**Mars 2020, Part 1: Powered by Plutonium**

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**NASA's Mars Perseverance Rover is loaded with technology developed by the Department of Energy and our National Labs.**

So much so, in fact, that we couldn't fit it all in one episode! In Part 1 of our two-part series on NASA's Mars 2020 mission, Direct Current follows the origins of the [Mars Perseverance Rover’s](https://www.nasa.gov/perseverance) nuclear-fueled power source on its incredible seven-year, 5,000-mile journey [from the lab to the launch pad](file:///C:\ne\articles\nuclear-power-system-delivered-florida-nasa-s-perseverance-rover). Read on for more about the [Multi-Mission Radioisotope Thermoelectric Generator (MMRTG)](https://rps.nasa.gov/missions/14/mars-2020/) — the long-lasting nuclear battery with an even longer name.

**Prepping Perseverance**

Prepping the Perseverance Power Source

[Multi-Mission Radioisotope Thermoelectric Generators](file:///C:\ne\articles\nuclear-power-system-delivered-florida-nasa-s-perseverance-rover) are ideal for space missions because they are compact, durable and reliable, providing continuous power over long periods of time. The Department of Energy provides radioisotope power systems to NASA for civil space applications. The MMRTG for the Mars 2020 mission was fueled and tested at the DOE’s [Idaho National Laboratory](https://inl.gov/mars-2020/). This spring it was shipped directly from INL to the launch site at Kennedy Space Center Florida for integration into the rover.

**Fueling the Future**

[](https://www.ornl.gov/media/73822)

Plutonium-238 is critical to deep space exploration. The special isotope has powered missions that have enabled us to explore the atmosphere of Saturn, see the heart of Pluto and traverse the surface of Mars. But what if missions like those were no longer possible? That's a question NASA faced not so long ago as the U.S. was in short supply of the isotope. The decision was made to restart pu-238 production and [Oak Ridge National Laboratory was the place to do it](file:///C:\ne\articles\oak-ridge-national-laboratory-automates-key-process-plutonium-238-production). In this episode of [ORNL's podcast "The Sound of Science,"](file:///C:\exit?url=https%3A//podcasts.apple.com/us/podcast/far-out-fueling-the-future-of-space-exploration/id1483253058%3Fi%3D1000461250495) you'll hear from the manager of the plutonium program, as well as from the team that makes the cladding to hold the fuel.

**Exploring with AI**

[](https://www.energy.gov/articles/you-can-join-department-exploration-mars-mission)

Courtesy of NASA

Watch a [video message](file:///C:\articles\you-can-join-department-exploration-mars-mission) from Under Secretary of Science Paul Dabbar as he shares how staff at [Oak Ridge National Laboratory](https://ornl.gov), [Idaho National Laboratory](https://inl.gov), and [Los Alamos National Laboratory](https://lanl.gov) helped power the Mars Perseverance Rover, and how you can help through [NASA’s AI for Mars website](https://mars.nasa.gov/news/8689/nasas-mars-rover-drivers-need-your-help/).

Transcript:

(UPBEAT SPANISH GUITAR MUSIC PLAYS)

MATT DOZIER: Hello and welcome to another episode of Direct Current! I’m your host, Matt Dozier. I hope you’re all staying safe and sane out there. Lots to cover in this show, so I’m just going to dive right in: We are going back to Mars! And by “we,” I mean NASA — specifically the NASA Mars 2020 mission, slated to launch for the Red Planet this summer carrying the Mars Perseverance Rover. Although you know, there is a LOT of Department of Energy time, technology, and brainpower invested in the Perseverance rover — so in many ways, you could say we’re going along for the ride. In fact, there’s so much good stuff from the Department of Energy and our National Labs on board this journey to Mars that I can’t cover it all in one episode. So, to help me kick off Part 1 of our two-part series on the energy side of NASA’s Mars 2020 mission, I spoke to one of the people setting the tone for this Department’s involvement in America’s space program: our very own Secretary of Energy.

(MUSIC FADES OUT)

DOZIER: Today I’m joined by a very special guest, making his Direct Current debut, the 15th U.S. Secretary of Energy, Dan Brouillette. Secretary Brouillette, welcome to the show.

DAN BROUILLETTE: Thank you, Matt. Great to be with you.

DOZIER: It's really good to have you on. So we're talking Mars 2020 and space travel today. Here at the Department of Energy, we deal with such an incredibly wide range of missions and scientific research that some people — including your predecessor, Secretary Perry — have said that DOE really stands for “Department of Everything.” You’ve put forward another suggestion: the “Department of Exploration.” What does that mean to you?

BROUILLETTE: Well, to me, the Department of Exploration means DOE at its very best, reaching for the edge of the horizon, pursuing transformative science and technology, which we do every day at our 17 National Laboratories. We have a deep involvement with space exploration, and a critical role on the Mars 2020 Rover.

DOZIER: So, in this episode, we're talking to DOE and National Labs staff who are playing a hugely important role in NASA’s upcoming Mars 2020 mission, that Perseverance Rover you mentioned in particular. How significant is this mission, in your mind?

BROUILLETTE: It's very significant. The mission is about more than just discovering the past, it's about really opening up the future. One of the mission's primary goals is searching for potential signs of past microbial life on Mars. That's incredibly important from a scientific standpoint, but even more important to my mind is that the mission also opens up the way to the future, for potentially future human missions to both the moon and to Mars. DOE's extensive involvement in this mission is absolutely noteworthy. The mission is a great example of the incredible capabilities of our National Laboratories. For instance, we’re supplying the fuel, the battery, and what's known as the the SuperCam. It's also known as the “Swiss Army Knife” of instruments, and it's going to play a key role in the search for signs of ancient life. Individual agencies might be able to supply a couple of these capabilities, but it’s only DOE that can bring all of them together in one complex — and we can offer even more than that.

(GUITAR MUSIC FADES BACK IN)

DOZIER: We’ll hear more from Secretary Brouillette later in the episode. Coming up: The saga of Perseverance’s nuclear heart, which completed its own journey of 7 years and nearly 5,000 miles before finally meeting up with the rover at Kennedy Space Center in Florida. Stick around.

(MUSIC FADES OUT)

(DIRECT CURRENT THEME PLAYS)

(UPBEAT SYNTH AND PIANO MUSIC PLAYS)

DOZIER: NASA’s Mars Perseverance rover is an engineering marvel. It’s the most sophisticated rover we’ve ever sent to Mars — and we’ve sent several, at this point. It’s crammed full of scientific instruments that will gather unprecedented details about the planet’s surface in our search for signs of ancient Martian life. Measuring 10 feet long, with six wheels, a mast and a robotic arm, Perseverance looks a lot like its predecessor, Curiosity. And with good reason — it shares the same basic body shape and a lot of the core components. Curiosity touched down with the Mars Science Laboratory mission in 2012. It was supposed to explore Gale Crater for two years. At the time of this recording, July 2020, it’s still going strong — 8 years later. Part of the reason it’s still going? It’s powered by a fuel source that can last decades without needing to be refueled, or recharged, or replaced.

(MUSIC FADES OUT)

BOB WHAM: You don't have extension cords, you can't run out for a repairman. You have to be totally reliable in whatever you put out into space.

DOZIER: That’s Bob Wham, Oak Ridge National Laboratory’s resident guru for the nuclear fuel that makes missions like Perseverance possible. So what’s the secret to their longevity? It’s not turmeric, or acai berries, or wheat germ — the Mars rovers, and dozens of other NASA missions, run on a diet of pure plutonium-238.

WHAM:  Right. This is a special isotope that releases a lot of heat when it decays. And the heat that it releases is converted to electricity or power that can be used aboard a deep space mission.

DOZIER: More from Bob in a moment. It takes about 110 Watts of electricity to run all of Perseverance’s various cameras, sensors, lasers, drills, spectrometers, processors and satellite uplink. Not to mention charging the batteries that let the rover drive around the surface of Mars.

JUNE ZAKRAJSEK: If you think about that, we’re running a whole spacecraft, the size of a small car, on 100 watts of power generation. That's about the same amount of power that's consumed in standard light bulb.

DOZIER: That’s June Zakrajsek with NASA Glenn Research Center. She knows a lot about what it takes to power space missions of all kinds.

ZAKRAJSEK: So NASA likes to explore, and we have to explore in some very distant locations, dusty locations, dark locations, and harsh environments. We generally can use solar energy to generate that electricity, but when we're in those kinds of environments, solar energy sometimes does not provide the power that we need. The light just does not get to those locations like we would need it.

DOZIER: Mars is a dusty environment — not quite as dusty as it’s sometimes depicted in TV and movies, but enough to hamper the effectiveness of solar power in the long run. And in real life, there’s no Matt Damon in a space suit stopping by to squeegee the dust off your solar panels.

ZAKRAJSEK: Batteries can also be used to power spacecraft, but in order to provide a battery with the lifetime that we have seen for some of our missions — like the Voyager missions are over 40-year-old missions that are still producing science for us — we need to have a different kind of technology.

DOZIER: That technology is nuclear energy. For Perseverance, the plutonium-238 is housed in a kind of “nuclear battery” called a multi-mission radioisotope thermoelectric generator, or MMRTG. I promise I won’t make you remember that. Just know that it’s a compact, tough-as-nails power system that can weather harsh environmental conditions, from the cold vacuum of space to the intense heat and vibration of takeoff and landing. There’s no moving parts, so less risk of something important breaking. And it can run for a really, really long time.

WHAM: This isotope has 90-year half-life, that means that half of it will be gone in 90 years. And it's good for deep space because typically they're multiple years or maybe decades-long missions, and you want to maintain a certain basic minimum power level for quite some time. So plutonium-238 provides that capability.

DOZIER: Bob is the manager of Oak Ridge National Lab’s plutonium-238 supply program. We’ve actually had him on the show before, for our “17 Labs in 17 Minutes” episode. That was back in 2016, when Oak Ridge National Lab had just produced the nation’s first new plutonium-238 in decades. Since then, the lab has ramped up production — from just a pinch of the all-important element to several hundred grams — with the goal of providing an ample supply for NASA’s future deep space missions.

(SYMPHONY WALTZ WITH STRINGS AND BRASS PLAYS)

DOZIER: So, how do they go about making plutonium-238? And how does it get from Oak Ridge, Tennessee, to the Perseverance rover, nestled inside the nose cone of an Atlas V rocket, 200 feet above the launch pad at Cape Canaveral Air Force Station in Florida? Turns out, the answer to that is pretty complex, involving a carefully synchronized ballet of scientists, engineers and nuclear experts, to make sure everything arrives in the right place at precisely the right time.

(MUSIC SWELLS)

DOZIER: So let’s take it step by step, beginning with a peek inside Oak Ridge National Lab’s plutonium-238 production setup. Bob and his team actually start out with a different element entirely, neptunium — that’s element 93, right between uranium and plutonium on the Periodic Table. And surprise, the neptunium is actually stored at another National Lab, halfway across the country in Idaho.

DOZIER: See, I told you it was going to be complicated! Here’s Bob again.

(MUSIC FADES OUT)

WHAM: Yeah, so in order to make plutonium-238, you have to start with a feedstock, and that feedstock is known as neptunium-237. The Oak Ridge National Lab essentially calls up the Idaho National Lab and phones in a shipment, let's say, for neptunium. We get neptunium on a just-in-time basis, it’s shipped to us and then we do the chemical processing here to make the targets. So you purify the neptunium and put it into form where it's suitable for irradiation in a nuclear reactor…

DOZIER: The neptunium is mixed with aluminum and pressed into pellets the size of a pencil eraser, which are then loaded into aluminum tubes, 52 pellets to a tube. Each tube is called a “target.” Those go into the “High Flux Isotope Reactor,” or HFIR, one of Oak Ridge National Lab’s world-class science user facilities. It’s kind of like a “nuclear oven” where the targets get baked with radiation for a good long while…

WHAM: … in our case, for HFIR between 50 to 60 days. Once it's irradiated, the neptunium 237 gets converted to plutonium 238 and when you remove it from the reactor and you allow it to cool for a little while, so that short lived fission products can decay.

DOZIER: From there, it’s over to what’s known as a “hot cell.” Scientists use elaborate controls to manipulate robotic arms behind a thick, shielded window that gives the whole scene an eerie greenish glow. Protected from the radiation, they use the arms’ grabber claws to mix flasks of chemicals that separate the plutonium-238 from the leftover neptunium-237, which gets recycled into more targets. The end product is plutonium-238 powder, which is an important step — but not quite ready for use in a space mission. Why? Well, let’s talk safety. This stuff isn’t weapons-grade plutonium, but it \*is\* radioactive, and launching things into outer space is inherently risky.

EASO GEORGE: So one of the things that we worry about is that if there's an accident either during launch or shortly after launch, that when these generators come back to Earth, and they'll crash into Earth at very high velocities, very high speeds. And we want to make sure that if — such a very low-probability event — but if something like that were to happen, that the iridium would contain the plutonium fuel and prevent it contaminating areas around where it strikes.

DOZIER: Easo George is the Governor’s Chair for advanced alloy theory and development at Oak Ridge National Lab and the University of Tennessee.

DOZIER: Easo is a world-renowned expert on alloys — metals created by combining two or more metallic elements — and he has a ton of experience working with iridium, which shields the plutonium and prevents any accidental release.

GEORGE: And the reason iridium is used is because of the environmental conditions that the material has to face are pretty extreme. So it has to have a very high melting point, about 2,000 Celsius. So, if you look at the periodic table, there aren't very many elements in the periodic table that have a melting point above that. In addition, it has to be resistant to oxidation and resistant to carbon, because the insulation in this material is made of carbon. And then when you narrow down the number of elements in the periodic table, that sort of only leaves iridium.

DOZIER: Oak Ridge National Lab was responsible for molding the ultra-tough iridium into the shape needed for the Mars Perseverance power supply.

GEORGE: So it looks like two thimbles, if people know what a thimble is. I don't know if the young people know what a thimble is anymore, but small cups. Tiny espresso cups without the handles. And the plutonium is put inside and then the two cups are brought together and welded shut.

DOZIER: If that sounds straightforward… it’s not.

GEORGE: And iridium is an unusual metal, it's a borderline brittle material. So processing this material requires a lot of skill, very narrow windows of temperature and strain rate over which it can be processed. If you don't do it right, it ends up cracking and so it's a pretty involved process to make these cups.

DOZIER: Like all the parts of the Mars rover, these iridium capsules — “clad vent sets” as they’re referred to, or “clads” for short — underwent rigorous testing to make sure they’re going to work properly under pretty extreme conditions.

GEORGE: When materials crack in real life, they always crack when they're subjected to tension. If they're compressed, it's very rare that that you end up cracking a material. So there's a gas gun that we use, the gas is used to fire a bullet and the bullet then strikes an impact plate. And the impact plate stretches the iridium samples. And we’re one of the few places that can do such tests at high strain rates in tension, at very high temperatures.

(SYMPHONY WALTZ WITH STRINGS AND BRASS PLAYS)

DOZIER: Oak Ridge National Laboratory’s contributions to the Mars 2020 mission are mighty. But the Lab didn’t actually put the finishing touches on the fuel capsules. For reasons we’ll explain, that job fell to another National Lab. And so this, Listener, is where we leave Oak Ridge, Tennessee, following the plutonium-238 and its iridium packaging more than 1,400 miles due west to the next stop on its cross-country voyage: Los Alamos, New Mexico.

(MUSIC SWELLS)

DOZIER: On the far end of this leg of the journey is Jackie Lopez-Barlow and her team at Los Alamos National Laboratory. Jackie manages the lab’s radioisotope power systems program.

(MUSIC FADES OUT)

JACKIE LOPEZ-BARLOW: So Los Alamos National Laboratory’s role is taking the plutonium-238 isotope dioxide, making a ceramic pellet, such as the same ceramic as you would get in a coffee cup, and then encapsulate that in an iridium shell, which we get from Oak Ridge National Laboratory.

DOZIER: Now, in case you’re picturing a coffee cup made out of plutonium, like I did, I’m sorry to burst your bubble — we’re talking molecular structure here, not the actual shape.

LOPEZ-BARLOW: Yeah. And the reason we use the ceramic is it's a very, very stable form, which in turn makes it more safe.

DOZIER: The Los Alamos team presses the plutonium into pellets and sticks those in a furnace, a lot like you would use a kiln to fire that lopsided vase you made in pottery class.

LOPEZ-BARLOW: We take that ceramic pellet after it's been heat treated. We will weld it into the iridium cladding. Now we can finally call it a fuel clad at that point, once it's encapsulated in the iridium, and we'll do a series of nondestructive tests.

DOZIER: A “fuel clad” is the technical term for a single lump of plutonium-238 sealed in its iridium shell. It’s the smallest unit of fuel that gets loaded into the power supply. It takes 32 clads to fuel the Mars rover up all the way. I asked Jackie what the clads look like, once they’re fully assembled.

LOPEZ-BARLOW: It's silver in color, it's kind of round, about an inch tall, and it's fairly heavy because it is a dense material. So if you were to hold it in the palm of your hand, it would take up about half the size of your palm of your hand. You wouldn't \*want\* to hold it in your hand, because it's extremely hot, about 400 degrees Celsius.

DOZIER: From that point, the Los Alamos team ran the little silver pucks of iridium-covered fuel through a battery of tests — no pun intended — to make sure they’re up to NASA’s standards.

LOPEZ-BARLOW: So we'll do helium leak to make sure our weld's OK. We will send it through ultrasonic testing and radiography to make sure we don't see any imperfections. We will then take a series of measurements to ensure that we've met our specifications to beat the thermal output requirement, and we're able to say, OK, now it's flight-quality, and it can be used for NASA applications.

DOZIER: Before we continue on our winding road to the launch site, it’s worth noting that none of this happened in a vacuum. NASA, the Department of Energy, Oak Ridge, Los Alamos, and our next stop, Idaho National Laboratory — everyone involved in the mission was in close contact every step of the way.

(SYMPHONY WALTZ WITH STRINGS AND BRASS PLAYS)

LOPEZ-BARLOW: We’re constantly in communication. That's one of the things about the team that we work with is, everybody is talking. Not just at my level, but all the way down to the people who are actually physically doing the work. We have a very, very strong team, which I think has led to a lot of our successes, and being able to work with Idaho directly, and Oak Ridge directly, if something were to come up or if there's questions, there's no hesitation in making sure that we're interacting and we're integrated together.

DOZIER: Next up: everything comes together, 800 miles away in Idaho.

(MUSIC SWELLS, THEN FADES OUT)

DOZIER: Timing is everything, as the saying goes, and that goes double for space missions.

KELLY LIVELY: Truly, to be successful in the business that I'm in, the planets have to be aligned.

DOZIER: That’s Kelly Lively, Department Manager for Radioisotope Power Systems at Idaho National Laboratory, about 30 miles from Idaho Falls.

LIVELY: I started at the INL 35 years ago. So I'm considered a veteran, I guess, at this point.

DOZIER: When Kelly says the planets have to be aligned, she’s being literal — NASA’s launch window for Perseverance lasts just a few weeks, when the Earth and Mars are at the closest point in their orbits. It’s her team’s responsibility to deliver the fully assembled nuclear power system to NASA in time for the launch. Miss the deadline, and it’s another 26 months until the two planets are back in the right place.

LIVELY: We are the final laboratory that takes the radioactive fuel that is manufactured at Los Alamos National Laboratory, which is provided to them by Oak Ridge National Laboratory, and we assemble the fuel clads containing plutonium-238 fuel into these nuclear power systems that are provided to us by private industry.

DOZIER: Let’s take a moment to talk about what the Perseverance power supply looks like fully assembled. The body of the unit was designed and manufactured by two private industry partners, Teledyne Energy Systems Incorporated and Aerojet Rocketdyne, respectively.

LIVELY: The unit itself is white, and it is a cylinder. So the cylinder is about 2 feet tall and about the same in diameter, short about 8 inches. Because around that cylinder you would have 8 cooling fins from top to bottom... Now the cylinder has a lid on it, and if you take that lid off there is a cavity in there where we would put our radioactive fuel. And the cylinder walls contain the thermoelectric devices that generate electricity from the heat from the decay of the radioactive fuel.

DOZIER: I’m going to be honest with you: it looks pretty boring for something that’s going to power one of the most exciting space missions ever to explore Mars. There’s no flashing lights, no high-def computer screens, no exhaust pipes or pistons — just a plain metal cylinder that provides just enough juice to power a light bulb. But this is a piece of technology that’s built for toughness, not for looks. And what it lacks in style or raw power output, it makes up for in durability, reliability, and LONGEVITY. This thing has got to survive 2.5 Gs and intense shaking during launch, then the long, cold ride through the vacuum of space. Next comes the “7 minutes of terror” anyone who followed the Curiosity mission will be familiar with, as it plummets to the surface of Mars. After all that, it’s got to continue delivering perfect, uninterrupted power to Perseverance as the rover carries out its mission, day after Martian day, for years on end.

LIVELY: There's a lot of pressure to do this correctly the first time, because we at INL have never fueled and tested a spare unit. So we haven't had the luxury of being able to fuel and test a couple of them, and if something should go wrong, we always have a backup unit. And that has just simply not been the case since we've been involved in these deep space missions. So we have a one-of-a-kind unit, it has a price tag of around $75 million, it's the only one of its kind for this mission, and there's no way you can do it again.

DOZIER: There’s no margin for error, so Idaho National Laboratory subjects the power system to its most rigorous testing yet. With the nuclear fuel inside the unit, they shake it, spin it, seal it in a vacuum chamber — keeping a close eye on the power output and stability of the unit every step of the way.

LIVELY: What you're trying to do is make sure if you provide the power system with some kind of movement, is the nuclear power system going to stay together or are parts in it moving that shouldn't be moving? Because it's a static system. There are no moving parts in it — and we don't want them to be moving!

DOZIER: That’s part of the beauty of it, right?

LIVELY: Yes, yes. It's an extremely reliable system. This program has enjoyed 60 years of providing these static nuclear power systems for NASA.

DOZIER: Before the power system can depart Idaho on the final stretch of its pre-launch voyage, every one of those test results has to meet pages upon pages of demanding design and NASA requirements.

LIVELY: So we have a multi-page (LAUGHS), hundreds of page, document called a specification that we have to test to and meet those requirements. So we prepare what's called an end-item data package. So that's the report that says, "Yep, we performed all of these tests in accordance with the specifications, and it has passed these tests with flying colors."

DOZIER: Kelly said the final printed copy of the report fills up six D-ring, 5-inch binders, and joked that it likely weighs as much as the power system, which clocks in at just under 100 pounds. In late 2019, Perseverance’s nuclear heart got the green light to proceed to Kennedy Space Center in Florida, its final terrestrial home before leaving Earth. But this isn’t the sort of thing you send via first-class mail. NNSA, the Department of Energy’s National Nuclear Security Administration, provided secure transport on the 2,500-mile drive from Idaho to Florida.

LIVELY: So those guys come up to our laboratory with their tractors, and we would already have our power system inserted into a steel cask inside our transportation trailer, which is a 52-foot-long semi-trailer.

DOZIER: A six-person “chase team” from Idaho National Lab followed close behind, monitoring the radioactive power supply in its liquid-cooled chamber the whole way down.

LIVELY: It’s a nuclear payload being transported across several state lines (laughs). So it’s kind of sobering, a sobering moment, you know, it’s just so amazing to be a little part of history.

(SYMPHONY WALTZ WITH STRINGS AND BRASS PLAYS)

DOZIER: Once safely at Kennedy Space Center, the power system got dressed in its Sunday best, the “flight hardware” that serves as its mechanical and electrical connection to the rover. The moment of truth for Kelly and her team came in April, when their little nuclear battery finally met Perseverance — freshly delivered from the Jet Propulsion Laboratory in Pasadena, California — at a clean room in another part of the complex.

(MUSIC SWELLS)

LIVELY: So they assemble the rover, and we bring over the power system, and it is mated for the first time in that clean room facility. And it's really exciting, too, because while many, many, many tests have been performed at this time, this would be the first time that the Perseverance rover would be powered by nuclear energy.

(MUSIC FADES OUT)

DOZIER: Despite all the build-up, connecting to the rover was a pretty straightforward affair, in the end.

LIVELY: Yeah, it literally plugs in with an 18-pin connector (laughs). It doesn't look like your 120v outlet in your home, but it plugs in and provides power.

DOZIER: Rover and power source were then separated until the time comes for the real voyage to begin. As the launch window approaches, the power supply has one last trip to make. First, a short distance over to Cape Canaveral Air Force Station, where a towering Atlas V rocket is stacked inside what’s called the “Vertical Integration Facility.”

LIVELY: So our power system would be hoisted on the outside of that building, from the apron on the ground floor, up 200 feet, landed on a mezzanine…

DOZIER: There, high above the tarmac, the power source will pass through a six-foot-door to find the rover waiting upside down in the spacecraft that will take it to Mars. The two will make one final connection, this time for life.

(SYMPHONY WALTZ WITH STRINGS AND BRASS PLAYS)

LIVELY: And then we will await to roll out to the launch pad with the Atlas V rocket about 3 days before launch, and it will sit there on the launch pad until the weather and all systems are identified as go.

(MUSIC SWELLS)

DOZIER: It will already have been on quite a journey by the time it launches.

LIVELY: Yes, on quite a terrestrial journey.

(MUSIC FADES OUT)

DOZIER: Once the mission launches, hopefully without a hitch (knock on wood), there’s still more work to be done — although not quite as “hands-on” as the earlier parts of the project.

LIVELY: So far, even though there's been threats, no one has duct taped me to the outside of the rocket to go with it (laughter) to make any repairs, so I guess that's good news, at least for me.

DOZIER: All three of the National Labs we’ve heard from today will continue supporting NASA as the Mars rover makes its way to — and investigates — the Red Planet. But the Department of Energy’s contributions to space exploration don’t stop there. I mentioned earlier that Oak Ridge National Lab recently started producing plutonium-238 for the first time since the 1980s. Here’s June Zakrajsek again to explain why that’s a big deal.

ZAKRAJSEK: About 30 years ago, we lost the ability to produce, domestically, plutonium-238, and today working with the Department of Energy and people like Bob Wham at Oak Ridge National Lab, and Jackie Lopez Barlow at Los Alamos National Lab and their teams, we've been able to reproduce the ability to provide domestically produced plutonium-238. NASA was making mission-limiting decisions because of heat source availability. So we now no longer have to do that. And some of the new material that they produced is actually powering Perseverance. And it will be part of that rover when it arrives at Mars.

DOZIER: The partnership between DOE and NASA actually stretches back a long way, even farther than you might think. And it has only gotten stronger over the years.

RITA BARANWAL: It's not our first time around — we have built in DOE nearly 50 radioisotope power system units that have powered more than two dozen US space missions.

DOZIER: That’s Rita Baranwal, Assistant Secretary for Nuclear Energy here at DOE. Her office played a coordinating role in the Mars 2020 power supply project from the start, helping keep all the different contributors on the same page.

BARANWAL: Clearly it takes a great deal of talent, of coordination and collaboration over many years, between numerous researchers at several of our labs, and they have thus far executed brilliantly.

DOZIER: They’re also looking ahead, and thinking about the needs of future NASA endeavors.

BARANWAL: So we've got Idaho National Lab, Los Alamos National Lab, and Oak Ridge National Lab working closely together with NASA to help fortify its fuel supply of plutonium-238. Oak Ridge recently automated part of this production process, and that allows them to produce up to 400 grams of plutonium-238 each year, and that moves us closer to the ultimate goal that NASA has for 1.5 kilograms per year by 2026. And while we in the have enough fuel to support space missions through the next decade, this continued partnership between DOE and NASA certainly ensures that there will be an ample supply of domestic plutonium to support future missions. I think having that fuel supply is very, very vital.

DOZIER: I asked Rita, who interned at NASA when she was younger, if this mission has added personal significance.

BARANWAL: Oh, it absolutely does. I am giddy with excitement over having gotten an invitation to attend the launch. I interned in the '90s at what was then NASA Lewis, it's now NASA Glenn in Cleveland, Ohio, and worked on projects developing composite materials for spacecraft. I can't even put it into words, how excited I am to be able to attend the launch.

(SLOW, CONTEMPLATIVE MUSIC WITH ELECTRIC GUITAR AND PIANO PLAYS)

DOZIER: When it comes to space exploration, D-O-E may not be the first letters that come to mind. But almost as long as we’ve been reaching for the stars, this Department and its predecessors have stood at the ready to help NASA’s missions go the distance. Here’s Secretary Brouillette one more time.

BROUILLETTE: We have a long history in space. We've powered many of the deep space missions going all the way back to the '60s. So we're very excited about that. We think that it's part and parcel to everything we do here at the Department of Energy. It's part of our energy mission, it's part of our energy security mission. It's also part of our national security mission. So we're very, very excited about our role here. Our goal with NASA was to always be reaching, growing, innovating, and exploring. Together we’ve opened up new worlds, and I’m convinced the best is still ahead. In fact, we've been working with NASA to better align our strategies under the National Space Policy to ensure that we think about how we could better work together. I'm looking forward to using the full capabilities of our Department and our National Labs to both power innovation and to power exploration, and to opening up all the new horizons and the new worlds of opportunity that we have before us. As I mentioned earlier, I’m tremendously excited about the upcoming Mars mission, but the best part is that we're really just at the beginning.

DOZIER: Next time: SuperCam, Perseverance’s laser-zapping, photo-snapping, rock-hunting, sound-recording, do-it-all Swiss Army Knife. You don’t want to miss it.

(MUSIC FADES OUT)

(BASS-DRIVEN HIP-HOP MUSIC PLAYS)

DOZIER: Thanks to everyone who contributed to this episode — and there were a lot of you. From Oak Ridge National Lab, thank you to Bob Wham and Easo George, with a special shout-out to Jenny Woodbery and Morgan McCorkle, who recorded those interviews. Go check out their fantastic podcast, “The Sound of Science,” to hear more stories about Oak Ridge’s groundbreaking research. Thank you to Jackie Lopez-Barlow at Los Alamos National Lab and Kelly Lively at Idaho National Lab. From the Office of Nuclear Energy, thank you to Rita Baranwal and Tracy Bishop, and thanks to June Zakrajsek and everyone at NASA who made this mission possible. We’ll have more Mars 2020 content on our website, energy.gov/podcast. If you've got a question about this episode or want to leave us some feedback, email us at [directcurrent@hq.doe.gov](mailto:directcurrent@hq.doe.gov), or tweet @energy. And if you're enjoying the show, share it with a friend and leave us a review on Apple Podcasts. Direct Current is produced by me, Matt Dozier. Sarah Harman creates original artwork for all of our episodes. This is a production of the U.S. Department of Energy and published from our nation’s capital in Washington, D.C. Thanks for listening!

(MUSIC FADES OUT)

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