AIAA

AEROSPACE MICRO-LESSON

Easily digestible Aerospace Principles revealed for K-12 Students and Educators. These lessons will be sent on a bi-weekly basis and allow grade-level focused learning. - AIAA STEM K-12 Committee.

THE RACE TO THE MOON

In the 1950s and 1960s, the United States and the Union of Soviet Socialist Republics (USSR, also called the "Soviet Union") were locked in a competition called the Cold War. Each country was trying to demonstrate to the rest of the world that its social systems, political and economic, were better than the other country's systems. One way that this played out was in space, with each country trying to outdo the other in accomplishing great things and making great advances in its space program. In a speech on May 25, 1961, President John Kennedy of the United States laid out a specific goal for the Space Race: "before this decade is out, of landing a man on the Moon and returning him safely to Earth."

Next Generation Science Standards (NGSS):

- Discipline: Motion and Stability: Optimizing the Design Solution
- Crosscutting Concept: Influence of Science, Engineering, and Technology on Society and the Natural World
- Science & Engineering Practice: Constructing Explanations and Designing Solutions

GRADES K-2

K-2-ETS1-1. Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.

Have you ever tried to learn something new, something you have never done before? Think back to when you first learned to ride a bicycle; you probably started on a tricycle when you were small, then a bike with training wheels, and then a 2-wheeler. When learning to play ball many kids play t-ball, or "coach-pitch," and eventually work their way into facing the pitcher from another team. There is always a progression to mastering a new skill.

The same thing is true of the space program. When the United States first began the journey to space, it had never been done before. Rocketry research had been directed toward war efforts during World War II, but then other applications were revisited after the war. Powerful V-2 rockets that had been used to launch weapons had to be converted so that they could safely carry equipment into space and back. Larger and more powerful

GRADES K-2 (CONTINUED)

rockets had to be developed, designed, and built to carry men into space and to bring them back. Many tests were done and improvements made before it was decided that humans could begin trying out this new type of vehicle.

Each stage of the process built on the success (or the lessons learned), from the stage before. From launching satellites, to orbiting the planet, to linking two spacecraft, the equipment and the missions became more and more complex. It was all those steps serving as practice runs for the moon landing that made a successful mission possible.

You may wish to look at the timeline provided on Wikipedia to see all the incremental steps that led to Apollo 11's historic landing and choose a few to investigate in more depth.

GRADES 3-5

3-5-ETS1-3. Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved

Imagine that you were going to a place that you've never been before. How would you prepare for such a trip? You'd figure out how to get there, whether to take a bicycle or a car or an airplane or something else, what direction to go and where to turn. You'd think about how long it would take you to get there, how much food you'd have to pack. You'd find out as much about the place as you could, so that you would be ready for what you would find there. And you'd think about how to get back home again, too.

How would you do all these things? In large part, you would ask other people who had already been there. You would ask them how they got there, what they found, what there was to see and to do, what they ate and drank while they were there.

Now imagine that you were going to a place that nobody had ever been before. You can't ask anybody what the place is like, because nobody knows. Perhaps you can figure a few basic things out, like whether it will get very hot in the summer or very cold in the winter, but that is all. What do you do?

This is the problem that the United States and the Soviet Union faced in the 1960s. The American president, John F. Kennedy, laid down a challenge in 1961 that the United States would "commit itself to achieving the goal, before this decade is out, of landing a man on

GRADES 3-5 (CONTINUED)

the moon and returning him safely to the Earth." Because the government of the Soviet Union wanted to show the world that it was better than the United States, they set the same goal for their space program.

How do you prepare for a trip that nobody has ever taken before? Going to the Moon involved flying in space, and NASA was still learning the basics on how to fly in space. (Something as elementary as trying to turn a valve on or off was still five years in the future—and the first attempt at doing that failed so badly there was some question as to whether the astronaut trying to turn the valve would survive.) To get to the Moon, NASA would need more practice in launching spacecraft from Earth, having them operate in space, and return to the Earth. They got this practice with the Gemini space program.

NASA also sent some robot missions to the Moon to see what they would find there. The early Pioneer missions were set to fly past the Moon and take pictures, although none of them succeeded. Following Pioneer, the Ranger missions were designed to crash-land on the Moon, sending back pictures until they crashed. NASA's next unmanned lunar exploration program was called Surveyor; the Surveyor spacecraft landed softly on the Moon and sent back pictures and other information of what they found there. In the meantime, the Lunar Orbiter program sent spacecraft into orbit around the Moon to take pictures of the surface and look for suitable landing spots for the astronauts.

All of these missions—Gemini, Ranger, Surveyor, and Lunar Orbiter—prepared the way for NASA to send astronauts to the Moon and to bring them home.

GRADES 6-8

MS-ETS1-4. Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

After the Second World War ended, a competition arose between the United States on the one hand and the Union of Soviet Socialist Republics on the other hand. Each country wanted to show the rest of the world that it would be a more powerful and more capable ally to other countries. One place in which this competition played out was in space, which people were just beginning to be able to reach with newly-designed rockets. One way of summarizing this race into space is by building a timeline of accomplishments—of "firsts"—in space. Here is a selection of them.

GRADES 6-8 (CONTINUED)

Accomplishment		
Absolutely first flight into space	**German V-2 launch, 10/3/42**	
	United States	**Soviet Union**
First flight into space	Project Hermes, 5/10/46	
First spacecraft to orbit the Earth	Explorer 1, 1/31/58	**Sputnik 1, 10/4/57**
First spacecraft to go into space beyond the Earth's gravity	Pioneer 4, 3/3/59	**Luna 1, 1/2/59**
First spacecraft to hit the Moon	Ranger 4, 4/23/62	**Luna 2, 9/12/59**
First spacecraft to photograph the back side of the Moon	Lunar Orbiter 1, 8/10/66	**Luna 3, 10/4/59**
First person into space	Alan Shepard, 5/5/61	**Yuri Gagarin, 4/12/61**
First person to orbit the Earth	John Glenn, 2/20/62	**Yuri Gagarin, 4/12/61**
First spacecraft to fly past another planet	**Mariner 2, 12/14/62**	Mars 6, 3/12/74
First multi-person crew in a spacecraft	Gemini 3, 3/23/65	**Voskhod 1, 10/12/64**
First person to "walk" in space outside a spaceship	Edward White, 6/3/65	**Alexei Leonov, 3/18/65**
First rendezvous of two spacecraft in orbit	**Gemini 6 and 7, 12/15/65**	Cosmos 186 and 188, 10/30/67
First docking of two spacecraft in orbit	**Gemini 8, 3/16/66**	Cosmos 186 and 188, 10/30/67
First spacecraft to land softly on the Moon	Surveyor 1, 5/30/66	**Luna 9, 1/31/66**
First spacecraft to orbit the Moon	Lunar Orbiter 1, 8/10/66	**Luna 10, 3/31/66**
First spacecraft to return from the Moon	Apollo 8, 12/21/68	**Zond 5, 9/14/68**
First crewed mission to orbit the Moon	**Apollo 8, 12/21/68**	
First crewed landing on the Moon	**Apollo 11, 7/16/69**	
First spacecraft to land on the Moon and return	**Apollo 11, 7/16/69**	Luna 16, 9/12/70
First spacecraft to orbit another planet	**Mariner 9, 11/14/71**	Venera 9, 10/22/75
First space station put into orbit	Skylab, 4/14/73	**Salyut, 4/19/71**

GRADES 6-8 (CONTINUED)

It was very difficult at the time to tell how the two countries were doing in the Space Race. While the United States publicized everything it was doing—including its spectacular failures—the Soviet Union kept its activities a secret until it had accomplished something.

Another "first" which may also be noted is the first person to die during a space mission. This was Vladimir Komarov, a Soviet cosmonaut who was killed on April 24, 1967 while landing when the parachute that was to slow his spacecraft down failed to open.

Note that all of the items on this list except the very first were done by either the Soviet or the American space programs. The United Kingdom, Canada, and Italy developed satellites in the 1960s that launched on American rockets and the French launched a satellite on a rocket of their own in 1965, but they lagged behind the Soviets and the Americans. More recently, many other nations have started space programs of their own, including China and India. What will the next "First" be, when will it take place, and who will do it?

GRADES 9-12

HS-ETS1-3. Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.

The Apollo space program is best understood in the context of the Cold War in the 1960s. After the Second World War, the Soviet Union had taken over the eastern half of Europe and imposed its communist economic and political systems on them. The United States, wanting to defend itself and its allies against the advance of communism, created the North Atlantic Treaty Organization (NATO) and armed itself with nuclear weapons. The Soviet Union also developed nuclear weapons—helped in large part with technology stolen from the United States. The rocket technology that was being developed in the 1950s provided an excellent way to deliver nuclear weapons: it was fast, taking less than an hour to deliver a warhead anywhere on the Earth; it was accurate enough to deliver the warhead to within its lethal distance; and there was no defense against it. This was the Cold War, a competition between great powers that lacked only shooting to make it a hot war. The acronym for the strategy called "Mutually Assured Destruction"—MAD—also seemed like its best description.

GRADES 9-12 (CONTINUED)

At the same time, peoples of Africa, Asia, and the Pacific were establishing their independence from the European colonial powers. These new nations could ally themselves with the United States and Western Europe, with their capitalist economies and democratic political systems, or they could ally themselves with the Soviet Union and the Communist Bloc with its economy and political system. The group of countries that these new nations allied with would benefit from the trade, military cooperation, and other interactions that they would bring.

The United States and the Soviet Union therefore competed with each other in many ways all over the world, trying to attract the allegiance of the newly-independent nations. Anything that one country could do, the other country would try to do better. A high-profile part of this competition was the "Space Race." The thinking was that the country that was more advanced in its space program would be more advanced in other ways and would thus be a more beneficial ally.

With this background, it becomes easier to understand first the United States' drive to land a man on the Moon and then the abandonment of the Moon so thoroughly only three years later. Once the goal had been accomplished, once President Kennedy's challenge had been met, there simply wasn't a compelling reason to continue the Moon program. NASA—and the rest of the United States—had other priorities.

It has come out recently that the Soviet Union was nowhere near as powerful in the 1960s as had been thought. It is important to note that at the time, this was not known. The Soviets put on a brave front, convincing everybody of their power—and of their willingness to use it. The launch of the Soviet Sputnik 1 before the United States' first launch of a satellite shocked the world and boosted Soviet prestige enormously. After Sputnik 1's launch, Soviet Premier Nikita Khrushchev boasted that "we have the ability to send a nuclear warhead to any place on the planet." People believed him. And in 1961, with the Soviet crushing of a rebellion in Hungary only five years earlier a recent memory, people also believed that they would not hesitate to do so if they thought it necessary.

Sixty Years Ago in the Space Race:

May 28, 1959: The United States launched a rhesus monkey named Able and a squirrel monkey named Baker into space on board a Jupiter ballistic missile.