MY WEIRD PROMPTS

Podcast Transcript

EPISODE #286

The Physics of Plane Wi-Fi: Musk, O'Leary, and Phased Arrays

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EPISODE SYNOPSIS

In this episode of My Weird Prompts, hosts Herman and Corn break down the explosive public feud between Ryanair’s Michael O’Leary and Elon Musk over Starlink’s aviation terminals. Beyond the social media insults lies a fascinating story of orbital mechanics and cutting-edge engineering. The duo explores how Low Earth Orbit (LEO) satellites solve the latency issues of traditional geostationary systems and how "phased array" antennas use mathematical interference to steer beams at supersonic speeds. From the Doppler effect to the debate over aerodynamic drag, learn why the future of travel might include lag-free gaming at 35,000 feet—and why some budget airlines are still refusing to get on board.

DANIEL'S PROMPT

Daniel

How does LEO connectivity work when you're on a plane moving at high speeds and varying altitudes? Specifically, how do receivers maintain a stable connection and manage data transmission while the aircraft is in flight?

TRANSCRIPT

Corn

Hey everyone, welcome back to My Weird Prompts. I am Corn, coming to you from our home in Jerusalem, and I have to say, I have been looking forward to this one all morning. The weather here is finally clearing up, and the view over the Old City is just spectacular today.

Herman

And I am Herman Poppleberry. Good to be here, Corn. We have a really juicy topic today that actually just blew up in the news over the last week. Our housemate Daniel sent us a voice note about this after seeing the latest back and forth between Michael O'Leary and Elon Musk. It is one of those rare moments where a corporate spat actually highlights a massive shift in how we interact with the world—or in this case, the sky.

Corn

It is such a classic clash of personalities, right? You have got O'Leary, the king of low-cost, no-frills travel at Ryanair, basically calling Musk an idiot on Irish radio because of the technical requirements of putting Starlink on planes. And then you have Musk being, well, Musk, firing back on X and calling O'Leary an "utter idiot" and even joking about buying Ryanair just to fire him. But beneath all that corporate theater and the "buy the airline" memes is a genuinely fascinating technical question that Daniel wanted us to dig into.

Herman

Exactly. Daniel was asking how this actually works. How do you keep a stable, high-speed internet connection when you are on a plane moving at eight hundred kilometers per hour, while the satellites themselves are screaming across the sky at twenty-seven thousand kilometers per hour? It is a double moving target problem, and the physics required to solve it are honestly pretty mind-blowing. We are talking about tracking a target the size of a suitcase from five hundred kilometers away while both objects are moving in different vectors at supersonic speeds.

Corn

Right, because for the longest time, in-flight Wi-Fi was just... terrible. It was slow, it was expensive, and it would cut out the moment you left the coast. I remember paying twenty dollars for a flight across the Atlantic only to find out I could barely load a text-only email. But now we are seeing claims of two hundred to five hundred megabits per second at thirty-five thousand feet. So, Herman, for those who might not be up on the latest orbital mechanics, why is the new Low Earth Orbit system so much better than what we had before?

Herman

It really comes down to the difference between GEO and LEO. Traditionally, planes used geostationary satellites, or GEO. Those are massive satellites parked thirty-five thousand, seven hundred eighty-six kilometers away in space. Because they are so far out, they appear to stay in the same spot in the sky relative to the ground, which makes them easy to point at. But the problem is distance. At thirty-five thousand kilometers, the signal has to travel about seventy thousand kilometers round trip. Even at the speed of light, that creates a massive delay, or latency. You are looking at six hundred to eight hundred milliseconds of lag. That is why your video calls would always fail and why even a simple webpage took forever to load. The "handshake" between your computer and the server just timed out.

Corn

And Starlink is much closer, right? Like, significantly closer.

Herman

Way closer. Low Earth Orbit, or LEO, is only about five hundred fifty kilometers up. In fact, SpaceX just announced they are lowering some of their newer V3 satellites to four hundred eighty kilometers to improve safety and de-orbit times. That is over sixty times closer than geostationary satellites. So, the signal travel time drops from nearly a second down to about thirty or forty milliseconds. It is basically the same latency you get with home fiber. But, and this is the big catch Daniel was hitting on, because they are so low, they are moving incredibly fast relative to the ground. They are not "parked" anymore. They are flying past you at seventeen thousand miles per hour.

Corn

So, it is like trying to have a conversation with someone while you are both on different high-speed trains going in different directions, and you're trying to throw a ball back and forth through the windows.

Herman

That is exactly the right analogy. A single Starlink satellite is only in view of the plane for a few minutes before it disappears over the horizon. So, the plane has to constantly "hand off" the connection from one satellite to the next without the passenger noticing a drop in their Netflix stream. If that handoff takes more than a few milliseconds, your connection drops. It is a logistical nightmare of timing and precision.

Corn

Let us talk about that "hand off" for a second. Because if I am on a plane, I am moving at five hundred miles per hour. The satellite is moving at seventeen thousand miles per hour. How does the receiver on the roof of the plane even find the next satellite that quickly? It's not like there's a guy up there with a joystick.

Herman

This is where the hardware gets really interesting. On old planes, you would see these big, bulbous humps on the top of the fuselage. Inside those humps were actual physical satellite dishes that used motors to mechanically tilt and point at the satellite. But motors are slow. They take seconds to move, they have mechanical wear and tear, and they break easily. Plus, they add a ton of drag.

Corn

I remember those. They looked like a little radome blister on the plane's back. They were quite prominent.

Herman

Precisely. But the new Starlink Aero Terminal is completely different. It is an Electronically Steered Phased Array antenna. It is a flat panel that has no moving parts at all. Instead of moving the dish, it uses thousands of tiny antenna elements that work together. By slightly shifting the timing, or the phase, of the signal sent to each of those tiny antennas, the terminal can "steer" the beam electronically. It uses constructive and destructive interference to point the signal in a specific direction without moving an inch.

Corn

Wait, so it's basically using math to bend the radio waves?

Herman

Exactly! It is the Huygens-Fresnel principle in action. By changing the phase by just a few nanoseconds across the array, the terminal can point at a new satellite in less than one millisecond.

Corn

Less than one millisecond? That is faster than a literal blink of an eye.

Herman

It is nearly instantaneous. So, while you are flying, the terminal is actually tracking multiple satellites at once. It is talking to one, but it is already "looking" at the next one. When the first one starts to get too low in the sky, it just flips the data stream to the next one in a fraction of a millisecond. To your laptop in seat twelve B, it looks like one continuous connection. It is so seamless that you can play a fast-paced online game like Counter-Strike or Helldivers Two while crossing the Atlantic, and you won't even notice the handoff.

Corn

That explains the stability, but what about the speed? Daniel’s prompt mentioned the varying altitudes and high speeds. Does the speed of the plane itself cause problems with the frequency of the radio waves? Like the Doppler effect? I remember that from high school physics.

Herman

You nailed it. That is a huge technical challenge. It is the same reason a police siren sounds high-pitched when it is coming toward you and low-pitched when it moves away. At these speeds—where the relative velocity between the plane and the satellite can be over eighteen thousand miles per hour—the radio frequency actually shifts. If the terminal and the satellite don't account for that Doppler shift, the data gets scrambled because the receiver is looking for the signal on the wrong frequency.

Corn

So how do they fix it? Do they just guess the shift?

Herman

No, they use a massive amount of real-time math. The terminal on the plane has a built-in G P S and an inertial navigation system. It knows exactly where the plane is, what its altitude is, and exactly how fast it is moving in three-dimensional space. At the same time, it has a map of the entire Starlink constellation—which, as of today, January twenty-third, twenty-six, is over nine thousand four hundred satellites. It knows where every single one of them is and exactly how fast they are moving.

Corn

So it calculates the expected frequency shift before the signal even arrives?

Herman

Exactly. It uses a Field Programmable Gate Array, or F P G A, to compensate for that frequency shift in real time. It "pre-tunes" the receiver to the shifted frequency. This is why you can maintain a connection even during takeoff or a steep descent when the altitude and velocity are changing rapidly. The terminal is constantly adjusting for the changing distance and the relativistic-like shifts in the signal. It is a level of precision that was simply impossible ten years ago.

Corn

That is incredible. Now, let us get into the drama Daniel mentioned. Michael O'Leary from Ryanair had a very public spat with Elon Musk about this. O'Leary claims that putting these antennas on his planes would cost him a two percent fuel penalty because of the weight and the aerodynamic drag. He basically said the cost isn't worth it for a low-cost carrier. Is he right? Is the drag that bad?

Herman

Well, this is where the numbers get contentious. O'Leary says two percent. If you are Ryanair and you spend five point five billion dollars a year on fuel, two percent is an extra one hundred ten million dollars. That is a huge hit to your margins. But SpaceX’s Vice President of Engineering, Michael Nicolls, actually fired back on social media last week saying their analysis shows the fuel increase for a Boeing seven thirty-seven is only about zero point three percent.

Corn

That is a massive difference. Two percent versus zero point three percent. Someone is either being very pessimistic or very optimistic.

Herman

It really is. Nicolls pointed out that O'Leary's two percent figure might be accurate for the old, bulky mechanical radomes—the ones that look like a giant hump. But the Starlink Aero Terminal is much lower profile. It is only about an inch or two thick and it sits relatively flat against the fuselage. Starlink actually argues that because it is so light—under sixty pounds—and so thin, the drag is negligible compared to the old systems. In fact, Qatar Airways just finished retrofitting their entire fleet of Boeing seven seventy-sevens and Airbus A three-fifties, and they claim the installation only takes about ten hours per plane now. That is ten times faster than the old systems.

Corn

And O'Leary's point was also about the "no-frills" model. He said his passengers won't pay even one euro for internet, so why bother with the drag? But then you look at airlines like United or Air France or Qatar Airways, and they are rolling it out for free. United is equipping more than one plane per day right now!

Herman

Right. And those airlines are seeing it as a competitive advantage. If you are choosing between two six-hour flights and one has free, high-speed Wi-Fi that actually works, you are going to pick that one every time. United expects to have four hundred fifty mainline aircraft fitted with Starlink by the end of this year. They are betting that the "United Next" strategy of premium service will win out. But for O'Leary, every cent counts. He even said he would pay no attention to Musk because Musk "knows nothing about flights and drag."

Corn

It sounds like O'Leary might be using old data or maybe he is just being intentionally difficult to negotiate a better price. He is known for that. He's the guy who suggested charging people to use the toilet, after all.

Herman

Oh, absolutely. It is very Jerusalem-style arguing, actually. Very passionate. But technically speaking, the Aero Terminal is a massive step forward in efficiency. It's not just about the internet; it's about the weight-to-performance ratio.

Corn

One thing I am curious about, and I think Daniel was hinting at this too, is what happens when you are in the middle of the ocean? There are no ground stations in the middle of the Atlantic or the Pacific. In the old days, that meant you lost your connection or had to rely on a very slow GEO link. How does Starlink solve the "middle of nowhere" problem?

Herman

That is where the "space lasers" come in. And I know that sounds like a science fiction trope, but it is very real. The newer Starlink satellites are equipped with Optical Inter-Satellite Links, or I S Ls.

Corn

Space lasers. I love it. Tell me more. How many lasers are we talking about?

Herman

There are over nine thousand lasers in orbit right now. Each satellite has multiple laser terminals that can sustain a one hundred gigabit per second connection per link. So, if you are a plane over the middle of the Pacific, your terminal talks to a satellite directly above you. That satellite might not be able to see a ground station on Earth. So, it uses a laser to beam your data to another satellite nearby, which beams it to another one, and another one, until it finds a satellite that is currently over a ground station in, say, Japan or California.

Corn

So they have built a literal mesh network in space. Your data is hopping from satellite to satellite at the speed of light.

Herman

Exactly. These laser links can stay connected over distances of five thousand kilometers. They are so precise they can maintain a link even while the satellites are moving at seventeen thousand miles per hour. This is why you can now get gate-to-gate connectivity. You don't have to wait until you are at cruising altitude anymore because the system doesn't need to wait for a clear line of sight to a specific ground station. It just finds the fastest path through the mesh.

Corn

That is a huge change. I remember the announcement from airBaltic—they were the first European airline to offer that gate-to-gate service. And now Qatar Airways has connected over eleven million passengers with this tech just in the last year. It really changes the experience of travel if you don't have that "dead zone" during taxi and takeoff. You can finish your Zoom call while the plane is literally pulling away from the gate.

Herman

It also changes things for the pilots. For pilots, having an always-on, high-bandwidth pipe means they can get real-time weather maps and updated flight paths instantly. They aren't relying on old-school radio bursts or slow satellite pings. It makes the whole flight safer and more efficient. They can even stream high-def video of the landing gear or other external sensors to ground technicians in real time if there is an issue.

Corn

So, we have the phased array steering the beam in a millisecond, the F P G A compensating for the Doppler shift from the eight hundred kilometer per hour speed, and the space lasers routing data over the ocean. It really is a feat of engineering. But let's look at the downsides. Is there anything that can still knock this connection out? What about weather? I know my old satellite TV used to cut out whenever it rained.

Herman

Weather is still a factor, but less so than you might think. Starlink uses the Ku-band for its primary communication. While heavy rain or thick clouds can cause some signal attenuation, being at thirty-five thousand feet actually puts you above most of the weather. You are literally flying above the clouds that would normally block a ground-based user. The only time you really face weather interference is during the initial climb or the final approach.

Corn

That is a fair point. You are already through the thickest part of the atmosphere for ninety percent of the flight.

Herman

Exactly. The main challenge at altitude is actually the "handover" density. In busy flight corridors, like the one between New York and London, you might have hundreds of planes all trying to talk to the same few satellites. Starlink has to manage that capacity dynamically, constantly shifting beams to make sure no single satellite gets overwhelmed. They are moving ten petabytes of data every single day across that network.

Corn

It is like a massive game of musical chairs, but with gigabits of data and everyone is moving at Mach zero point eight.

Herman

And the chairs are also moving at seventeen thousand miles per hour. It is a logistical nightmare that is only solved by massive automation. There is no human in a control room doing this. It is all handled by the network's internal logic and AI-driven beam management.

Corn

So, thinking about Daniel's question about "maintaining a stable connection," it really is this invisible dance between the plane's G P S, the satellite's orbital data, and the electronic steering of the antenna. If any of those pieces fail, the whole thing falls apart.

Herman

Right. If the plane's G P S glitched and the terminal thought it was five miles away from where it actually was, it would point the beam at the wrong spot in the sky and the connection would drop instantly. The precision required is incredible. We are talking about pointing a beam with a width of just a few degrees at a target five hundred kilometers away while both of you are moving. It's like trying to hit a moving fly with a laser pointer from across a football stadium while you're on a merry-go-round.

Corn

It reminds me of the discussion we had way back in episode nine about fine-tuning systems. This is like the hardware version of that—fine-tuning the physical alignment of a signal in real time.

Herman

It really is. And the result is that we are finally seeing the "death of the offline flight." For some people, that is a tragedy. They liked the forced isolation of a long-haul flight. They liked having an excuse not to answer emails for ten hours.

Corn

I'm one of those people who misses the quiet, honestly. There was something peaceful about being unreachable. But I can't deny the tech is impressive. Let us talk about the takeaways here. If someone is listening to this and they are about to book a flight, what should they actually look for if they want this kind of experience?

Herman

Well, the first thing is to check the airline. United Airlines is the big one in the U S right now—they are putting it on over one thousand aircraft. Hawaiian Airlines already has it on their long-haul flights. airBaltic is the leader in Europe, and Air France is catching up fast—they expect their entire fleet to be done by the end of twenty-six. Qatar Airways is the global leader for widebody planes. If you see "Starlink" on the amenities list, you can expect speeds around one hundred fifty to two hundred fifty megabits per second and latency low enough for a Zoom call.

Corn

And what about the cost? Is it always going to be free? Or is that just a temporary perk to get us hooked?

Herman

The trend is leaning toward free, but often with a catch. For example, Air France requires you to be a Flying Blue member. It's a way to drive loyalty. But because the "cost per bit" for Starlink is so much lower than the old GEO systems, airlines can afford to give it away as a perk. It is becoming like the "free peanuts" of the digital age. If you don't offer it, you look behind the times. Even Lufthansa is rushing to catch up now, though they say it will take them until twenty-twenty-nine to finish their fleet.

Corn

Unless you are Ryanair, apparently. O'Leary would probably charge you for the oxygen if he could get away with it.

Herman

Well, Michael O'Leary is a special case. But even he might be forced to pivot. Imagine if easyJet or Southwest starts offering free Starlink. Ryanair would have to follow suit or lose the business traveler market entirely. No business traveler is going to sit on a two-hour flight without Wi-Fi if the competitor has it for free.

Corn

It is interesting how the technology is driving the economics. By making the terminal lighter and the service cheaper, SpaceX has essentially forced the airline industry's hand. And now they are testing "Direct to Cell" capabilities with their V3 satellites. In the future, you might not even need the plane's Wi-Fi. Your phone might just talk directly to a satellite through the cabin window.

Herman

That is the next frontier. But for now, that Aero Terminal on the roof is the gold standard. It's a piece of tech that weighs less than a standard checked bag but connects you to a global mesh network of lasers and silicon.

Corn

So, to summarize for Daniel: the stability comes from sub-millisecond electronic beam steering. The speed comes from being sixty times closer to Earth than old satellites. The global coverage comes from space lasers. And the "moving target" problem is solved by high-speed math and Doppler compensation.

Herman

That is the My Weird Prompts summary in a nutshell. It is a combination of orbital mechanics, radio physics, and a very public billionaire feud. It's the most high-tech soap opera in the world.

Corn

I love it. And hey, if you are listening to this on a plane right now using Starlink... first of all, that is meta as heck. Second of all, let us know how it's working! You can find the contact form on our website at myweirdprompts.com.

Herman

Yeah, we would love to hear some real-world benchmarks from our listeners. Are you actually getting those two hundred megabit speeds? Is it stable during turns? We've heard reports of people getting up to five hundred megabits on Qatar Airways. Is that true?

Corn

Actually, that is a great question. Does the plane tilting during a turn affect the connection? If the plane banks at thirty degrees, does the antenna lose the satellite?

Herman

It can, but the phased array antenna is designed to compensate for that. It can "scan" up to sixty degrees off-center. So unless the pilot is doing some serious stunt flying or a very steep tactical descent, the antenna can usually stay locked onto the satellite even during a standard bank or turn. The math just adjusts the phase of the elements to "look" sideways.

Corn

Man, the more we dig into this, the more I realize how much work is happening just so I can scroll through social media at thirty thousand feet. It is a lot of effort for my cat videos.

Herman

It is a triumph of human ingenuity dedicated to the most mundane tasks imaginable. But that is the beauty of it, right? We build these incredible systems so that the complex stuff becomes invisible. You shouldn't have to think about F P G As and Doppler shifts; you should just be able to watch your movie.

Corn

Well said, Herman Poppleberry. And I think that is a perfect place to wrap this up. Daniel, thanks for sending in such a timely prompt. It was great to finally have an excuse to talk about space lasers and Michael O'Leary in the same sentence. It really made my morning.

Herman

It was a highlight of my week, honestly. And hey, if you have been enjoying the show and you are a regular listener, we would really appreciate it if you could leave us a quick review on your podcast app or on Spotify. It genuinely helps the show reach new people who are as curious as we are. We are trying to hit ten thousand reviews by the end of the year!

Corn

Yeah, it really does make a difference. You can also find all of our past episodes, including the one on fine-tuning we mentioned, at myweirdprompts.com. We have got an R S S feed there for subscribers too, and some cool merch if you want a "Space Lasers" t-shirt.

Herman

Alright, I think that is it for today. This has been My Weird Prompts.

Corn

Thanks for listening, everyone. We will see you next time. Stay curious!

Herman

Until next time!

Corn

So Herman, do you think O'Leary is actually going to buy a Starlink kit for his house just to see if it works? Or is he too cheap for the monthly fee?

Herman

I think he'd try to negotiate a "no-frills" version of Starlink that only connects on Tuesdays and requires him to pedal a bike to power the terminal.

Corn

"Low-Earth Orbit, but you have to stand on one leg to get a signal."

Herman

Exactly. "Priority bandwidth" costs an extra ten euros, and you have to bring your own ethernet cable.

Corn

Well, whatever the case, I'm just glad we don't have to pay for the Wi-Fi in this house. Although, with Daniel's data usage, maybe we should start charging him.

Herman

Amen to that. See ya, Corn.

Corn

See ya, Herman.

Herman

And thanks again to Daniel for the prompt. We'll have to tell him the full "space laser" story over dinner. I think he'll be interested in the V3 upgrades.

Corn

Oh, he's going to love it. He's a sucker for anything with the word "laser" in it. He still has that laser pointer from the nineties.

Herman

Aren't we all? Alright, signing off for real this time. Bye!

Corn

Bye!

Herman

My Weird Prompts is a collaborative production. For more information, visit myweirdprompts.com.

Corn

And remember, no question is too weird. Keep them coming! We love the technical ones.

Herman

Safe travels, everyone—whether you're on the ground or at thirty-five thousand feet.

Corn

Hopefully with good Wi-Fi.

Herman

Hopefully. Bye!