Forward! To the Moon

Final Script as Recorded

00:00	Probably one of the most significant things we can think about, when we think about Apollo, is that it has opened for us, “for us” being the world, a challenge of the future.
00:15	The door is now cracked, but the promise of that future lies in the young people, not just in America, but the young people all over the world, learning to live, and learning to work together.
00:31	The valley of Taurus-Littrow on the moon, which I was privileged to visit in 1972, is one of the most magnificent valleys in the solar system.
00:43	The roll of bright craters and dark hills finally intersects the bright slopes of the massifs that form the mountain walls.
00:54	The north massif is at least 6,000 feet high above the valley floor, but the south massif rises to over 7,000 feet, and they are silhouetted, in a sense, against a blacker than black sky, and within that black sky, hanging over the south massif, is this beautiful planet earth that we call home.
01:36	Within a single lifetime, we’ve progressed from the first space rocket launch, to using space technologies in our everyday lives.
01:48	Both governments and private companies have taken up the challenge, launching near-Earth satellites for communication, imaging and navigation.
01:59	Low Earth orbit has become another part of the world economy.
02:04	The International Space Station has been continually inhabited for over twenty years, hosting teams of astronauts who carry out research and trial

	new, robotic technologies.
02:20	Now, we are ready to start a new chapter in the history of human endeavor: to take our first steps towards a permanent, off-world presence…
02:32	*FORWARD! To the Moon!*
02:45	The Moon: our closest neighbor in space, and the perfect training ground for more distant travel to Mars and beyond.
02:54	The Moon is also an interesting destination on its own, with ancient geology giving clues to our own planet's history.
03:03	NASA has sent astronauts here before, but this time, it's different: an international effort supported by multiple partnerships with governments and private enterprise, all with a shared vision of our future in space.
03:25	The NASA program that landed humans on the moon last century was named after the Greek sun god, Apollo.
03:32	NASA's 21st century program to take humans forward to the Moon is called Artemis, the Greek moon goddess, the twin of Apollo.
03:44	NASA's Artemis spacecraft is called Orion.
03:49	As with all twins, there's some similarities.
03:53	The Orion Crew Module, which carries the astronauts, looks at first glance very similar to Apollo's Command Module.
04:02	Both spacecraft have the same conical shape.
04:05	But there are many more differences here than similarities.
04:09	The Apollo Command Module was manually controlled by analogue knobs and switches, with less computing power than a smartwatch.

04:18	Orion has been developed using cutting-edge materials and technologies, certified for long-term missions.
04:25	In partnership with private companies, NASA is using the Artemis program to drive innovation across the space sector.
04:34	Like Apollo, Orion is attached to a Service Module, which carries supplies and provides extra thrust.
04:42	This module is provided through a partnership between NASA and the European Space Agency.
04:49	Power for longer missions is provided using super light efficient solar panels, rather than fuel cells.
04:56	So, why does such an innovative craft as Orion have the same shape as Apollo?
05:02	It turns out there's one very good reason these spacecraft look similar: the astronauts have to come back.
05:10	And if you travel to deep space, you come back fast.
05:16	Plunging into Earth's atmosphere at 11 kilometers per second, or 25,000 miles per hour, this shape gives the best chance of survival: self-orienting, with heat shield down.
05:31	Digital technologies have come a long way over the past fifty years, but physics hasn't changed, and the math works out the same.
05:41	So, Orion can bring astronauts safely down to Earth, but to get up into space in the first place?
05:49	For that, Orion will need a little help.
06:01	Launch is the most dangerous time for any astronaut.

06:05	A Launch Abort System is attached to the Orion crew module, ready to power them away to safety should anything go wrong.
06:13	Its rockets are so powerful that the acceleration alone could knock the passengers unconscious, but this will help ensure the safety and security of our beloved astronauts aboard the largest rocket ever built.
06:31	As tall as the Statue of Liberty, SLS involves a core stage with two vast fuel tanks, one for liquid hydrogen and one for liquid oxygen.
06:44	These tanks feed four, car-size rocket engines with an explosive mix.
06:52	To lift Artemis into Earth's orbit, these engines, along with two solid rocket boosters, will accelerate SLS to 34,000 kilometers per hour, or 21,000 miles per hour.
07:13	The SLS Upper Stage will give Orion its final push forward to the Moon.
07:27	To select the best possible crew, NASA has considered the individual skills and experience of hundreds of trained astronauts, to select the eighteen members of the Artemis Team.
07:40	I think I've always looked up at the Moon and thought about what it would be like to be there.
07:45	We're going to the Moon to explore, and we're going to the Moon for scientific discovery.
07:49	I don't look at this as my own accomplishment, or something just for me.
07:53	This is our mission, this is everybody's mission, our entire planet's really.
08:01	I was sitting at my desk in the Russell Senate Office Building, and I got a phone call from a Houston phone number, and by the time I answered, I missed it.

08:07	And so I called back, and after a lot of waiting and being transferred, I was transferred to Janet Kavandi, who was the chair of our board, and she asked me if I wanted to come to Houston, and commit to training.
08:17	And I actually pinched myself several times walking back to my office.
08:20	There is no way that this is a real thing.
08:22	I'm gonna wake up and be so disappointed.
08:23	When I woke up the next day, I actually had an email from Janet saying, "It was not a dream."
08:28	It was actually unreal.
08:32	When I realized that being an astronaut is really the opportunity to expand our understanding of the cosmos, make our world a better place, all while inspiring the next generation.
08:46	NASA said that it's accepting applications for new astronauts.
08:49	Of the roughly 3,500 applicants NASA is expecting, only about 15 will be selected for training.
08:57	And I thought to myself, "Well that's crazy. There's no way that I would ever be accepted to become an astronaut."
09:04	And I went home and I spoke with my husband about it, and he looked at me like I was crazy.
09:08	And he said, "Why would you ever pass up such an incredible opportunity. If you never apply, you're never gonna know if you could make it or if you could've made it."
09:16	That really changed my perspective on life.
09:20	Going to space is awesome.

09:23	In your mind, you're thinking, "I can't believe this is actually happening."
09:26	It's the coolest experience ever.
09:30	One of the best decisions of my life was taking summers away from grad school to work search & rescue in Yosemite.
09:35	One of my favorite parts of the job was getting thrown into situations where I wasn't quite sure what to do.
09:41	The confidence I gained from that was that I can deal with the unexpected and adapt and overcome.
09:50	Watching rockets launch, right?
09:52	I mean watching shuttle launches as a kid was an enabler for me, it was like "How do I become a part of that? How do I join that team to go do that?"
09:59	My previous job was to keep the world from going backwards.
10:03	This job is about getting the world to go forwards.
10:13	Whoever flies Orion to the Moon will have a formidable journey ahead.
10:19	The Moon is 384,000 kilometers or 240,000 miles from Earth.
10:27	It will take the Artemis astronauts about five days to reach it, every moment trusting their lives to the hundreds of engineers who designed and built Orion's protective systems.
10:42	Beyond Earth's magnetic field, the spacecraft will be exposed to the dangers of deep space.
10:49	Intense radiation and high-speed particles from the Sun can damage both electronics and human bodies.

10:57	Artemis has been designed with these challenges in mind, to bring our astronauts safely back to Earth.
11:06	Artemis is not an end in itself, but just the first step towards a sustainable future in space.
11:14	For this reason, NASA is leading development of an orbiting spaceport called the Lunar Gateway.
11:24	The Gateway provides a rendezvous point for landers, cargo and supplies needed to support landed operations on the lunar surface, and extra living space for visiting astronauts.
11:37	Constructed by robotic missions in years leading up to the astronauts' arrival, it will be used by both crewed and robotic spacecraft.
11:48	The Gateway has an unusual orbit.
11:50	Every seven days it dives within 3,000 kilometers of the Moon's surface before looping back out to 70,000 kilometers.
12:00	This orbit keeps it in radio contact with the Earth, while also allowing contact with the far side of the Moon.
12:06	It takes less fuel for departing spacecraft to escape the Moon's gravity.
12:11	It's also easier for arriving spacecraft to meet up with the Gateway.
12:17	Close to the Moon, the Gateway will help with logistics of shuttling astronauts, robots and materials up and down from the surface.
12:27	Fitted with its own thrusters, the Gateway is really a spaceship, and can adapt its orbit as required for different missions.
12:37	At the same time as the Gateway is being prepared, private companies will be landing a series of NASA science instruments and technologies on the Moon through the CLPS initiative.

12:48	The “Commercial Lunar Payload Services” program will help perform science experiments, test technologies and demonstrate capabilities to help NASA explore the Moon, and prepare for human exploration.
13:05	CLPS missions include tests of a lidar precision navigation system, technology that could help future craft land safely at a Moon Base.
13:16	Testing of advanced solar cells will help with the design of future long-term surface missions.
13:22	The LuSEE instrument, on one of the CLPS’ landers, will carry out initial tests using a small radio telescope.
13:32	This will measure the low-frequency radio environment on the lunar surface, and make the first cosmological measurements from the Moon.
13:52	With everything in place, it’ll be time to start a new chapter in our history, for the Artemis-3 mission to take humans to the Moon’s surface.
14:03	…five, four three, two, one.
15:08	We are down.
15:26	After those first astronauts have proven this new route to the Moon, what will we make of this opportunity?
15:34	How might a Moon Basecamp look years after we return to the lunar surface?
15:40	There may be large structures for mining facilities, geological research, and transportation networks for materials and inhabitants.
15:50	The materials and resources found on the Moon will also be important for sustained exploration of the lunar surface.
15:57	Astronauts will periodically venture out on the surface in space suits, their own personal spacecraft.

16:05	On the Moon, there are many dangers.
16:08	The vacuum of space, drastic temperature changes, abrasive Moon dust, and space radiation are just some of the challenges.
16:17	So, for much of their stay, astronauts will be protected inside habitats underneath the lunar regolith.
16:26	It's safer below the surface of the moon.
16:29	From here, they will use telerobotics to control robots up on the lunar surface.
16:37	It's also safer above, orbiting high overhead.
16:42	From the Gateway, astronauts will be able to remotely operate robots at multiple sites across the Moon.
16:50	In contrast to controlling them from Earth, there is almost no time delay, making delicate and responsive movements possible, with the ability to react to rapidly changing situations.
17:05	Early Artemis missions will land in the Southern Polar Region.
17:10	This largely unexplored area offers exciting opportunities.
17:16	Found within the South Pole-Aitken Basin, the 21-kilometer wide and 4-kilometer deep Shackleton Crater is a possible landing site for the Artemis program.
17:28	This region on the lunar far side holds important clues for understanding the geology and history of the Moon.
17:36	Also, in the southern polar region, the Sun's light reaches the surface nearly parallel to the ground, casting long shadows.
17:45	With no atmosphere to scatter it, this sunlight can never reach within several of the region's deeper craters.

17:53	At the crater rim, it is always day, but the depths lie in eternal darkness.
18:00	With temperatures down to -248°C, or -414°F, these craters may well conceal water ice.
18:13	Water is necessary for astronauts to drink, but it can also be split to provide Hydrogen and Oxygen.
18:21	Oxygen to breathe, and oxygen and hydrogen are fuel for rockets.
18:31	The VIPER Mission stands for the Volatiles Investigating Polar Exploration Rover, is a mission that's following on the heels of a number of previous lunar missions all about the hunt for water-ice on the Moon.
18:46	And so if you can actually get it right there on the Moon instead of bringing it from Earth, it could be a game changer for saving on the cost to do it, and just the convenience of having it right there where you are working on the Moon.
19:00	VIPER is a four-wheeled rover.
19:02	Each of its four wheels can independently drive, steer and have the height adjusted.
19:09	If the entire rover is embedded in soft soil, the combination could combine into a walking, crawling or swimming type behavior, enabling it to slowly extricate itself from this stuck condition.
19:24	Robotic technologies are crucial for realizing the vision of lunar exploration and off-world economy.
19:31	Future robots will be more independent, using artificial intelligence to make decisions about how best to complete their assigned tasks.
19:40	Dozens of innovative robots are under development for a wide range of roles.

19:45	Armstrong is our lab robot that we've developed to test various facets of telerobotic operation.
19:51	Our most innovative technology on the Armstrong robot is the stereo camera that we use to stream a video feed into a virtual reality headset, for the human operator to be able to see directly through the eyes of the robot.
20:05	DuAxle is essentially two axle rovers joined together to drive as one, and the benefit there is that you can go and explore much more terrain, versus being tied to a lander.
20:16	When you hit the surface, you can actually drive around a crater, you can go many many kilometers, to visit some new site.
20:23	Most recently, a mission called Moon Diver.
20:26	So Moon Diver is an interesting mission to go explore a lunar pit, but the idea is to send a tethered rover into that pit and explore the sides.
20:34	And the sides are more akin to unlocking history, almost like you're reading a textbook.
20:40	And so answering those questions of "How did we get here?", "Where are we going?" and "Did life ever get started in our solar system?" are paramount goals for NASA.
20:52	Robots will be central to one of the most exciting opportunities the Moon offers: deploying a radio telescope able to look back to the very beginnings of our Universe.
21:06	Out there, we know, are faint radio signals sent from the far edge of our universe, called the Cosmic Microwave Background.
21:18	In addition, hydrogen signals emitted from the Dark Ages of the Universe, before the first stars formed, are received at low radio frequencies.

21:30	Sadly, these Dark Age radio signals are swamped by the constant radio chatter coming from our own planet, and the ionosphere above the Earth's surface.
21:42	Earth's radio signals spread out through space, but they are blocked by the Moon's rocky body, creating a radio shadow in our own backyard.
21:54	The Moon always keeps the same face turned away from Earth.
21:59	This creates the only place in the solar system that is consistently shielded from our planet's radio pollution.
22:08	Here in the silence, what secrets might we hear whispered from the Universe?
22:17	A large, surface telescope called FARSIDE will only be possible when the Gateway enables direct human contact with the far side of the Moon.
22:27	Only then can astronauts telerobotically deploy and maintain such a facility.
22:41	It's such an exciting time, because with the Artemis program, we'll be sending humans back to the Moon.
22:47	We'll be establishing a sustainable presence on the Moon, and you can be a part of that effort.
22:53	And maybe that's as an astronaut, or maybe that's as an engineer, or maybe that's doing some incredible research on the surface of the Moon.
22:59	One of my ultimate goals is to be able to work in NASA's STEM Engagement program.
23:05	I want my future students to be inspired to study space the same way I was when I was in grade school.
23:10	I wanna be an astronaut, and I'm excited about space exploration because we'll discover more about the universe.

23:18	I'm interested in space exploration because it holds the key of how the universe was created.
23:24	And I think that one day, we're gonna be able to answer all our questions that we weren't able to answer now.
23:31	That just really excites me about space exploration.
23:33	The more we understand what's out there, the better we'll understand what it is to truly be human.
23:39	Astronomy is something that has always inspired me, no matter what I have done.
23:43	I make it in on my art, I always talk about astronomy.
23:47	I love astronomy.
23:49	And when I'm older, I hope to be able to design and put together the artificial intelligence softwares that will navigate rovers on Mars and the Moon, so that they can pave the way to some day help us stand there ourselves.
24:06	The Moon is only the beginning of our exploration.
24:10	Missions to the Gateway and the Moon's surface will provide a testbed for developing new and better systems for living and working in deep space.
24:21	Leaving the Lunar Gateway at its farthest point from the Moon requires a lot less fuel than launching from the surface of Earth.
24:29	This makes it easier to return home, or to set off toward other worlds.
24:37	No human has ever visited another planet, and for very good reasons.
24:44	Firstly, the distances are huge.

24:47	Each round trip to Mars will take over two years, longer than any previous crewed mission.
24:56	SLS will help deliver supplies and equipment into Martian orbit and its surface in preparation for a Martian landing.
25:06	It’s a challenge worth pursuing, not just for human achievement, but also for scientific discovery.
25:16	The first humans NASA sends to Mars will use spacecraft and technologies developed directly from the Artemis missions.
25:26	With Artemis, we are advancing technology.
25:31	We are expanding our scientific knowledge.
25:35	We are launching the next era of space exploration.
25:41	We are taking the next steps into the future.
25:45	We are the Artemis generation!
25:49	Forward! To the Moon!