AEROSPACE

★ ★ ★ AMERICA ★ ★ ★

FAA's approach to averting ground collisions includes a runway lighting scheme that's so expensive it's probably not at your airport. An affordable alternative could be coming.

A new light for safety

PAGE 22

MAY 2024 | A publication of the American Institute of Aeronautics and Astronautics | aerospaceamerica.aiaa.org

AIAA
SHAPING THE FUTURE OF AEROSPACE

NASA/Bill Ingalls

NASA's realist-in-chief

Gene Kranz famously said "Failure is not an option," and if Jim Free were to rally NASA, his saying might be "Budget is not an excuse." NASA's fiscal 2024 funding represented the agency's first decrease over the previous year since 2013. NASA must nevertheless find a way to make progress on its programs. It's a skill that could prove vital, given that the debt ceiling agreement struck by President Joe Biden and House Republicans last year also caps next year's spending at just a little above the 2023 appropriation. Of special concern is progress toward the Artemis moon landings that are supposed to be stepping stones toward crewed missions to Mars, and the robotic Mars Sample Return mission, whose approach NASA is rethinking after reviewers warned it would cost $11 billion and take a decade longer to retrieve the samples than originally planned. I sat down with Free last month at the Space Symposium in Colorado Springs for a wide-ranging discussion that began with the money question. Here is our conversation, lightly edited and compressed. — *Cat Hofacker*

JIM FREE

Positions: Since January, associate administrator of NASA, the highest-ranking civil servant. 2021-December 2023, head of NASA's Exploration Systems Development Mission Directorate, overseeing Artemis and other exploration missions. 2017-2020, led the aerospace division of Peerless Technologies Corp., an Ohio-based consultancy. 2013-2016, director of NASA's Glenn Research Center in Ohio. Since 1990, has held various engineering and management roles at NASA centers, starting at NASA Goddard working on the first and second generations of the Tracking and Data Relay Satellite, NASA's spacecraft that relay communications between Earth and geostationary orbit. AIAA senior member.

Notable: Youngest person to be appointed director of NASA Glenn. As head of the Exploration Systems Development Mission Directorate, oversaw the 2022 Artemis I uncrewed loop around the moon: the first operation of an Orion crew capsule in deep space and the inaugural flight of a Space Launch System rocket.

Age: 55

Resides: Cleveland

Education: Bachelor of Science in aeronautics, Miami University in Ohio, 1990; Master of Science in space systems engineering, Delft University of Technology in the Netherlands, 2004.

Q: In this difficult budget environment, how do you make sure Artemis and other large programs get adequate funding without detracting from smaller projects?

A: Showing progress and getting hardware done, hitting our milestones, is the No. 1 thing we have to do. We set out a program plan to do these things. Almost all the time, it's very aggressive schedules, big technical challenges to overcome, but we have to hit the milestones or explain why we're not. Both of those are equally as important. That, to me, is the greatest advancement and proving of why we need the budget we do, or proving to our stakeholders that we can be trusted with the dollars we've been given. And that's any program we have. Some of these things are really hard. That's not an excuse; that's just a reality. When we miss something — and I'm saying "we" because a lot of times NASA's out there in front, but we have a whole aerospace industry behind us; we need their [industry's] buy-in too when we put a proposal or a contract out. There's got to be realism in that. There's got to be delivery from our partners, there's got to be delivery from us when it's NASA-provided hardware. So we all have to show how we're doing, why we're doing the things that we are, why we're having trouble, and be open and honest about it. When you can show delivery, you can show why you're late and be honest about the problems that you have; that's a credibility that you need to show for the tax dollars.

Q: On the third Starship test flight, what was your reaction, and what does it indicate about the likelihood of meeting the 2026 target for Artemis III l?

A: I watched a lot of it on Turkish Airlines, if you can believe that. They had live TV on there, so I watched it on the BBC. I was really happy in particular with one of the technical milestones: doing a propellant transfer.

SpaceX says it transferred liquid oxygen oxidizer from one tank to another aboard the Starship upper stage during the March 14 test flight. — CH

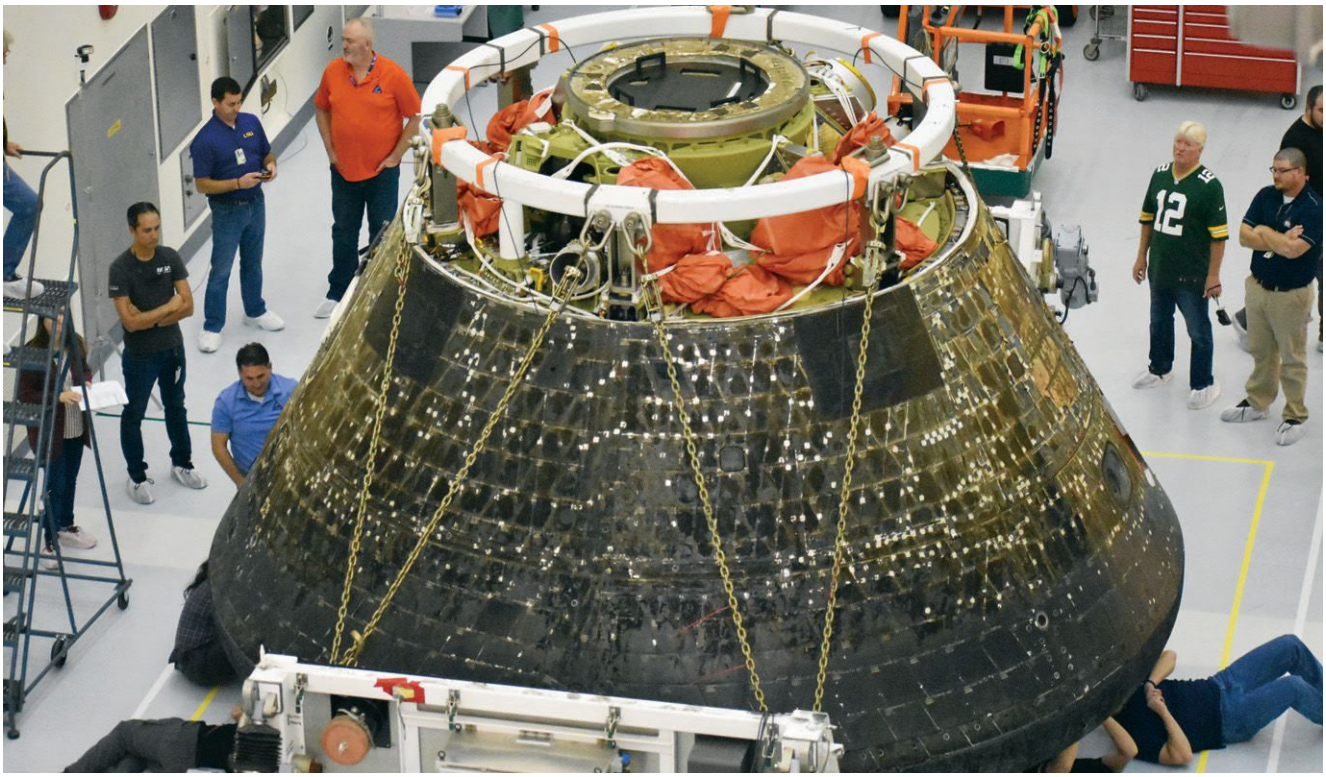
That's huge for us, because that's what they're going to have to do to refill the depot multiple times and to fill the lander. So seeing that happen is excellent. Seeing the booster performance, all the engines work and going uphill, the good hot staging that they did, the Starship performance. That video's spectacular. I've been saying it for a while: They've got to launch 12 to 15 times to do our one mission, so we as their customer have to hold them to the date we've signed up to contractually. We need to do every single thing we can to support them to hit that milestone, and I believe that we are. But ultimately, they've got to hit that. So how I'm feeling about it is I'd like to see another pad in place, I'd like to see them launch multiple times, I'd like to see them do the long-duration cryo test, the ship-to-ship transfer. I'd like to see them perform to what they've signed up. And that's just not SpaceX. It's our suit contractor, we need Lockheed Martin to perform on Orion, we need Boeing to perform on SLS. There's a lot of things that have to line up for that Artemis III mission.

Q: How's the analysis of Orion's heat shield progressing?

A: It's going good. We've spent a lot of time getting to root cause. There's kind of a mental barrier you have to put up to not jump to flight rationale because you could miss what the root cause is.

"Flight rationale" means NASA and its contractors have completed the analysis and work necessary to consider flight readiness of a spacecraft, in this case Orion for the Artemis II crewed flight. Post-flight analysis of the

"When you can show delivery, you can show why you're late and be honest about the problems that you have; that's a credibility that you need to show for the tax dollars."



▲ NASA is still analyzing the heat shield of the Orion capsule that completed the Artemis I flight. More material eroded during atmospheric entry than expected, prompting the agency to push back the crewed Artemis II mission to September 2025, a delay of one year.

NASA/Skip Williams

uncrewed Orion that flew around the moon in the 2022 Artemis I mission showed that more heat shield material than expected ablated away as the capsule was slowed by Earth's atmosphere. — CH

We continue to do testing and analysis, trying to put together a thermo structural model right now. That's what's key. That's rooted in data from Artemis I and all the testing that we've been doing in larger panels of the heat shield. We're going to do an independent review team, hopefully starting the end of this month to get just another set of eyes to say, "Did we get there?" We've had someone following us from an independent perspective who's been very good at asking questions and saying, "Hey, here's some other theories." Hopefully, the review team will finish the end of June. And we've begun to dip our toe in the flight rationale — how we do the skip, do we do the skip? How could we fly the mission different?"

During Artemis I, an uncrewed Orion crew capsule dipped into Earth's upper atmosphere and back out to demonstrate the until-then-untried "skip maneuver" for reducing heating and acceleration for the descent back to the surface. — CH

The other thing that overlays on that is the Artemis II crew that's been involved every step of the way. They get regular briefings from the team; they have the opportunity to raise their concerns. They're very happy we're doing the independent review team to get eyes on there. We've really stepped into this in a careful manner. And frankly, it's a flight test. That's what the first mission was, that's what the second mission should be: another flight test. So we have to take that mindset for all of the issues. The heat shield was just the most prominent one.

Q: Can you speak to how crew selection will be done in light of diversity, equity and inclusion?

A: We always say we pick the skills of the crew based on the mission we're going to fly. That's not going to change for Artemis. So that's the overarching premise, but where it starts is how we choose our astronaut classes. To bring folks in that have that diversity of background, both professional and personal, and then we train them with the basics, and then they get specialized training along the way. So if you start with a diverse group and you bring them along and give them the skills, picking your crews is based on the skills. So if you have a broad and diverse skill group, it's not going to be a problem to fulfill those goals.

NASA has pledged that Artemis III will include the first woman to land on the moon, and that the first person of color will walk on the moon in a future Artemis landing yet to be announced. — CH

Q: Because Artemis is being done under this moon to Mars framework, is there a similar urgency to land humans on Mars as soon as possible?

A: I don't think we're going to get there in the 2030s. When you lay out the Artemis missions and then you say, "OK, we have to start developing the technologies." So the Space Technology Mission Directorate has to come up with this list. We've had a lot of discussions about the tech we think we need for Mars. They have to develop it to a certain technology readiness level, then either ESMD [Exploration Systems Mission Directorate] has to take it or SMD [Science Mission Directorate] has to take it and grow it so then we're ready to go. And by the way, we want to learn from our lunar missions, too, so that pushes the timeline to probably the early 2040s for a human to Mars mission. And then you look at the practical reality of trying to overlay a lunar program and a Mars program. We have to start that development so early. How do we do that from a budgetary perspective? We have to make the compelling case of why we need to do that, and then our stakeholders have to decide, "Yes, we want to do that." Our job is to plan it, our job is to work the objectives, set the goals, develop an architecture, and then we phase that architecture based on really what budget we can do. But ultimately, our job is to say, "Here's what it takes to get there," and then let others decide if they have the appetite to pay for that.

Q: SpaceX seems determined to get to Mars before the 2040s — Elon Musk has suggested as early as 2029. Does it matter if the first humans to Mars are sent on a private mission versus a government one?

A: I think the goals are different. If your goal is to just get there and not come back, that's not something that we espouse.

Musk's long-term goal is to create a "self-sustaining" city of at least 1 million people on Mars. — CH

We have to marry science with our human exploration. When they have to get too far apart, they start fighting and it leads nowhere good. And they shouldn't be far apart; we have to do the science while we do the exploration. So if SpaceX wants to go there on their parameters, that's really up to them. But our goal is to bring our crew back. When we look at Starship's ability to bring the crew back and what you'd have to do to refuel Starship, we think that's significant infrastructure to do that, which would take years to bring that vehicle back. The Starship ability versus nuclear thermal versus nuclear electric, that's the trade space that we're in now so that we can define and we can mature nuclear thermal and nuclear electric, or the technologies that SpaceX needs in terms of in situ resource utilization. All of that goes into that road map that we need STMD [Space Technology Mission Directorate] to start maturing. We have to do some early development so we can trade the performance of all of that to decide what our final configuration will be to go to Mars with humans.

▲ NASA last month issued a request for proposals for alternative methods for retrieving some or all of the 30 samples of Martian rock and dirt that the Perseverance rover has collected to date. This sample, collected in March, was photographed by the CacheCam in the rover's belly.

NASA/JPL-Caltech

Q: How critical is Mars Sample Return to sending a NASA crew to Mars?

A: There's one very obvious connection: Planetary protection, even for Mars Sample Return, is incredibly difficult. We're actively working to figure out how the samples would be contained and stored to guard against cross-contamination, as well as how we would make sure crews don't leave microbes on Mars or bring anything back with them. So everything Mars Sample Return is doing to help us get down that path is perfect, even if there was no further connection beyond that. The MSR samples come from Jezero Crater. We need to understand, is that the place we want to go? What we're doing now in parallel, out of our architecture concept review, is actually looking at the seven questions for Mars. The first is what are the science goals that we need? What we don't want to do is design for a single spot on Mars, because then that limits our architecture and we won't be able to go anywhere else. We need to understand what Jezero Crater holds for us. We're also looking at how the objectives from MSR and our moon to Mars objectives interrelate so that we can look for the alignment so that whatever MSR does in the future, whatever that architecture may look like, we can relate it.

▲ Three weeks after the March test flight of a Starship-Super Heavy, SpaceX conducted a static fire of the Super Heavy booster it plans to fly for the next flight. NASA's Jim Free says that while he was "very happy" with the progress on the March flight, he'd like to see "multiple" Starship launches this year.

SpaceX

Q: So it sounds like canceling MSR is not an option.

A: It's certainly not something we want to put on the table. But ultimately, it goes back to the first thing that you asked me about: We have a responsibility to always look at our programs and say, "How are they doing?" Everybody's like, "Oh, well, you want the money from MSR to fund Artemis." That's not the case. Artemis is a national capability. You can almost look at MSR as a national capability. MSR is not like other science missions in that if I don't do this science mission, I'm just not going to get this bit of science. MSR is complex and not a lot of other countries are doing something similar. So we need to look at it from that capability. For right now, we don't want to cancel it, but we're trying to keep our options open.

Q: It seems like demonstrating a robotic round trip to Mars alone would be incredibly valuable for planning human missions.

A: Right, because you can instrument it much like we instrumented the Curiosity and Perseverance rovers to understand entry, descent and landing. We learned about the atmosphere and what it takes to go through it and what eventually we'll need for our humans. Even the radiation exposure on the way out; we learned about that too. That will be incredibly important to protect the humans going out there.

Q: Even though a final decision hasn't been made, how would you characterize the importance of nuclear propulsion on a scale of "critical" to "not necessary, but it'd be nice to have"?

A: It requires a huge amount of infrastructure to get the vehicle there and back, whether it's a SpaceX option or some other cryogenic option. So when you look at nuclear thermal and nuclear electric, that's a lot less overhead. So the architecture is beneficial. We don't know enough right now, because we haven't gotten quite the funding levels to develop both to the point to make an informed choice. There's certain technical aspects of NTP that are just challenging, like storing hydrogen for that long. Maybe the Blue Origin lander will help us do that, or some of the other tech development.

He's referring to the proposed lunar lander that NASA selected for the Artemis V landing, currently scheduled for 2030. — CH

For nuclear electric, that's probably more about power conversion. So we need to invest in both their development to make that important down select.

Q: Switching gears to aeronautics: Boeing will own the X-66A, which represents a different contracting approach. Will this be an outlier or part of a new trend?

A: I want to note that Lockheed Martin is investing a lot in X-59. The contract didn't start out that way, but it's where we are today. So to Lockheed's credit, as we've faced some difficulties, they've stepped in with their own investments. X-66 is starting out as a shared partnership, very similar to the public-private partnerships we're doing for the Artemis human landers,

▲ Boeing in January shared a video of the first steps taken to convert this retired MD-90 into the X-66A Sustainable Flight Demonstrator. Among the modifications, the aircraft's wings will be removed and longer, thinner ones installed, supported by trusses, meaning thin support beams. Boeing and NASA say this truss-braced transonic airframe, when paired with Pratt and Whitney GTF engines, could burn 30% less fuel than today's airliners.

Screengrab from Boeing video

LTV [Lunar Terrain Rover], for suits, buying things as a service. So it's not out of the ordinary overall for NASA, but it's certainly unique for Aero [the Aeronautics Research Mission Directorate]. It's discussing what are the needs of Boeing, what are their desires, where do they want to get to? We have to respect the timeline of when they can invest. I've been hearing lately that they may want to accelerate things a little bit from where they are. So I think it's exposing the aeronautics side to some of the things we're doing in space, but with a very important application of reducing fuel burn. I had a chance to walk through the MD-90 that they're going to take the big fuselage section out of to create X-66. It was really cool standing there; it's a big section of fuselage. I think the goals are tremendous with where we're trying to get to, with net-zero carbon emissions by 2050 and eventually zero emissions. The zero-emission goal is very difficult, and you're well on your way to that with the 30-plus-percent reduction [in fuel burn] with X-66.

Q: Do you think if development of X-59 began today, that program would be focused on sustainable supersonic flight instead of mitigating the sonic boom?

A: That's a good question. I know there's that debate of why are we doing X-59? I still think it's [the sonic boom] a technology that eventually we're going to need to understand. In January, I was down at a SpaceX launch [of a Northrop Grumman Cygnus cargo capsule to the International Space Station]. When the first stage comes back from Falcon 9, it's got two sonic booms. Those are significant emotional events when you're like a mile away, which is where we were. So I think we can advance everything at once. We can work through the sonic booms, and we're working away to be sustainable. Eventually, those may be able to come together and provide another step in the aeronautics pathway. So would we do it now? I don't know. It's still important information that we think we need to figure out. That's why we're still pressing forward with all the phases to eventually do the cross-country testing of the X-59.

Q: Looking forward, how does the constrained budget in the fiscal 2025 request impact your planning for future years?

A: We actually just released our internal guidance for '26, so we'll start talking about that in the November/December timeframe. The Fiscal Responsibility Act is not applicable to our '26 budget. Now, I'm not saying "Hey, the government has all this money to spend, and we're just going to put all this out there." But we don't have the caps that have been there for fiscal 2024 and 2025. We still need to justify any additional dollars we need, and we will do that. Ultimately, we want to keep our science flowing; we want to get to the aviation safety aspects; we need our tech development to do our exploration; we need the development of commercial low-Earth orbit destinations. So we're going to put things out there and justify where our potential overages will be in order to keep ourselves moving down, to do our Artemis missions faster, to find a safe way to deorbit the space station and still have that low-Earth orbit capability. We're not saying we're going to ask for $50 billion, but we are going to put the things in there that we think we need to keep our missions moving forward. ★