Episode Book

EPISODE #5747

Jamming Drones: The Physics of the Wearable Skylock Kit

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SYNOPSIS

Skylock's Wearable Kit is a compact RF counter-drone system now in operational service — detecting hostile drones out to two kilometers and jamming out to three, with Ukrainian troops, the US Army in Europe, and the IDF in Gaza all using it. But how does jamming actually work when drones hop frequencies and spread their signals thin? This episode unpacks the inverse-square law, signal-to-noise ratios, FHSS and DSSS, and the barrage-versus-spot jamming tradeoff — and explains why jamming range is structurally longer than detection range. Same equation, evaluated in two directions.

TRANSCRIPT



Corn

...which is why the battery is always the actual constraint, not the physics. Every time. You can write whatever equation you like on the whiteboard, and then somebody has to carry the answer up a hill.



Herman

Right, and that's true of basically every RF system ever fielded. The theory is elegant. The hardware is a guy with a backpack.



Corn

Which is a decent place to start, because Daniel sent us something this week that's the same idea in a much smaller package. There's a piece in the Jerusalem Post about a wearable counter-drone system now in operational service. Skylock's Wearable Kit. Compact RF detection and jamming, detect hostile drones out to two kilometers, jam out to three, and it gives directional alerts so troops can take cover or reposition before the drone ever identifies where they are. Ukrainian troops have used it, the US Army has tested it in Europe, and the IDF has been maneuvering with it in Gaza.



Herman

And Daniel's reaction was, I think, most people's reaction. He's surprised that electronic countermeasures can be lightweight enough to wear at all. Then he wants to know what jamming actually entails. The popular picture is emitting noise on the same frequency as the opposing signal to disrupt the flight controls. And then his real question: with frequency hopping and other techniques, the fight between broadcast and jamming must be much more complicated than that. And finally he wants the underlying electromagnetic physics, the stuff that holds whether the jammer is on an aircraft, on a vest, or on a pole somewhere.



Corn

Three questions in one. What is it, how does jamming actually work, and what's the physics underneath all of it.



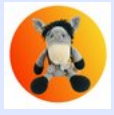
Herman

Let's do all three.



Corn

Start with the thing itself, because the form factor is the headline.



Herman

Skylock, Israeli company. The Wearable Kit does two jobs usually done by two separate pieces of equipment. It listens, and it talks. On the listening side, RF detection out to two kilometers. That's passive. It's not pinging anything, it's just sitting there with a receiver and an antenna listening for the emissions a drone has to make to be a drone.



Corn

Which every drone with a remote operator makes, by definition. If a human is flying it, there's a link.



Herman

Control uplink, video downlink, sometimes telemetry. Those are all radio emissions, and they're all detectable if you know what frequencies to look at and you're close enough.



Corn

And the directional part. That's the piece that actually changes behavior. Knowing there's a drone is one thing. Knowing which way to turn your head is another.



Herman

Directional alerts let a unit take cover or reposition before the drone has identified them. So the value proposition isn't just "shoot it down," it's "don't be seen in the first place." In an environment where every squad has a quadcopter overhead, being seen is most of the danger, because the drone itself is often just the spotter.



Corn

And then the jamming side, three kilometers, which is further than the detection range. That gap is interesting. Two kilometers to hear it, three to interfere with it.



Herman

That gap is the whole physics of the episode. That's not an accident of engineering. That's a structural feature of how jamming and detection work, and it falls directly out of the inverse-square law.



Corn

So where does the popular model break?



Herman

The popular model is: drone is on frequency X, you broadcast noise on frequency X, the drone can't hear its controller, it fails safe and drops. And that model is correct. For about the first thirty seconds. It works perfectly against a drone on a fixed channel, and it has worked for decades. But it's a model of a world where the drone sits still on the spectrum, and drones have not sat still on the spectrum since roughly the Second World War.



Corn

So the naive jammer is shouting over one channel, and the drone just walks to another one.



Herman

Start with a radio link. You've got a transmitter at some power, radiating in all directions. That signal spreads out as it travels, so the power per unit area falls off with the square of the distance. At the receiver, what matters is the signal strength arriving versus the noise floor. Every receiver has a noise floor, it's thermal, it's in the electronics. The receiver can pull a signal out of that noise as long as the signal is sufficiently above it. That ratio is the whole game.



Corn

Signal to noise.



Herman

And here's the key move. A jammer doesn't have to be louder than the transmitter at the transmitter's location. It has to be loud enough at the drone's receiver to raise the noise floor. You're not outshouting the controller, you're drowning the drone's ability to hear the controller.



Corn

Which is why you don't need a transmitter as powerful as the one you're fighting.



Herman

You need enough power at the target's location to matter. And the drone's receiver is a small, cheap, low-power thing on a battery. So the noise floor you have to raise is not a high bar.



Corn

Is that why the jammer covers three kilometers and only detects at two? Because it's easier to mess with a receiver than to hear a transmitter?



Herman

Partly, but the more precise reason is that the two jobs are asymmetric. When you're detecting, you're trying to hear a signal from a drone two kilometers away against your own noise floor, with your own receiver's sensitivity. When you're jamming, you're broadcasting from your position to the drone's position, and you only need to arrive at a level that clutters its receiver. The drone's receiver is designed to hear a nearby controller, and it will happily be confused by a somewhat distant loud noise. So jamming has an easier signal-to-noise job than detection, given similar power, and that shows up as range.



Corn

So the numbers aren't arbitrary. They're the same equation evaluated in two directions.



Herman

Same equation, different thresholds. Detection is "I can hear you over my own hiss." Jamming is "you can hear me over yours."



Corn

So that's the simple case. Fixed frequency, you broadcast noise, the drone loses lock, failsafe, done.



Herman

Right. Which is why every serious drone program since the nineties has used some form of spread spectrum, because the fixed-channel drone is a dead drone the moment somebody turns on a jammer.



Corn

And Daniel's instinct here is correct. This is where it stops being a shouting match.



Herman

So take the two main techniques. First, frequency hopping spread spectrum, FHSS. The transmitter and receiver agree on a sequence, and they hop channels together, synchronized, many times a second. The control link is only on any given channel for a sliver of a second. A jammer that doesn't know the pattern can only cover some fraction of the band at any instant. It might knock out a hop here and there, but the link as a whole still gets through, because the receiver only needs the hops it can hear.



Corn

So you're not trying to block the signal, you're trying to block enough of the signal that the error correction gives up.



Herman

And the receiver is designed to lose hops. It has to be, because the drone is in flight and the link is not perfect anyway. So a narrowband jammer hopping in the dark is fighting a receiver specifically designed to shrug off what the jammer is doing.



Corn

How fast are these hops, typically?



Herman

Bluetooth uses sixteen hundred hops per second, as a reference point for consumer hardware. Military links can be much faster. The point is that it gets fast enough that a jammer trying to chase it with a narrowband transmitter is always one step behind, and being one step behind is the same as being useless.



Corn

And the second technique?



Herman

Direct-sequence spread spectrum, DSSS. Instead of hopping between channels, you spread your signal across a very wide band at low power density. So your signal is everywhere in the band at once, but it's quiet everywhere. A narrowband jammer only affects a sliver of it. You'd need to jam the entire band to touch the whole signal, and that costs a lot of power.



Corn

So the two techniques are different answers to the same problem. One moves the signal around. The other smears it thin.



Herman

And the jammer has essentially two responses. It can barrage, or it can spot.



Corn

Define the terms, because this is where most people get lost.



Herman

Barrage jamming is broadband noise across the entire band the drone might be using. Blunt, indiscriminate, and it works. It doesn't matter where the drone hops, because you're covering everything. The cost is enormous power, because you're spreading your energy across megahertz of spectrum instead of concentrating it. And also, you're now a giant beacon.



Corn

Because you're shouting across the whole band.



Herman

You're broadcasting across the whole band at a fixed location. Anybody with a receiver and a direction-finding antenna can find you in seconds. Which is why barrage jamming is typically done by aircraft, or by expendable systems where you don't care if it gets found, because the whole point is that it gets found and draws the shot.



Corn

And spot jamming is the opposite. Concentrated on one channel, high power per channel. But only one channel at a time.



Herman

High power, narrow. If you know where the drone is in the spectrum, you can put serious energy right on top of it. But if the drone is hopping, you're always arriving late. You have to follow the hops, and the difficulty of following hops is the difficulty of knowing the hop pattern.



Corn

So the arms race is: the drone makes its pattern unpredictable, and the jammer tries to predict it.



Herman

Or the jammer gives up on predicting and just barrages, and then the drone's response is to make the band so wide that barrage jamming costs too much power to be feasible. Every generation of this is a tug of war over power and bandwidth.



Corn

Let's make it concrete. Say the drone is on 2.4 gigahertz, hopping across eighty channels. And you're a wearable with a battery.



Herman

Then you're in a hard spot. If you barrage the band, your power is spread across the whole thing, so the power per channel is small, and the drone may just keep flying. If you spot-jam, you can put real power on one channel, but you're only on one channel at a time, and the drone is somewhere else for most of the second. So the wearable has to be smart. It has to figure out the hop pattern, or prioritize, or work together with other units.



Corn

Which is presumably where the directional alerts matter. If you know which way the drone is, you can focus your jamming beam instead of broadcasting in a circle.



Herman

That's one of the advantages a wearable can build on. But now's a good time to talk about the detection side, because it's the part people skip, and it's the part that makes the whole thing work.



Corn

Go.



Herman

RF detection is passive. You're not transmitting anything, so nobody knows you're listening. You're just sweeping the band and looking for emissions that look like a drone link. Control signals, video links, telemetry. And modern systems can fingerprint them, because a DJI drone doesn't sound like a military link.



Corn

And the direction finding is what gives you the bearing.



Herman

Direction finding on a small package is clever engineering. You don't have room for a big parabolic dish on a soldier's vest. So what you do instead is an antenna array, several small antennas, and you compare the amplitude or the phase of the signal arriving at each one. If the signal is stronger on the left antenna than the right, it's coming from somewhere on the left. Combine a couple of comparisons and you get a bearing.



Corn

Get a bearing and you know which way to look.



Herman

Which is a different kind of information than "there is a drone out there." Both are useful, but only one of them lets a squad do something about it.



Corn

So the wearable does two jobs in sequence. It hears, and then it tells you where. And then, if you choose, it jams.



Herman

And that sequence is why the whole system works at all. Detection informs jamming. You can aim your jamming instead of spraying it. And that's not a small deal, because aim changes power requirements by a lot. If you're broadcasting in a circle and only a sliver of the energy lands on the drone, you're wasting most of your battery. If you're broadcasting in a cone pointed at the drone, most of your power is arriving where it needs to.



Corn

And if you don't know where the drone is, you can't point at it.



Herman

Then you're stuck broadcasting or barraging, and both of those drain the battery fast and get you located.



Corn

So this is what makes the form factor possible. It's not just that the electronics got smaller. It's that the system can do more with less power, because it knows more.



Herman

The intelligence of the system is what buys you the power budget.



Corn

Now the interesting part. What does it mean that this capability is now wearable? Not a truck, not a plane, not a dedicated EW platform. A soldier's vest.



Herman

It changes a lot, and I want to be careful here, because a lot of the coverage treats this as a single product story, and it's not. It's the latest visible point on a curve.



Corn

Meaning what's happened to the trend line?



Herman

Jamming used to be a theater-level asset. If you wanted to jam something, you needed a platform, a crew, and a lot of power. The EA-18G Growler is the canonical example. It carries jamming pods and can put serious energy on target from a long way away. But it's a theater asset. You don't give one to a squad.



Corn

You don't even give one to a battalion.



Herman

So the historical picture was that EW lived at the top of the command structure. What's changed is that the electronics got small, the antennas got small, the software got smart, and the batteries got better. So you can now do a useful subset of what a Growler does, at the squad level, for hours.



Corn

Useful subset. That's the caveat.



Herman

This is not a Growler in a vest. It's a specific set of capabilities packaged small. Skylock's system is aimed at the drone threat, which is the threat that infantry actually faces now. So it's a focused tool, not a general-purpose EW suite.



Corn

And the focused tool is the right tool for the threat.



Herman

The drone threat at the squad level is: see a quadcopter, either lose your position or take casualties. Both of those are bad, and both are somewhat preventable with early warning and jamming. So the wearable is aimed exactly at the problem it's meant to solve.



Corn

That's the deployment context. Ukrainian troops using it, US Army testing in Europe, IDF maneuvering in Gaza. Those are three different environments, and I'd guess each one stresses different parts of the system.



Herman

Very different. Ukraine is the densest drone environment on the planet right now. Both sides are using thousands of small drones a day. The EW environment is saturated, which means the system has to perform in a crowded spectrum. There's a lot of jamming happening, a lot of spoofing, and your system has to work in that soup.



Corn

And Gaza is close. Urban, dense, short ranges. Two kilometers of detection is not the binding constraint.



Herman

In Gaza, the range is fine, but the environment is cluttered. Concrete, buildings, reflective surfaces. Multipath is a genuine problem for direction finding, because the signal arriving at your array may have bounced off a building, and now your bearing is wrong.



Corn

So the directional alert can lie to you.



Herman

It can. Not maliciously, just because that's what the environment does. Which is why none of these systems are a replacement for training and judgment. They inform, they don't decide.



Corn

And Europe is the peer-adversary testbed. Does this work against a sophisticated opponent who's been thinking about countermeasures the whole time they were building the drone?



Herman

Which is where the whole thing starts to look less like a solution and more like one move in a game.



Corn

Let's take the limits head-on, then.



Herman

First limit, and it's the one everyone lists, fiber-optic tethered drones. If the drone has no radio link because it's connected to the operator by a fiber, there is nothing to jam. The link is a glass strand. You can't transmit noise down it from a distance, and you can't intercept it.



Corn

So it just ignores you.



Herman

It ignores the jammer entirely. And there's a lot of movement toward fiber-optic drones specifically because the EW environment has gotten so hostile that RF control is no longer reliable. Which is a fascinating inversion. Jamming got so good that the response was to abandon radio.



Corn

What else?



Herman

Autonomous terminal guidance. If a drone has a camera and an onboard computer, and it's been told "hit that truck," then in the last few hundred meters it doesn't need its operator. It locks onto the target, it flies itself in. So you can jam the control link, and the drone keeps going.



Corn

Because there's nothing left to jam in the terminal phase.



Herman

There's no link in the terminal phase. The link was there for the middle of the flight. The end of the flight is onboard.



Corn

And the third?



Herman

Adversary countermeasures. Drones can use harder-to-follow hop patterns, lower-power emissions that are harder to detect, directional uplinks that only point at the operator. All of these are being worked on, and the jammer is playing catch-up.



Corn

So the wearable kit is a snapshot, not a permanent feature.



Herman

Nobody in this space thinks they've solved it. It's a race.



Corn

Let's do the friendly-fire problem, because that's the one that gets less attention than it deserves.



Herman

It's the one that bites in the real world. If your squad is broadcasting jamming across a band, you're in that band too. Your radios are in that band. Your squad's drones are in that band. You can jam yourself.



Corn

How do systems avoid that?



Herman

Frequency planning, so you jam a range that your own equipment doesn't use. Time-sharing, so you jam in bursts coordinated with your own transmissions. Directional jamming, so you point away from your own assets. And rules of engagement, which is the least glamorous and the most effective. Somebody has to decide when to turn the jammer on and when to keep it off.



Corn

And the deciding is exactly the hard part, because you don't always know what's in the air.



Herman

You don't. And that's the deepest practical limit. The physics is knowable. The tactics are not always knowable. The question "is that drone ours" is not a physics question, and no amount of signal processing solves it completely.



Corn

The system works when it's told to work, and the skill is in the telling.



Herman

Which is where a lot of the training and doctrine lives. The machine handles the electrons. The humans handle the ambiguity.



Corn

Okay. There's a piece of this I want to sit with. If jamming is now wearable, and detection is now wearable, and this is happening across many militaries at once, the spectrum at the squad level is no longer a nice quiet place.



Herman

It's a contested environment.



Corn

It's the same contested environment that exists at the theater level. Same physics, same techniques, same tradeoffs. Only now it's happening in a radius of a couple of kilometers around a hundred meters of dirt, with three soldiers in it.



Herman

That has doctrinal consequences. If you're used to thinking of EW as something that happens above your head and outside your control, that assumption is now wrong. The squad has to think about it. The squad has to make decisions about it.



Corn

Which means the squad has to understand it. And understanding it, at the level we've been talking about, has not historically been part of infantry training.



Herman

It's getting there. Slowly. Ukraine has accelerated that a lot, because Ukrainian soldiers have had to learn this stuff in the field under fire, and a lot of that knowledge is flowing back into Western doctrine.



Corn

What does the wearable actually change about tactics?



Herman

The most immediate thing is early warning. If you know a drone is coming before it sees you, you can move. You can get under cover. You can disperse. You can stop what you're doing, which, if you're on a road, is the most important thing you can do. A lot of drone kills come from the drone seeing the convoy first.



Corn

The value is in the seconds between detection and observation.



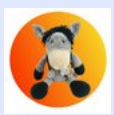
Herman

Those seconds are the whole product. The wearable detects at two kilometers, the drone probably doesn't identify you until one, and the jammer can reach out to three. That's a window. In that window, you can break line of sight. You can turn off. You can go to ground. You can call it up the chain.



Corn

The system is less about killing drones and more about denying them the clean shot.



Herman

Which is a much better way to think about it. The point of these systems is not to shoot down everything in the sky. The point is to make the drone's job harder, so that fewer attacks get through. That's a different kind of win, and it's the kind that's achievable.



Corn

There's a larger point in there about infantry in general.



Herman

There is.



Corn

For most of the last century, the infantry's main problem was other infantry, and fire support, and armor. Air was handled above their heads. Now the infantry's chief local threat is a small aircraft, and they have to have a tool to deal with it. Which is a genuine reversal.



Herman

It's a reversal that goes back to the First World War, in some ways. Then the airplane was a threat from above, and the infantry had to cope with it. Then air power professionalized, and the infantry's problem became "don't get spotted by air, and if you do, call somebody." Now the threat is smaller, cheaper, more numerous, and it's back at the squad level. Ten-dollar quadcopter, hundred-thousand-dollar countermeasure.



Corn

Which sounds lopsided until you remember that the drone might kill three people, and then it's not lopsided at all.



Herman

The economics of defense are always like that. You spend a lot to prevent a small cost, but the prevented cost is the cost of a life, so it's not really a comparison.



Corn

Back to the physics for a second, because there's something I want to nail down before we wrap. Daniel asked about the physics that applies whether the jammer is airborne, worn, or anywhere else. What's the invariant here?



Herman

The invariant is the signal-to-noise ratio at the receiver. Everything else changes. Power changes, antenna size changes, altitude changes, frequency changes. But the fundamental equation is always the same: can the receiver tell the signal from the noise? Every jamming technique, every countermeasure, every counter-countermeasure is a way of shifting that ratio in one direction or the other.



Corn

The Growler wins by having enormous power and a big antenna. The wearable wins by listening and aiming.



Herman

Same equation. Different terms. The Growler is applying brute force to the power term. The wearable is reducing the noise term's competitor, so to speak, by being smarter about where it points.



Corn

Daniel's question, the one about the physics that applies everywhere, has a clean answer. It's the ratio.



Herman

It's always the ratio. Which is why the arms race never ends. Both sides can always push on one of the terms.



Corn

Change one thing and the ratio moves. Change the hop rate and the ratio moves. Change the antenna gain and the ratio moves. Change the drone's receiver sensitivity and the ratio moves.



Herman

Every move in the game is a move on that one number.



Corn

Okay. I know that look.



Herman

Go ahead.



Hilbert

The thing nobody budgets for is heat. Not power. Heat.



Herman

Say more.



Hilbert

I ran a repeater site for about a year, out on the coast, late seventies, early eighties. Two racks, and a hundred-watt amplifier in the second one. The spec sheet said a hundred watts. What it didn't say was that a hundred watts out meant about two hundred and fifty in, and the rest of it goes off as heat. That amp had a fan on it the size of a dinner plate, and if the fan failed, the thing cooked itself in under ten minutes. We learned that the hard way one August.



Corn

You were the one carrying the spare fan.



Hilbert

We had two spares. That was the rule. Not one, because one spare is no spare. That's what the old man at the site taught me, and it's the only thing I remember from him. You don't keep one of a thing you need. You keep two, or you keep none, because with one you'll be tempted to use it.



Herman

That's not a bad rule for anything, actually.



Hilbert

It applies to a wearable jammer just as much as it applies to a repeater site. You can have the best amplifier in the world, and if you can't get the heat off it, it's a brick. If you're on a soldier's chest, there's no fan. There's no air conditioning. So the power has to be low compared to a rack-mounted unit, and it has to be pulsed, and it has to run in short bursts. The physics doesn't care. The soldier's chest does.



Corn

The answer to "why is the power modest" isn't really "because the electronics aren't good enough." It's "because you can't cool a hundred-watt amplifier on a person."



Hilbert

You can't. Nobody's solved that. It's not a software problem. A hundred watts is a hundred watts. It doesn't care how small you made the chip.



Herman

Which is a useful reminder that the constraint on wearability isn't the transistor count. It's the thermal envelope. The last decade of miniaturization has been about making the electronics smaller, not about making the heat smaller. Heat is conserved.



Hilbert

It is. There's a company in Manchester that used to sell a liquid-cooled version of that amp. Not for us. Too expensive, and it needed a pump, and a pump is another thing that breaks.



Corn

What happened to the original amp?



Hilbert

We replaced it in '83 with a solid-state unit that didn't need the fan. Still ran warm. Everything runs warm. That's the bit that nobody puts in the brochure. The brochure says the power. It doesn't say where the power goes when it isn't going into the antenna.



Herman

It goes into the air, one way or another. There's no way around that.



Hilbert

There's a fella I worked with, Gerry, and he used to say it: everything is a heater, if you leave it on long enough. He wasn't wrong.



Corn

Everything is a heater. That's the whole episode, isn't it.



Corn

You've just told us why the wearable jammer is a low-power device with a duty cycle. Because a person can't cool a hundred watts.



Herman

That loops right back into the barrage-versus-spot tradeoff. The reason a wearable can't barrage the whole band is that barrage means putting power into a wide swath of spectrum, which means either high power in total, which means heat, or low power per channel, which means it doesn't work. The thermal envelope is what forces the wearable to be clever.



Corn

The cleverness is not a design choice. It's a thermal requirement.



Herman

A battery requirement, and a weight requirement. But thermal is the one that's easiest to forget because you can't see it on a spec sheet.



Corn

The whole system is really constrained by the fact that a person has a surface area, and heat has to leave through it. That's the boundary condition.



Herman

Every other miniaturization story of the last thirty years has been about removing the constraint on the electronics. Physics didn't remove the constraint on the heat. The heat is still the heat.



Corn

Everything is a heater. Which lands us on a question I don't think has a clean answer. If jamming is now wearable, and detection is now wearable, and both sides have them, what happens when every squad on both sides of the line has one?



Herman

Then the spectrum at the squad level becomes a proper contested environment, and the advantage shifts to whoever can operate without RF at all. Fiber-optic drones. Autonomous terminal guidance. Visual signaling. The old fashioned stuff.



Corn

Which is a strange place to end up, given we started with a piece of electronics.



Herman

It's the pattern of the whole field. The more you contest the spectrum, the more you push people off the spectrum, and then the contest is over who can work without it.



Corn

The miniaturization curve doesn't stop. Today's wearable is tomorrow's pocket-sized, and the same physics is underneath it. Same ratio, same heat, same tradeoffs.



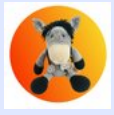
Herman

Same everything. Just less of it.



Corn

That's the whole show, really.



Herman

Then let's say the goodbyes before we think of anything else.



Corn

Thanks to Hilbert Flumingtop for producing.



Herman

This has been My Weird Prompts. If you've got a minute, a review helps other people find the show. We'll be back soon.



Corn

See you tomorrow.