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TITLE: THE DEVELOPMENT AND EMPLOYMENT OF THE LANDING VEHICLE,  
TRACKED

SCOPE: A brief history of the development and employment of the  
Landing Vehicle, Tracked, as manufactured by The Food  
Machinery Corporation, during the Pacific offensive  
7 August 1942 through 1 April 1945.

41-51

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## DEVELOPMENT AND EMPLOYMENT OF THE LANDING VEHICLE, TRACKED

On August 7, 1942, the Pacific offensive was launched with the attack at Guadalcanal. On that date a relatively unknown vehicle, the LVT, made a quiet unpretentious entrance into combat. That modest introduction resulted in development both mechanically and tactically that was soon to pace the Pacific war. Its evolution was rapid, combat prompted, and combat tested. The field manual was yet to be written.

The idea of an amphibious tank, as with many other military machines, was not new. Water obstacles, having long taxed the ingenuity of the military, inspired the conception of an amphibious tank as early as 1588. As recorded in the works of the Italian, Agostino Ramelli, this weapon was a crude box-like affair mounted on four wooden wheels. Necessary couplings were installed to facilitate land transportation by horse power. Rotational power applied through a crank system to paddle wheels mounted on each side provided forward movement in the water, directional control being accomplished through the employment of a rudder oar protruding from the stern. The bow contained a fighting compartment with loop-holes for the muskets of the bow gunners. Immediately behind the fighting compartment space was provided for an assault team which debarked by means of a ramp up and over the forward end onto the hostile shore.

In 1922 Walter Christie produced an armored amphibious tractor that was quite similar in hull design to the Renaissance model just described. It was a small track-laying vehicle using a propeller for motive power while water borne. The tracks were suspended by means of dual wheels fore and aft. This vehicle was tested on the Hudson River in New York in December of 1922. An improved model mounting a 75mm gun, center guide tracks, and an improved Christie suspension was tested by the Marine Corps in 1924 during winter maneuvers in Cuba. This tractor performed well the dual role of an amphibian, presenting a possible solution to the problem of getting artillery ashore with the assaulting troops. In 1927 the Marines used six of them in China. With the advent of disarmament appropriations were cut causing the Christie to be discarded. The Japanese Government later purchased these plans and by 1939 had developed an amphibious tank.

During the period 1924-1931 many odd looking vehicles were presented as the answer to the dual requirements demanded of an amphibious vehicle. Many were little more than conventional boats mounted on rubber tired wheels, some even boasted detachable side mounted paddle wheels as found in the Jagger 1925. Others were more promising, such as the British amphibious tractor tested in England in 1931. This British design carried an armored turret, a most desirable feature. Due to lack of funds, however, very little was done by the United States toward the

development of an amphibian craft until 1940.

In 1939 newsreel cameramen assembled at Clearwater, Florida, to film a demonstration of an unusual rescue machine developed by Donald Roebling.

The inadequacy of conventional craft and vehicles was noticed by Roebling during the rescue work following the hurricane that leveled the Everglades section in 1933. This prompted him to build a machine capable of satisfactory operation under any emergency peculiar to that section. He built his first machine that year but spent until 1939 perfecting it. It was the performance of this machine, the Roebling "Alligator", that was brought indirectly to the attention of the Navy and Marine Corps through the media of the newsreel. Having long been aware of the need of such a vehicle, they were impressed and arrangements were made for a demonstration.

After a successful demonstration, an order was placed for two Roebling "Alligators" for test purposes. The first one was delivered to the Marines in November, 1940. Following these tests, the Navy contracted with Food Machinery Corporation for the manufacture of 200 LVT(1)s, the first of which was delivered in July, 1941.

The Landing Vehicle Tracked Mark I, referred to as the Roebling "Alligator", LVT(1), or Amphibious Tractor, as produced by Food Machinery Corporation in July, 1941, was an unarmored

full tracked vehicle designed to incorporate some tank parts then in production. (The power train of the old M3 light tank is used in all LVTs with the exception of the Borg Warner.) Powered by a seven cylinder, radial, air cooled engine located in the stern, the all metal tracks drive the vehicle on land or water. Hydraulic grousers mounted on the tracks provide propulsion in the water and additional traction on land.

While the LVT(1) was in production, the Navy requested that it be redesigned, the basic idea being the production of a vehicle capable of withstanding the grueling treatment characteristic of combat operations. Working in conjunction with Donald Roebling and the Navy, Food Machinery Corporation was able to design and construct the first test models in the amazing time of six months. The LVT(2) test models were delivered in October, 1941.

In spite of this more advanced development, the LVT(1) design was frozen shortly after December 7, 1941, to enable mass production.

The LVT(1) or "Alligator" was first introduced to combat by the Marines at Guadalcanal in August, 1942. Their performance as personnel and cargo carriers was remarkable, but being unarmored, were not looked upon as combat vehicles. On only one occasion was an LVT used as a combat vehicle. This action consisted of a single vehicle, supported by infantry, being employed for the purpose of cleaning out a cave. Two major defects were reported:

First, unloading cargo over the side was at best difficult, and in the case of heavy equipment impossible, without the aid of an "A" frame or crane. Second, they were highly vulnerable to small caliber fire.

Although one design, the LVT(1), was frozen in production, development work continued. The LVT(2) passed the requirements laid down by the Bureau of Ships the same month the Marines hit Guadalcanal. These LVT(2)s were put into production immediately by Food Machinery Corporation in their Riverside, California, plant. This vehicle, Landing Vehicle Tracked Mark II was named the "Water Buffalo" by the Navy and was more efficient than the LVT(1) in both stability and performance. Improved grousers were installed on this model greatly reducing the replacement and maintenance required. The cab was lowered and cut back forming a fore deck and giving the vehicle a lower silhouette in the water. With these and other minor exceptions, the vehicle varied very little from the LVT(1).

The importance of the LVT to amphibian operations was forcefully demonstrated at Tarawa. This operation, more than any other, established the LVT as an outstanding new weapon of island warfare and had a decided bearing upon their subsequent employment and development.

In wresting Tarawa Atoll, one of the Gilbert Islands, from the Japanese, the main effort was directed at Bititu, one of the

small coral islands of the atoll.

A study of Bititu revealed that approaching from any direction, the attacker would be forced to cross a coral reef, the ideal obstacle so aptly described by Admiral Nimitz: "The ideal defense barrier has always been the one that could not be demolished, which held up assaulting forces under the unobstructed fire of the defenders and past which it was impossible to run, crawl, dig, climb, or sail. The barrier reef fills these conditions to the letter, except when sufficient amphibious tanks and similar vehicles are available to the attackers." (Cinc. Pac. Op. Report, November 1943). Obviously, amphibious vehicles were demanded by the nature of the operation, but only amphibious tractors were available. The tanks, LVT(A)(1)s, although tested and approved, were not yet in quantity production.

The necessity of employing amphibious tractors was recognized early in the planning phase and additional LVTs were requested to supplement the 75 serviceable vehicles of the 2nd Marine Division. Due to shortage of shipping space only 50 LVT(2)s were received, making a total of 125 LVT(1) and (2)s available for the operation.

Three battalion landing teams were to land simultaneously on three adjacent beaches. The first three waves of the assault were carried in LVTs. The first wave was composed of 42 vehicles; the second wave, 24 vehicles; the third wave, 21 vehicles; while

the remaining troops of the assault battalions were boated in LCVPs. (Landing craft, vehicle, personnel).

As the assault waves moved from the line of departure toward the beach, they were lost to observers' view in the smoke and dust caused by the intensive naval gun and air bombardment. This made it necessary to cease the supporting fire of the naval guns, leaving a void of twenty three minutes during which the only fire support the assault waves had was furnished by the two destroyers marking the line of departure. This enabled the enemy to overcome the initial shock produced by the preparatory fires, allowing him time to re-man his positions and weapons. Consequently, the volume of enemy fire increased progressively from air bursts at 3000 yards--long range machine gunfire--to about 200 yards from the beach at which time all available enemy weapons opened fire in an attempt to stop the attack before it reached the beach. At least eight vehicles were disabled by fire, failing to reach the shore. Two more were put out of action by mines placed on the reef. The remainder managed to make the beach and discharge their troops.

All of the LCVPs following in the wake of the tractors were stopped by the reef, forcing the men to wade 400 to 500 yards through a perfect field of fire to the beach. One company suffered over 35 per cent casualties while in the water. Others waited for the tractors which were backing off the beach, taking



maximum advantage of their 14 gauge armor protection. Upon launching into deep water at the edge of the reef, approximately 15 more tractors sank due to holes torn in the hulls by enemy fire. The amphibious tractors were then regrouped to shuttle troops and supplies to the beach throughout the remainder of the 76 hours it took to conquer Bititu Island. The LVTs were the only means able to get supplies and troops ashore, other than manhandling, during the first days of battle. Later a boat passage beside a pier was cleared allowing some boats entrance.

The LVT emerged from Tarawa, its first real combat, a new weapon with a battle proven reputation. In comparison with other type landing craft, its performance of transporting troops under heavy fire was outstanding. Tarawa gave the LVT the opportunity to prove itself the only vehicle capable of gaining a strongly defended beach over the coral reefs of the Pacific atolls, the only vehicle possessing the necessary characteristics enabling it to cross the perfect obstacle. The LVT had become, in a 76 hour battle, a major evolution of the island hopping Pacific war.

This short violent action set the pattern for future development and technique of employment and brought into sharp focus the following facts:

1. Coordination of naval gunfire and air bombardment with

the movement of the assault waves was imperative.\*

2. Provision had to be made for a sufficient number of LVTs to insure the landing of all the assault troops, including reserves, and replacement vehicles as necessary.\*

3. The necessity of developing amphibious tanks or rocket launching amphibians capable of placing a volume of fire on the beach during the last 300-500 yards of the approach, and providing close support to the infantry until tanks and artillery landed.

4. The desirability of armor to protect the LVT against small arms and shell fragments.

The highly coordinated effective operations that followed amply illustrated how well the recommendations and lessons were utilized. It follows that the primary mission and basic employment of the amphibian tank were prescribed before the vehicle had completed final tests which were in progress at that time.

The desirability of armor to protect against small arms and shell fragments, the recognized need of getting heavier weapons in with the assault waves, as well as increasing demand for amphibious tanks, caused the highest priorities to be given to the production of the LVT(A)(2) and the tank LVT(A)(1).

These two new vehicles were to see action in the Marshalls

\*Capt. James R. Stockman, USMC, The Battle for Tarawa, pp. 67-68

as part of a provisional LVT battalion organized by the 7th Infantry Division. The 7th Infantry Division had made plans for their coming operations in the Marshalls which were altered to include LVTs after studying reports on their efficient performance in the Gilberts. It was the general opinion at that time that the amphibians were essential to guarantee the initial success of any island landing.

The division formed the provisional LVT battalion by using the personnel of the three regimental anti-tank companies equipping them with LVTs returned from the Gilberts. At this time the Army's first amphibian tank battalion, the 708th, arrived at Pearl Harbor.

The Commanding Officer of the 708th Amphibious Tank Battalion, Lt. Col. J. L. Rogers, was placed in command of the provisional battalion which was to consist of four tractor groups and one amphibious tank company. The fourth group and the amphibious tank company were manned by personnel of the 708th Amphibious Tank Battalion.

The tractor groups were each equipped with 34 LVTs, 14 were the new armored tractor LVT(A)(2), and 20 were the LVT(2) or unarmored type. The tank company had 17 LVT(A)(1)s.

The Landing Vehicle Tracked (Armored) Mark II, LVT(A)(2)s, were the new armored tractors that had been tested and approved in January 1943 and subsequently put into production in April of

that same year. They are identical to the LVT(2) with the exception of the  $\frac{1}{2}$ " armored cab and the  $\frac{1}{4}$ " steel hull. Cargo carrying capacity was reduced by the additional armor approximately one ton. This vehicle previously had been used in the Southwest Pacific New Britian Campaign. It was found to be excellent in reducing hastily organized centers of resistance as well as in breaking trails through the jungles. Their performance in these operations brought enthusiastic response from the assault troops but official reports indicated that heavier armor and turret development were undesirable and unnecessary. These reports were made based largely on the viewpoint of using the vehicle as a cargo and personnel carrier exclusively, considering the vehicle's use in combat only as a rare exception.

The LVT, officially called the Landing Vehicle Tracked (Armored) Mark I, was to see its first action. Although it had been designed by Roebling in 1942, it was not placed into production until August, 1943. This vehicle is in reality the LVT(A)(2) with a M5 light tank turret built over the cargo compartment. Two scarf gunner positions cut between the engine wall and rear of the turret provided flank and rear protection. This amphibious tank carries a 37mm gun, a coaxial machine gun, a 30 caliber machine gun mounted in each scarf gun position, and is manned by a crew of six men.

Considering the fire power and armored characteristics of

During this operation we find the LVTs divided into combat and cargo vehicles for the first time, the armored amphibian being recognized as a combat vehicle with a fighting mission.

It is well to note at this time that the amphibians were not used on land to any great extent, their mission only taking them 100 yards inland. In the landing on Carlson Island the vehicles operated on land to a greater extent, but it was against very light resistance and over fairly suitable terrain.

The amphibious tanks and armored amphibious tractors proved themselves capable of landing under heavy small arms fire, for which they were designed, but it is quite likely under heavier caliber fire more vehicles would have been lost.

The employment of the armored LVTs during this operation was to be followed with minor variations throughout the remainder of the war. Basically the methods of employment in this operation were as follows:

1. Armored characteristics were utilized by placing the armored LVTs in the lead wave and on the exposed flanks.
2. All weapons opened fire upon the beach at approximately 500 yards as naval gunfire was moved inland.
3. The principle of the armored vehicles moving inland setting up a perimeter defense for the beachhead was employed.
4. Close support was furnished to the infantry by the 37mm guns of the (A)(1) pending arrival of the land tanks.

Recommendations submitted for improvement of the LVTs included a bow gun to be installed in the cab just in front of the assistant driver on the (A)(1).

(The Landing Vehicle Tracked (Armored) Mark IV, LVT(A)(4), was the offspring of the earlier LVT(A)(1) and was placed in production in March, 1944. This vehicle was simply the turret for a 75mm Howitzer Motor Carriage, M8 mounted over the cargo compartment of the LVT(A)(2). The turret has  $1\frac{1}{2}$ " armor on the front, 1" armor on the sides and rear, and carries a modified version of the 75mm pack howitzer. The only other weapon was a 50 caliber machine gun mounted in a turret ring mount.) A limited number of these vehicles were made available to the 708th Amphibian Tank Battalion, which was at that time preparing to support the 4th Marine Division in the assault on Saipan and Tinian in the Marianas Group.

This operation is of particular interest because it very clearly demonstrated the limitations of the LVT, becoming a ready reference for recommendations in its employment in following operations.

The 708th Amphibious Tank Battalion received a total of 16 LVT(A)(4)s, four were issued to each company. The companies placed one in each platoon as platoon commander's vehicle. Being the interior vehicle of the platoon, it was afforded the protection of the scarf guns mounted on the (A)(1)s. The remaining (A)(4) was retained in company headquarters.

In the attack on Saipan the tank battalion formed the lead wave, each company leading an assault battalion. This placed the four line companies abreast, each company hitting a beach approximately 500 yards in width. The amphibious tanks, closely followed by the first two waves of tractors, were to proceed inland 1500-2000 yards to a line called the O-1. Upon reaching the O-1 line, the tractors would discharge their troops who would, with the amphibious tanks, secure the beachhead. The tractors were to return to the beach reverting to beach control. Troops in the following waves were to unload on the beach pushing on toward the O-1 line clearing out by-passed resistance. Upon arrival of the land tanks, the amphibious tanks were to support the Marines as ordered.

The following table illustrates the progress of the amphibious tanks from H-hour until H plus 410. Thirty four out of the 68 LVT(A)(1)s and (A)(4)s crossing the line of departure arrived on the O-1 line by 1000 hours.

	<u>Co. A</u>	<u>Co. B</u>	<u>Co. C</u>	<u>Co. D</u>
Set on fire during approach	1			
Immobilized on reef		1		1 (Engine Failure)
Destroyed by anti-tank and artillery fire	3	2	1	2
Stopped by obstacles	7	2	6	2
Arrived O-1 line H plus 80	6	13	10	5
Arrived O-1 line H plus 125				6
Arrived O-1 line later D-Day plus 2 minus 3				
Total on O-1 line at H plus 410	8	13	7	11

At the end of D-Day the battalion had approximately 28 tanks operating.\*

Most of the vehicles immobilized on obstacles were recovered and placed in action during the next ten days due to excellent maintenance within the battalion.

By the end of operations on Saipan and Tinian, the 708th Battalion had suffered 30 per cent personnel casualties, 16 LVTs completely destroyed and 14 partially destroyed. They loaded 38 amphibious tanks that were operative for the return trip to Pearl Harbor.\*

As compared with the action in the Marshalls, the casualties suffered by the amphibious tank battalion on this operation were extremely high in both personnel and vehicles. It is to be noted that the period of land operation was ten times greater on Saipan. Only excellent maintenance and rotation of vehicles enabled the unit to keep tanks reporting to the front lines each day. The wear on an amphibious tank during prolonged periods of land operation is exceedingly great.

When under artillery fire, the loss of vehicles is excessive as they do not have enough armor protection. It is interesting to note that only eight LVTs were destroyed progressing to the O-1 line out of a total of 30 LVTs destroyed or partially destroyed

\*Lt. Col. J. L. Rogers, Report on 708th Amphibious Tank Battalion, Marianas Operation, 1 September 1944



during the operation. This indicated that most economical use would be to limit the amphibians to establishing the beachhead and giving initial fire support, using them as land tanks only in extreme emergencies.

This operation pointed out that the LVT is extremely sensitive to land obstacles particularly of the type upon which it can "belly-up". This is partially due to hull construction and lack of engine power. The LVT was also effectively stopped by rice paddies.

The Landing Vehicle Tracked Mark IV, an unarmored cargo-personnel carrier equipped with a stern ramp, was put in production by December of 1943. Some of these vehicles were used in the Marianas campaign, proving quite superior to any other cargo or personnel carrier. The ramp greatly facilitated debarkation of troops and unloading of cargo.

By October 20, 1944, the assault on Leyte, P. I., was launched. The LVT had passed its several stages of development from Roebeling's mercy machine to the LVT(A)(4). The pattern of the amphibian assault was found to be sound. However, the employment was still in the stage of growth. Profiting by past experience, it was decided that the LVTs would proceed the assault troops inland only 500 yards supporting by direct fire until masked by the infantry, at which time the companies, now equipped with three LVT(A)(4)s and two LVT(A)(1)s in each platoon, would

go into position for indirect fire mission.

The 776th Amphibian Tank Battalion, having previously trained with the 7th Infantry Division Artillery, accomplished its initial assault mission and subsequently went into indirect fire positions. The artillery battalions surveyed the platoons in enabling them to fire through the artillery battalion's fire direction center. This worked with such effectiveness that other amphibious tank battalions adopted the idea and started training immediately following the Leyte operation.

The 780th Amphibian Tank Battalion supporting the 96th Infantry Division, also fired indirect fire on this operation. The method differed from that employed by the 776th Amphibious Tank Battalion in that all fires were controlled by battalion personnel. Due to shortage of both men and fire control equipment, this was found unsatisfactory and discarded in favor of the method used by the 776th Amphibious Tank Battalion.

The artillery role of the LVT was the most outstanding advancement brought out by this campaign. The Marine Corps' dream of heavier weapons to accompany the assault troops had indeed been realized.

Each amphibious tank battalion as now organized can land 75 howitzers on the beach in the lead wave at H-hour. This is equivalent to 12 artillery batteries of six guns each, capable of indirect fire a few minutes after H-hour. "A most important

secondary mission, which may be destined to become the primary mission of such units, is the indirect fire support given to the infantry prior to the landing of the divisional artillery."\*

With the fall of Japan, the LVT had achieved an enviable record of combat. It had fulfilled, in its spectacular progress, the life saving mission that had prompted its creation by Donald Roebling. This was done directly by its use in evacuating many wounded, and indirectly by safely transporting troops ashore in the face of enemy fire.

Based upon recommendations resulting from its performance in action, new models were developed. As these new vehicles were used in the field, the doctrine of employment was written. With the conclusion of the war, our LVTs were the best vehicle of their kind in the world, but this standing had been achieved in spite of the many faults constantly stressed throughout the war. The operating limitations were static after the production of the LVT(A)(2). The models that followed were little more than additions of armor and armament. The LVT(4) represented the greatest change, and this consisted of changing the location of the engine compartment to permit the installation of a stern ramp.

The outstanding limitations to be overcome in light of future

\*Lt. Col O. K. Kane, After Action Report, 776th Amphibious Tank Battalion, 20 October 1944--30 January 1945

development are:

1. The slow speed and lack of maneuverability in the water.
2. The lack of mechanical reliability and power necessary for satisfactory performance on land. The ratio of combat time spent on water to that spent on land in each operation makes this a paramount consideration.

To overcome the limitations of our present LVT and to provide a vehicle capable of overcoming the defenses that will undoubtedly be set up to defeat its landing, may result in radical departure from the present design. Whatever the trend, a more satisfactory amphibian will result only from striking an accurate balance between the desirable characteristics in our most advanced boat and land vehicle designs. This balance must be determined by the mission assigned after gaining the hostile shore.

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T A R A W A

The LVTs were the only means able to get troops ashore



T A R A W A

The LVTs were the only means able to get troops ashore





THE "Water Buffalo" AMPHIBIOUS TRACTOR: LVT(A) (2)



THE "Water Buffalo" AMPHIBIOUS TANK: LVT(A) (1)



AMPHIBIAN ASSAULT



THE "Water Buffalo" AMPHIBIOUS TANK: LVT(A) (4)



S A I P A N

The LVT(A)(4)'s first engagment



THE "Water Buffalo" AMPHIBIOUS TRACTOR: LVT (4)

1  
2  
3



LVT(1) LANDING VEHICLE TRACKED

Mark I ROEBLING "ALLIGATOR"