A History of Bell Helicopter and its Military Rotorcraft

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Bell Helicopter has always been at the forefront of military rotorcraft technology. Beginning with the Model 30 Ship 1 in the 1940s to today's new technology, the V-280 Valor, Bell has never wavered. A history of Bell Helicopter's military involvement will be discussed through four main helicopter models: Model 30, Model 47, UH-1 Huey, and tiltrotor aircraft.

I. Introduction-Beginnings and Company Formation

Larry Bell, founder of the Bell Aircraft Company, and his brother Grover became interested in aviation at a young age. After graduating from high school, both worked for the Glenn L. Martin Company, which eventually merged with the Marietta Corporation and Lockheed to become Lockheed Martin. Grover worked as a pilot and two years later, in 1912, Larry became his mechanic. Unfortunately, Grover was fatally injured in an aircraft crash. This event nearly drove Larry Bell away from the aviation industry for good, but his interests proved too strong. After Grover's death, Larry worked as a stockroom clerk. When he left the Glenn L. Martin Company in 1925, he had risen to the position of vice president and general manager of the company. He then worked for and partially owned the Consolidated Aircraft Company in Buffalo, New York, but left the company in 1935 when it moved to California. It was then that Larry Bell decided to form his own company.[1]

The Bell Aircraft Company first specialized in the design and production of fighter aircraft including the P-39 Airacobra. In 1938, Bell was asked to tour Nazi Germany to observe the aviation capabilities Hitler possessed. He was most impressed by a twin rotor helicopter. Bell was exposed again to the helicopter in 1941, shortly before the United States entered World War II. A man by the name of Arthur Young had invented one in the United States.

Arthur Young graduated from Princeton University in 1927 with a mathematics degree, but was more interested in philosophy than he was in aviation. He wanted to develop his own philosophic line of thought. In order to do this, he wanted to find a practical problem that he could spend 10 to 15 years exploring so as to get a "better grasp on how things work".[1] He came across a paper describing something called the Flettner concept. It was a method for improving the efficiency of windmills by putting a small propeller at the end of each blade to provide an increase in the windmill's rotation.[1] Young thought this concept could be a means of powering the rotor on a helicopter. He worked on this problem for nine years but could not develop a fully controllable and stable helicopter using the Flettner concept. However, he was able to learn from his failures and essentially laid the groundwork for the development of a successful helicopter. He decided in the 1930s that he would have to consider other concepts for helicopter design and in 1938 attended a conference to learn what others in the field were working on, such as a tail rotor to counter the torque created by the main rotor and the idea of a hinged main rotor. After returning home, Young built a small, remote-controlled helicopter using both of these new concepts. However, the helicopter remained unstable due to the hinged rotor. To alleviate this issue, he designed a stabilizer bar with weighted tips to act as a gyroscope and keep the hinged rotor in the correct plane. The bar was located immediately below and 90 degrees to the main

rotor blades and its center was pivoted to the mast.[2] Butterbaugh, an employee of Bell Helicopter, explains the stabilizer bar in the following manner:

"If the helicopter, while hovering in level attitude is tilted in any direction, the rotating bar, due to its inertia effect, will tend to remain in a horizontal or level attitude. In doing so, it will cause the rotor, by means of a control mixing lever assembly, to feather in such a manner that the consequent tilting motion of the rotor plane is damped sufficiently to provide improved stability and control response characteristics.[2]"

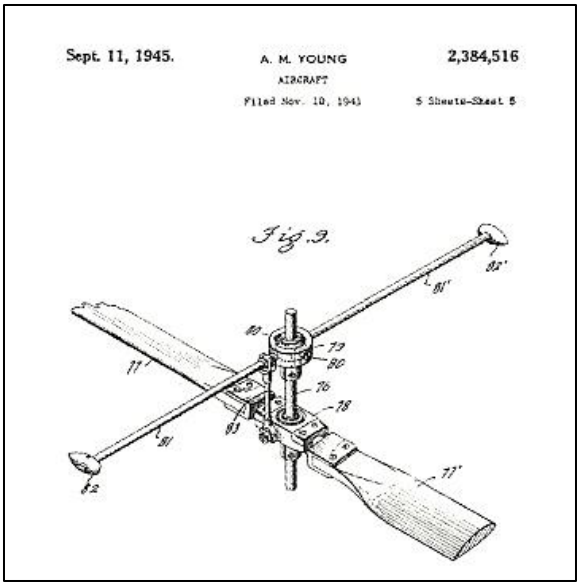

Figure 1. Arthur Young's patent for the rotor and stabilizing bar system

Once the instability problem was solved, it was time to build a full size model. However, Young needed financial backing. After meeting with Larry Bell in 1941 and demonstrating the helicopter's capabilities, the two worked out an agreement: Young would move to Buffalo and be in charge of Bell helicopter development and Bell would provide the financial backing to design, develop, and manufacture two full-size helicopters. Thus began the company that is now Bell Helicopter.

II. The Model 30

Shortly after Young arrived in Buffalo, the helicopter operation was moved to Gardenville, New York, where progress on a full-scale helicopter quickly commenced. In just six months, Young's team was able to design and construct the first Bell helicopter. It was designated the Model 30 and referred to as Ship 1. The fuselage was made of plywood beams, the tail cone of riveted magnesium, the rotor blades of fir and balsa wood with a steel reinforcement bar down the leading edge, and was powered by a 165 horsepower Franklin engine.[1] Its first tethered flight occurred on December 29, 1942. The Gardenville team performed several tethered development flights using Ship 1. This allowed the team to learn how to pilot the helicopter and determine what improvements were needed. Once the pilots were confident in their abilities, they moved on to free flights and continued to improve the helicopter.

Ship 2, the second Model 30 helicopter to be developed by the Gardenville team, featured several changes from Ship 1. The control system in Ship 1 was unlike any that would be installed in today's helicopters. The pilot's right hand operated the cyclic control and throttle while the pilot's left hand operated the collective control and anti-torque control. This was called a pump-handle control system. None of the controls were operated by the pilot's feet. When Ship 2 was designed, foot pedals were installed for anti-torque control. The helicopter project was publicly announced in May 1944, as it was very hard to keep the project a secret with all the public flying of the Model 30 at the Gardenville facility and the local airports. More public demonstrations were performed. Once its hovering capabilities were realized, the helicopter was called on by the public to perform rescue missions.

Figure 2. Model 30 Ship 3 in a demonstration flight. Young appears on the far side.

A third Model 30 was eventually built and was utilized as a testing helicopter to develop techniques for autorotational landings. The Model 30 was never marketed as a product to be sold. Additional improvements were needed before the team was ready to sell their helicopter. This led to the development of the Model 47.

III. The Model 47

In 1945, the Gardenville team moved to the Bell Aircraft location in Niagara, New York, because the larger operation could produce the helicopters more quickly. Once this move was completed, the team was expanded from around 30 to approximately 100 engineers and workers and they soon began developing the Model 47. The Model 30 Ship 3 served as the basis for the Model 47. When riding in the Model 30, some passengers complained that they were uncomfortable sitting out in the open so close to the main rotor. In response, the team developed the idea to enclose the passengers in a bubble canopy. The first Model 47s produced, designated

Model 47A, had the bubble canopy installed. It turns out that the bubble canopy actually improved the performance of the helicopter.[1]

Figure 3. A Model 47D displays the bubble canopy and stabilizer bar.

In 1946, the Army placed an order for twenty eight Model 47As, ten of which were given to the Navy. The Army designated this helicopter the YR-13 while the Navy designated it the HTL-1. The next Model 47 to be procured by the military was the Model 47D and its derivative the Model 47D-1. The Model 47D-1 was developed when the impact of competition began to be felt by the company. In order to compete with Stanley Hiller's Model 360 which could carry 3 people, the Model 47D-1 was developed to seat three people, was 1000 pounds lighter than the 47D, and payload was increased by 35% over the 47D. A Model 47D-1 with an upgraded engine and improved transmission and gearbox was purchased by the Army and designated the H-13E. At first, the Army was unsure what type of missions the helicopters could be useful for. They were first used as a liaison aircraft but eventually someone recommended using the helicopters to lift wounded troops from the frontlines to hospitals. Even though a limited number of helicopters

were assigned to the medevac mission, hundreds of wounded soldiers were successfully saved in the first few months of the operation. Consequently, in view of this extremely useful capability, more than 490 of these were produced for the Army.

The Korean War brought another challenge to the Bell helicopter team: could they develop an armed attack helicopter? Marine Corps officers informed the team that Russian-built tanks were giving them trouble. The best way to combat them was to use Bazookas, a tube held on the soldiers' shoulder that launched a short range rocket with a warhead. In the locations where Russian tanks were encountered, Bazookas were not readily available. A potential solution to this problem was to devise a method for attaching a Bazooka to a helicopter. This would increase the mobility of the Bazooka and make the helicopter into an anti-tank weapon.[1] The team did develop a method for mounting the Bazookas to the helicopters, but the idea was scrapped for fear that arming the helicopters would give the enemy reason to shoot them down. This would endanger the helicopters that were used to transport wounded troops to hospitals. Even though rocket-firing helicopters were delayed until a later war, Bell helicopters had a significant impact on the Korean War and helped to save many lives that would have been lost without the assistance of the helicopter. It is said that 18,000 of the 25,000 wounded rescued by helicopter were carried by Bell Model 47s. Records also show that the wounded were evacuated by helicopter to a hospital in less than 20 minutes after being injured. This was faster than most traffic accident victims in metropolitan cities.[2] Bell helicopter performance in Korea allowed for rotary aircraft to become an integral part of Army, Navy, Air Force, and Marine units.

IV. The UH-1 Huey

During the Korean War, a few problems with the H-13 were discovered: it had a range problem and the fuel tanks were in a poor location, giving the helicopter a center of gravity issue. As a result, once the Korean War ended, the Army developed specifications for the design of a new medevac helicopter. This helicopter was to be powered by a gas turbine engine and called for an 8000 pound gross weight, a mission radius of 100 nautical miles, and a service ceiling of 6000 feet out of ground effect. At the time, these requirements described a helicopter on the cutting edge of technology. In February 1955, the Army chose the design that Bell submitted and this award "made Bell Helicopter".[1] They designated it the XH-40 and it was the first turbine powered aircraft ever ordered by the Army. The new XT53 engine produced 700 horsepower and powered a 44 foot rotor that still used Arthur Young's stabilizer bar to stabilize the helicopter. This new helicopter could carry four patients inside as well as a medical attendant, which was improved capacity over the H-13s. While these helicopters were in the prototyping stage, the Army changed its designation system and the XH-40 became the HU-1, thus gaining its familiar nickname the Huey. It was then re-designated UH-1, but the Huey nickname stuck. In 1961, one of the Model UH-1s became a test craft to see what type of armaments could be installed on a helicopter. Around the same time, the UH-1B was put into production. The difference between the A and B models was an increase in horsepower (960 versus 700) and it could carry five wounded soldiers versus the four that the Model A could carry. Over 1000 UH-1Bs were produced for the Army between 1961 and 1965. The Huey Model A and B arrived in Vietnam in 1962 as medevac support for the South Vietnamese army before the United States officially became involved in the conflict. Later that year, the Hueys entered service in Vietnam, equipped

with rocket launchers and machine guns. By the end of 1964, more than 300 Huey Model As and Bs were in operation in Vietnam.

Figure 4. An armed Huey used in Vietnam equipped with an M-60 machine gun mount and seven-round rocket pods.

While the H-13 was very successful at performing its duties during the Korean War, its engine did not produce enough power for the helicopter to operate at the high altitudes it often needed to fly at. The Huey Model UH-1D was developed to solve this issue and the Huey's inability to operate on very hot days. Unfortunately, this issue was not fully addressed, as the 1100 horsepower engine from the Model UH-1C was retained. The Model UH-1D was, however, able to carry 13 fully equipped troops and was, therefore, able to transport a full rifle squad. Over 2000 UH-1Ds were produced for the Army by the time production was halted in 1967 with over 300 of them in combat in Vietnam. The Huey Model H finally solved the issue of operation at high altitude/temperatures.[1] It utilized a 1400 horsepower engine that provided enough power to operate in these tough conditions. To date, more Model H Hueys have been built than any other

model, with the Army purchasing more than 3500 and 1300 more being exported to other countries. A total of 18 other nations have purchased a version of the Huey for military use.

Other branches of the military were also interested in the Huey. In 1962, the Marines chose the Huey as their next generation assault support helicopter and by 1965, armed UH-1E Marine Hueys were used in combat in Vietnam, transporting troops and flying escort missions. The Air Force also selected the UH-1F as a support helicopter for its ballistic missile launch sites. The Air Force Hueys featured a new, more powerful engine, a new transmission, and a stall-resistant 27 inch rotor chord. This gave the Air Force Huey increased speed and maneuverability. Variations of the Huey are still presently used by the military.

V. Tiltrotor Technology

Tiltrotor technology also had its beginnings at Bell. Long before Bob Lichten was hired by Bell in 1949, he had begun to research and develop a tiltrotor aircraft. In 1951, the Army issued the Convertible Aircraft Program Request for Proposal. In response, Bell submitted Lichten's design, the Model 200 (designated the XV-3 by the Army and Air Force) and was awarded a contract to build 3 full-scale XV-3 tiltrotor aircrafts.[3] Once these aircraft entered into ground and flight tests, dynamic instability problems were discovered. The original three-bladed articulated rotor design was replaced with a semi-rigid two bladed rotor.[4] Wind tunnel tests were performed and more modifications were made to improve the stability. The rotor diameter was reduced from 25 to 23 feet, external struts were added to stiffen the wing, and a significant increase was made in the stiffness of the rotor controls.[3] These modifications allowed the pilot to perform a dynamically stable full conversion of the XV-3 from helicopter to airplane mode in

1958. The XV-3 was then tested by the Air Force in 1959. Despite numerous noted deficiencies in aircraft performance and flying qualities, the Air Force test report concluded that tiltrotor technology was feasible and that it should be given serious consideration.[3]

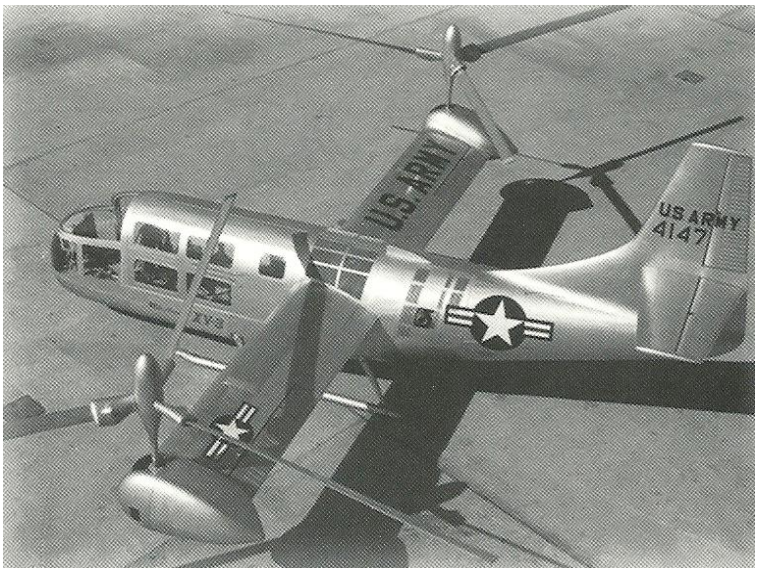

Figure 5. The first tiltrotor aircraft to fly, the XV-3.

In 1971, NASA and the Army announced a competition to build a demonstration aircraft to prove the concept of tiltrotor technology. Bell submitted a new design, designated the XV-15. It was very similar to the XV-3, but had a more streamlined appearance and two swiveling engines connected by cross-shafts in the wings so that the aircraft could fly on one engine.[1] The competition was completed in 1973 and won by Bell. The first full-scale XV-15 was flown in 1977, but NASA was very cautious, so Bell could only fly the aircraft in helicopter mode. Finally, a full free-flight conversion from helicopter to airplane mode was made in 1979. It could fly at speeds of more than 300 miles per hour and was capable of transitioning between modes through a wide range of speeds.[1] The success of the experimental XV-15 aircraft led to expansion of the program.

Under the military Joint Services Advanced Vertical Lift Aircraft Program (JVX), the V-22 Osprey was developed. The Navy, who managed the program, insisted that Bell needed an industrial partner in the development of the V-22 program. Boeing was chosen because they had an ample amount of technology that could be brought to the new program and there would be no competition, as Boeing did not have tiltrotor technology. Full-scale development began in 1985, flight tests began in 1986, and the first actual flight took place in 1989. Despite disagreements between Congress and the Pentagon about whether or not to fund the V-22 program, it was announced in late 1994 that the Department of Defense was committed to full-scale production of the V-22.[1] The Navy and the Marine Corps still use the V-22 today for combat assault and assault support missions. They were used in Afghanistan to support Operation Enduring Freedom.[5]

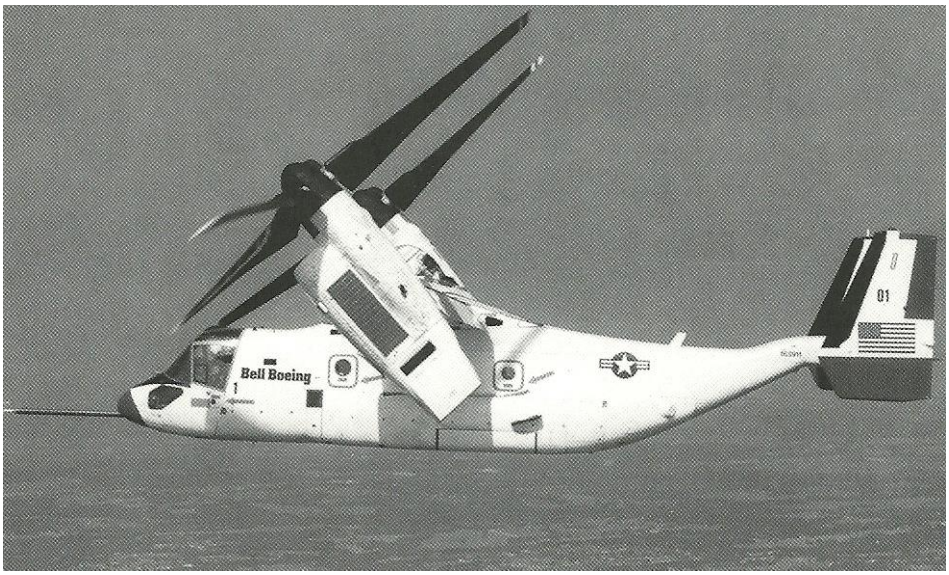

Figure 6. The V-22 Osprey shown during conversion.

VI. Conclusion

From 1950 onward, military orders were what kept Bell Helicopter running.[1] While they have since moved into the commercial/civilian sector as well, Bell Helicopter continues to remain at the forefront of military technology. In October 2014, the Bell V-280 Valor tiltrotor was selected as a finalist by the Army's Future Vertical Lift program to potentially replace the long-serving UH-60 Blackhawk.[6] It is similar to the V-22, but is smaller, faster, and much more maneuverable. Bell's longstanding history of being at the forefront of military technology development will not cease in the foreseeable future.

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