AirSpace Bonus!

AirSpace Presents NOVA Now

Nick Partridge:

Hey, listeners. Season four of AirSpace is just around the corner, but we have an interesting bonus drop for you today.

Matt Shindell:

These days, the news cycle turns so fast. It's hard to really absorb some of the reporting. So today we're going to slow your scroll with an episode from our friends at the PBS podcast, NOVA Now.

Emily Martin:

It's a show hosted by Alok Patel that digs into the science behind the headlines, whether the news is about climate, politics, vaccines, or just one of your favorite holidays. You'll meet scientists, engineers, technologists, and more who are helping us understand our world.

Nick Partridge:

Today's episode explores how satellites have shaped our understanding of modern life and what lies ahead at the intersection of space and justice. We really liked it and we hope you do too.

Emily Martin:

Here's NOVA Now.

Alok Patel:

Greetings, earthlings, who are so tired of being stuck at home and hearing the same political headlines over and over again. Let's switch it all up and talk about space.

Newsclip audio:

History-making link up in orbit as the SpaceX crew and the Dragon capsule….Today the first round of U.S. Space force enlistees graduated right here in San Antonio.

Alok Patel:

And there's a piece of technology we all rely on that's really shifted how we both explore and exploit space.

Newsclip audio:

Iran's Revolutionary Guard says the country is now able to quote, monitor the world from space…

China says it has sent the world's first 6G experiment satellite into space….

South Korea's first military communication satellite was launched into space…

In California, people living near Vandenberg Air Force Base were warned today about sonic booms. This Falcon 9 rocket carried the satellite into orbit that will monitor sea levels…

What's lurking, up there in the sky?...

Alok Patel:

Satellites! Extremely complex packages of engineering that give us almost limitless benefits like watching TV, tracking the weather, finding our way home, making calls around the world, exploring outer space. They basically deserve a really big thank you for making our sheltered in place lives manageable.

There are about 6,000 satellites orbiting earth right now, and of those nearly half are still operational. Just this year, humankind has launched hundreds of satellites with flags from every continent, except Antarctica. But maybe that'll change, I don't know. What's up penguins? And we even have more than a dozen orbiting Mars. Mars! So straight up, we need to give you the dish on satellites. Get it. I'm funny. But for real, they're an integral part of our modern world that help us understand our planet and ourselves.

This is Nova Now, where we explore all the celestial far out science behind the headlines and this astronomical body we call planet earth. I am Alok Patel.

Jeffrey G. Masek:

You often hear the statement, well, humans aren't big enough or powerful enough to affect something like U.S. atmosphere or the land surface, and yet you can look at the record and see that transition occurring through land use and urbanization and so forth.

Alok Patel:

Jeffrey G. Masek, who goes by Jeff, is a project scientist for Landsat 9 at NASA's Goddard Space Flight Center.

Jeffrey G. Masek:

I think when we look at that, we realize that we're a lot more powerful than we think we are in our ability to change the environment.

Alok Patel:

The Landsat program is a collaboration between the U.S. Geological Survey and NASA.

Audio clip:

In 1972, a satellite was launched, which will help to manage world agriculture, Landsat.

Alok Patel:

Beginning with Landsat 1, the program's launched a total of eight satellites since the early 70's, providing the longest continuous space-based record of the surface of the earth.

Jeffrey G. Masek:

We acquire imagery of all the earth's land and coastal areas every eight days. So we've assembled this long record of how the planet has changed and that's designed to support land management decisions by governments at state, local, national level and individuals as well.

Alok Patel:

So we have five decades of information and knowledge about our planet from outer space. Can you tell us a little bit about what we've learned about our lovely blue planet from space?

Jeffrey G. Masek:

In general, what we've seen just graphically, is how dynamic the planet is in response to human activities. When you grow up in an area, your neighborhood, for example, you don't really notice the changes that occur over years and decades, right? It's just kind of almost seems constant. But when you run the movie in fast motion, suddenly you see all of these changes and the urbanization and the changes in forest management and all of that, right? I mean, we see areas where agriculture suddenly goes in, irrigated agriculture into desert environments, for example, and then we see it fade away again. We see areas that convert from forests to soybean fields, big areas in South America. I think one of the recent real big accomplishments of the program has been looking at ice sheet velocity tracking. So when you look at Antarctica or Greenland and how they're changing response to climate warming. With Landsat data, you're basically able to track features on the surface and create a velocity map for the ice sheets. And people are doing that year in year out now, which is pretty fascinating.

Alok Patel:

Okay. So speaking of all these Landsat images, I'm going to look at them in real time. I'm on climate.nasa.gov. I'm going to compare Landsat images of Greenland glaciers from 1972 to 2019. Here we go. So off the bat, it already looks like there's less glacier, if you compare the two pictures. I see more of the brown earth, more of these like rocky peaks and this other picture, it looks like the glacier is almost not present. Like it's retreated away. And this other picture there's water where there probably shouldn't be, like the glacier has melted. If that sounds like climate change, it's because it is.

Radio chatter:

25, status check. Go, Alice. Go center. Go LDCM

Alok Patel:

Today, two of the Landsat satellites are still orbiting our planet, Landsat 7, since 1999 and Landsat 8 that was launched in an Atlas V rocket from Vandenberg Air Force Base in California in 2013.

Launch audio:

Five, four, three, two, one, zero, and ignition, and lift off of the Atlas V rocket on the Landsat data continuity mission. Continuing the 40 year legacy of reserving first natural resources from space.

Alok Patel:

Landsat 9 is the next mission. It's got souped up sensors and is scheduled for launch next year. Eventually it'll replace Landsat 7, which is nearing the end of its life. Let's zoom out for a sec, take an astronauts view. Maybe a Matt Damon from the Martians view. A satellite is an object in space that orbits around another object. There's natural satellites like our moon and artificial satellites, like the International Space Station, both orbit the earth. Artificial satellites can be operated by governments, the military, commercial companies and places like universities or research centers. They can be classified by their purpose. There's communication satellites, like the AT&T T-16, the latest in a fleet that's supporting the DirecTV satellite television service.

Jeffrey G. Masek:

There are military defense satellites. Those are also often imaging satellites.

Alok Patel:

Geostationary Operational Environmental Satellites that help meteorologists observe and predict local weather events, space science satellites for research, earth observation satellites like Landsat.

Jeffrey G. Masek:

And, of course, GPS, which is huge.

Alok Patel:

GPS! I love GPS. Do you know what actually stands for? It's Global Positioning System, a navigation system that's made up of 30 satellites, as of now.

Jeffrey G. Masek:

If you get in those GPS, gives you your location on your cell phone, and that is a satellite constellation that the U.S. operates.

Alok Patel:

For anyone out there who disrespect satellites, I would like you to remember the days when we used to try to drive places without our phones. Stopping in gas stations and asking which direction is what city-

Jeffrey G. Masek:

With the paper map atlas, right?

Alok Patel:

Yeah. Yeah. Satellites were first imagined by such visionaries as Sci-Fi writer, Arthur C. Clarke, who in 1945 suggested that if you launch an object with enough velocity, it could fall into orbit around the planet. It would be the Soviets who had placed the first human-made satellite into a low-earth orbit in 1957. Sputnik 1, a 23-inch metal ball that carried a thermometer, batteries and a radio transmitter to space. These days, satellites come in all shapes and sizes, not just 23-inch metal balls.

Jeffrey G. Masek:

There are some now very small CubeSats that can fit in the palm of your hand. The Landsat satellites are larger. They tend to be a sort of school-bus sized or minivan sized.

Alok Patel:

The Landsat satellites are remarkable feats of engineering that allow us to watch our planet.

Jeffrey G. Masek:

It's basically an imager mounted on top of what we call a satellite bus. Okay. So the imagers are the instruments, like the camera and the satellite bus provides the life support for everything that the imager has to do. So the power of the solar array, the fuel for maneuvers, the antennas to bring the data down...

Alok Patel:

Can you tell us a little bit more about the instruments? Walk us through the technology and how we get these incredible images from the Landsat satellites.

Jeffrey G. Masek:

Sure. So Landsat images in a lot of different spectral wavelengths. So our eyes see in the visible part of the electromagnetic spectrum. Landsat goes beyond that into the infrared and into what we call this thermal infrared. So, that's basically looking at heat coming from the earth. Landsat 9 and Landsat 8 have two separate instruments on board. The operational land imager gets to the shorter wavelengths. The light comes from the sun, it reflects off the surface of the earth and it arrives at a telescope that's on the instrument. And basically the light bounces around, it gets focused onto a focal plane, which converts the light into an electrical signal.

Alok Patel:

Which gives a measure of the brightness of the earth surface.

Jeffrey G. Masek:

The second one is called TIRS, thermal infrared sensor, is dedicated for the longer wavelengths, for the thermal infrared. So we can look at surface temperature and instead of the light coming from the sun, it's basically radiation that comes from the surface temperature. So it's emitted radiation from the planet itself, corresponding to the surface temperature that again goes up to the instrument through a telescope and through the detectors.

Alok Patel:

This radiation is proportional to earth surface temperature.

Jeffrey G. Masek:

The data that the satellites image, we think of them as pictures, but in fact, they're measurements of surface reflectance or surface temperature.

Alok Patel:

Each satellite positions itself to capture images in direct sunlight once every 99 minutes. So about 14 times a day.

Jeffrey G. Masek:

The Landsat uses a 705 kilometer altitude at orbit.

Alok Patel:

That's about 438 miles above me right now in my closet sound booth. As a Landsat satellite travels from the North pole to the South pole, it's capturing data over a hundred and fifteen mile wide swath, which means a full picture of our planet is ready in a little bit more than 16 days. And then the cycle starts again. Now I understand satellites are designed with kind of a lifetime in mind, oftentimes they can go beyond that expectation. How do you know when a satellite has kind of reached the end of its life? And then after that, what happens to them? Do they get a proper space burial or do we just leave them up there?

Jeffrey G. Masek:

Yeah. So, USGS operates the satellites, monitors all of the systems on board. And so what we find, for example, is you may be running low on fuel, right? And if you run out of fuel, you can't do the necessary maneuvers to keep the satellite in the proper orbit. The gyros or reaction wheels may fail. In that case, you have a hard time maintaining the attitude of the satellite and that's considered dangerous because at that point you're kind of an out of the control vehicle and in the orbit, and you can run into other things, it's considered bad manners. So when you lose enough systems, then basically you make the determination to de-orbit the satellite, and you fire some thrusters, you bring it into a lower orbit and, there's various policies for how fast you have to de-orbit a satellite, but it's usually sort of decades, it takes. And you just let it reenter and burn up. More recent satellites actually have to be actively de-orbiting so that you know what ground target you're going to hit when the satellite de-orbits.

Alok Patel:

I often think about the movie Gravity, and space debris potentially hitting something. Do we worry about the size of Earth's orbit and a potential time when it could get too crowded and those incidents could start happening?

Jeffrey G. Masek:

So space debris is a big problem, and it's an operational problem for the Landsat satellites. We're on occasion having to move the satellite out of the way of some piece of space debris, and that interrupts the imaging cycle. And so it's a hassle.

Alok Patel:

Okay. So perhaps that movie Gravity is a little over-hyped, but space junk is still an issue. Space debris usually refers to human made particles, and it's estimated that there are more than 900,000 pieces of this stuff in orbit, ranging from about half an inch to around four inches. And there are natural objects out there as well, like meteors. And these can definitely be hazardous, but there's a much higher likelihood of a collision with a human made object.

Jeffrey G. Masek:

But in general, when it starts to get near the end of life, we move it out of the way. That's the most important thing you can do. What you find is that certain orbits are useful and certain orbits are not so used. Landsat is in a particular orbit called a sun synchronous orbit where every overpass is the same local time for imaging. So the solar illumination conditions are the same for every image, which is desirable. There are other orbits just above or below it that really aren't used very much. And so the trick is to move the satellite out of an operational orbit into some other orbits that's not used very much where it'll be kind of out of the way.

Alok Patel:

Satellites can be grouped together as they orbit, which works well when they have a shared purpose.

Jeffrey G. Masek:

In NASA, we have something called the A-Train for atmospheric observations for example. It has several satellites to look at the atmosphere, all in a train.

Alok Patel:

Just like a line of cars in the same lane, on a highway or a line of ducklings following their mom, as they're crossing that highway.

Jeffrey G. Masek:

And they do have to worry about how close they come. And if there's an avoidance maneuver, because there's some kind of debris coming toward the first one, then they all have to kind of jump out of the way in a coordinated fashion. So, that's the big part of satellite maintenance.

Alok Patel:

The Landsat program is just one of the many projects using satellites. In less than a hundred years, the space above us has become a place for innovation and contributions to society. We'll meet someone who's talking about just this, how space can help us improve life down here on this blue planet.

Dr. Danielle Wood:

We’re at an exciting period in the space journey where there's opportunities to put more and more satellites in space, but yet we have to take care so we don't create so much debris or risk of collision in space that we actually miss the chance to use these space technologies for our benefit on earth.

Alok Patel:

Dr. Danielle Wood is an assistant professor at the MIT Media Lab. She's also the director of the Space Enabled research group. Remember the possible issues with space junk? In 2019, the World Economic Forum created a transdisciplinary consortium that includes Space Enabled and teams from the European Space Agency, the University of Texas at Austin, and a company called Bryce Space and Technology. They're working on the space sustainability rating, a new and innovative way of addressing the orbital challenge.

Dr. Danielle Wood:

So we're identifying actions that companies can take to earn a good rating so that an operator of a satellite can have a sustainable mission. And for us, sustainability means, we're trying to avoid colliding with other missions, we're trying to avoid being debris, meaning leaving the mission as trash in the orbit for a long time after they're finished. So we want to give basically a score, to any group from government or companies or universities, and to celebrate those who are doing their best to reduce debris. What's interesting though is, a lot of people want to go basically to the same place in space because they're interested in operating for similar activities. And the physics means that you might want to go to somewhere near another neighbor of yours.

Alok Patel:

And is there an organization that kind of centralizes the authorization for satellites, or is it just up to other countries, other space programs to follow the rating scale or to apply for it or to pay attention to it?

Dr. Danielle Wood:

So the first thing you need to know is there any time an object is launched to space, every satellite and every rocket, is launched by a country, meaning it's under the authority of a certain country. So it's very good that we already have national laws that review the plans for space missions before they go to space. And each object that goes to space, whether it's a satellite or a rocket or an instrument, has been applied to make sure they're following the standards of that particular country. So on one hand, the space sustainability rating is not trying to replace national regulations or national processes of giving licenses for satellites and rockets. What we are actually trying to do is encourage operators of satellites to even go beyond what's required by their country. So we'll give even a better score if a mission does better than what's required by the law.

Alok Patel:

The consortium is sharing the rating system with countries around the world so national governments can choose to include it as one of the items they consider when deciding whether to approve the launch of a new satellite. And when it starts, the rating will be voluntary. This work has some history behind it.

Dr. Danielle Wood:

I am very thankful about what happened in the early years of the space era.

Alok Patel:

Danielle Wood is a scholar of societal development with a background that includes satellite design, earth science applications, systems engineering, and technology policy.

Dr. Danielle Wood:

Because this was also a period of the cold war and it was not obvious whether countries would come together to make a peaceful approach to working in space or whether instead we would actually make worse some of the tensions that were already in place, became pressure in the United States and the Soviet Union. We could have really seen space programs lead to further aggressions and perhaps even another world war but instead we saw countries come together and identify the fact that space is another global commons. Just like we see with the oceans, Antarctica, places that really belong to all humans equally, not to particular countries.

Alok Patel:

In 1967, the Outer Space Treaty was open for signature in the United States, the United Kingdom and the Russian Federation. It provided the basic framework for international space law.

Dr. Danielle Wood:

The Outer Space Treaty established as a key principle, which says that, space is the common heritage of all humankind. And therefore it should not be a place for one particular country or company, but it should be a place to be considered a shared opportunity. So that whoever is acting in space now is really in a sense a steward of it for those who might use it in the future, not just for their own current needs.

Alok Patel:

The treaty was the first of five organized by the United Nations committee on the peaceful uses of outer space and has now been signed by more than a hundred countries.

Dr. Danielle Wood:

From every region, including Latin America and all over Africa and Southeast Asia and Eastern Europe and the Caribbean. So there really is a mix of countries around the world helping to shape the current debates around space policy and playing a role in deciding how and where we operate in space and under what conditions we do so. And when you think about the intersection between space and justice, there's kind of three big questions. One is, what has been the legacy? How has technology played a role in either advancing or reducing justice? The second is, what do we see today in terms of today's space technology and is it being used sort of uniformly around the world to serve people and make sure that they have what they need from the benefits of space? And the third is, as we look to the future we're going to expand and have more people living and working in space on the longterm, we want to ask what justice will look like for the kind of communities we're going to create.

Dr. Danielle Wood:

So my class in the fall, I teach my students to read some key history from the last 500 years, and to really engage with the reality of colonization and slavery and mismanagement of power by countries toward other countries, and by groups like different racial groups to other groups. And we ask the question, what have we done wrong in our human history recently that we should not carry forward into space? The anti-colonial view says, let me consider that what I do in a global commons, a place that's shared by different countries, is not just up to my country and my country's benefit, but should be done in a way that considers future generations and asks, what are the concerns of other stakeholders, other countries, other indigenous groups that may have certain views.

Alok Patel:

I think that concept of people acting in researching space are stewards for the future, is an important one. And I really respect how you frame space technology in a way that should benefit everyone. And so I want to ask you, if you could give us some examples of space technology that's been developed that supports and encourages sustainable development on earth.

Dr. Danielle Wood:

The United Nations does an excellent job curating the sustainable development goals as an aspirational list of the ways we all need to work together to change the world.

Alok Patel:

17 sustainable development goals are at the heart of the UN's 2030 agenda for sustainable development that quote, "provides a shared blueprint for peace and prosperity for people in the planet now and into the future. They recognize that ending poverty and other deprivations must go hand in hand with strategies that improve health and education, reduce inequality and spur economic growth, all while tackling climate change and working to preserve our oceans and forests," unquote, mic drop.

Dr. Danielle Wood:

Now, part of what my team does is constantly ask, what are the ways that space technology can be used both to monitor the progress and to actually manage, make progress towards the SDGs.

Alok Patel:

Danielle Wood's Space Enabled team has identified different space technologies that can support the sustainable development goals, and a few in particular directly address these goals with the help from satellites. For example, communication satellites can help with disaster recovery. Satellite positioning is helping track endangered wildlife, and earth observation satellites can help us tackle hunger by allowing us to understand what areas on the planet are in danger of drought. The Space Enabled team is even working to help respond to the COVID-19 pandemic in different parts of the world. Let's be real, space technology has shifted the way we see our planet and ourselves. What do you think is going to be the future for space technology? What do you want to see happen?

Jeffrey G. Masek:

Well, there's a lot of things happening now that are really exciting.

Alok Patel:

That again, is Jeff Masek.

Jeffrey G. Masek:

The commercial world has kind of pioneered a model in which there are constellations of small satellites. Landsat 8 and Landsat 9 are pretty big systems and they get all of their imagery from one large platform. When you look at some of the commercial companies out there, they don't necessarily have the capabilities of Landsat, in terms of the spectral bands they acquire, the quality of the data, but they acquire a lot of data and they do it by launching fleets of small satellites, in some cases, hundreds of CubeSats.

Alok Patel:

CubeSats are very small cube-shaped satellites, as the name suggests. They come in different sizes based on a standard unit that's about four inches long. Standardization helps make them cheaper to produce. The idea was to help make space access affordable for the university science community. And now, not only universities, but high schools, middle schools, even elementary schools have been able to start their own CubeSat program. They've been used for all sorts of things, including remote sensing and communications.

Jeffrey G. Masek:

That's a model that NASA is looking at. I don't think we can put Landsat on a CubeSat, just for technical reasons, but we are looking in the future at constellation approaches where we sort of break up the mission into a series of smaller satellites. Because it's also more resilient, right? I mean, we could have a single point of failure, knock on wood, we don't have one, but if we had a single point of failure with Landsat 9, we'd be kind of out of luck for several years. If you launch a constellation of satellites and you have a single point failure, you can live with it.

Dr. Danielle Wood:

The expensive satellites that people often think of, a lot of the actual cost is going into the testing and the review of the engineering over and over before it's launched.

Alok Patel:

Here again is Dr. Danielle Wood.

Dr. Danielle Wood:

Because if you have a big, expensive salad that cost hundreds of millions of dollars, you want to make sure that it's going to work and work well for many years. If you're building a satellite that's more like the size of a toaster and it should last for less than a year and you might offer to have more of them after you finished this one, then you can spend less time on the engineering, on the testing, the design, but you still want to make sure you're using parts that make sense and trying to get the design as good as possible. But you also might have more opportunities over this 10 year period to keep trying new technologies, rather than sort of waiting 10 more years to try the next generation.

Alok Patel:

And technology keeps on advancing. Landsat satellites today can capture objects as small as a hundred feet on the ground, but future missions could provide even higher resolution.

Jeffrey G. Masek:

We don't have the resolution to look at Area 51 very well.

Alok Patel:

Aah, cool.

Jeffrey G. Masek:

There was a researcher at Goddard who was using satellite data, including Landsat, to look at penguin populations in Antarctica.

Speaker 18:

Satellite images taken over the Antarctic show large stained patches of sea ice identified as the birds' guano, leading to the discovery of new breeding sites. And as the BBC's Victoria Gil reports, there are now thousands more penguins than first thought.

Alok Patel:

That's awesome.

Jeffrey G. Masek:

Yeah. I mean... And that is one cool thing about Landsat, is people are always finding new applications, right? So it's not just like one thing you do again and again, there's always new stuff to find.

Alok Patel:

I love that report, penguin poop identified.

Jeffrey G. Masek:

Exactly. Can't see the penguins, but you can see their poop.

Alok Patel:

What? Someone had to make it.

Jeffrey G. Masek:

Right.

Alok Patel:

You download the Landsat data for free from the U.S. Geological Survey website. Comb through it, maybe you might discover something, if you do, share it with Jeff. NOVA Now is a production of GBH and PRX. It's produced by Ian Coss, Ari Daniel, Johnson Gonzales, Isabel Hibbard, Sandra Lopez-Monsalve and Christina Monnen. Julia Cort and Chris Schmidt are the co-executive producers of NOVA. Dante Graves is director of audience development. Sukee Bennett is senior digital editor. Robin Kazmier is science editor. Emma Yuke is research intern, and Nina Prozuki is managing producer of podcasts at GBH. Our theme music is by the Milky way's best turn-tablist, DJ Kid Koala.

Alok Patel:

I'm Alok Patel. We'll be back in two weeks, which has plenty of time for you to look up satellite names and pick out your favorite. Maybe you can name your dog or a child a satellite name. My favorite one is FUNcube-1, but shout out to ALEs, era cube 8B, BlackSky Pathfinder, Shaonian Xing, Sky Brazil-1, Tycon, THEOS, Ursa Major, WildBlue-1, ZACube-2, Kanopus-V, Hodoyoshi and Iridium. Are these satellites are superheroes? And while we're all looking up in the sky and looking at stars and the thousands of satellites and maybe the space debris, I hope you're all staying safe and you have a very, very happy holiday season.

Emily Martin:

That was a special presentation of the NOVA Now podcast here on the AirSpace feed. If you liked it, you can check out more wherever you get your podcasts and keep an ear out for a cameo from AirSpace in their feed, and stay tuned for season four of AirSpace coming in February.