Act I: Introduction

[00:00:00] **Nick Howard:** What you are about to listen to is a work of imagination, but not fantasy, set in the year 2050.

(Sound of a plane landing close by. We are at the entrance of the Los Angeles airport - also known as LAX - where Paul Harper just got off his last fueling technician training shift)

[00:00:08] **Paul Harper:** I bet that’s my ride getting in now...

(Enters into the airport - there is a bit of a quiet cacophony of the various types of machines trying to sell you things in a modern airport - sort of like a casino - vying for your attention, there is a general hum, people and hustle and bustle.)

[00:00:11] **Paul Harper:** Just finished my final shift of the LAX electric supercharging program. Now I’m about to fly home.

(Sound of a notification on Paul’s watch.)

[00:00:18] **Paul Harper:** Hmm... ummm... I just got a notification about my flight on my holowatch.

[00:00:22] **Paul Harper:** [Angry] Oh bloody hell, mate. My flight to Sydney has been delayed by 8 hours. *sigh*

[00:00:27] **Paul Harper:** We can build a colony on Mars, but flights can’t depart on time.

[00:00:32] **Paul Harper:** I’ve got to get there faster. My wife Sandra went into labor this morning...

[00:00:38] **Mutinta Banda:** That’s electric supercharging technician Paul Harper. He’s allowing us to tap into his digital diary. Today, Paul’s going to provide us a window into sustainable aviation as we explore how this industry radically adapted to reduce carbon emissions and protect our climate.

[00:00:56] **Mutinta Banda:** I’m your host Mutinta Banda and you’re listening to Climate Vision 2050.

[00:01:00] **News Clips:** More trees will be planted in 2024 as carbon offsets for the aviation industry.

[00:01:06] **News Clips:** A new algae biorefinery is proposed for 2035 as synthetic fuels take off.

[00:01:12] **News Clips:** Supersonic planes - planes faster than the speed of sound - will re-emerge for passengers by 2040.

[00:01:18] **Mutinta Banda:** Aviation connects our world; bringing people closer together and providing experiences that enrich our lives.

[00:01:24] **Mutinta Banda:** In this episode, we’ll be exploring aviation’s challenging route to decarbonization: How new aircraft design, alternative fuel sources, and infrastructure improvements have helped the industry meet its sustainability goals.
Act II: How the World Works

(Paul is still in the airport, moving around through the crowds. Voice is elevated, yelling slightly into the microphone. Rolling suitcase behind him.)

[00:01:38] Paul Harper: My mate in air traffic control told me my flight was delayed because the arriving plane isn’t here - seems there’s some rerouting happening at the moment due to heat waves in the Midwest. He’s checking for me if there might be another option. Come on, come on. Please have another flight. *sigh*

(Sits down in a section of the airport)

[00:02:08] Paul Harper: I first started in this industry because my mother was a flight attendant. She used to tell me stories about being up in the air on 737s or A320s, looking out at the clouds, bringing carts up and down the aisles. Climate change and automation have completely transformed the industry. Today, there are electric aircraft supercharging station technicians - like me - biofuel specialists, liquid hydrogen fueling technicians, onboard safety officers... Everyone’s got their niche.

[00:02:38] Paul Harper: LAX has been one of the largest aviation hubs in the world for almost a hundred years, and it’s still on the cutting edge. They have all four of the major types of aircraft.... Traditional tube and wing body aircraft and sleek delta wing supersonics run on sustainable aviation fuels, the triangular blended wing body planes run on liquid hydrogen... and of course there are electric aircraft,

(Sound of a message coming into Paul - a beep of some kind - that alerts him.)

[00:03:00] Paul Harper: [Exasperated sigh] That’s my mate he says there’s only one alternative option - a supersonic leaving within the hour. That would cut the entire journey almost by half.

[00:08:04] Paul Harper: I could buy a new electric motorcycle with the price difference. *sigh*. But being there... well... That’s priceless.

[00:08:15] Paul Harper: [Exasperated noises] I wonder if I can even get a cancellation seat…

[00:08:19] Paul Harper: I’ve got to at least try.

(Soundscape fades out.)

[00:03:15] Mutinta Banda: Decarbonizing aviation seemed like an insurmountable challenge, especially in comparison to other modes of transport. Gokcin [Gok-Chin Chin-Ar] Cinar is an assistant professor of aerospace engineering at the University of Michigan. She’s the director of the integrated design of environmentally-friendly aerospace systems lab. That’s IDEAS lab for short.

[00:03:21] Gokcin Cinar: We had to deal with something completely new because for more than a hundred years since the Wright Brothers’ aviation depended solely on fossil fuel and the conventional aircraft propulsion systems– the systems that generate thrust to move the aircraft in the air.

[00:03:41] Gokcin Cinar: And well, we must move hundreds of passengers in the air flying, meaning the vehicle has to generate enough thrust and lift to carry all that weight in the air. So it has been and still is important to design the lightest possible vehicle that can do the job safely. So weight is extremely important. So that was one of the biggest challenges that we had to overcome. Still a challenge that in 2050 we are working towards.

[00:04:15] Mutinta Banda: At the IDEAS lab, Gokcin investigates the systems design and integration for sustainable aircraft concepts.

Gokcin Cinar: Air transportation is one of the safest modes of transportation. That’s why historically we have been very cautious when it comes to radical changes because radical changes bring risk. To mitigate the risks we needed to put an enormous amount of effort, time, and money into research, development and testing of these novel propulsion systems, which can bring zero emissions and can make sustainable aviation a reality.

[00:05:04] Mutinta Banda: Flying is more popular than ever, increasing the difficulty in decarbonizing the industry. Ryah Whalen is a senior director at BCG who works with airlines and members of the aviation sector to decarbonize.

[00:05:24] Ryah Whalen: We’ve seen the rise of the middle class in countries like India and China. We’ve seen the development of Africa and the rise of the middle class in some of those regions has allowed those consumers to access flights. And so you’ve seen shifting traffic patterns where it’s not as driven today by North America and Europe as it was 30 years ago.
Mutinta Banda: Aviation systems have undergone an enormous transformation as they’ve worked to adapt to extreme weather conditions.

Ryah Whalen: With climate change, storms have gotten so much more severe and actually a lot more unpredictable. And so we’re seeing a lot more delays today due to weather than we would’ve 30 years ago. But thankfully, given computer modeling, we often know further in advance when there are going to be storms and when there are going to be delays. The other big thing is flights are much more turbulent today. And turbulence and severe turbulence, they can happen not just in storms, but when there’s what’s called clear air. And it’s actually two to three times more frequent today than it was back in 2020.

Mutinta Banda: Clear-air turbulence has increased due to the effects of climate change, as carbon dioxide in the atmosphere has impacted jet streams.

News Clips: Violent buffeting of aircraft in some cloudless regions are predicted to increase in the 2030s.

News Clips: New jobs will be created by 2040 to build out airport infrastructure to accommodate sustainable fueling options.

News Clips: Facial recognition technologies are set to phase out all forms of paper and digital tickets by 2050 at all major airports across the globe.

Mutinta Banda: Back in the main area of the LAX airport, Paul begins to make his way toward Terminal D, where supersonic flights depart from.

(Sound of a rolly suitcase trailing along on the floor, Paul is running through security.)

Paul Harper: Coming up to the security check.

(Paul is quieter. He’s walking on a moving platform - slight beeping of the machine scanning.)

Paul Harper: While you are on the moving platform the machine uses facial recognition systems to scan your boarding pass and passport. Your bag and clothing are checked automatically -- the retinal scan does a background check. Some have a whinge about the whole thing, but I’m fine with it. My mother told me that they used to make you wait in huge lines and you would even have to take off your shoes!!! Hahaha, can you imagine?

(Paul starts talking at normal volume again.)

Mutinta Banda: Today in 2050, flight delays are often caused by the rerouting of planes to mitigate the effects of what’s known as contrails.

Ryah Whalen: In 2020, if you were to look up at the sky outside of an airport or outside of an urban area near an airport, you would see these small white lines behind planes and they’re actually caused by water vapor. When a plane burns traditional fuel, it produces a bunch of different particles. One of those particles is CO2, right, which we know causes global warming. One of the other things that come out of a plane is actually water. And that water vapor produced these lines behind planes in certain atmospheric conditions. And those contrails, while the contrails themselves only last for a couple of minutes, the global warming impact while highly uncertain in 2020. It was thought to be, you know, two to three times that of CO2.

Mutinta Banda: The density of contrails can be so intense that they can turn into cirrus clouds. These are a naturally occurring type of cloud that acts as a blanket over the earth - especially at night - and traps heat in. Unlike CO2 though, this water vapor only sticks around for a limited period of time - causing an immediate but less long term effect. This means there was a huge opportunity to mitigate global warming impacts by routing planes based on weather patterns and the atmospheric conditions that cause contrails.

Gokcin Cinar: When such atmospheric conditions exist in an aircraft’s flight path aircraft simply change the altitude. They fly lower where it is warmer, the temperature is warmer, so it is less likely for the aircraft to create contrails. The advanced air traffic management systems that we have today can accommodate these flight path alterations very seamlessly.

(Back at the airport.)

Mutinta Banda: Paul arrives at the gate for the supersonic flight to Sydney.

(At the gate, rolly suitcase, puts the bag on a sensor)

Paul Harper: I managed to snag a seat at an enormous fee - but it will be worth it if I can be there when my baby is born.
[00:10:34] **Paul Harper:** I’ll put my bag on the conveyor here.

(Sensor makes a noise)

[00:10:38] **Paul Harper:** [Ugh] I’m charged a fee for extra weight. They’ve never been stricter about weight for cabin baggage - every extra pound means extra fuel.

(Starts walking onto the airplane - speaking more quietly.)

[00:10:52] **Paul Harper:** I’m coming into the plane now. The interior of these supersonic jets are long and narrow - they’re what’s known as a delta wing configuration. They’ve got a long tube and triangular wings. They run on sustainable aviation fuels. There are two single seats on either side of the aisle.

[00:11:04] **Paul Harper:** C32, H32… F32. Found my seat.

(Soundscape fades out.)

[00:11:08] **Mutinta Banda:** Back in the 2020s there was one type of passenger plane; they were basically a tube with wings. The wings doubled as the fuel tanks. Today in 2050 we have long sleek supersonic planes run on sustainable aviation fuel and blended wing body planes run on liquid hydrogen. Blended wing body planes look like one big triangle or old stealth fighter jets. The passengers sit in the wings on these planes.

[00:11:23] **Ryah Whalen:** The blended wing body itself is about 20% more efficient than a traditional plane. And it has the added benefit of you don’t actually have to store fuel in the wings and so you’re open to many different fuel types, right? It’s much easier to load canisters of pressurized liquid hydrogen onto a blended wing body. You couldn’t put that in the wings of a traditional plane. And so we’ve actually been able to marry the blended wing body design with new types of fuel to get to flights that are much more sustainable.

[00:12:01] **Mutinta Banda:** Blended wing body planes are more aerodynamic than traditional models, maximizing efficiency and creating new opportunities for liquid hydrogen fueling. But before liquid hydrogen started to really take off, the aviation sector started working with what’s known as sustainable aviation fuel or SAF. There are two main types of these fuels; what’s known as biofuels and synthetic fuels.

[00:12:20] **Ryah Whalen:** So biofuels are made from feedstocks. The stuff that you can make biofuels from is fascinating. You can take used cooking oil and convert it into fuel. You can take agricultural waste, forestry residue, sugar cane, all types of things. You can take and use chemical processes to make fuel that can actually power planes. And what’s so interesting about these is when they actually fly in the air, you’re still emitting CO2. You’re just capturing that CO2 very recently. And so the overall reduction is circular.

[00:12:56] **Mutinta Banda:** The benefits of these types of fuels are that they can be used with the traditional tube and wing-body planes and airport fueling infrastructure. But collecting these types of fuels can be an incredibly challenging process.

[00:13:11] **Ryah Whalen:** When we’re talking about used cooking oil, we’re actually talking about used cooking oil at restaurants. And so there’s only so much used cooking oil that can actually go around, right? And you can imagine the complexities of collecting used cooking oil and driving a van around a city to every restaurant to collect used cooking oil to make fuel. Like there’s just not enough of that.

[00:13:48] **Gokcin Cinar:** Synthetic fuel is also a type of sustainable aviation fuel. It is created by capturing the carbon from air or even other industrial processes. And then you synthesize it with hydrogen. **Mutinta Banda:** The challenge with synthetic aviation fuels is that this is an incredibly complex process, and one that requires massive amounts of renewably sourced electricity. One large producer of synthetic fuels for aviation today is the North Sea Energy Island, one of the oldest energy islands in existence. Renewable electricity is harnessed from massive wind turbines to be put to use to create fuels for the transportation sector. You can learn more about the production of these sustainable aviation fuels in episode 1 of our series, Ballad of the Wind Rigger.

[00:15:12] **Mutinta Banda:** The electric aircraft is another climate innovation...
[00:15:18] **Gokcin Cinar:** Electric aircraft or electrified aircraft really took off in the 2020s on paper. So there were a lot of people working on new designs of these hybrids, electric propulsion concepts or fully electric, smaller aircrafts. There were lots of different startup companies, for instance back then who did flight tests with hybrids, electric or fully electric aircraft. The problem back then was that, so these, these aircraft, hybrids, electrical, electric aircraft use lithium ion batteries. So, the issue with these batteries was that they were very, very heavy, compared to how much energy they could store.

[00:16:07] **Mutinta Banda:** This means that these aircraft are limited to short-haul flights. Another drawback is that lithium ion is not an infinite resource. The benefits of these types of planes are that they are fully emissionless.

One popular type of electric aircraft are air taxis. These are small aircraft that offer an alternative to ground transportation, and helipads across cities make vertically departing and landing a breeze.

[00:16:35] **Mutinta Banda:** The most recent innovation in fueling technologies for aircraft are those that run on liquid hydrogen. Liquid hydrogen emits water vapor instead of CO2. Although the water vapor still contributes to contrails, the long term climate effects are dramatically reduced. Some of the challenges of working with liquid hydrogen are that it is extremely flammable and difficult to store in insulated tanks without leakages.

[00:17:03] **Mutinta Banda:** Also, the entire design of planes needed to change to be fueled with liquid hydrogen along with airport infrastructure.

[00:17:14] **Gokcin Cinar:** Storing the liquid hydrogen is definitely a big challenge. You need to keep it very, very cool. As a passenger, though, you don’t even see these storage facilities. But at some airports there are storage sites with insulated tanks to store hydrogen. But other than that, some other major airports get their hydrogen from a nearby location that generates hydrogen and for other airports they have hydrogen delivered to them through the Global Hydrogen Transportation Network that we have. So we have solved most of those infrastructure challenges for hydrogen delivery to major airports, but there is still more infrastructure to be built for smaller, less crowded airports.

(Airplane soundscape)

[00:18:08] **Mutinta Banda:** Paul flies faster than the speed of sound over the Pacific Ocean, enjoying some of the amenities that his flight has on board.

(Paul speaks loudly)

**Paul Harper:** I’m wearing a VR headset, which is provided to everyone on board and if I click this button here.

(Clicks some buttons)

[00:18:25] **Paul Harper:** I’m tapped into the 3D cameras attached to the bottom of the plane. So not only am I able to look out over the clouds and ocean from my seat, but I actually get a 360 degree view of everything around me.

[00:18:41] **Paul Harper:** Everyone who is flying supersonically is given noise-canceling headphones to use. I’ve also applied automatic noise cancellation to this recording so that you can’t hear the sound of the plane. But if I turn it off for a brief moment...

(Brief sound of supersonic flight - yells the lines below)

[00:18:58] **Paul Harper:** That noise cancellation makes this a much more peaceful way to travel.

(Turns noise cancelling back on)

**Paul Harper:** There are no stewards on this flight, just one safety officer.

(Sound of the trap door opening in the roof compartment.)

[00:19:07] **Paul Harper:** I placed an order about 15 minutes ago for a bean burger and now it’s coming down from the ceiling above my seat.

(Starts chewing a bit.)

**Paul Harper:** 3 hours to go.

**Act III - Looking Forward & Looking Back**

[00:19:27] **Mutinta Banda:** At times, decarbonizing the aviation sector seemed like an impossible task. Along the way, we’ve learnt some important lessons about how to adapt.

[00:19:41] **News Clips:** Next year in 2035, battery recycling facilities will open near many regional airports.

[00:19:47] **News Clips:** The Global Hydrogen Transportation network will expand its operations by 2042.
News Clips: A startup claims they’ll have the first sustainable hypersonic passenger flight ready by 2055.

Mutinta Banda: Action could have been taken much more quickly than it was in aviation and the importance of collaboration cannot be understated...

Ryah Whalen: I mean, when you just think about the aviation sector, you have OEMs, you have fuel producers, you have airline operators, you have airports, right? There’s every different sector where to move to a different solution, they need to play their role, right? You couldn’t, airlines themselves could not fly a blended wing body plane if an OEM did not, did not produce that plane and airlines could not fly on sustainable aviation fuel if the airport didn’t set up the infrastructure and the supply chain to fuel a plane with sustainable aviation fuel. And not only that, but the international nature of travel and the way a plane flies from New York to Singapore and then back to New York, you have to have those solutions in New York and in Singapore for the sector to reach net zero.

Mutinta Banda: But the process is not over yet, there is still so much to be done and new innovations are needed to safeguard this industry for the future.

Gokcin Cinar: Well, infrastructure continues to be a major challenge, especially for hydrogen. The production rate of synthetic sustainable aviation fuels is still being improved. There is definitely more room for improvement there. Also, scientists are working on new chemistries that can unlock more energy, dense and safe batteries. We continue working with other industries to make electric, make the electric power grid a hundred percent renewable at airports all around the world.

Mutinta Banda: Paul touches down in an air taxi on the helipad at the RPAH hospital in Sydney...

(Sound of an electric air taxi taking off from a helipad on the roof of a hospital)

Paul Harper: The air taxi helped shave off a bit more time...

(Sound of Paul running down the stairs, panting, footsteps... echoey)

Paul Harper: Maternity ward is this way.

(Opens a hospital door... goes into a place with some beeping hospital-type noises)

Paul Harper: Uh... where’s the room.... [mumbles names: Smith, Mcdonald...] Harper!! She’s here!

(Door opens - silences for a brief moment, and then the sound of a baby crying.)


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