

# 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 GRAF ZEPPELIN'S POLAR EXPEDITION

The advent of flight made exploration of the Earth's remote areas much easier by removing a serious problem. Instead of having to slog their way through difficult terrain, explorers could simply fly over it. This was exemplified by the Graf Zeppelin's expedition to the northern parts of Eurasia in late July 1931. In 136 flight hours, from July 24 through July 31, the airship explored Franz Josef Land, the Siberian coast of the Taimyr Peninsula, and Novaya Zemlya, covering 6,600 miles in all. This lesson describes its travels.

Next Generation Science Standards (NGSS):

- \* Discipline: Physical Science.
- \* Crosscutting Concept: Scale, proportion, and quantity.
- \* Science & Engineering Practice: Constructing explanations and designing solutions.

### GRADES K-2

NGSS: Forces and Interactions: [Analyze data to determine if a design solution works as intended to change the speed or direction of an object with a push or a pull.](#)

The LZ Graf Zeppelin was an airship that used a special kind of gas, called "hydrogen," to allow it to float in the air the way a piece of wood floats in water. The gas is not a lot lighter than air, so it takes a lot of it to lift a small bit of



cargo. Because of this, most of the Graf Zeppelin was made up a large bag of this gas—776 feet long and 80 feet in diameter—and only a little bit at the bottom, called the "gondola," was the Graf Zeppelin's cargo. Engines onboard the Graf Zeppelin powered propellers allowing it to move around where its crew wanted it to go. The propellers were mounted in the back of the airship pushing it forward; movable fins in the back allowed it to be steered in whatever direction the pilot directed it.

In July 1937, some scientists rented the Graf Zeppelin to go and explore the Earth's north polar regions. The expedition took eight days to carry out. Flying high above the surface of the Earth, the explorers were able to go over land and sea, over hill and valley, taking pictures and other data as they went. They were able to explore in a week what would have taken somebody on the ground (and the water) several years.

## **GRADES K-2 (CONTINUED)**

The advantage of speed in exploring by air led to several other advantages. When one is preparing an expedition out into the unknown, one needs to take along everything that one will need for the expedition. All the food that everybody on the expedition will eat, all the clothing that they will need to wear, dishes, cooking utensils, soap, and much, much more needs to be planned for and brought along. One needs also to be prepared for anything that one might encounter on the expedition: hot and cold weather, wind and rain, and large and ferocious animals for starters. Since the Graf Zeppelin would only be out for a week and a day, the expedition did not need to pack nearly as many supplies as a land-based expedition would have needed. Less space needed for supplies and support equipment leaves more space for scientific equipment.

Another advantage of using the Graf Zeppelin for the polar expedition was comfort. Being a passenger liner in its common use, the Graf Zeppelin was equipped with heated quarters and a galley (kitchen) which usually prepared luxury food. The explorers on the polar expedition enjoyed accommodations that were far, far better than most explorers before (or since) them had lived in. [An article about the expedition mentions the electrically-heated cabins and their picture windows.](#) This is a great contrast to land-based expeditions in which the explorers had to walk over the rough terrain, pulling sleds filled with supplies (either themselves or with teams of sled dogs), and pitching camp every night.

## **GRADES 3-5**

NGSS: Engineering Design: [Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.](#)

The K-2 lesson describes the advantages that an expedition by air has over a land-based expedition. These are, in short, the ability to move quickly above both the land and the sea, the resulting shortened time that an expedition requires, and from that the lightened load of food and other supplies needed to support the expedition. Another advantage is the comfort and safety of the airship in contrast with the hard travel over mountain and valley and through jungle, tundra, and swamp.

Exploring an area from the air has its disadvantages, though. The same distance that allows the explorer to fly over the land (or sea) prevents him from studying it closely. The Graf Zeppelin flew at a height of 500-1,500 feet above the ground level. This was close enough

### **GRADES 3-5 (CONTINUED)**

for the people on board to take detailed photographs of the land forms and to see trees and large animals, but there was much more that they could not see or do. They could not take rock samples or any plant specimens without landing, for example. They could not see any smaller animals such as insects.

Another disadvantage of the Graf Zeppelin's style of exploration is its brevity. The same high-speed nature of the expedition that allowed planners to pack only for a week instead of several months also prevented the scientists from spending any significant length of time in any one place. They could not see the changes to any one place from season to season; in fact, they could not even see the changes from day to night—or what would pass for night in the land of the midnight sun—or from high to low tide on coastlines. They could take snapshots of the places they visited and that is all. For an initial pass to see what is out there, this is enough, but to learn about any place in detail it is not at all sufficient.

NASA's exploration of the Solar System follows a pattern that we can see in the Graf Zeppelin's polar expedition. In exploring Mars and other planets, NASA first sent spacecraft to fly by their destinations, taking pictures and seeing what was out there. This mirrors the Graf Zeppelin's high-speed fly-by expedition over the northern edge of the Asian continent. After the fly-by spacecraft, NASA sent other spacecraft to orbit the planets, lingering there and examining the planets in detail and over a long period of time. The next step is to send spacecraft to land in different places on the planets or in other places that the orbiters have found nearby. After that, for Mars at least, NASA has sent rovers to move across the planet's surface, exploring in detail.

### **GRADES 6-8**

NGSS: Scale, proportion, and quantity: In considering phenomena, it is critical to recognize what is relevant at different measures of size, time, and energy and to recognize how changes in scale, proportion, or quantity affect a system's structure or performance.

“A map in the hands of a pilot is a testimony of a man's faith in other men; it is a symbol of confidence and trust. It is not like a printed page that bears mere words, ambiguous and artful, and whose most believing reader—even whose author, perhaps—must allow in his mind a recess for doubt. A map says to you, ‘Read me carefully, follow me closely, doubt me not.’ It says, ‘I am the earth in the palm of your hand. Without me, you are alone and lost.’” – Beryl Markham, West With the Night

## GRADES 6-8 (CONTINUED)

With the advent of satellites, we now have photographs of every part of the Earth's surface. In times past, though, this was not the case. There were areas on the surface of the Earth which mapmakers had never visited and for which no maps existed. Three centuries ago, the satirist Jonathan Swift wrote that "Geographers in Afric-Maps / With Savage-Pictures fill their Gaps, / And o'er inhabitable Downs / Place Elephants for want of Towns." By the time of the Graf Zeppelin's polar voyage, though, virtually all of the temperate and tropical parts of the Earth had been explored and mapped in greater or lesser detail. The polar regions, though, were still unexplored. Exploring the region of the Graf Zeppelin's flight (70-80 degrees north latitude and 40-100 degrees east longitude) [a world map from 1920](#) and [a map of the north polar region from the same year](#) is instructive: the shape of Novaya Zemlya (around 75 N, 60 E, called "Nova Zembla" on the maps) differs, Novaya Zemlya has a small island next to it on one map but not the other, the islands north of the Taimir Peninsula (around 100 E longitude) are partially outlined on the world map but are completely missing from the polar map, and more.

A map is a smaller picture of an area of land. To make a map, one must first explore the land that is being mapped. While one is exploring the area, one records landmarks that one finds and where those landmarks are—the distance and direction from each landmark to the next. If one sees something in the distance, one can measure its direction and estimate its distance and put it on the map as well, but this is much less accurate than actually visiting the place and making the measurements directly. As you can imagine, exploring an area of land thoroughly enough to make a good map is a long and arduous process. One reason for this is that one's exploration route follows a line, a one-dimensional object, while the area to be mapped is two-dimensional. The exploration route needs to criss-cross the area to be mapped quite thoroughly in order to cover the area. [The 1920 polar map](#) shows the routes the polar expeditions followed in their explorations.

Contrast this one-dimensional surveying process with the Graf Zeppelin's ability to fly over the land and sea, taking pictures as it went. A photograph is inherently two-dimensional; with a photograph of an area in hand, one can transfer landmarks from it to the map directly. If one has two photographs of the same landmarks taken from two directions, one can use a stereoscopic viewer to see the area in three dimensions. The process is much, much faster than a land-based survey. When the Graf Zeppelin flew over Franz Josef Land, ["\[a\] Russian scientist aboard the Zeppelin estimated that three hours of aerial mapping represented about four summers of survey work by a land-based party."](#)

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## GRADES 9-12

NGSS: Earth and Human Activity: [Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.](#)

The LZ Graf Zeppelin took off from Friedrichshafen, Germany, on July 24, 1931, bound for the north coast of Eurasia. In its eight-day expedition it covered some 6,600 miles, averaging about 55 miles per hour while it was flying. [You can find a map showing its itinerary and a day-by-day log of its path here.](#) The log speaks of it crossing the Arctic Circle on the evening of July 26 and reaching Prince Rudolf Island, the northernmost point of its expedition, near midnight on July 27/28.

Lest we imagine the Zeppelin flying on its way as the day settled into the darkness of night, it is worth remembering where it was and at what time of year. The expedition started on July 24, just over a month after the Summer Solstice (33 days, or 0.09 of the year). Multiplying that decimal by the 360 degrees that the Earth orbits around the Sun in one year and taking the cosine gives the approximate result that the latitude of the Sun north of the Equator on that date was about 0.84 of the latitude of the Tropic of Cancer, or just less than 20 degrees. This means that any latitude north of about 70 degrees north was experiencing the “midnight sun” or 24-hour sunlight. By the end of the expedition eight days later, the Sun had moved another two degrees farther south and so the lowest latitude of “midnight sun” was about 72 degrees. And even after sunset, with the Sun just barely below the horizon the twilight is still fairly bright. [In Berlin at the end of July, the Sun sets around 9:00 PM but evening astronomical twilight does not end until after midnight.](#) (As an aside, the length of day, sunrise and sunset times, and directions of the sun at sunrise and sunset are something of an eye-opener for most Americans. Selecting a place like [Franz Josef Land](#), which is near the northernmost point that the Graf Zeppelin visited on its expedition, shows even more extreme variation.)

Why, do you think, was the expedition scheduled for the time of year that it was? Having long days and short nights was one obvious reason. The weather is another reason: winter is much colder than the summer in that part of the world; in addition, storms are more frequent during the winter there. The organizers of the expedition wanted sunlight and clear weather to allow them to take pictures of the ground beneath them.

## **GRADES 9-12 (CONTINUED)**

Another critical aspect of the mission that is not immediately obvious is the question of paying for it. Exploration is not cheap and the Graf Zeppelin's flight, although much shorter and therefore less expensive than a ground-based mission, was still not free. The organizers hit upon a novel idea to raise money for it: they asked the German and Russian governments to commission special commemorative stamps of the flight which they then put onto postcards. As it left Germany, the Graf Zeppelin carried about 660 pounds of these postcards with the German "Polar Fahrt" stamps on them; off the coast of Franz Josef Land it met a Soviet icebreaker, the Malygin, and delivered its mail. In exchange it received another 260 pounds of postcards with Soviet commemorative stamps on them, which it carried back home to Germany. These postcards were then sold to stamp collectors worldwide, paying for the expedition. [The stamps can still be bought from collectors.](#)

Sixty Years Ago in the Space Race:

July 26, 1958: [The American Explorer 4 was successfully launched into orbit. It re-entered on October 23, 1959.](#)

July 29, 1958: [United States President Eisenhower signed a law creating the National Aeronautics and Space Administration \(NASA\).](#)