

MY WEIRD PROMPTS

Podcast Transcript

EPISODE #193

Eyes in the Sky: The Physics of Global Missile Detection

Published January 08, 2026 • Runtime: 29:54

<https://myweirdprompts.com/episode/missile-detection-technology-explained/>

EPISODE SYNOPSIS

In this episode of My Weird Prompts, Herman and Corn peel back the layers of global missile defense systems to answer a listener's question about how we sense threats from thousands of kilometers away. They discuss the critical transition from legacy satellite systems like SBIRS to the Next-Gen OPIR and the Proliferated Warfighter Space Architecture (PWSA). The duo dives deep into the "look-down problem," explaining how sensors distinguish a rocket's chemical fingerprint from the "noise" of forest fires and solar reflections. From the historic 1983 Petrov incident to the physics of Mach disks and the engineering of phased array radars that see over the horizon, this conversation covers the incredible invisible infrastructure working at light speed to keep the world informed and safe.

DANIEL'S PROMPT

Daniel

"How do countries detect missile launches from a long distance? What are the technologies involved in this high-stakes form of remote sensing, and how is it possible to distinguish missile launches from other events with similar thermal signatures, like forest fires or atmospheric events?"

TRANSCRIPT

Corn

Hey everyone, welcome back to My Weird Prompts. I am Corn, and I am sitting here in our living room in Jerusalem with my brother.

Herman

Herman Poppleberry, at your service. It is a beautiful day outside, but today we are diving into a topic that is, quite literally, high stakes.

Corn

It really is. Our housemate Daniel sent us a voice note about this, and it is something we have actually lived through recently. He was asking about how countries detect missile launches from huge distances. When you are sitting in a bomb shelter and the sirens go off, you realize there is this massive, invisible infrastructure working at light speed to keep you informed. We saw this firsthand during the intense missile and drone attacks over the last couple of years, particularly in twenty-twenty-four and twenty-twenty-five, when regional defense systems were pushed close to their operational limits.

Herman

Exactly. It is one of those technologies that you hope you never have to think about, but once you start looking into the physics and the engineering behind it, it is absolutely mind-blowing. We are talking about sensing events that happen thousands of kilometers away, often within seconds of them occurring. Right now, we are actually in the middle of a massive architectural shift in how this is done.

Corn

Right, and Daniel specifically wanted to know about the remote sensing aspect. How do you distinguish a rocket motor from, say, a massive forest fire or a weird atmospheric reflection? It seems like a needle in a haystack problem, but the haystack is the entire planet.

Herman

That is a great way to put it. And remember, we touched on some of this back in episode one hundred and seventy-five when we talked about modern missile warfare, but today we are really going to peel back the layers on the sensors themselves. The first thing to understand is that missile detection is not just one thing. It is a layered system of systems. You have got the space layer, the terrestrial radar layer, and the signal processing layer.

Corn

Let us start with the space layer because that is usually the first line of defense. If a missile launches in a desert halfway around the world, how does a satellite three or four hundred kilometers up know it is happening?

Herman

Well, it actually starts even higher than that. For decades, the backbone has been the Space Based Infrared System, or S B I R S, which uses satellites in geostationary orbit—about thirty-five thousand seven hundred and eighty-six kilometers up. At that height, a satellite stays fixed over one point. But as we speak in early twenty-twenty-six, the Space Force is transitioning to something called Next-Gen O P I R, or Overhead Persistent Infrared. In fact, the first Next-Gen O P I R G E O satellite is scheduled for launch in the mid-twenty-twenties, with the current planning window targeting around twenty-twenty-six.

Corn

Wait, why the upgrade? Was S B I R S not good enough?

Herman

S B I R S was incredible, but the threats are changing. Modern missiles are being designed with faster-burning, dimmer engines that are harder to see against the Earth's background. Next-Gen O P I R uses much more sensitive focal plane arrays along with improved sensors and processing. These are essentially giant digital camera sensors, but instead of seeing visible light, they are tuned to specific infrared bands.

Corn

Okay, so it is a heat map. But a rocket engine is basically a giant blowtorch. I imagine that stands out quite a bit, right?

Herman

It does, but space is surprisingly noisy in the infrared spectrum. This is what engineers call the look-down problem. The Earth itself is warm. Clouds reflect sunlight, which is called sun-glint. You have got lightning, volcanic activity, and yes, forest fires. To solve this, the sensors look at very specific parts of the spectrum. Most systems use multiple bands, like the two point seven micron band, which is where water vapor emits energy, and the four point three micron band, which is the signature of carbon dioxide.

Corn

Why those specifically?

Herman

Because those are the primary combustion products of rocket fuel. When you burn tons of propellant, you create a massive cloud of hot C O two and water vapor. By looking for those specific chemical fingerprints, the satellite can ignore a lot of the background noise from the sun or the warm ground.

Corn

That is fascinating. So it is not just looking for heat; it is looking for the chemical signature of a fire. But Daniel asked about distinguishing it from a forest fire. A forest fire is also burning carbon-based material, right?

Herman

It is, but the temperature and the intensity are orders of magnitude different. A forest fire might reach one thousand degrees Celsius, but a rocket motor is pushing three thousand degrees or more. More importantly, it is about the physics of the plume. Have you ever seen those little diamond shapes in the exhaust of a jet or a rocket?

Corn

Yeah, the shock diamonds or Mach disks.

Herman

Exactly! Those are caused by the pressure of the exhaust interacting with the atmosphere. Modern high-resolution sensors can actually resolve the spacing of those diamonds. That spacing tells the system the thrust of the engine and the altitude of the missile. A forest fire does not have shock diamonds. It does not have a velocity of four kilometers per second.

Corn

So it is the combination of the chemical fingerprint, the extreme temperature, and the movement. But what about the motion Daniel mentioned? A missile is moving incredibly fast.

Herman

That is the second-order effect. The algorithms are not just looking for a hot spot. They are looking for a hot spot with a specific acceleration profile. A ballistic missile has a very distinct curve. It starts slow and gets incredibly fast very quickly as it sheds weight. A forest fire is static. An airplane is moving, but its engines are nowhere near as hot as a ballistic missile. Even a lightning strike, which is very hot, only lasts for milliseconds, whereas a rocket burn lasts for minutes.

Corn

That makes sense. But I am curious about the atmospheric events Daniel mentioned. Like, could a particularly bright reflection of the sun off a high-altitude ice cloud trigger a false alarm?

Herman

It actually has happened in the history of these systems. There is a famous story from nineteen eighty-three involving a Soviet officer named Stanislav Petrov. Their early warning system, called Oko, reported what appeared to be several incoming American missiles. It turned out the system had mistaken the sun reflecting off the top of high-altitude clouds for the thermal signatures of launches. Because the satellites were in a Molniya orbit—a highly elliptical path—the geometry of the sun, the clouds, and the sensor created a perfect storm of false data.

Corn

That is terrifying. I mean, we are talking about the potential for accidental nuclear war because of a cloud.

Herman

Right. And that is why modern systems are so much more sophisticated. Today, we use staring sensors versus scanning sensors. Older satellites had to scan the Earth line by line, like an old television. Modern ones, like the ones in the new Proliferated Warfighter Space Architecture, or P W S A, have huge focal plane arrays that essentially stare at the entire hemisphere all at once. They can see changes in brightness in real-time without having to wait for a sensor to sweep across the area again. This allows them to do much better temporal analysis. They can see the flicker of the engine, the staging process where one part of the rocket drops off and the next ignites. That kind of detail is almost impossible to fake.

Corn

You mentioned the P W S A. Is that different from the geostationary satellites we talked about?

Herman

It is a huge shift. Instead of just a few giant satellites thirty-five thousand kilometers away, the Space Development Agency is deploying Tranche One of the P W S A in Low Earth Orbit, at roughly one thousand kilometers up. By the mid-twenty-twenties, the goal is to have on the order of a hundred-plus of these smaller satellites in orbit as part of Tranche One. Because they are closer, they can see much dimmer threats, like hypersonic glide vehicles, which stay lower in the atmosphere and are harder for the high-altitude satellites to track.

Corn

So we have these eyes in the sky staring at the planet. But once the missile burns out its fuel, it is not a giant blowtorch anymore. It is just a cold piece of metal flying through space. How do we track it then?

Herman

That is where the radar layer comes in. Once the boost phase is over, the missile enters what we call the midcourse phase. It is coasting. At this point, infrared is less effective because the object is cooling down, although high-end sensors can still pick up the faint heat of the re-entry vehicle against the cold background of space. But primarily, we switch to ground-based or sea-based radar.

Corn

And these are not just your standard airport radars. I remember we talked about the B G P networking for J F K airport back in episode two hundred and eighty-seven, but these military radars are on a completely different scale.

Herman

Oh, absolutely. We are talking about phased array radars the size of apartment buildings. Things like the Ballistic Missile Early Warning System, or B M E W S, and the A N slash T P Y dash two. These use thousands of small antenna elements to steer a radar beam electronically. They can track hundreds of objects simultaneously.

Corn

Wait, you said steer the beam electronically? They do not actually rotate like the ones you see on top of ships?

Herman

Most modern early warning radars are stationary. They look like giant, slanted pyramids. By changing the phase of the signal sent to each individual antenna element, they can move the radar beam across the sky in microseconds. It is much faster and more reliable than a mechanical dish. Some of these radars, like the Over-the-Horizon systems, can even bounce signals off the ionosphere to see over the curvature of the Earth.

Corn

That is incredible. So they are essentially using the upper atmosphere as a mirror to look around the bend of the planet.

Herman

Exactly. It is called Skywave propagation. By using high-frequency radio waves between five and thirty megahertz, they can detect launches from more than six thousand kilometers away. But there is a trade-off. Over-the-horizon radar is less precise. It can tell you something is coming, but it might not give you the exact coordinates needed for an interceptor. That is why you need the combination. The satellite sees the flash, the over-the-horizon radar confirms the movement, and then the high-resolution X-band radars lock on to provide the precise tracking data.

Corn

I want to go back to the discrimination part. Daniel asked about how we distinguish missiles from other events. We talked about forest fires and clouds. But what about decoys? If a country launches a missile, couldn't they just throw out a bunch of shiny balloons or heaters to confuse the sensors?

Herman

That is a very sophisticated question, and it is the heart of the arms race in missile defense. It is called target discrimination. When a ballistic missile reaches the vacuum of space, it can release decoys. Because there is no air resistance, a heavy warhead and a light Mylar balloon will travel at the exact same speed on the same trajectory. To a simple radar, they might look identical.

Corn

So how do you tell which one is the actual threat?

Herman

You look at the nuances. You look at how the objects wobble or tumble. A heavy warhead has a different moment of inertia than a hollow balloon. You use multi-spectral imaging to see how they reflect light and heat. And you wait until they start to hit the atmosphere again. This is called the terminal phase. Once they hit the air, the light decoys slow down rapidly due to drag, while the heavy warhead keeps its momentum. This is where the physics of atmospheric re-entry does the sorting for you.

Corn

But by then, you only have seconds to react.

Herman

Exactly. That is the high-stakes part. The goal of the entire detection pipeline is to give the decision-makers as much time as possible. In the context of what we experienced here in Jerusalem, the system has to calculate the predicted impact point within seconds. It has to decide which neighborhoods need to be alerted and which do not.

Corn

That is something I always found fascinating. When the sirens go off here, it is not the whole city every time. It is very localized. That implies the math being done is incredibly precise.

Herman

It is. The system takes the radar data, calculates the ballistic arc, accounts for wind and atmospheric density, and draws an uncertainty ellipse on the map. If your house is in that ellipse, your phone starts screaming. It is a massive triumph of real-time computation. We are talking about solving complex differential equations in milliseconds. And as of twenty-twenty-six, much of this is transitioning to a new ground architecture called F O R G E, which stands for Future Operationally Resilient Ground Evolution. It uses A I to process the massive data streams from all these different satellites and radars simultaneously as it takes over more work from legacy systems.

Corn

You mentioned earlier that the satellites use staring sensors now. Does that mean they are capturing video, or is it more like a continuous stream of data points?

Herman

It is more like a high-speed data stream. Each pixel on the sensor represents a specific area on the ground. The system is looking for a change in the radiant intensity of those pixels. If a pixel suddenly gets a thousand times brighter and that brightness starts moving across adjacent pixels in a way that matches a rocket's profile, the system flags it. But because the data volume is so high, a lot of the processing happens on the satellite itself. It is called edge computing. The satellite only sends back the data for the pixels that are doing something interesting.

Corn

What about the newer stuff? I have been reading about hypersonic missiles. Does that change how we detect them? Because they do not follow a nice, predictable ballistic arc, right?

Herman

It changes everything, Corn. Hypersonics are the biggest challenge for detection systems right now. Standard ballistic missiles go very high into space and then come back down. They are easy to see because they are high up and follow a predictable path. Hypersonic glide vehicles stay much lower in the atmosphere—usually below one hundred kilometers—and they can maneuver.

Corn

So they stay under the radar, literally?

Herman

Exactly. They fly in the gap between where traditional air defense radars look and where some space-based sensors are optimized. This has led to the development of a whole new layer of satellites called the Hypersonic and Ballistic Tracking Space Sensor, or H B T S S. These are being placed in Low Earth Orbit, much closer to the ground, so they can track these dimmer, maneuvering threats with much higher sensitivity. The first H B T S S prototype satellites were launched in the mid-twenty-twenties for on-orbit testing, and they are in the process of being integrated into the broader missile-warning architecture.

Corn

It feels like a constant game of cat and mouse. Every time we get better at sensing, the missiles get better at hiding.

Herman

It really is. And it is not just about the hardware. It is about the AI and machine learning that processes the data. With the sheer amount of data coming off these new staring sensors, a human could never look at it all. You need algorithms that can filter out the noise of a sun-glinting ocean or a massive lightning storm in the tropics without missing the one pixel that represents a launch. This is where new AI-enabled ground systems come in, which have been a growing focus of recent defense budgets for processing space- and ground-based sensor data.

Corn

Speaking of noise, I was thinking about the environmental impact of all this. Does the constant monitoring of the Earth's thermal signature give us any side benefits? Like, could these same satellites be used for something else?

Herman

That is actually a really cool second-order effect. While these satellites are classified military assets, the data they collect is sometimes shared for civil use. For example, during massive wildfire seasons, the infrared data from early warning satellites can help fire services detect new outbreaks in remote areas much faster than ground observers could. They can see the heat signature of a new fire starting in the middle of a national forest almost instantly.

Corn

That is a great example of a dual-use technology. It is designed for war but ends up helping with disaster management.

Herman

Precisely. And they also use it for monitoring volcanic eruptions. A volcano's thermal signature is very distinct, and being able to track the heat buildup before an eruption can provide vital early warnings for aviation and local populations. We have seen this used effectively for eruptions in the Pacific over the last few years.

Corn

I want to circle back to Daniel's question about how it is possible to distinguish these events. We talked about the spectrum and the motion. But what about the chemistry? Does the exhaust of a rocket have a specific chemical signature that we can see from space?

Herman

It does! This is where it gets really nerdy. When a rocket burns fuel, it produces specific combustion products like carbon dioxide, water vapor, and sometimes aluminum oxide. These molecules emit and absorb light at very specific wavelengths. By using spectrometers, sensors can actually identify the chemical composition of the plume.

Corn

So you can tell not just that a rocket was launched, but potentially what kind of fuel it is using?

Herman

Yes. And if you know the fuel, you can often narrow down the type of missile. A solid-fueled missile, which can be launched almost instantly, has a different chemical signature than a liquid-fueled one, which takes longer to prepare. Solid fuels often contain metallic additives like aluminum to increase thrust, which show up as distinct features in the spectrum.

Corn

That is wild. It is like a chemical fingerprint being left in the sky.

Herman

Exactly. And the resolution of these sensors is getting to the point where they can see the Mach disks in the plume. As I mentioned, the spacing and shape of those diamonds can tell you about the engine's thrust and the altitude. It is an incredible amount of information derived from just a few pixels of light. It allows intelligence agencies to identify the specific model of a missile before it even reaches its peak altitude.

Corn

It really highlights how much work goes into the back end. Like Daniel said, most people just see the result, but the orchestra of decisions and mathematics happening behind the scenes is staggering. From the moment the first photon hits a sensor in orbit to the moment the siren goes off in our neighborhood, it is a journey of data moving at the speed of light.

Herman

It really is. And for our listeners, if you are ever looking at those satellite maps of the world at night, just remember that there are eyes up there looking at a much more complex version of that map. They are not just seeing the lights of cities; they are seeing the thermal pulse of the entire planet. They are looking for the one-in-a-billion event that could change history.

Corn

So, Herman, if you had to summarize the key takeaways for Daniel and everyone else listening, what are the big things to remember about how we detect these launches?

Herman

I would say there are three main things. First, it is all about the spectrum. We use infrared because it cuts through the noise and highlights the immense energy of a rocket motor, specifically looking for the C O two and water vapor signatures. Second, it is about the motion. Algorithms filter out static heat sources like fires by looking for the specific acceleration and speed of a missile. And third, it is about the layers. No single sensor is perfect, so we use a combination of satellites in high and low orbits—like the new P W S A constellation—massive ground radars, and sophisticated signal processing to build a reliable picture.

Corn

And I think the most important thing for me is that second-order effect we mentioned—how this high-stakes military tech can actually help us with things like climate monitoring and wildfire detection. It is a reminder that even the most specialized technology often has broader applications.

Herman

Absolutely. And you know, it is funny. We live in this era where we take for granted that we will get a notification on our phones if something is happening. But the chain of events required to make that notification happen involves everything from orbital mechanics to quantum physics in the sensors. It is a massive, global-scale machine that never sleeps.

Corn

It really does. And hey, if you are enjoying these deep dives into the tech that runs our world, we would really appreciate it if you could leave us a review on your podcast app or on Spotify. It genuinely helps other curious people find the show.

Herman

Yeah, it makes a big difference for us. We love seeing the feedback and hearing what topics you want us to tackle next. Maybe we can do a deep dive into the ground systems like F O R G E next time.

Corn

Definitely. And remember, you can find all our past episodes, including the ones we mentioned today about networking and missile tech, at our website, myweirdprompts.com. There is a contact form there if you want to send us a question, or you can find us on Spotify.

Herman

We have got a lot more to explore. I think next time we might need to look into how these interceptors actually hit a target moving at five kilometers per second. That is a whole other level of crazy math. We could talk about the hit-to-kill technology and the Golden Dome initiative.

Corn

Oh, I am definitely down for that. The hit-to-kill technology is mind-blowing. But for now, I think we have given Daniel a pretty good overview of the sensing side.

Herman

I hope so. It is a fascinating field, even if it is born out of necessity.

Corn

Well, this has been My Weird Prompts. Thanks for joining us for episode two hundred and ninety-two.

Herman

Until next time, keep asking those weird questions.

Corn

Bye everyone.

Herman

See ya.

Corn

You know, Herman, I was just thinking about the sheer volume of data we mentioned. If those sensors are staring at the whole Earth, the bandwidth required to send that back to a ground station must be insane.

Herman

Oh, it is. That is why a lot of the initial processing actually happens on the satellite itself. They use specialized chips, like radiation-hardened F P G A s, to do the first level of filtering. They do not send back a video of the whole Earth. They only send back the data for the pixels that are doing something interesting. It is the only way to keep the latency low enough to be useful.

Corn

That makes sense. It is edge computing, but in space. And with the new laser links between satellites in the P W S A, they can pass that data around the world without even needing a ground station in every country.

Herman

Exactly. It is a mesh network in orbit. If they tried to send everything via traditional radio, they would clog up their own communication links. It is all about efficiency and speed.

Corn

It is amazing how every problem in this field has a solution that leads to another interesting engineering challenge.

Herman

That is the beauty of it. It never ends. The more we see, the more we need to process.

Corn

Alright, I think that is a wrap for real this time.

Herman

Sounds good. Let us go get some coffee.

Corn

Deal.

Herman

And maybe check if Daniel has any more prompts in the queue. He has been on a roll lately.

Corn

He really has. I think he spends his whole day just thinking of things that make us have to do hours of research.

Herman

And we love him for it.

Corn

We do. Alright, thanks for listening everyone. We will catch you in the next one.

Herman

Bye!