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Amphibious Tiltrotor for Rescue Operations
Subsonic Rotary Wing Project

By

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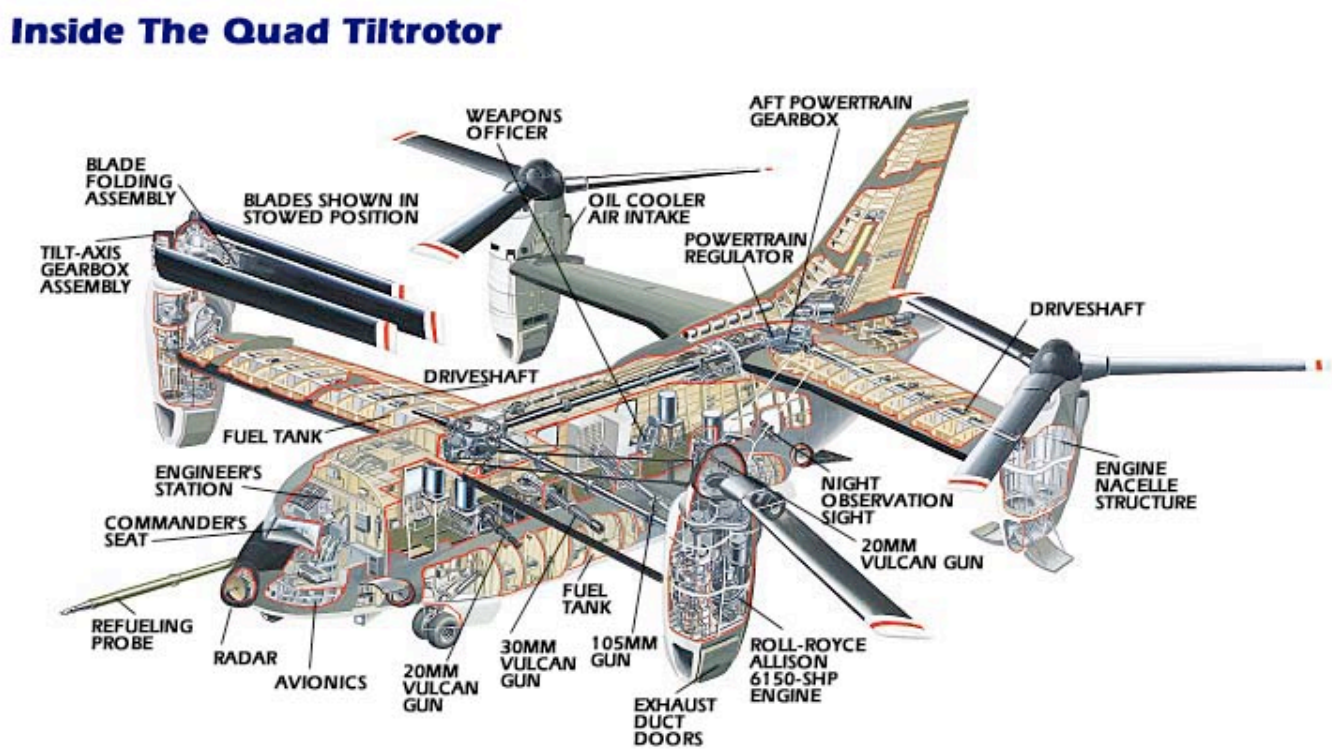
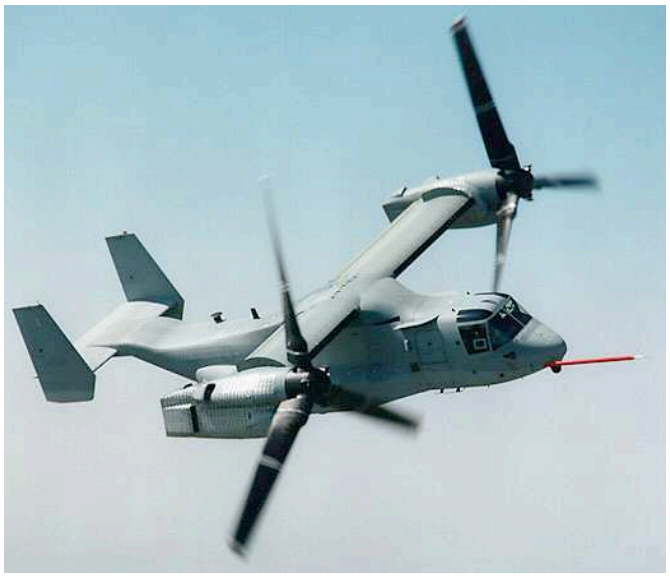
An amphibious tiltrotor could potentially revolutionize modern aviation as well as contributing vastly to the current search and rescue teams of the world. The tiltrotor is capable of a vertical takeoff and exceeds the speeds of standard helicopters whilst having better maneuverability than most small airplanes. Incorporating these already spectacular abilities of the tiltrotor with aquatic capabilities would make a formidable aircraft. This craft would undoubtedly prove indispensable to companies and governments the world over. Though no plans for an amphibious tilt rotor are currently known to the public, companies such as Bell, which is currently developing a Quad Tiltrotor (Bell QTR Quad Tiltrotor, www.aviastar.org),



Artist rendering of Quad Tiltrotor
http://www.hahnsoft.com/images/quad_tiltrotor.jpg

have high demands for their tiltrotors and almost certainly are considering developing a craft designed for aquatic landings, as this capability would prove invaluable to their customers. As helicopters have already proven to be incredibly useful in many civil, commercial, and military aspects, a faster, more versatile craft, such as the tiltrotor would surely prove highly beneficial.

One of the most popular tiltrotors currently available is the Bell/ Agusta BA609 ("Bell/Agusta Aerospace Company"). The capabilities of this craft make it a highly desirable alternative to traditional helicopters as well as small airplanes. The BA609 has a maximum takeoff weight of 7,631 kilograms, a maximum cruising speed of 275 ktas and a maximum range of 700 n. miles. (Bell) These features along with it's capability of a purely vertical takeoff and landing make the craft an impressive and, in many cases, more effective alternative to both small airplanes and traditional helicopters. The BA609 features a length of 13.3 meters and a width of 18.3 meters, similar in length to a small airplane and in width to a large helicopter (Bell). Another, and perhaps the most widely known, tiltrotor is the V-22 Osprey, primarily used as an amphibious assault transport of troops, equipment and supplies from ships and land bases ("Marine Corps"). This craft is substantially larger than the BA609 and is a major feature of the United States Marine Corps. It is designed for expeditionary assault, raid operations, cargo lift and special warfare ("Marine Corps"). It also features in-flight refueling and is designed with composite materials ("Marine Corps"). Though incapable of landing on water, its use as an effective means of transportation from ship to land serves as a prime example of the benefits of an amphibious tiltrotor.



(V-22 Osprey) ("V-22 Osprey")

A tiltrotor that is capable of a true aquatic landing would have a myriad of uses and prove to be a huge benefit to many features of society. Anything from oceanic experimentation to search and rescue missions would be greatly aided by an amphibious tiltrotor. Rescue crews would be able to go further and much faster than they currently can and innumerable lives would be saved by the implementation of a tiltrotor with amphibious abilities.

A helicopter commonly used by the Coast Guard in aquatic search and rescue missions is the HH-60J Jayhawk which is capable of a maximum range of 700 nautical miles at a speed of 140 knots (Pike). Impressive feats have been carried out by the highly trained Coast Guard personnel, such as the daring rescue 200 miles into the Atlantic, off the coast of Virginia, in December of 2000. During which, one Jayhawk rescued 26 members of a sinking ship, and another rescued the remaining eight (Day). As impressive as this seems, it should be noted that the BA609 tiltrotor has a speed of nearly twice that of the Jayhawk and an operational ceiling five times the Jayhawk's, allowing the BA609 to operate above storm clouds and reach targets faster than the traditional helicopter.

With the development and implementation of an amphibious tiltrotor into the Coast Guard's search and rescue teams, more lives could be saved faster. If it was designed with similar engines as the BA609 then twice the speed of the current helicopters could be achieved, and in emergency rescues time is paramount. By cutting the time it takes the rescuers to reach the victims in half, quicker medical attention could be administered. The BA609 is capable of being outfitted with many different interiors, from a standard utility which would seat many different passengers to an air medical interior which would feature multiple intensive care units and resemble the interior of an ambulance. If the amphibious tiltrotor was similarly outfitted it would be capable of rescuing large numbers of victims or in other circumstances, administering immediate medical attention to several more seriously injured victims.

Another important use of an amphibious tiltrotor would be in the transportation of supplies. The United States Marine Corps already utilizes this ability in the V-22 Osprey but a more widespread use of this capability could be made available with the development of an amphibious tiltrotor. If this ability was fully utilized it would help provide relief to those effected by a large scale disaster, be it natural, or manmade. A current example of the usefulness of a tiltrotor in providing relief would be the earthquakes in Haiti. Relief is slow to arrive to the Haitian people but if tiltrotors were used, the time it takes for supplies to reach the people could be cut in half. This is but one of the numerous examples of the usefulness of an amphibious tiltrotor in the transportation of supplies.

Another, highly prevalent, natural disaster that would have greatly benefited from the use of amphibious tiltrotors was the Tsunami occurring in Sri Lanka in 2004. This disaster killed

over 150000 and left over a million others homeless and stranded ("National Geographic News").

Helicopter providing relief to tsunami victims
http://www.theage.com.au/ffximage/2005/01/04/relief4_gallery__550x350.jpg

Though rescue crews worked valiantly, supplies were slow to come and rescue operations were painstakingly slow. Helicopters and other standard aircraft were used to the upmost of their capabilities, however, the helicopters were often not fast enough and the airplanes were incapable of taking off without a runway, most of which were out of commission. With the use of an amphibious tiltrotor traveling at 300 knots, this delay could have been dramatically improved. Supplies could have been delivered and lives saved at perhaps twice the rate of the actual rescue attempts. With a occupancy of 50 passengers and the ability to cruise at a speed of 300 kts, a single amphibious tiltrotor would be able to move upwards of 150 victims to a safe location 50 miles away from the disaster zone. With a fleet of these tiltrotors, innumerable lives could be saved and with the V-22 Osprey's ability to carry a load of 10000 pounds (marines) hundreds of tons of supplies could have been moved at twice the speed of helicopters to those victims in need. Hundreds of victims of the tsunami were swept out to sea with the receding tide, without help nearly all of these people drowned ("National Geographic News). Utilizing the ability to land on water, an amphibious tiltrotor would have been capable of saving these

people. While standard helicopters, too, could have saved many of these lives, they generally lack the speed necessary, whereas the tiltrotor would have more than ample speed to reach these people in time.

Yet another natural disaster who's relief that could have benefited from an amphibious tiltrotor was Hurricane Katrina. This hurricane hit the southern United states with disasterous results. Over 1800 people lost their lives and more than 81 billion dollars in damage occurred ("Hurricane Katrina"). Though an amphibious tiltrotor could not have helped with the huge amount of damage inflicted, lives could most definitely have been saved. Yet again, heroic efforts took place to save the victims of the hurricane, but for many it was too little too late. Helicopters proved highly effective in rescuing people stranded atop buildings and carrying supplies to many in need, however, helicopters lack the speed that a tiltrotor could provide. With the use of an aquatic tiltrotor, that could land directly on the water to rescue lives if need be, the supplies could have been delivered much more quickly and many more lives could have been saved. Up to 50 victims could have been rescued, whisked away to a nearby shelter, and the tiltrotor could take off to rescue more victims all within 20 minutes, cutting the time of the rescue helicopters in half. Though those who were drowned or crushed by the debris of the initial storm were likely doomed even with the use of a tiltrotor, the victims who were stranded for hours or days atop buildings, or on debris could undoubtedly have benefited greatly from the use of a speedy tiltrotor by the rescue efforts.

The control and prevention of forest fires would also be greatly benefited by an amphibious tiltrotor. Annual forest fires are an immense problem throughout America. Over the past six years, an average of 54,796 acres are destroyed annually due to forest fires in the United States. In 2006, alone, over 320,000 acres were destroyed by wild fire ("National Interagency Fire

Center"). The average amount of area destroyed by wild fires is on an upward curve as Science AAAS recognizes in their article "if the average length and intensity of summer drought increases in the Northern Rockies and mountains elsewhere in the western United States, an increased frequency of large wildfires will lead to changes in forest composition…" (Westerling, A.L.). Current fire fighting techniques dictate that the fire be contained and then allowed to burn out. This act of containment is often very difficult to achieve, as is exemplified in the fast-burning fires occurring in California in 2006. Helicopters are a common feature of fighting forest fires, and are very effective. Yet a tiltrotor with speed superior to that of a helicopter would be still more effective. Particularly a tiltrotor with capabilities to land on water and fill a tank, later to empty this tank upon a fire as is needed. If a body of water were present within 20 miles of the wild fire, an amphibious tiltrotor could make extremely fast trips, dumping its water and returning to refill as many times as is necessary to contain the blaze. The greatly increased speed provided by the tiltrotors would make fighting the wild fires much quicker and would help slow the increasing rate of land destruction across America.

A helicopter fighting a forest fire (http://davidwallphoto.com/images/{7FBD2B24-1D6E-46B7-A7E0-29A1B11E5F45}.jpg) though effective, a tiltrotor could carry a much larger supply of fire retardants or water and move faster than this helicopter.

Military use of tiltrotors is already a somewhat commonplace occurrence, yet the implementation of amphibious tiltrotors would greatly benefit the military. The V-22 Osprey

can be outfitted with multiple machine guns and cannonry, making it an effective escort for slower moving craft. These Ospreys are an important part of the American airforce currently in Iraq and Afghanistan. An amphibious tiltrotor could effectively be used as an escort of ships and landing craft, as well as troops making amphibious landings. The Osprey and other tiltrotors are capable of landing and launching from aircraft carriers at sea as well as many other desirable abilities such as air to air refueling. The Osprey is also capable of carrying 24 armed troops, and meets all U.S. Special Operations Command's requirements for a high speed, long range, vertical lift aircraft (V-22 Osprey). Despite all of these abilities, no current tiltrotor is capable of landing on or launching from water. This ability would serve the military well in many ways.

The designs of current tiltrotors are highly complex and adding amphibious qualities to these craft, while maintaining the speed and dexterity which provide tiltrotors with their desirability would be a highly difficult task. Using the BA609, or a similar craft, as a base from which to build an aquatic tiltrotor could present several problems in the way of efficiency. The BA609 has a maximum takeoff weight of 7631 kg but is only truly useful with a weight under 2500 kg (Bell). With the addition of heavy floating utilities, and any additional equipment required to make the tiltrotor capable of landing and launching from water would lead to a seriously reduced weight capacity on the tiltrotor. The aerodynamics of the BA609 would also likely be thrown completely off by the addition of the floating equipment usually used on small aircraft, which means that an entirely new design for this equipment would have to be developed for an aquatic tiltrotor to maintain its aerodynamics and thereby its speed and efficiency. The equipment could not be mounted to the wings of the tiltrotor as these are both foldable and inverted in airplane mode and mounting the equipment to the body would throw off the aerodynamics entirely so the tiltrotor itself would likely need to be completely redesigned. The

reconstruction of the tiltrotor would prove to be a challenge, yet the benefits of this craft would undoubtedly prove to be more than worth the work and effort put into this redevelopment.

Due to these possible weaknesses in power, a four-propeller, or Quad tiltrotor, such as the one being developed by Bell could be the best option for an amphibious tiltrotor. The two extra propellers would provide more than enough power to make up for the weight of the floating equipment and as the design for the Quad tiltrotor is so drastically different than the traditional two-propeller tiltrotor that the addition of equipment to make it capable of landing and taking off from water might not have so extreme an effect upon the aerodynamics of the craft. The Bell QTR four-propeller tiltrotor is still purely in development, however, so no actual data as to its performance has been recorded. This makes it difficult to compare the four-propeller to the two-propeller tiltrotor, but as the ratio of power to weight will increase in the QTR it seems only logical that it will be capable of carrying more weight at greater speeds than its two-propeller counterparts. If this is the case then the amphibious tiltrotors may well be equipped with four propellers as well as the additional floating equipment, meaning that they may be even faster and more powerful than the tiltrotors of today.

Amphibious tiltrotors would prove to be a highly beneficial addition to current aviation. Modern tiltrotors are already an integral part of aviation, combining qualities of both helicopters and airplanes. With the addition of aquatic abilities, tiltrotors may prove to be an indispensable part of many aspects of society, from search and rescue operations, to the military, to fire fighting. This craft could likely surpass the helicopter as the preferred means of rescue at sea if developed. The military too could reap the benefits of a craft capable of reaching the speeds of a plane with the versatility of a helicopter, that is capable of landing on land and sea, and the forests and plains of the world could be better protected by an amphibious tiltrotor, scooping up

and dropping huge loads of water at extreme speeds. These are merely a few examples of the many benefits available with the development and introduction of an aquatic tiltrotor. If an amphibious tiltrotor is developed and widely distributed, people everywhere could feel the benefits of an improved human mastery of the skies and seas.

Works Cited

"A helicopter fighting a forest fire." Web. 4 Jan 2010. <http://davidwallphoto.com/images/{7FBD24-1D6E-46B7-A7E0-29A1B11E5F45}.jpg>.

"The BA609: The Worlds First Civilian Tiltrotor." *Bell/Agusta Aerospace Company*. 2006. Bell/Augusta Aerospace Company, Web. 22 Jan 2010. <http://www.bellagusta.com/air_ba_main.cfm>.

"Bell QTR Quad Tiltrotor project." *Aviastar*. 25-6-2008. Web. 22 Jan 2010. <http://www.aviastar.org/helicopters_eng/bell_qtr.php>.

Day, Dwayne. "Search and Rescue Helicopters." *U.S. Centennial of Flight Commission*. U.S. Centennial of Flight Commission, Web. 19 Feb 2010. <Day, Dwayne. "Search and Rescue Helicopters." U.S. Centennial of Flight Commission. U.S. Centennial of Flight Commission, eb. 15 Jan 2010. . >.

"Helicopter providing relief to tsunami victims." Web. 15 Jan 2010. <http://www.theage.com.au/ffximage/2005/01/04/relief4_galler__550x350.jpg>.

"Hurricane Katrina." *US. Department of Health and Human Services*. US. Department of Health and Human Services, Web. 2 Jan 2010. <http://www.hhs.gov/disasters/emergency/naturaldisasters/hurricanes/katrina/index.html>.

"Inside the Quad Tiltrotor." *Hahnsoft.com*. Web. 19 Jan 2010. <http://www.hahnsoft.com/images/quad_tiltrotor.jpg>.

"MV-22 Osprey Speed Range and Vertical Fligh." *Marine Corps*. 2010. United States Marines, Web. 26 Dec 2009. <http://www.marines.com/main/index/winning_battles/gear/aircraft/mv_22_osprey>.

"National Interagency Fire Center." *Fire Information-National Fire News*. 25 Jan 2010. National Interagency Fire Center, Web. 25 Jan 2010. <http://www.nifc.gov/fire_info/nfn.htm>.

Pike , John. "Quad Tiltrotor QTR." *GlobalSecurity.org*. 22-09-2005. GlobalSecurity.org, Web. 22 Jan 2010. <http://www.globalsecurity.org/military/systems/aircraft/qtr.html

Shipley, Bob. "XV-15 Tiltrotor Research Aircraft." *Simulation Laboratories*. 9-12-2002. Web. 22 Jan 2010. <http://www.simlabs.arc.nasa.gov/library/tiltrotor/ctr20th.html

Streep, Abe. "The Personal Tilt-Rotor." *PopularScience*. 221-10-2008. Popular Science, Web. 5 January 2010. <http://www.popsci.com/military-aviation-amp-space/article/2008-10/personal-tilt-rotor>.

"The Deadliest Tsunami in History?." *National Geographic News*. 7 1 2005. National Geographic Society, Web. 17 Jan 2010. <http://news.nationalgeographic.com/news/2004/12/1227_041226_tsunami.html>.

"V-22 Osprey." *Boeing.com*. 1995. Boeing.com, Web. 5 Jan 2010. <http://www.boeing.com/rotorcraft/military/v22/index.htm>.

"V-22 Osprey." *www.jetfly.hu*. Web. 18-1-2010. <http://www.jetfly.hu/rovatok/repules/katonai/hirek/prognozis_060222/V-22%20Osprey.jpg>.

Westerling, A.L. "Warming and Earlier Spring Increase Western U.S. Forest Wildfire Activity ." *Science Magazine* 18-8-2006: n. pag. Web. 13 Jan 2010. <http://www.sciencemag.org/cgi/content/full/313/5789