Sending out an SLS

A visit to the Michoud Assembly Facility and the Stennis Space Center, where NASA's Space Launch System is taking shape.

by **John Sealander**

RIGHT
The LH2 tank in the High Bay area at Michoud.

You've heard it. We've all heard it. "We're going back to the moon by 2024 and this time we're going to stay". It's an audacious claim but at a cavernous factory in East New Orleans, there is a dedicated group of people committed to turning this dream into reality. They're doing it with a new programme called Artemis whose success in many ways hinges on the successful development of the Space Launch System (SLS), currently the world's biggest and most powerful rocket.

You really can't understand the Artemis programme until you understand the Apollo and Space Shuttle programmes that preceded it. In Greek mythology, Apollo and Artemis were brother and sister. NASA's version of Apollo and Artemis is pretty much the same story. There is a strong family resemblance in these two lunar programmes, especially when it comes to the SLS.

The Artemis programme has been criticized by some as being anachronistic and unnecessary. Why isn't NASA developing reusable rockets like SpaceX and Blue Origin? Why are we spending so much time and money reinventing the wheel? The answer to these questions can be found at the Michoud Assembly Facility and nearby Stennis Space Center. Without the unlimited budgets of the 1960s that were unlocked by a space race and a national commitment to beat the Russians to the Moon, to a great extent NASA would have to rely on what it already had.

BELOW
Rollout of the first core stage (CS1) for the Artemis 1 mission from the Michoud Assembly Facility, scheduled for launch no earlier than late 2021.

LEFT: NASA / ABOVE: JOHN SEALANDER

It didn't take NASA long to realize they actually had quite a lot. They still had an operational factory where the Saturn V boosters were assembled. They still had the B1/B2 test stand where Apollo rockets went through static-fire testing. Most importantly, they still had 16 flight proven RS-25 engines left over from the Space Shuttle programme. Even the spacecraft itself is like Apollo on steroids, and has been quoted as such by a cynical media unaware of the extraordinary progress logged in the well-nigh 60 years since the Apollo spacecraft was designed. The crew module for the Orion spacecraft may look like a larger version of the Apollo Command Module but believing it is so is a bit like comparing a Boeing 747 of the 1960s with one flying today – or a B-52 of the 1950s with the sophisticated variants today equipped with glass cockpit and sophisticated avionics. But Artemis is both SLS and Orion, although Orion is going nowhere without the SLS.

WHAT IS IT?

Without being in the least bit detrimental, the Space Launch System is essentially a programme created from spare parts using existing assembly and testing facilities. All four Artemis 1 engines have been flown before. One of these engines, number E2045, has already been flown 12 times. In total, the four RS-25 engines that will power the Artemis 1 core stage have contributed to 21 successful Space Shuttle flights. There's nothing fundamentally new about the SLS Block 1 boosters either. These are basically the same solid rocket boosters that accompanied every Shuttle launch – only better. The new improved boosters have five propellant segments instead of the Space Shuttle's four. Nevertheless, although the SLS core stage itself is more sophisticated than the Apollo-era rockets, it is strikingly similar. The massive 64.6 m tall core stage is not reusable and will be powered by liquid hydrogen and liquid oxygen, just like the second and third stages of Saturn V and the External Tank for the Shuttle that preceded it. In fact, Shuttle ET technology is enshrined within the SLS core stage.

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While it is true that the Artemis programme is already over budget and behind schedule, it is still years ahead of an all-new programme that would have had to be developed from scratch. Without the treasure trove of resources that the Apollo and Space Shuttle programmes left behind, NASA wouldn't be going back to the Moon at all. And it stands at the tip of an enduring commitment for NASA to get back into the "big booster" world. After all, development of Orion and the big rocket that would launch it to the Moon really began in 2004. Cancelled in late 2009 by the Obama administration, Congress reinstated both Orion and the big rocket, this time forcing a redesign of what was at the time known as Ares I and calling it the Space Launch System. And so we are here now – less than four years from when, as NASA boss Jim Bridenstine likes to say, the first woman and the next man will land on the Moon.

TESTING TIMES

When you enter the 43-acre Michoud Assembly Facility you realize that it would be very difficult to duplicate something like this today. There isn't the will and »

« there isn't the money. Michoud has made significant upgrades over the years, including the world's largest friction stir-welding tool and state-of-the-art additive manufacturing capabilities. The important thing however is that the facility already exists.

The same goes for the nearby Stennis Space Center where the SLS for Artemis 1 is undergoing static fire testing. It is doubtful that NASA could build something like Stennis today. Back in the 1960s, they had to relocate the residents of five entire towns to build the enormous 13,500-acre test facility. They created an extensive canal system with Panama Canal style locks to accommodate the huge barges that transported the Saturn rockets from the Michoud Assembly Facility. They built an enormous test stand that utilized more steel than the Eiffel Tower. In today's environment, it would take until 2024 just to write the environmental impact statement for a project of this magnitude.

As the press believe it to be, Artemis is basically Apollo on steroids, powered by left over bits and pieces of the Space Shuttle programme. Will it work? That remains to be seen. When you look at what has already been accomplished, there are reasons to be optimistic. The Artemis 1 core stage is complete. Significant segments of Artemis 2 and 3 can be seen scattered throughout the cavernous Michoud Assembly Facility. It's easy to get the impression that the programme is moving along at full speed.

Full speed ahead for NASA is different than full speed ahead for Space X or other private companies. NASA is a government entity. It has experienced failure and is extremely concerned with safety. Everything is rigorously tested and then tested and tested again. A variety of test articles have already been created to ensure that everything from the integrity of the welding equipment to the safety of the transportation systems is maintained. A mockup of the core stage that is identical in weight and size to the real thing has already been transported to the Stennis Space Center and Kennedy Space Center using the newly refurbished *Pegasus* barge. The last thing NASA wants to do is to damage one of these very expensive rockets on its way to launch.

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The same care is going into refurbishing each of the 16 available RS-25 engines at an amazingly clean Aerojet Rocketdyne factory located on the premises at Stennis Space Center. It is taking three to five years to get these proven engines ready for flight and each of them will be better than new when complete. Aerojet Rocketdyne's real challenge comes when the first 16 RS-25 engines have been used. The team that created these engines is gone. Some of them have passed away, taking their knowledge with them. The RS-25 is an incredibly robust and reliable engine, but to keep it that way in the future, a lot of things will have to be relearned.

When you contrast the RS-25 programme's three to five year production cycle with Elon Musk's claim that he will soon be able to build a Raptor engine every 12 hours with a target of 500 Raptor engines a year, you can see why the entire Artemis programme is falling behind schedule. Unlike Space X, NASA totally depends on Congress for funding and can't afford a failure. An abundance of caution takes time. The SLS for Artemis 1 is now at Stennis where it will spend almost a full year on the B1/B2 test stand before it heads to Kennedy Space Center for an unmanned launch around the Moon.

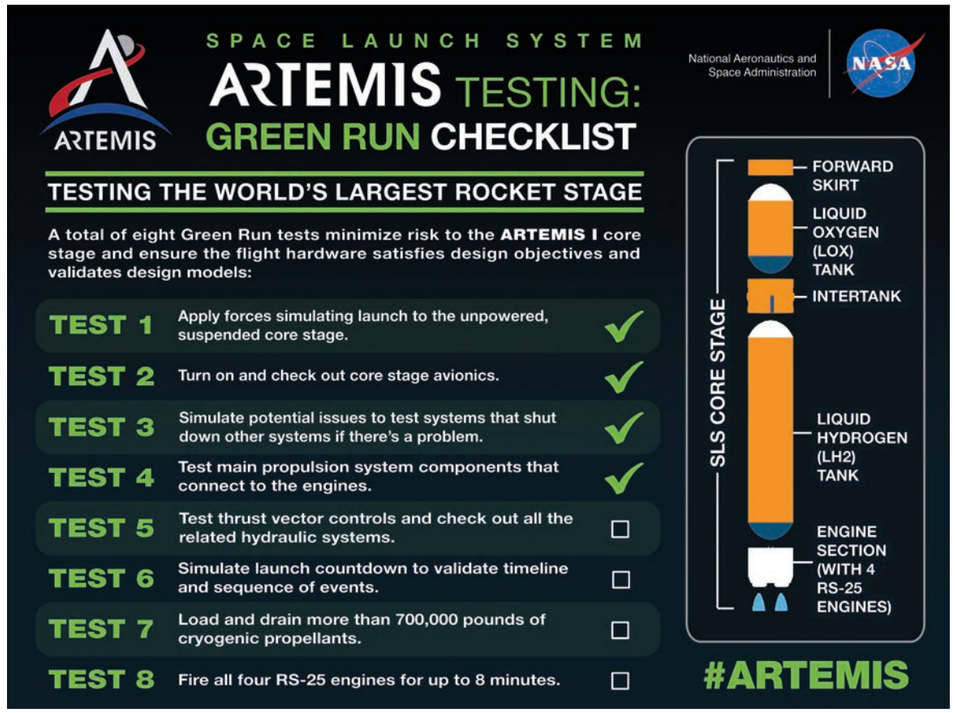
CONTROLS

NASA is doing everything it can to control costs and keep the programme moving forward. Production costs are already 30% lower than they were during the Apollo era. That's a big deal. Engineers at Michoud love to talk about additive manufacturing. This is basically 3D printing for the rest of us. When you stop using a lathe to carve parts out of a block of metal, you not only eliminate waste, you simplify the entire manufacturing process. There is a lot of additive manufacturing taking place at Michoud these days. Engineers are learning how to make increasingly sophisticated parts using fewer steps than were previously possible. The combination of sophisticated additive manufacturing techniques and the gigantic friction stir-welding machines that are used to create the enormous barrel segments for the Artemis core stages have been a game changer. Although the Michoud Assembly Facility has been operational since World War II, when it was used to build tank engines and cargo planes, the facility's original employees wouldn't recognize the place today.

One can only hope that politics won't derail the Artemis programme. At a time when all the pieces are finally coming together, it would be disaster to see the programme cancelled or postponed when political winds inevitably shift. The climate that created the Apollo programme may never exist again. It was a unique set of circumstances that made it possible to go directly from John F. Kennedy telling the world "We choose to go to the Moon in this decade and do the other things, not because they are easy, but because they are hard", to Neil Armstrong replying "That's one small step for man, one giant leap for mankind". It all happened in less than a decade.

Returning to the Moon will be harder this time. The Cold War is over and people's priorities have changed. Returning to the Moon is important, but it is no longer a national priority. The one thing that hasn't changed is the dedication of the people actually building the rockets. To these people at Michoud and other centres around the country, the 2024 deadline is very real. When you see what the people at Michoud and Stennis have already achieved, it's hard not to be optimistic. For many reasons, they have to be allowed to succeed. SF

RIGHT
Thrust buckets at the Stennis test stand.



LEFT
A NASA infographic showing tests completed to date on the "green run" schedule, rounding out with a live firing of the SLS's core stage total duration of eight minutes.

LEFT: NASA / ABOVE AND RIGHT: JOHN SEALANDER

ABOVE
Developed for the Shuttle External Tank, the Friction Stir Welding technique has been crucial for assembly of the core stage barrel segments.