by the engines. Finally, the use of polymer and ceramic composites for the engines will make the aircraft lightweight while maintaining maximum engine performance ("Concorde's Successor").

VI. Take Off

When it comes to take off, the most problematic issue that we face today is long, extended runways. Some current aircraft cannot be accommodated by some airports because they require longer runways. Our problem with extremely high demand for air travel is exacerbated by this issue. Future commercial aircraft must demonstrate the ability to take off and land using shorter runway lengths.

The Silent Airliner will be capable of operating in and out of 6000 ft runways. It will use a split flap in the wing to change the angle of attack, which will increase lift. The pilot will be able to change the angle of the entire aft engines downward by 10º. This will greatly strengthen thrust during takeoff. Once the Silent Airliner reaches its required altitude, the pilot will be able to switch the engines back to 0º. Since the canards are also maneuverable, the pilot can also control their angle of attack and generate more lift. The inverted-V tail also provides substantial lift ("All Sonic, No Boom").

VII. Speed and Travel

Supersonic speeds are a necessity for future air travel between continents. Present day aircraft may take up to 22 hours when traveling from North America to Australia. This causes frustration to both leisure and business passengers. Aerodynamics is the key to flying faster than the speed of sound. It is necessary to increase an aircraft's lift to drag ratio in order to increase speed and efficiency (Liefsson).

The Silent Airliner will travel at Mach 1.8. At this speed, travel time from North America to Australia will be lowered to less than 5 hours. In order to make this possible, my aircraft will exhibit outstanding aerodynamics by adapting to its environment during flight. The "Central Nervous System" will inform the pilot of necessary changes in order to adapt and aircraft structures such as the canards will quickly respond to flight controls. Throughout travel, the Silent Airliner will be able to maintain an uninterrupted supersonic flight over land and sea. The aircraft will travel at an increased altitude of 48,000 ft which will help lessen sonic boom (Wiley).

Not only are the engines powerful, but the positioning of them at the trailing edge of the wing increases the aircraft's speed. Studies at Virginia Polytechnic Institute showed that placing the engines in that position decreased the force needed for propulsion (Liefsson). Along with the wings' internal suction system, "the nozzle and aft fuselage create some suction on the forward facing surface of the aft fuselage" and eliminate boat-tail drag. The nacelle and exhaust nozzle's intake utilizes a "cheese cutter- like splitter plate in order to control airflow spillage and shockwave "(Wiley).

VIII. Environmental Effects

For many decades, we have been seeking ways to fly greener and quieter. The aviation industry places a huge burden on the environment. Aircraft emissions have gone up and are currently one of leading contributors of carbon dioxide to the atmosphere. The Federal Aviation Administration (FAA) estimated the greenhouse gas emissions for aircraft will increase 60% by the year 2025 (Raine). An alternative source of fuel is necessary to prevent CO2 from building up, and to produce fuel easily without having to impact growing crops and agriculture. It would require acreage the size of Florida to grow enough soybeans to provide a 15% blend for jet fuel in order to fuel the US aircraft fleet ("Latest on Algae Fuel…"). Noise pollution is another major environmental challenge that we face. As commercial aircraft take off and land in airports, residential areas are affected by the noise they generate.

There are many alternative fuels that researchers have tested. However, the most likely alternative that will be available for commercial use by the year 2020 is algae biofuel. Many

successful flight tests have been made with algae. Scientists predict that algae biofuel will be in commercial use in the next 10 years (Lane). Therefore, the Silent Airliner will use algae biofuel for its operation.

There are several factors that make algae a good candidate, and beneficial for future aircraft fuel. Algae are easy to produce and can yield 100 times more fuel than soybeans in the same acreage. These aquatic creatures are grown in salt or brackish water, and do not compete for arable land like soybeans and corn do (Phenix). Using a huge bio-reactor, which is a series of chambers or ponds designed to boost algae growth, even less space would be required during algae fuel production. A bio-reactor, occupying acreage the size of Maryland, could supply fuel for all of the world's aircraft (Gonzalez). Algae biofuel emits lower carbon compared to fossil fuels with 25% less particulate emissions ("Biodiesel"). Algae grow with a steady feed of warmth, light and CO2 (Henley). Therefore, as aircraft emit carbon, it will be taken in and used by the growing algae, resulting in a carbon neutral outcome (Watts). The clean burning engines of the Silent Airliner will reduce emissions from take off to landing of the aircraft ("Quiet Supersonic Transport…").

Sonic boom is not the only sound that the Silent Airliner will minimize. Noises we hear from today's commercial aircraft will also be diminished in the future. The use of non-afterburning engines along with acoustic absorber materials will lower engine noise. Similar to owls, the wings of the aircraft will have "fimbriae" structures which will breakdown turbulences into micro turbulences. This structure muffles the sound of the air rushing over the wings' surfaces (Lewis). Finally, the Silent Airliner's broad distribution of lift-generating surfaces will tone down noises made by the airframe as it travels.

IX. Fuel Efficiency

Efficient fuel is the key to greener and uninterrupted flights. Our current commercial aircraft not only utilize a lot of fuel, but they also have low flight ranges. This leads to longer flights and passenger inconvenience: problems which must be solved as demand for air travel increases. Today's aircraft are not as aerodynamic as they could be. The drag significantly lowers fuel efficiency and severely increases fuel consumption. New modern day aircraft are 70% more fuel efficient than 40 years ago, and 20% more efficient than 10 years ago. In this regard, the goal of airliners is to achieve an additional 25% fuel efficiency by the year 2020 ("Fuel Efficiency").

The Silent Airliner's smooth structural design will allow it to fly 10% farther on its fuel supply during supersonic flight than it can at subsonic speeds ("All Sonic, No Boom"). Using biofuel will "increase aircraft payloads and range, reduce fuel consumption and extend engine

life" (Demerjian). The Silent Airliner will have a range of 4000 nautical miles and a fuel consumption of 3 passenger miles per pound of fuel. This will be possible not only through the use of biofuel, but by also reducing the aerodynamic drag. Several aspects of the Silent Airliner that I stated before will allow for an aerodynamic flight. The aircraft's ability to adapt to its environment will obviously be one leading factor that makes my aircraft more aerodynamic. The suction system embedded on the wing will expand laminar flow across the aircraft's wings, thus reducing the amount of friction. The winglets will improve fuel efficiency and cruising range by reducing induced drag at the wingtip (Dunbar). Engine/Airframe combination is optimized for low drag as well ("Quiet Supersonic Transport…"). The design includes a top-mounted active isentropic air inlet and an adaptive leading edge in the wings, both of which will promote aerodynamics during flight.

X. Operation Cost

Production and operation cost is an issue that will severely impact the development of this aircraft. There are several factors that make modern day aircraft operational costs high. First of all, airliners cannot keep up with the growing number of air travel demands. They try to compensate by adding on as many passengers as they can in one flight. However, this adds weight to the aircraft and increases fuel consumption. The higher the fuel consumption, the higher the operating cost will be. Added cost also comes from complicated fuel production and negative environmental effects.

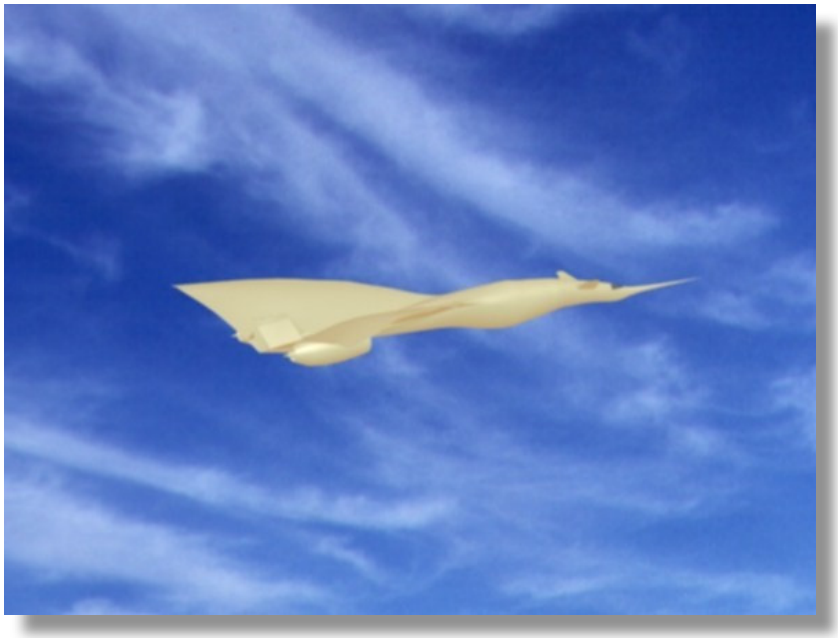
The Silent Airliner is the solution to high operation costs. Its supersonic speed will address the high demand for flight. It will drastically reduce the travel time and ensure uninterrupted flights. My design proves to be extremely efficient when it comes to fuel. The fuel consumption will be lowered through aerodynamics. High technological advancement will make flights faster, and easier as well. Algae biofuel production is uncomplicated and can yield more fuel per acre than soybeans or corn; furthermore, it does not compete with arable land. This biofuel makes good business sense because it is capable of increasing both payload and range of flight (Demerjian). The silent airliner will not be a burden to the environment and it will provide a clean flight, and create a system of net zero carbon emissions.

The overall cost for this airliner will be cheap for passengers, but beneficial to airline companies. Airlines will be able to accommodate a high number of air travelers with faster, more frequent flights. This will increase their total profit without having to increase the ticket price. The aircraft itself will be easy to maintain and will demonstrate durability and longevity.

XII. Design Usefulness in the National Aerospace System of 2020

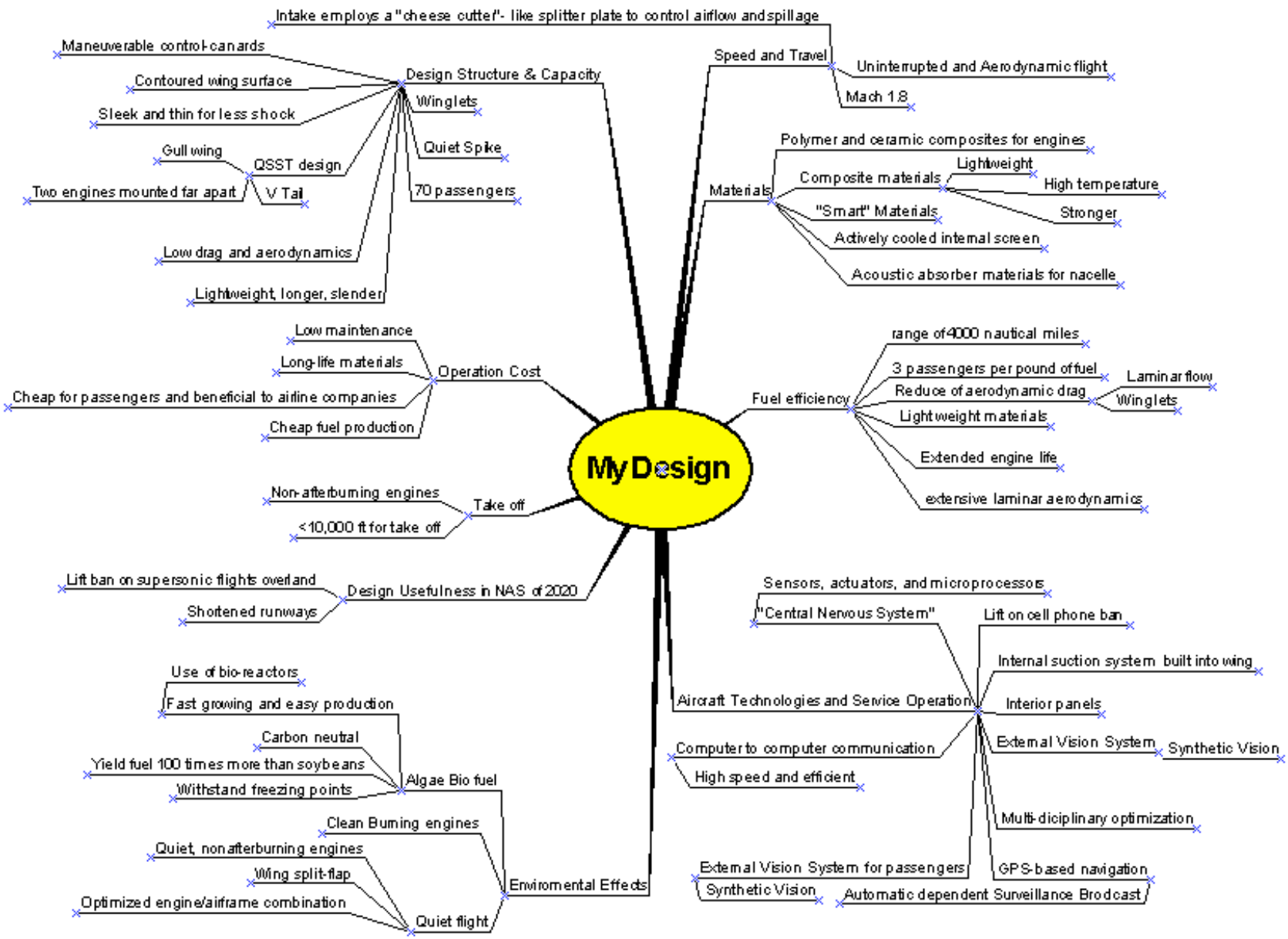
The National Aerospace System will be revolutionized by the year 2020. When this design is in use, the NAS and the government will lift its bans on transcontinental supersonic flights. The Silent Airliner and its design show that sonic boom can be minimized. Airports will have shortened runways, and the Silent Airliner will be accommodated in any airport. Its substantial lift will reduce the required runway length. By the year 2020, technology will flourish. We will rely mostly on technology in order to provide an organized flight system. Some modern day technology will be considered old-fashioned in the near future. For example, the use of control towers will be replaced by computer-to-computer communication between airports and the aircraft. Antiquated radars will be replaced by advanced GPS system for navigation.

Our local Norfolk International Airport will be able to accommodate supersonic aircraft like the Silent Airliner without disturbing its nearby residential areas. The takeoff and landing will be extremely quiet, and will offer cleaner emissions compared to today's aircraft. This is crucial in view of the tougher standards for combating smog imposed by the US Environmental Protection Agency (EPA). Urban areas like Hampton Roads will require new methods for reducing emission from pollution sources, which includes aircraft. If not, Virginia will fail the new national standard set by the EPA in the year 2008 (Harper).



The Silent Airliner

Credits: Howard Sherburne Jr.


MyDesign
Design Structure & Capacity
Intake employs a "cheese cutter"- like splitter plate to control airflow and spillage
Maneuverable control-canards
Contoured wing surface
Sleek and thin for less shock
Winglets
Quiet Spike
70 passengers
Low drag and aerodynamics
Lightweight, longer, slender
QSST design
Gull wing
V Tail
Two engines mounted far apart
Speed and Travel
Uninterrupted and Aerodynamic flight
Mach 1.8
Materials
Polymer and ceramic composites for engines
Composite materials
Lightweight
High temperature
Stronger
"Smart" Materials
Actively cooled internal screen
Acoustic absorber materials for nacelle
Operation Cost
Low maintenance
Long-life materials
Cheap for passengers and beneficial to airline companies
Cheap fuel production
Fuel efficiency
range of 4000 nautical miles
3 passengers per pound of fuel
Reduce of aerodynamic drag
Laminar flow
Winglets
Lightweight materials
Extended engine life
extensive laminar aerodynamics
Take off
Non-afterburning engines
<10,000 ft for take off
Design Usefulness in NAS of 2020
Lift ban on supersonic flights overland
Shortened runways
Aircraft Technologies and Service Operation
Sensors, actuators, and microprocessors
"Central Nervous System"
Lift on cell phone ban
Internal suction system built into wing
Interior panels
External Vision System
Synthetic Vision
Multi-diciplinary optimization
GPS-based navigation
Automatic dependent Surveillance Brodcast
External Vision System for passengers
Synthetic Vision
Computer to computer communication
High speed and efficient
Enviromental Effects
Algae Bio fuel
Use of bio-reactors
Fast growing and easy production
Carbon neutral
Yield fuel 100 times more than soybeans
Withstand freezing points
Quiet flight
Clean Burning engines
Quiet, nonafterburning engines
Wing split-flap
Optimized engine/airframe combination

XII. Conclusion

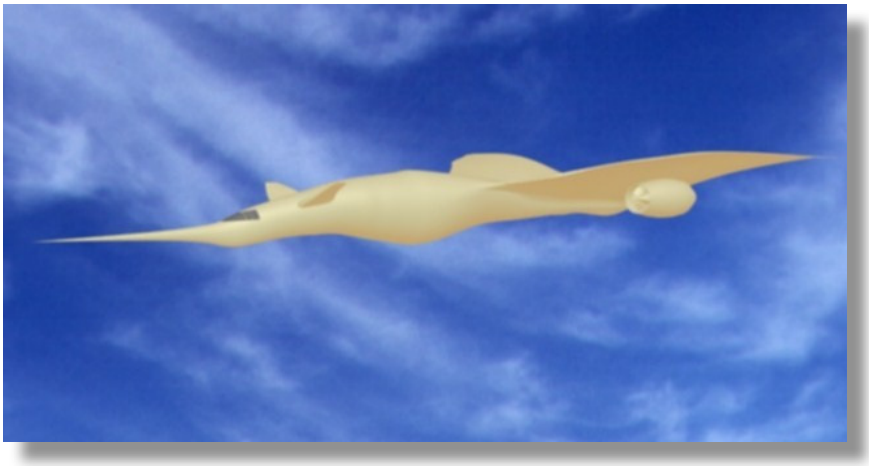
Unlike the Concorde, my design will be commercially viable. The Silent Airliner will exhibit outstanding aircraft virtues such as durability, longevity, and profitability. This design will be the solution for the future of supersonic travel. It will overcome the obstacles and challenges that prevent us from flying at supersonic speed. Through boom shaping, we will be able to reshape the sonic boom signature that supersonic aircraft generate and it will optimize aerodynamic performance during all phases of flight.

For further study, researchers must focus on sonic boom and engine noise reduction, controlling emissions, and continuous technological development. Mitigation of aircraft noise is not impossible, but will be complicated, especially with supersonic aircraft. Carbon dioxide is not the only chemical that is released into the environment during fuel combustion. Researchers must seek to control the release of other chemicals, such as various oxides of nitrogen, and water vapor. The Silent Airliner design requires high levels of technology; therefore, it is necessary to keep up the trend of increasing technology in order to develop the necessary equipment for the future.

Nevertheless, the Silent Airliner is promising, and will be beneficial to the whole of society. This design is possible to create, but will require deeper research and higher technology.

"The future is not something we enter. The future is something we create."

– Leonard I. Sweet



The Silent Airliner

Credits: Howard Sherburne Jr.

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