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# FROM THE “ALLIGATOR” TO THE LCAC: HOW AMPHIBIOUS MILITARY VEHICLES EVOLVED IN TIME



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## INTRODUCTION

In recent times, amphibious warfare returned to prominence, with many military operations around the world being conducted by amphibious troops. From D-Day to Ukraine, marines from different countries have a long history of successful deployment in war theatres, mainly due to their preparation and their capabilities. Readiness, flexibility, and cross-domain operativity are the basic features of amphibious units, which find themselves fighting in one of the most difficult types of warfare. Sea, land, air, space, and cyberspace are all fundamental domains to organising and carrying out a successful amphibious operation. For this reason, to operate in such a complex and multifaceted environment, amphibious units benefit from unique vehicles and assets that help them in their operations.

Amphibious units' main task today is to launch operations from the sea to coastal zones. This type of operation is called a "ship-to-shore operation" and it involves the engagement of landing forces, traditionally marines, to conquer coastal objectives. The consequence is that these troops need to move on the sea and the land at the same moment, maintaining in both cases firepower and fighting capabilities. Amphibious vehicles are the assets that enable this type of movement and have a fundamental role in amphibious operations since they can operate both on land and at sea. It must be said that amphibious operations do not only involve the use of amphibious vehicles such as Amphibious Assault Vehicles (AAV), Amphibious Combat Vehicles (ACV) or Landing Crafts Air Cushioned (LCAC). Usually, amphibious troops employ a mixture of these types of vehicles and some air assets, especially helicopters for transportation, such as the Multi-Role Helicopter AW-101, or fire cover, such as the Attack Helicopter AW-129. Moreover, aircraft, such as the F-35B or the AV-8 Harrier, that can take off from aircraft carriers are commonly employed to support the troops on the ground or to prepare the battlefield for their landing.

However, this paper will focus on amphibious military vehicles, going through their recent history, to explore their main features and examine their strengths and weaknesses. Moreover, it will provide some insights into the latest developments and improvements for amphibious vehicles. To do so, NATO's main amphibious forces are taken into consideration, namely the US, the UK, Spain, Italy, and France. However, in the end, some insights about China are also drawn.

## HOW TO CONNECT LAND AND SEA? HISTORY OF AMPHIBIOUS FIGHTING VEHICLES

World War I convinced militaries that static battles were the new way to fight a war. Almost everyone thought that trenches, heavy defences, barbed wire, and machine guns, were the distinctive traits of future wars and that militaries should adapt to them. What happened on the land also influenced sea warfare and especially amphibious warfare. Was it still possible to conduct a landing operation against a heavily defended coastal zone? The answer to this question was no, it was no longer possible, or at the very least it was impossible with vehicles that offered no protection to the landing troops. If World War I created the problem, it also gave the solution. The appearance on the battlefields of the first mechanised units, even if still rudimentary and mostly ineffective, by Britain and Germany, completely shocked the world and pushed countries to concentrate their military expenses on these types of new assets. However, tanks and mechanised units were also the starting base for developing new amphibious vehicles, with firepower and armoured protection (Gourley, 2022).

Ronald Roebling is the inventor and first developer of modern amphibious vehicles. He was the engineer who, in 1935, completed the prototype of the “Alligator”, an amphibious tractor (Amtrac). Roebling took inspiration for his work from several hurricanes that hit Florida between 1926 and 1932, which pushed him to create a vehicle for rescue during floods (Gresham, 2020). His article about this prototype was published in LIFE magazine and attracted the interest of the US military, which, in 1938, offered him a contract to develop a prototype for military purposes (Bows, 2020). This interest was also motivated by the fact that in the 1920s, in a US document called “War Plan Orange”, US strategists foresaw a conflict with Japan in the Pacific Ocean. However, the designed winning plan consisted of a slow advancement toward Japan by the American Pacific Fleet, conquering small islands one-by-one, to establish checkpoints. But to conquer these islands, amphibious operations were needed (Gresham, 2020). The strategy implied a great use of amphibious forces, but it would have been impossible without effective vehicles and assets to conduct these operations. Roebling’s “Alligator” would have been the solution. Roebling’s efforts in military production resulted in the Landing Vehicle Tracked 1 (LVT-1), which was first employed during World War II in the Battle of Guadalcanal for logistical support (Bows, 2020). This version was still too slow and did not provide troops with enough firepower and armoured components. However, LVT-2, LVT-3, and LVT-4 gradually improved the LVT-1 basis, thanks to upgraded suspensions, a larger cargo capacity, a loading ramp, a powerful 250hp engine and a machine gun, that allowed US Marines to massively use them also in full-combat operations for ship-to-shore operations (Bows, 2020). These improvements were also the consequence of some research on foreign amphibious vehicles. Simultaneously, the Japanese commissioned Daihatsu to develop the first military amphibious prototype. However, a Chinese photographer provided US Marines with the Japanese tests, and the US were able to readapt their vehicles to the new challenges posed by the enemy (Gresham, 2020).



Fig. 1: LVT-1 training at Hampton Roads, Virginia (USA) during WWII. Source: US Government. [https://upload.wikimedia.org/wikipedia/commons/thumb/8/8b/LVT-1\\_2.jpg/640px-LVT-1\\_2.jpg](https://upload.wikimedia.org/wikipedia/commons/thumb/8/8b/LVT-1_2.jpg/640px-LVT-1_2.jpg).

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The successes of the LVT during the conflict in the Pacific pushed General Holland M. Smith of the US Marine Corps to affirm that “without these landing vehicles, our amphibious offensive in the Pacific would have been impossible” (Maynard Lt. Col., 1946). This and other appreciations made to Roebling’s products paved the way for further state funding to further develop and improve amphibious vehicles. From this moment on, US military industries started to manufacture different versions of the same model, such as the Landing Vehicle Tracked Personnel (LVTP), for the personnel carrying, the Landing Vehicle Tracked Command (LVTC) with enhanced command and control capabilities, and the Landing Vehicle Tracked Recovery (LVTR), for search and rescue operations (Gourley, 2022). Moreover, the experiences of the Korean War between 1950 and 1953, and the first phases of the Vietnam War, resulted in the production of the LVT-5 and LVT-6 models. In 1971, the deliveries of the latest LVT-7 model started. This new vehicle was the best amphibious vehicle in the world at the time and provided US and NATO powers with improved tactical flexibility since it was suited both for land and sea combat and was significantly faster than the previous models.

The LVT-7 was the last model of the LVT series, as in 1977 the US Marine Corps decided to change the name and the role of the LVT, which formally became the Amphibious Assault Vehicle (AAV), with a broader role and enhanced operational tasks and capabilities. The AAV-7 was equipped and improved with hydraulic components, and a great electronic apparatus, which included the latest military electronic improvements, such as the Position Location and Reporting System (PLARS), for autonomous data diagnostics and analysis (Bows, 2020). Moreover, it was powered by a Cummins VT400 diesel engine and equipped with an M2 Browning 50-cal and an MK19 automatic grenade launcher for improved firepower (Doyle, 2008).

However, despite a relatively successful history in the production of amphibious vehicles for the US Marines and their allied countries, it must be pointed out that some projects for other vehicles were started and then terminated due to a lack of results. The main example is the Advanced Amphibious Assault Vehicle (AAAV), also known as the Expeditionary Fighting Vehicle (EFV). The program started in 2001 to produce a vehicle more like a tank than an Amtrac. It should have been a merge between the M1 Abraham Tank and an AAV. The main characteristics should have been extremely high mobility, speed, and firepower both on land and at sea. However, after 10 years of research, and only a few prototypes, in 2011 US Defence Secretary Gates declared that the program was terminated to focus on more promising projects such as the Amphibious Combat Vehicle (Gourley, 2022).

## **WHAT IS HAPPENING TODAY?**

Today, NATO's main amphibious powers, namely the USA, the UK, Italy, Spain, and France, are still relying on the AAV-7 for ship-to-shore operations. Its real effectiveness was proved during several amphibious operations in both the Gulf Wars. To keep it effective and modern, this vehicle is constantly upgraded with the latest technological improvements, applied to the model that is still the same as 1977. The crew is composed of the pilot, the commander, and the machine gunner, moreover, the vehicle can carry a platoon of 21 soldiers and their commander (Esercito Italiano, 2022). Another widely employed vehicle by most NATO amphibious forces is the Bandvagn Skyddad 10 (BvS10) or Viking Armoured Vehicle, for the Royal Navy. This armoured vehicle comprises two main cabins for personnel carry and ship-to-shore movement. However, this vehicle is not specifically designed for amphibious operations, but it is an all-terrain vehicle that can be employed also in jungles, deserts, and arctic zones (Royal Navy, 2022).



However, the new Amphibious Combat Vehicle (ACV) is the most promising asset. In fact, in 2019 US Marine Corps commissioned BAE Systems and Iveco to build a new amphibious vehicle to support and cooperate with the AAV-7. The two industries started with the common structure of the AAV-7 to design a new vehicle with strongly improved capabilities, especially regarding speed and manoeuvrability. It can reach 105 km/h on land, and more than 6 knots on the sea (BAE Systems, 2022), compared to the AAV-7, which maintains the same speed of more than 6 knots on the sea but can reach only 70 km/h on land (BAE Systems, 2022). Apart from the classic P, C, and R versions, this vehicle also presents an ACV-30 version, with a 30mm medium calibre cannon (BAE Systems, 2022). To summarise, this vehicle could have a huge impact on future amphibious operations, also due to its possibility to integrate an “Advanced Reconnaissance Vehicle-Command, Control, Communication and Computers/Unmanned Aerial Systems mission payload on an Amphibious Combat Vehicle (ACV) variant” (BAE Systems, 2022).



Fig. 2: Amphibious Combat Vehicle (ACV)) during a training exercise. Source: U.S. Marine Corps photo by Ashley Calingo.  
[https://upload.wikimedia.org/wikipedia/commons/thumb/a/ab/Amphibious\\_Combat\\_Vehicle\\_190228-M-YL753-265.jpg/640px-Amphibious\\_Combat\\_Vehicle\\_190228-M-YL753-265.jpg](https://upload.wikimedia.org/wikipedia/commons/thumb/a/ab/Amphibious_Combat_Vehicle_190228-M-YL753-265.jpg/640px-Amphibious_Combat_Vehicle_190228-M-YL753-265.jpg).

Another interesting amphibious asset is the Landing Craft Air Cushioned (LCAC). This vehicle is practically a hovercraft, with a 1,5 m air cushion that allows it to reach 70% of the world's coastlines, compared to 15% reachable by traditional landing crafts (United States Navy, 2022). This hovercraft has been produced by Bell Aerospace Textron and Lockheed Martin since 1987, and it is currently employed by the US Navy and by the Japanese Self-Defence Forces, for logistic and ship-to-shore operations. It has proved its effectiveness in different amphibious operations, such as in Somalia, Kuwait, and Bangladesh (Textron Systems, 2015). Its main feature is that it can carry a total load of around 68,000 Kg at 92 km/h speed on the sea. This tremendous result is made possible thanks to its two big turbines and the air cushion. Moreover, it also has consistent firepower with “2 12.7mm MGs” (United States Navy, 2022). And different gun mounts that can support “M-2HB .50 cal machine gun; Mk-19 Mod3 40mm grenade launcher; M-60 machine gun” (United States Navy, 2022). Even if it is mainly employed on the sea, to fully exploit its capabilities, this vehicle can also be deployed on land terrains, despite a huge loss of speed, and for this reason, is considered an amphibious vehicle.



Fig. 3: US Navy LCAC.

<https://www.istockphoto.com/fr/photo/v%C3%A9hicule-%C3%A0-coussin-dair-lcac-de-lunited-states-navy-gm1422035235-467469920?phrase=LCAC>

## CHINA'S MAIN ASSETS

Regarding other amphibious forces around the world external to NATO, the main one is China, that in recent years embarked on significant investment in amphibious warfare. China is giving a lot of attention to its amphibious branch, as several amphibious exercises demonstrate (Xuanzun, 2022). The reason for this renewed interest in amphibious forces is the environment in which the People's Liberation Army Navy (PLAN) must operate. Several atolls, a great coast to defend and the incredible number of archipelagos in the Chinese Sea urge the PLAN to have a consistent amphibious component. Here, the People's Liberation Army (PLA) Marine Corps (China's landing troops) carry out their duties with an operational and organizational model based on the one used by US Marines.



Fig. 4: Chinese ZTD-05. Source:

<https://upload.wikimedia.org/wikipedia/commons/thumb/5/5e/ZTD-05-1.jpg/640px-ZTD-05-1.jpg>.

The PLA Marine Corps operate several different amphibious vehicles, such as the biggest LCAC class in the world, namely the Russian Zubr class which can carry up to 360 soldiers. However, three of these amphibious vehicles constitute the backbone of the PLA amphibious assets. The first two are the ZBD-05 Infantry Fighting Vehicle, and the ZTD-05 Assault Vehicle. These two vehicles belong to the Type-05 family, and they are both produced by the China North Industries Corporation (NORINCO). They are very similar to what would have been the EFV since they resemble more a tank than an AAV. However, they maintain a great speed both in water and on land, with a maximum speed of 45km/h and 65 km/h respectively. They can carry around 15 soldiers including the crew, and their main features are great firepower and tremendous manoeuvrability compared to similar land vehicles since they are lighter (Army Technology, 2014). Regarding the armament, the ZBD-05 is equipped with “a 30mm automatic cannon, a coaxial 7.62mm machine gun, AGS-17 automatic grenade launcher, and two Hong Jian-73C anti-tank guided missile (ATGM) launchers one on either side of the turret” (Army Technology, 2014). The third main amphibious vehicle operated by the PLA Marine Corps is the ZBL-08 Infantry Fighting Vehicle. This vehicle is an 8x8 multirole mission vehicle, and its main task, except for carrying troops, is to support landing troops during ship-to-shore operations. For this reason, it is equipped with a “30mm autocannon, machine gun, Anti-Tank Guided Missile (ATGM) support (HJ-73C series missiles), and smoke grenade dischargers” (Military Factory, 2019).



Fig. 5: Chinese ZBL-08 during Sibul/Interaction 2021. Source: [https://upload.wikimedia.org/wikipedia/commons/thumb/b/bf/Xibu\\_zbl08\\_2.jpg/640px-Xibu\\_zbl08\\_2.jpg](https://upload.wikimedia.org/wikipedia/commons/thumb/b/bf/Xibu_zbl08_2.jpg/640px-Xibu_zbl08_2.jpg).

As it is possible to observe, China is rapidly trying to bridge the gap between its Marine Corps and the US Marine Corps, considered the most efficient in the world. To do so, the Americans are taken as a model, but Chinese industries can produce high-performing vehicles relatively quickly. China is growing rapidly in military capabilities and its amphibious military vehicles only confirm this thesis.

The water domain is fundamental to China, also because its aspirations toward Taiwan are becoming increasingly pressing for the international community, and the possibility of a conflict is not remote. Regarding Taiwan, China is not lacking options to invade the island due to its military strength and the relative weakness of Taiwan. However, with the help of some US military advisors, Taipei is starting to employ a defensive tactic called the “porcupine tactic” (Gilli, Gilli, 2021). This tactic should allow the Taiwanese to resist a possible Chinese surprise assault by employing relatively low-cost armaments, such as shoulder-fired missile launchers, sea mines, mortars, and anti-ship weapons.

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These assets would constitute the quills of the porcupine, which can protect itself from outside threats (Aitken, 2022). By employing this type of asymmetric defence, Taiwan has a bigger chance of resisting China in a military confrontation (Christensen, Fravel, Glaser, Nathan, Weiss, 2022). This tactic is relevant for Chinese amphibious forces since it interdicts and makes it more difficult to attack the island without a land assault, which would allow them to slowly conquer all the territory. By looking at the recent exercises that China held in this geographical zone, it is clear that the main option in the case of a land assault would be an amphibious operation, to land on Taiwanese coasts to begin to conquer the entire island (Gilli, Gilli, 2021). The hypothesis of an amphibious assault pushed China to increase its investments in its amphibious component and vehicles are one of the priorities in their plans. In particular, the difficult conditions of the Taiwan Strait require Chinese amphibious vehicles to be equipped with powerful and well-balanced engines to be able to resist strong sea currents.

## **CONCLUSIONS**

This paper showed that amphibious vehicles are a fundamental asset to amphibious operations since they allow troops to conduct ship-to-shore operations and landing assaults. The backbone of NATO amphibious forces is constituted mainly by AAV-7. However, they also employ other vehicles, such as the BvS10 or the LCAC. Moreover, recent evolutions demonstrate the improved capabilities of the new ACV. On the other side, NATO competitors such as China have several amphibious vehicles that can carry and complete different tasks. China in particular is building a great amphibious component, in line with its armament plan and aspirations toward Taiwan.

To conclude, it can be said that the history of amphibious military vehicles shows the importance they had, and they are still having in several battles and wars. Indeed, the pace at which militaries around the world developed and are still developing their amphibious assets is a symptom of the importance that countries are giving to their amphibious components. Moreover, it is also a symptom of how important technology and military innovation are to succeed in overcoming natural obstacles, such as, in this case, coastal impediments.



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