WHO WERE THE WRIGHT BROTHERS AND WHERE ARE THEY TODAY?

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Airplanes are special

Few products in the history of the world have been identified so completely with technological progress as has the airplane. That may arise from an innate desire in human beings to fly, perhaps as a demonstration of our ability to conquer all obstacles that nature might impose. Or, it might come from our marvel at the apparent impossibility of a gigantic airplane lifting off the ground so effortlessly and carrying us quickly to a distant destination. We are also amazed by the latest innovation in airplane technology and a desire to understand how it works, at least a little bit. I have found that the students who take my composites class almost universally have a desire to learn about composites because of their love of airplanes and the technology on which they are built. Those of us in the composites field identify with airplanes, even when our work is far away from aerospace.

In many ways, the development of the airplane has led to some of our greatest achievements as humans and also to some moments of great sadness. The airplane has affected wars and peace as, perhaps, no other technology. The development of the airplane and its child, space travel, have been dominant technologies for the entire 20th Century. However, something else is special about airplanes that is not quite so readily apparent, but becomes clear to us as we examine the technologies that have enabled human flight. Let's take a few moments to reflect on what has happened in flight technology over the past three hundred years and especially during those wonderful hundred years since December 17, 1903 when human powered flight and humankind's conquering of the sky became a reality.

Wilbur and Orville

In at least one critical way, the Wright brothers were typical of those who dreamed of flying ever since ancient days. However, those dreams became more a true vision of the future

in Europe and the United States during the late 1700's and early 1800's. Some visionaries, like the Mongolfier brothers, used balloons to achieve their lift into the sky as early as 1783. Although balloon technology was important in helping us understand our world, it has remained mostly an exciting sport, even until today. Balloon technology continued to develop until, in 2002, Steve Fossett went non-stop around the world in a balloon which seemed to be the ultimate quest for balloonists. But, the technology for true conquering of the air seemed to lie beyond balloons. For the Wright brothers, they believed that wings were to be the basis of sustained, powered flight as they envisioned it. They, therefore, looked to the technology being developed for gliders.

Throughout the 1800's, curious and determined experimenters like Sir George Cayley of England, Otto Lilienthal of Germany, and Octave Chanute and Samuel Langley of the United States developed the concepts behind aerodynamics that enabled model gliders to achieve impressive flights of up to 4,200 feet. These glider models allowed the experimenters to discover that the arched shape of a bird's wing was a key to its flight. Thus, various shapes were tried and, eventually, a table of lift values provided by curved wings was developed. These glider flight pioneers also discovered that thrust and lift could be considered separately, thus providing for their individual refinement and allowing the separate development in creative ways that went beyond the technology of birds.

Moving to gliders large enough to carry humans then became the goal and Lilienthal was able to fly many times in his personal gliders. Sadly, he was eventually killed in a glider crash when trying out a variation of his technology. His gliders were like the hang gliders of today– controlled by movements of the pilot's body. Several other glider accidents showed that the secrets of manned flight were not yet revealed. But, something new had been added to the quest for human flight sought by the earliest visionaries. That new contribution made by the glider experimenter was real, systematic science.

The stage was set for the Wrights who were both visionaries and scientists, but added yet another critical element to the development of sustained human flight. That new element was

entrepreneurship. Wilbur told his father, as they began their quest, “I believe that flight is possible, and while I am taking up the investigation for pleasure rather than profit, I think there is a slight possibility of achieving fame and fortune from it.”

The Wrights were visionaries, but they were also highly innovative, self-taught engineers whose experimental skills were honed in their bicycle shop. Hence, they followed in the footsteps of the visionary scientists of the 1800's who developed so much knowledge using gliders. Wilbur wrote the Smithsonian Institution in 1899 (then headed by another pioneer flight scientist, Samuel Langley) asking for a summary of the information that had already been developed. The Wrights made several interesting gliders and kites to test their theories of wing design and control methods. Almost none of these worked well. Then a breakthrough occurred.

They had been traveling regularly from their home in Dayton, Ohio, to Kitty Hawk, North Carolina, because of the strong and quite constant wind along the North Carolina shore. On the way back to Ohio they realized that many more experiments needed to be done but that the prove-out trips to North Carolina to test each new development would be prohibitively expensive. They conceived of a way to test the models in their shop in Ohio. They invented the wind tunnel.

The next breakthrough occurred when they also realized that they should break the problem of flight down into several smaller problems. They worked on control, leaving thrust and lift alone. Then, when they felt that they had a method for control, they would work on one of the other elements of flight. For instance, when investigating lift, they tied off the control mechanism so that they could see the effects of lift more clearly. They finally had the details of glider flight worked out and successfully built and flew (many times) full-size gliders in 1902. They seemed to have worked out many of the lift and control problems.

The thrust component was then tackled. They invented the modern design for propellers using wind tunnel experiments and built them in their bicycle shop. With assistance of their machinist, they designed and built a four-cylinder internal combustion engine which they mounted on their newest version plane. They seemed to have all the pieces separately worked

out, but would they work together? They were confident and somewhat in awe of their good success. Orville wrote, “Isn’t it astonishing that all these secrets have been preserved for so many years just so that we could discover them!!”

They took their new model to Kitty Hawk where they had become minor celebrities to the locals. A few local witnesses gathered on the sand dunes on December 17, 1903 to see whether the Wrights would be successful. That morning Orville climbed onto the lower wing of their bi-wing plane and guided it for 12 seconds over 120 feet along the shore. A local caught the flight in a photograph that seems to suggest a hesitating feeling of success. That same day, more successes came (best: 852 feet for 59 seconds) and with them the confidence of knowing that powered human flight had been achieved. They dubbed the airplane “Flyer I”. Then their entrepreneurial spirit kicked in.

Newspaper reports of their success followed quickly. However, most of these reports were inaccurate and not very responsible. The problem was that the Wrights did not follow up with public flights. They wanted to make sure that the technology and patents were carefully worked out before they gave the world a look. They moved their work closer to their home in Dayton and soon (1904) built the Flyer II which became the first plane to fly in a circle. In 1905 they built the Flyer III which could stay in the air for over half an hour and perform most of the maneuvers that would be required of a reliable and controllable commercial airplane.

Finally, in 1908, the Wrights began a series of public flights to advertise their Model A biplane. They began taking orders and started producing planes at the rate of four planes a month. However, just looking at their planes was enough to give competitors ideas on how to improve them. The Wrights became so involved in the various patent lawsuits that they failed to keep ahead of the technology. Soon, new technologies were developed and being flown by others. The Wrights tried to maintain control over the market, but the advances were happening too fast and were too different from the patented technologies of the Wrights. The death of Wilbur in 1912 from typhoid fever seemed to end the era of the Wrights. Orville continued on, but his enthusiasm had waned.

Military Impetus and Civilian Circus

We all know that airplanes came into warfare during WWI. Their role was first reconnaissance and then active engagement in battles. European airplane manufacturers seemed to have a lead in providing military planes for WWI. The Fokker was the plane of Germany's Red Baron while the Sopwith Camel was the plane favored by the British. By the end of WWI in 1918, airplanes had demonstrated (crudely, to be sure) all of the roles that military airplanes would play in the future except troop transport.

Civilian uses for the airplane, except for flying the mail, seemed to focus around air shows, air races, and contests. Barnstormers would fly around the country entertaining people with acrobatic stunts and rides for those who were brave. This was a golden age for airplanes, in large part because they were so unusual and so fun. Adding to their allure was the accomplishment of Charles Lindbergh in 1927. He flew an American plane from New York to Paris in 33 hours, non-stop and unaccompanied. In the days of dead reckoning navigation, this was truly a major feat. He rightly was given a hero's welcome in both France and the United States.

During these golden years, the visionary engineer-entrepreneurs of the United States were busy building airplanes and learning how to improve the technology. Companies established during these years included: Martin Company, Douglas Company, Lockheed Company, Curtiss Aeroplane and Motor Company, TWA, North American Aviation, Northrop Aircraft and Boeing. Most were started by one or two people using garages and other available space (such as behind a barbershop, a cleaners and dye shop, a small hotel, a church, and an apricot cannery) as their initial manufacturing locations. Each company seemed to be headed by tremendously dedicated individuals who, like the Wrights, had vision, engineering skill, and entrepreneurial instincts. These American companies and similar companies in Europe would prove to be vitally important in the development of the airplane, especially during WWII.

WWII and the Modern Era

While the Germans had clearly understood the importance of air power at the beginning of WWII, the Allies had strangely lagged behind in military aircraft development. Consequently, the German *Luftwaffe* was a powerful force that was largely unchecked during 1939 and early 1940. The biggest problems encountered by the *Luftwaffe* seemed to be the weather and their own mistakes. For instance, during the evacuation from Dunkirk, when both the English and French armies were being hurriedly transported from Europe just ahead of the German advance, the *Luftwaffe* was grounded by the weather, thus allowing for a relatively uneventful evacuation across the English Channel. War experts believe that if the *Luftwaffe* would have attacked the transport ships during those days of evacuation, the British and French armies would have been so decimated that they would not have been able to repel a German invasion of England. But, the weather saved the troops and the golden oratory of Winston Churchill ("... We shall not flag or fail. We shall go on to the end… We shall fight in the seas and oceans… We shall fight on the beaches, we shall fight on the landing-grounds, we shall fight in the fields and in the streets, we shall fight in the hills; we shall never surrender"), dissuaded Hitler from the invasion which might have been successful and would have changed the war.

Not too long after those disastrous days of the early war, the British aviation industry developed the Spitfire–a fighter that wrecked havoc on the German bombers that were trying to win the Battle of Britain without an invasion. Eventually the American aviation industry joined with the British and subjected German industries to day and night bombing. Similarly, air power also proved to be pivotal in the Pacific part of the war, eventually leading to devastating bombing runs on the Japanese mainland which undoubtedly shortened the war.

When WWII was over, many engineer-entrepreneurs within the major airplane manufacturing companies were given permission to explore the possibilities of aircraft for civilian applications. Many of these engineers laid the foundation of the vast and extremely successful modern aviation industry. Others felt restricted by the size of the major airplane companies and they began to explore applications on their own, eventually developing the products and technology that would be the basis of the fiberglass reinforced plastics industry.

Still others recognized the need for new materials and manufacturing techniques, many of which were developed by engineer-entrepreneurs in both big and small companies.

With the growth of the civilian aircraft business and the many people who started to fly as passengers, safety and government regulation became major factors in building airplanes. These restrictive factors were best handled by ever larger and more complex companies building ever larger and more complex planes. These companies began to acquire the small entrepreneurs and then to merge together among themselves. The emergence of space as an important part of the aerospace industry further accelerated this consolidation of aerospace companies.

Today

Aerospace is now dominated by a few very large companies. Innovations are made incrementally and over a very long time. For safety, that is probably good. For dynamic market development and progress, that is probably bad. Entrepreneurs within the large aerospace companies find it hard to get support for something really different and innovative.

Even those aerospace engineer-entrepreneurs outside the large companies who want to develop a new aerospace technology find that major developments require tremendous infusions of capital. There are, of course, small aerospace contracts for these people, but those contracts are highly restricted and usually suppress rather than encourage innovation because of the need to meet rigid specifications. A few true innovators (such as Burt Rutan and Larry Ashton) continue to prod the aerospace industry, but even these visionaries need strong corporate support and still have long incubation times for their innovations to be widely adopted.

The large aerospace firms and similar firms in other industries need to learn a few lessons. First, they must find a way to allow internal innovation by engineer-entrepreneurs. This will probably require that the big companies give profit possibilities and company time to those employees who want to be innovative. Also, the big companies need to be willing to take risks. That means that they must be less focused on their quarterly reports and more on their earnings in ten years. The investors of Wall Street must recognize this vision and be willing to not only allow it to happen but encourage it. When that occurs, the large companies will promote

management that understands how to make the companies grow through innovation. Sadly, that is not the case at present in aerospace and probably not in most of the other major industries in the world.

Therefore, **where then are the visionary engineer-entrepreneurs of today?** I believe that the true visionary engineer-entrepreneurs are in small businesses. There they can experiment and innovate. They can test new markets, fail, and then recover to try again. Like the Wright brothers, these modern engineer-entrepreneurs learn from the past but also recognize that they need to develop new science and technology. They are surprisingly agile in the way they approach products and markets. They are the future of industrial growth. (In fact, over the last ten years, the net production of new jobs in the United States has been exclusively in the small business sector. Big business has produced no new growth even though it represents two-thirds of the gross national product.)

I think that many of these visionary engineer-entrepreneurs are in FRP and Advanced Composites, but probably not in the big companies. They are owners of small shops where products are manufactured for new and exciting markets. They may even be making old products but using new materials to make them better. Why, just the past two weeks I have taken my composites class on field trips where I saw just the kind of visionary engineer-entrepreneurs that I have been describing. Among many other innovating and interesting products, I was surprised to see these engineer-entrepreneurs making a product that seemed to tell the whole story that we have been discussing in this article. In two different plants, they were making bicycles parts.

Reference publications from which much of the data for this article was extracted:

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