AirSpace Season 1, Episode 7

Space Junk

Emily Martin:

Matt, Nick, what would you want to collect if you could snag anything from the surface of a planet or from orbit or somewhere out in space?

Nick Partridge:

Neil Armstrong's boots.

Emily Martin:

Are his boots on the moon?

Nick Partridge:

Yeah.

Emily Martin:

Why are his boots on the moon?

Nick Partridge:

The lunar over shoes that went over the feet of the space suit, the like, you know the footprint, the famous photo of the footprint?

Emily Martin:

Yeah.

Nick Partridge:

That's the print of the over shoe.

Emily Martin:

Wait we don't have his boots?

Nick Partridge:

No to save weight. Like the rocks were the priority.

Emily Martin:

The rocks were the priority.

Nick Partridge:

Like they didn't need the shoes. They knew what the shoes were made of.

Emily Martin:

Right. They knew what the shoes were made of.

Nick Partridge:

So Neil Armstrong's boots are still up on the moon.

Matt Shindell:

Space is a mess at any moment. There are literally thousands of objects just cluttering up Earth orbit.

Nick Partridge:

There's big stuff like meteors and the ever increasing number of satellites that we put up. And then there's the tiny things.

Don Kessler:

Every time something runs into each other at these very high velocities, it literally creates millions of millimeter sized particles and thousands of centimeter sized particles.

Emily Martin:

And it's all those little particles that can cause some big problems.

Dr. Lisa Rand:

A piece of debris smaller than a half an inch around, if it's traveling about five or six miles per second, could hit as hard as a bowling ball moving at 300 miles per hour.

Emily Martin:

This episode of AirSpace is all about orbital debris

Matt Shindell:

Trash, but this is high risk, high value trash.

Nick Partridge:

We'll talk with the scientist who first predicted this space mess and find out what can be done to keep our cell phones working and our national defense systems secure.

Matt Shindell:

And we'll find it out how likely it is to be hit with a piece of orbital debris from here on earth.

Dr. Lisa Rand:

I can talk about space junk till the cows come home. In fact, speaking of, I didn't even tell you about the cow. I didn't, we didn't even talk about reentries. I didn't tell you about the cow that got hit in Cuba in 1960 and caused a huge protest.

Emily Martin:

Space junk, or said another way, how fishing nets, lasers and gecko feet are all related.

Nick Partridge:

It's all coming up next on AirSpace from the Smithsonian's National Air and Space Museum with help from PRX. Welcome to AirSpace. I'm Nick Partridge.

Emily Martin:

I'm Emily Martin.

Matt Shindell:

And I'm Matt Shindell.

Nick Partridge:

It's not so surprising that there is a bunch of trash and debris in space. Nearly every species makes waste and trash of some sort just in the course of life. So when space exploration began, so did the garbage.

Matt Shindell:

Space trash.

Emily Martin:

What do you think the oldest piece of space garbage is?

Nick Partridge:

Sputnik.

Emily Martin:

It's not there anymore.

Nick Partridge:

Okay.

Emily Martin:

And I always think about that scene of from WALL-E. While he's attached to the spaceship, flying out of Earth's orbit and you go and it like crashes through this giant cloud of satellites. The very last satellite that stuck on WALL-E's head that he has to like shake off so it can like fall back down to earth is Sputnik. So it makes it look like Sputnik's still up there, but it's not.

Matt Shindell:

Okay. So the oldest piece of manmade-

Emily Martin:

Human-made.

Matt Shindell:

... human-made. Excuse me. So the oldest piece of bi-ped made... The oldest. Hm. The oldest piece of human-made technology that is still floating out there in space is the Vanguard 1 satellite, which we lost contact with in 1964, but still remains in orbit. That is like our little piece of space legacy, our oldest piece of space-

Emily Martin:

How old is it?

Matt Shindell:

... heritage out there.

Emily Martin:

Sputnik went up in 1957. So when did Vanguard get launched?

Matt Shindell:

Vanguard was launched in 1958. So not that long after Sputnik.

Emily Martin:

So why do we actually leave stuff up there though? Right? Like if it's still up there, and we lost... I mean, if we lost contact with it, is that why it's still there?

Matt Shindell:

Well, once something is in orbit and runs out of fuel, there's not much you can do to control it. Especially if you did lose contact with it.

Emily Martin:

But Sputnik came back down and burned up in Earth's atmosphere.

Matt Shindell:

Yeah. I mean the earth, if you're in an orbit that's low enough and degrading, if you're being degraded, you will burn up.

Nick Partridge:

That's harsh.

Emily Martin:

So all orbits are degrading, right? There's no such thing as a perfectly stable orbit. Even the moon is actually moving away from us. But the way to think about it is the objects that orbit in what we might call low earth orbit, which is much closer to the earth, those will reenter Earth's atmosphere, those will be the least stable. And the things that orbit much further away from the Earth, those could be an orbit for, from our human perspectives, forever.

Matt Shindell:

Yeah. And if you think about the way that the astronauts went to the moon, they were in a relatively large spacecraft on top of a huge Saturn V rocket. And by the time they come back to earth, they're in just the small command module having shed every other part of that mission along the way. So just the nature of that type of travel means that you're leaving things all through your path.

Emily Martin:

This is a huge problem. We're just going to be littering Mars and the next asteroid and the moon and making them giant garbage heaps.

Nick Partridge:

One of the first photographs taken on the moon is of a white beta cloth trash bag sitting under the lunar module. It's like a Starbucks cup that fell out of your car and rolled underneath.

Matt Shindell:

Yeah.

Nick Partridge:

Everything in space, if it's up there for any length of time, if it's in orbit, is moving at least 17,500 miles an hour. Right?

Matt Shindell:

Right. In space, there's nothing to slow you down.

Nick Partridge:

Or to hear you scream. Is it moving in like a harmonious kind of river flow? Is everything moving along at the same direction?

Emily Martin:

No. I mean, you think about it as like a shell of debris kind of surrounding, encapsulating the entire earth. And when you think about an orbit, an orbit is just one circle-ish shape. And so it's, they're all going in different directions. They're not just around the equator or like lines of longitude. I mean, you can have an orbit be in any direction.

Matt Shindell:

Right. And some satellites were put up to be in geosynchronous orbit, which means that they stay over the same part of the earth as the earth turns. Others were put up to orbit the earth, go around the entire earth. And so not everything was put up into the same type of orbit.

Emily Martin:

Where the danger really lies right now is in the amount of debris that would get created when two spacecraft, two satellites crash into one another. Because it's not just about how much they weigh or how big they are, it's about all those additional little bits and pieces that they can create when they crash into each other.

Matt Shindell:

So the film Gravity shows a pretty extreme example of what can happen if things go wrong.

Speaker 8:

Houston update.

Speaker 9:

Well, we have a full on chain reaction.

Matt Shindell:

Satellites suddenly collide with each other and a big, massive debris is created. Astronauts who are in space suddenly find themselves bombarded.

Speaker 8:

Most likely a [inaudible 00:06:49] gone bad. Shrapnel.

Nick Partridge:

I love Gravity. I really, I love it.

Matt Shindell:

I saw Gravity in a 3D IMAX theater, so it was like I was there with Sandra Bullock and it was crazy.

Emily Martin:

I watched it on an airplane. I had the exact opposite experience as you watching that film.

Matt Shindell:

I can't imagine watching it on a small screen.

Emily Martin:

Tiny, tiny screen. But it's, I mean, it's actually really cool. You've got all this debris flung out towards the space station and I'm not sure that's exactly how it would work. But the danger that creating all that debris poses is a very real threat to astronauts, especially those who are living up in space.

Matt Shindell:

Yeah. And what's not really addressed through most of the movie, because we're following Sandra Bullock, is that every satellite is suddenly down.

Speaker 9:

Telecommunication systems are dead. We expect a communications blackout at [inaudible 00:07:38].

Speaker 10:

We lost the visual of debris nine o'clock.

Speaker 11:

Half of North America just lost their Facebook.

Matt Shindell:

So that line from George Clooney's character did stick with me. And I decided to ask Dr. Lisa Rand how serious that Facebook scenario really could be. Lisa is a historian of science technology and the environment.

Dr. Lisa Rand:

If the satellite information infrastructure were to disappear, it would be more just things not quite working the way that they're supposed to. Your cell phone calls being dropped. Not being able to take money out of an ATM. Air Force leadership has made very clear that our Department of Defense, our defense operations could not really operate without products from space.

Everything from agricultural planning, to disaster relief, to climate studies, to even warnings about whether or not a solar storm is going to reach us and impact our electrical grids. All of those are inextricably intertwined with the satellite infrastructure and would be very, very difficult, if not impossible, to operate without satellites.

Matt Shindell:

So what are we talking about when we talk about how crowded it is up in space? How much stuff is actually there?

Dr. Lisa Rand:

Well, there's still a lot of space in space. Space is very, very, very, very large. That said, the space surveillance network tracks quite a bit of debris that's up there. There's an estimated 500,000 objects of a size of about a centimeter or larger-

Matt Shindell:

500,00?

Dr. Lisa Rand:

But we can only track about 23,000 of those because that's what our radars are able to track at current state-of-the-art.

Matt Shindell:

Mm-hmm (affirmative).

Dr. Lisa Rand:

Those can range from flecks of paint, small objects shed screws, things that are shed by the regular operation of satellites, to empty rocket casings. All of these things can be a threat to spacecraft in orbit.

Matt Shindell:

Mm-hmm (affirmative).

Dr. Lisa Rand:

We can only see a relatively small fraction of the objects that are up there that could still pose danger to operational spacecraft, including a crude spacecraft.

Matt Shindell:

Mm-hmm (affirmative).What are we doing? Or what are we thinking about doing to solve this problem?

Dr. Lisa Rand:

Well there are two main methods that most space policy analysts consider when thinking about the debris problem. One is called mitigation. Which is creating less debris and allowing the space environment to clean itself. And the other mode is called remediation, which is the active removal of debris that's up there. Remediation tends to be the sexier kind. There's all these different models. People have proposed space lasers from the ground to take down objects. There's a Japanese company that's designing a large net based on really old fishing net technologies. To a NASA project that is modeled on gecko's feet intended to grasp an object without having to require the same velocity as say a harpoon, which is a model that Airbus, I believe, developed for the European space agency.

Matt Shindell:

So backing up for a second. You just said gecko's feet and lasers and harpoons. That's quite a diverse list. Is there one that stands out for you?

Dr. Lisa Rand:

I like the gecko's feet model that I mentioned. This is one that's being prototyped by NASA right now. And there's some really amazing videos online of it being tested. So I like this model because it engages with bio mimicry. Here we're talking about spaces on earth, things like places like the ocean that we think of as being very natural and biological. Versus outer space, which is a place where life as we know it can't really exist without careful technological shielding, right? Without creating an ecosystem for it to survive.

And yet the pads on gecko's feet can grasp, either to a surface or to an object, in a way that doesn't require that same exertion of force. So if you were to use an object based on this, the way that gecko's feet work, you could approach it, grasp it without having to hit it really hard and perhaps drag that back into the atmosphere where it could then be destroyed by pressure and friction. And I do know that they've run a test in a microgravity flight where one NASA researcher is pretending to be piece of debris, the other one is holding the prototype system and kind of just grabbing the other researcher with it.

Nick Partridge:

Gecko feet would be a good name for a band. Do you guys want to start a band called gecko feet?

Matt Shindell:

I think it seems like something you could possibly sell like a 12 year old boy like a toy called gecko feet. Or even a food called gecko feet. They would eat that.

Nick Partridge:

Really grabs your attention in addition to your space junk.

Matt Shindell:

Yeah.

Nick Partridge:

I could say the word gecko feet all day. And I've seen the gecko feet work. I've seen them in the workshop in the lab and they seem to work crazy well. You'd have to get them pretty big though. Or figure out a way to maneuver them. Some of the other ideas, the harpoon sounds cool, but I'm a big fan of the laser cannon, putting a laser cannon on the ISS. Instead of blasting the thing out of space, hit superheat of very fine layer on the surface of the debris. So you've got some thing zipping around orbit at 17,500 miles an hour. It vaporizes just a little tiny surface layer, which creates a plasma jet that works as a retro rocket and de-orbits the junk. So you're not actually destroying or disintegrating it. You're just heating it up to the point where it's got an equal and opposite orbital reaction.

Matt Shindell:

Hmm.

Emily Martin:

That's the coolest thing I've ever heard.

Nick Partridge:

Right?

Emily Martin:

I mean, think about it. One of the reasons there's so much garbage up there right now anyways is because it's so expensive to put additional fuel up on those spacecraft for the sole purpose of helping it de orbit or control its de orbit. Which is ideally what you want to do. So this actually, you only send one thing up there to use to sort of give them a fake kind of fuel so that they will de orbit.

Nick Partridge:

Yeah. And the one that the, one of the ones they're looking at runs off a cell phone battery.

Emily Martin:

No.

Nick Partridge:

It's a 17 pound cell phone battery, but yeah. It's just a lithium-

Emily Martin:

Okay that's not the same thing. That's not the same thing.

Nick Partridge:

Well, I mean, it was when we carried Nokia.

Emily Martin:

That's 17 cell phone batteries.

Nick Partridge:

Okay, fair enough. Yeah.

Matt Shindell:

That battery weighs about as much as my cat.

Nick Partridge:

That's fair.

Emily Martin:

We're going to take a short break, but stay with us. We'll talk about international interstellar air traffic control with Don Kessler. He's a retired NASA scientist who was one of the first to think about and model the dangers of space debris. That was over 40 years ago. He'll talk about what changes might be coming over the next 40 years.

Don Kessler is credited with being the first NASA scientist to worry about space junk. He started back in the 1960s. NASA had just put the first American into space, Alan Shepherd.

Speaker 12:

Two, one, zero. Emission. Lift off.

Speaker 13:

Roger. Lift off and the clock has started.

Emily Martin:

Teams of engineers were racing to craft foolproof plans for a mission to the moon. They were trying to think ahead about all the things that could go wrong.

Don Kessler:

We were worried about the natural meteoroid environment when we were planning our trips to the moon and so forth.

Emily Martin:

Meteors were and continue to be a threat to space missions. And over time, Kessler's concern shifted from just meteors to human-made space debris. An inter-agency space debris committee was formed and they laid out some rules.

Don Kessler:

One is that you get rid of the, any energy sources so that things don't accidentally explode in orbit.

Emily Martin:

Space debris could either explode with leftover fuel on board, or it could simply run into each other. Either way, lots of little pieces of space debris get formed.

Don Kessler:

Every time something runs into each other at these very high velocities, it literally creates millions of millimeter sized particles and thousands of centimeter sized particles, which that one event alone makes it exceed the natural meteoroid environment. You will always have to design spacecraft against man-made debris, as opposed to natural debris.

Emily Martin:

With Kessler's urging, international partners now monitor and regulate what is added to space, track what's already there, and decide on what has to come down. There's something called the 25 year rule.

Don Kessler:

After you finish using something, either as a payload or a rocket body, it has to be out of space. So all you need is a little extra fuel in order to make that happen. But the unfortunate side of that is it's voluntary. And each agency has a little bit of power over how they do it. And for example, the European space agency is very strong about, you will follow the 25 years rule or we will not let you launch into space. But we had always an out at the secretary of... One of the secretaries anyway could waiver that rule. And we've had a history of them being wavered a lot.

Emily Martin:

So we don't follow the rules that we tried to-

Don Kessler:

That we actually set up. That's beginning to change. And everybody now is saying, well we're definitely going to follow the 25 year rule. But there needs to be some sort of penalty if you don't.

Emily Martin:

That's got to be harder to enforce too.

Don Kessler:

It is. It may require changing international law.

Emily Martin:

So I'm actually really interested in your outlook now. And how has it sort of changed with time?

Don Kessler:

With time, it's definitely taken, it's more serious. NASA considers it one of their biggest safety concerns of all of their space flights. I'm really encouraged with the amount of international participation in this, but there are ways that I'm also disappointed. All of the monitoring of the small stuff that we are doing is done by powerful radars on Earth and they are beam radars where you just statistically sample the environment and see how many small objects pass through that radar beam and count them.

But we need to fly, we need to monitor the environment. That's one thing. There's also changes needed in the way we regulate things. There needs to be a regulatory agency on an international level. For example, we have the FAA, which is operated on an international basis where people can coordinate all the aircraft activities so that we can fly from one country to another and each country then takes on a

certain amount of responsibility. We do not have that in the orbital debris community or anything like that. And it's sort of disappointing that that's not happened.

Emily Martin:

Which is surprising when you consider how much we all rely on those satellites for our communications, our daily lives now revolve around computers we hold in our pockets. And those only work because of the satellites we're flying around the world.

Don Kessler:

Yes. Space is really part of our infrastructure now, and it needs maintenance just like anything else. And we're not doing it like we should. There's a lot of ideas of how to get things out of orbit, but they've never been tested. They're all in theory. And then there's a question of what do you do with it once you capture it? You can always let it re-enter. But is that the best economic thing to do?

Emily Martin:

Kessler keeps up with all the latest net, harpoon, and gecko feet concepts. And there's another that he's particularly interested in.

Don Kessler:

There are people who say that we need raw material, access to raw material in earth orbit, and even talked about capturing an asteroid and putting in an earth orbit. So you can mine it and actually move manufacturing into space. We've got a lot of mass in earth orbit from satellites that are just, that are dead. Why not gather them up and essentially mine them?

Emily Martin:

Oh for sure. I mean, we're certainly building economies now around recycled materials. So why not use the stuff we've already put up there?

Don Kessler:

Right. Yes. It's the ultimate recycling.

Nick Partridge:

So Don Kessler proposed these models in the 1960s and said by the year 2000, we would see satellites causing debris as they collided, right?

Emily Martin:

Yeah. I mean, his models predicted that there would be enough debris in space by the year 2000, that large chunks would actually start hitting one another.

Nick Partridge:

Did we see it happen by the year 2000?

Emily Martin:

No, it didn't actually happen by the year 2000, but by 2009, we saw a collision of a Russian communication satellite with a US communication satellite creating these huge clouds of debris. And this wasn't exactly the first proof of concept of his models, but this was one of the big major proofs of concept of his models.

Nick Partridge:

I met Don Kessler a little bit after that, a little after 2009. And he had been traveling around speaking at various conferences. And somebody in the group asked, do you ever say I told you so. And he said, no, I don't have to.

Emily Martin:

But it's really hard to get the international community together. We're the consumers, right? Satellite radio, cell phones, wifi. So do you think that you could use sort of the people of the world as a way to kind of push this and advocate this?

Matt Shindell:

Right. Could we make demands on those companies or vote with our choices?

Emily Martin:

With our dollars.

Matt Shindell:

Right. About what types of plans we would support?

Nick Partridge:

What's the orbital equivalent of not in my backyard?

Emily Martin:

Not in my place in space?

Matt Shindell:

Not above my head? I don't know.

Nick Partridge:

That's good.

Emily Martin:

Not in my place to space. I mean, but think about it. I mean-

Matt Shindell:

It seems like it would take a pretty large awareness campaign.

Emily Martin:

Sure. There hasn't been a good got milk campaign about keeping space clean.

Nick Partridge:

That reminds me of something that one of the Apollo 8 astronauts said. Apollo 8 was the first mission to the moon. They didn't land, but it was the first time that humans had gone beyond low earth orbit. And they go out and they go around the far side of the moon and when they get to the other side, they see the earth rising above the lunar horizon. And it's this really striking image, this beautiful blue and white Oasis in this vast inky darkness. And they took a photo of it. And the astronauts said that they had gone into space to explore the moon and what they discovered was earth.

And the people back on earth intellectually knew that earth was a sphere floating in space, but to see it in full color was an entirely different thing. And it really drove home the message and created this huge swell of awareness of the environmental movement. So what is the equivalent to the Earth rise photo that will make people realize this thing that everybody kind of recognizes that space is sort of junked up. Like what's going to snap it into focus?

Emily Martin:

Everyone knows their smartphones are connected to satellites. Maybe we use this space debris as a tipping point. Maybe everybody can rally behind the need to protect those connections. So clean up space, clean up the planet.

Matt Shindell:

Let's start from the outside in.

Nick Partridge:

We've spent a lot of time talking about the dangers of space debris, but we've left out one memorable aspect of the whole space junk story. And that's reentry. Many of the space inventions and prototypes we've been discussing are being designed to bring decommissioned objects out of orbit and back into the Earth's atmosphere where they'll most likely burn up safely.

But not always. Sometimes the space junk crashes into the ocean or maybe down into the street. With increasing numbers of objects entering the Earth's atmosphere, and doing so with greater and greater frequency, historian Lisa Rand says we still don't need to be too concerned about objects falling from space.

Dr. Lisa Rand:

Only one person that we know of has been hit by a piece of space debris. It's a woman in Oklahoma who was hit on the shoulder by a piece of mesh that was confirmed to be shed from a piece of a rocket. She was not injured, but it was confirmed that she was hit by a piece of space debris.

For the most part objects that fall from space tend to fall in the oceans that cover three quarters of our planet surface. Perhaps most famously in 1979, the first United States space station called Skylab fell from the sky and pieces of it survived and hit the ground in the Australian Outback. The local government fined NASA $400 for littering. The bill went unpaid until relatively recently when a disc jockey somewhere in America raised the funds and now there's a paid in full sign up at that museum.

In 1960, a piece of an American rocket fell to earth in Cuba. Under the Castro regime, the Cuban government reported that the rocket shards had hit a cow and killed the cow. At the US embassy, several hundred students and a few cows and one bull all demonstrated against what they saw as an act of imperialism by the United States. That they had sent this Yankee rocket to destroy really this living symbol of pastoral agricultural abundance.

And they even claimed that this was an act of atomic aggression. It's been reported that the United States compensated the Cuban government to the tune of $2 million for this cow, which is a lot of money for a cow. That's very, very unlikely that anyone listening to this podcast will ever encounter a piece of debris on the ground. That said, it's always a little scary when you hear something the size of a bus is falling from the sky.

Emily Martin:

That's it for this episode of AirSpace. We'll be back in just two weeks with another episode.

Matt Shindell:

That's right. No more waiting for a whole month. We'll be coming back really soon.

Nick Partridge:

And we'll be talking about the test space telescope launch and the search for exoplanets.

Emily Martin:

How could you not be excited about exoplanets. Finding more exoplanets it means we might find bugs.

Nick Partridge:

Bugs?

Emily Martin:

Bugs.

Nick Partridge:

That's your goal?

Matt Shindell:

Micro bugs.

Emily Martin:

Well, it's not going to be intelligent life at this stage. I don't think.

Nick Partridge:

Mammals, maybe?

Emily Martin:

I'll go with... well, mammal-ish type things.

Nick Partridge:

Hairy aliens?

Emily Martin:

Something like that.

Nick Partridge:

Okay.

Matt Shindell:

Our AirSpace producer is Jocelyn Frank. Mixed by Tarek Fouda. Our executive producer is Katie Moyer.

Nick Partridge:

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Emily Martin:

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Nick Partridge:

I think it goes we're whalers on the moon. We carry a harpoon. But there ain't no whales. So we tell tall tales. And single whaling tune.

Matt Shindell:

There's always a song.

Speaker 14:

From PRX.