INVESTIGATIONS IN INVASION INNOVATION; THE ARCHAEOLOGICAL AND HISTORICAL STUDY OF A WWII LANDING VEHICLE TRACKED IN SAIPAN

WILLIAM SHAWN ARNOLD
DECLARATION

I certify that this thesis does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any university; and that to the best of my knowledge and belief it does not contain any material previously published or written by another person except where reference is made in the text.

W. Shawn Arnold
2010
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Introduction
Statement of Purpose

The advent of amphibious watercraft such as the amphibious tractor for use during World War II (WWII) is directly responsible for saving numerous U.S. lives. The ability to drive invasion forces through the water and over shallow reefs to deliver them on shore prevented considerable causalities as it prevented the invasion force from having to wade hundreds and sometimes thousands of meters across lagoons under heavy enemy fire (Armagnac 1945, p. 121). Unfortunately, these machines have been nearly forgotten through time and have taken a back seat to technology such as the planes and tanks of the era.

The amphibious tractor, also known as the Amtrac or Landing Vehicle Tracked (LVT), was the workhorse of World War II in the Pacific Theater. Their unique ability of being capable of traveling both in and out of the water provided them an advantage other vehicles lacked. Amtracs were called upon to perform a wide array of tasks. These roles include delivering assault troops to the beach, evacuating wounded, delivering supplies, and acting as mobile command posts and mobile weapons platforms (Croizat 1953 p. 46).

The aim of this study is to further our understanding of the significance of amphibious vehicles used during World War II, particularly in relation to the Battle of Saipan. This thesis will explore the necessity of amphibious craft due to the physical and environmental demands of the battlefield through the approach outlined below. It will also explore the ways in which crews made changes to the vehicles during the war in order to protect and prolong the life of not only the
vehicle but also the crews themselves. Finally it will explore how these modifications directly influenced later Amtrac production designs.

*Introduction to the Amphibious Tractor*

The name Amphibious Tractor (Amtrac) is a general term referring to an amphibious vehicle that is propelled on land and in the water by a tracked propulsion system (figure 1-1). These vehicles are also referred to by their military title, Landing Vehicle Tracked (LVT). Following the designation LVT is a number, which signifies the production model of the LVT. An “A” in parenthesis signifies that the LVT is an armored version. The title armored can refer to the fact that is covered in armored plates for assault purposes or that it is equipped to operate as a mobile artillery unit. The artillery versions are easily recognizable because they have a large caliber weapon mounted on the top.

The LVT is one of the first true amphibious vehicles. It is propelled by tracks that mount cleats known as grousers. These grousers act as paddles in order to propel the vehicle through the water and provide traction while crossing reef flats and shoreline terrain (United States Marine Corps Air-Ground Museum, 1997, p. 6). Amtracs are constructed of steel and are kept afloat by air contained in pontoons on both sides of the vehicle. These vehicles have a single engine propulsion system consisting of tracks mounted on both the port and starboard sides.
Carrying capacity and the intended mission of the LVT changed through time and design modifications reflect these changes in LVT manufacture. The versatility of the Amtrac allowed for the easy adaptation of a wide range of roles in amphibious warfare. The first military production model is known as the LVT-1. The LVT-1 saw its first combat action during the Solomon Islands campaign in 1943 (Croizat 1999, p. 112). LVTs were intended to only carry cargo to the landing zone once the Marines secured a beachhead. However, because the fringing reef was too shallow for the traditional landing craft to deliver the Marines close to shore, the LVTs were used to ferry the invading forces to the shoreline (Croizat 1999, 113). Thus began the Amtrac’s life as a troop carrier and assault craft. This change in role affected military doctrine for the remainder of the war in the Pacific.
Military leaders recognized the potential for the implementation of the LVT as an amphibious assault vehicle from this first combat use. Invasion forces added additional machine guns to their existing LVTs and placed orders for more LVTs with extra mounted weapons (Bailey 1986, pp. 56-69). As the war drew on, military commanders determined additional modifications were needed and the production of diverse designs for special purposes commenced. As a result, a definite serration of LVT design exists from cargo carrier (LVT-1) to armored troop delivery systems (LVT-4 [Armored Cab]) to armored artillery platforms (LVT [A]-1 and LVT [A]-4, these machines are also known as Amphibious Tanks or Amtanks).

Interestingly, the people who operated these machines also devised ways to improve and prolong not only their own lives but also the life of their LVTs (Baker 2004, pp. 4-9, 253). These improvisations, known as “field expedient armor modifications,” have been discussed by historians and are observable on the LVT (A)-4 site in Saipan (Boal 2006, p. 5). Further, these modifications are the specific focus of this study in relation to individual and troop action as demonstrated in the archaeological record.

Study Area

This study will focus on an amphibious tractor located in Tanapag Lagoon, Saipan, Commonwealth of the Northern Mariana Islands (figure 1-2). This particular Amtrac is known as a Landing Vehicle Tracked (Armored) -4 (LVT [A]-4). An archaeological consulting firm, Southeastern Archaeological Research, Inc. (SEARCH) originally noted the site archaeologically in a survey report in 2008
(Burns 2008, pg.84). No further archaeological investigation was conducted by searching beyond positive target identification (Burns 2008, p. 84).

In July 2009 and April 2010 archaeological surveys of the site were conducted as a part of a project to record submerged WWII heritage in Saipan's waters. The site was recorded using basic maritime archaeological survey methods of baseline offsets, triangulation, trilateration and photographic recording. All data was compared to historical records in order to determine the exact type and production model of the vehicle.

The LVT (A)-4 is resting at a slight angle in a depth of between 2 feet (ft) (.6 meters [m]) and 10ft (3.05m) of water on a sandy area between patch reefs in Tanapag Harbor, Saipan.

Figure 1-2: Approximate site location outlined in yellow. (Image: Google Earth accessed May 10, 2010).
The lower superstructure is mostly intact however the majority of exterior armor plating and superstructure is missing from the upper portion of the craft around the turret. Also missing are the armor track covers and the armor covering of the cab. Other notable damage includes large, jagged holes in the bow armor and in the ballast area (pontoons) on both sides of the amphibious tank.

During the initial site visit researchers noted the possibility that several field expedient armor modifications were made to this vessel. Boal defines field expedient armor modifications as changes made after the vehicle has left the production facilities (Boal 2006, p. 5). Field expedient armor modifications made to this LVT (A)-4 are of particular interest to this study because they provide a glimpse into the individual actions of LVT crews during the war.

Approach

This study will utilize a holistic approach to explore the use of LVT (A)-4s in the Battle of Saipan. Identifying the processes that may have affected this site will be used to determine the site’s formation. Muckelroy pioneered site process evaluation for maritime archaeological sites in his book *Maritime Archaeology* (1978). Since that time others have expanded the method of process evaluation. Ward et al (1999) expands on Mulckelroy’s site formation processes model by including environmental, chemical and biological factors. Gibbs (2006) identifies the importance of the relationships between documentary, archeological and oral data sets in order to recognize differences. Jung (2009) also recognizes WWII wreck
site patterns in determining site formation processes of aircraft. By understanding the nature of the site, a logical conclusion about the site’s formation can be obtained.

This research will conduct an in-depth analysis of documentary records in order to better understand the cultural processes affecting LVT use on the Western Invasion Beaches of the Saipan battlefield in June 1944 and the sites of two battles on the northwestern side of Saipan in July 1944. This research will also conduct a complete archaeological survey of the LVT in the Lagoon to identify important site formation processes evident in the physical record. Site formation process methodology applied to this LVT site offers an increased understanding into how and why the tactical use of amphibious vehicles was necessary and how the site may have been formed and what natural and cultural factors have affected it since its formation.

Research Data and Research Questions

This study proposes to conduct archaeological and historical research in order to better understand the use and significance of amphibious vehicles during the WWII Battle of Saipan. The physical and environmental setting of the battlefield will be explored through historic research. Historical data includes both primary and secondary literature, photographs and maps collected from the Combined Arms Research Library (CARL) archives online and various publications concerning the Battle of Saipan. Archaeological data includes the survey and mapping of the LVT and its environs in Saipan’s Lagoon. This information will be compiled and analyzed
using the process evaluation of site formation approach to address the following research questions.

Main Question:

What is the significance of the Landing Vehicle Tracked (LVT) during the invasion of Saipan as it relates to the development of the LVT as a machine of war?

Subsidiary Questions:

1. How were LVTs used in the invasion of Saipan?
2. How and why did the LVT crews modify their vehicles for the Battle of Saipan?
3. How are these modifications reflected in the archaeological record?

Significance of Research

LVTs are a unique vessel that aided in preserving the lives of U.S. troops. Their significance in battle has been largely overlooked in historic accounts of WWII. This study will conduct historical research into the use of LVTs by the U.S. in the Pacific and fill the historical gap that exists for this vehicle. It will do this through historical research into the Battle of Saipan and the use of LVTs in this full-scale assault. It will also highlight the use of one particular LVT located in Saipan and examine specific skirmishes and plans within the overall campaign.

The LVT (A)-4 was introduced for the Battle of Saipan and marks a definite change in the equipment and supplies for U. S. troops fighting in the Pacific theater during WWII. This study is significant because it is the first archaeological examination
of this LVT type. Thus, it investigates the design, manufacture and use of this vehicle for the first time. Additionally, it is historically documented that LVTs were often modified by their crews to enhance capabilities and limit loss in war. This study is the first to investigate from an archaeological perspective these in-field battle modifications to compare and contrast baseline manufacture details and standardizations with alterations made by the user. Further, a "process approach" will be used to review the natural and cultural factors, which affected the vehicle and site as it is observed today. This approach has been applied to both shipwrecks and aircraft wrecks but has yet to be applied to vehicles of this nature.

Limitations of this Study

The investigations of this thesis are limited to one LVT (A)-4. Due to time constraints in the field, it was impossible to survey any other LVTs. Thus the data presented in this thesis is representative of only one LVT (A)-4 and does not necessarily reflect all of the LVTs used during the Battle of Saipan. The lack of available documents relating specifically to the salvage and disposal of LVTs in Saipan limits the ability to definitively link this site to these actions. Specific mention of LVTs in historic accounts are brief and sometimes not present in documents. This may indicate that LVTs have been overlooked or disregarded by the authors.
Chapter Outline

This chapter (Chapter 1) explains the basic foundation for this study. It provides a brief outline of the approach, which will be used in this research. The limitations of the study also are acknowledged in this chapter.

Site formation analysis using the process approach is discussed in Chapter 2. A brief overview of what site formation processes are and how they have been previously used to examine wreck sites will be presented.

Historical data contained in Chapter 3 explains the development and evolution of the Amtrak from domestic rescue vehicle to providing direct artillery support during an amphibious invasion. New LVT models are introduced after major campaigns in the Pacific during World War II. Design changes outlined in Chapter 3 provide the basis for understanding the implementation of field expedient armor modifications by the manufacturer in production models throughout the war effort.

Chapter 4 describes the methodology used in recording the site. Descriptions of how data was recorded are provided in this chapter.

Analysis in Chapter 5 describes the archaeological results demonstrated through photographs and scaled drawings. The focus of this chapter is to establish all of the features noted during the archaeological survey. These features are used to aid in determining the present condition in the discussion.

The discussion in Chapter 6 compares the archaeological findings of Chapter 5 with historical military documents. Utilizing the process approach to site
formation investigations, site features are discussed and possible explanations for the features are given. Research Questions will be answered in this chapter.

The concluding chapter (Chapter 7) presents an overview of all available information concerning the site formation of the LVT (A)-4 in Tanapag Lagoon. The significance of the modifications to this LVT (A)-4 in the Battle of Saipan and its impact on future Amtrac designs are also discussed. Recommendations for the LVT (A)-4 located in Tanapag Lagoon are discussed as well as future research concerning Landing Vehicles Tracked.
Chapter 2
Approach: Process Analysis
Introduction

Research questions regarding this study will be addressed using “process analysis.” Process analysis consists of examining a broad array of factors that may have influenced a wreck site in order to determine the formation processes of a site (Schiffer 1976; Muckelroy 1978; Ward 1999; Gibbs 2006; Jung 2009). These factors include cultural and natural (biological and environmental) effects to which a site may have been subjected. Maritime archaeologists adopted process analysis first from terrestrial archaeologists and have since adapted it to studying sites underwater. Process analysis has been particularly useful to maritime archaeologists studying historic period sites who often use process analysis for the purpose of determining site formation where historic records are conflicting or nonexistent (Gibbs 2006, p.4; Jung 2009, pp.21-22).

An analysis identifying the many processes that may have affected a site offers archaeologists the opportunity to more clearly understand how a site has entered the archaeological record and what became of it afterwards. It does this by placing emphasis on significant natural and cultural processes that influence the nature of a site (Muckelroy 1978; Ward 1999; Gibbs 2006, Jung 2009). On historic sites these factors are identified through historical research and observed seabed distribution. Historical documents sometimes describe cultural processes that affect a site such as primary and secondary salvage and the disposal of equipment. While observed seabed distribution can also provide clues of cultural activities such as salvage or wrecking behaviors. Natural processes are identified through observed seabed distribution, testing and monitoring. Natural factors that may
affect a site are wave energy, composition of sea floor and sediments, the actions of marine organisms and the chemical breakdown of a site (Muckelroy 1978; Ward 1999; Gibbs 2006; Jung 2009).

Process Analysis as a Research Tool

Process analysis methodology for underwater archaeology is derived from Mulckelroy’s analysis of how shipwrecks enter the archaeological record. He relates that by understanding the processes that have intervened between the time of the wrecking event and rediscovery of the wreck, researchers can better understand the archaeological record (1978, p. 157). This thought process is illustrated in a flowchart (figure 2-1)(1978, p. 158), which outlines the process of the wrecking event and effects on cargo in a simplistic format.

Figure 2-1: Muckelroy’s Flowchart (1978, p. 158).
The flowchart is basic and follows a simple outline formula. As an example, Muckelroy states that heavier items such as metal objects that cannot float would not have disappeared during the wrecking process (Muckelroy 1978, p. 166). Therefore, a lack of heavy items would indicate salvage operations of some sort. Assessing the possibility of salvage includes both observed seabed distribution and possible historical documentation concerning salvage records (Muckelroy 1978, p. 166).

Ward et al (1999) introduced a new process based model for wreck site formation concerning environmental processes (figure 2-2). This model provides a more in-depth view of how natural forces such as the sediment types and hydrodynamic environment influence site formation. Also provided are formulas for measuring the rate of corrosion and decomposition of a maritime site.

![Figure 2-2: Ward et al modified diagram of wreck disintegration (1999, p. 564).](image-url)
Other researchers have expanded the analysis of processes affecting wrecks to include a wide array of cultural influences and deliberate disposal of derelict vessels. Gibbs (2006) contributes cultural strategies that may have occurred prior to and during the wrecking event and their associated archaeological signatures (figure 2-3)(pp. 9-18). These strategies include but are not limited to:

- **Pre-impact threat phase** in which the planning of a voyage is conducted and modification of the vessel may be deemed necessary.
- **Pre-impact warning phase**, which includes course changes and the jettisoning of cargo in order to lighten a vessel.
- **Impact** and the actions that are dependent on the nature of the wrecking event.
- **Recoil**, which includes the survivors’ salvage of cargo and establishment of a camp.
- **Rescue and post disaster** is defined as the complete abandonment of the wreck and its contents.

Gibbs describes the pre-impact “threat” phase as the initial gathering of knowledge about the mission to be undertaken (2006, p.8). He goes on to state that the response to potential conditions to which a vessel may be exposed can be expressed in many ways, such as the design of a new vessel, the modification of existing vessels, equipage, selection of route and strategy of the voyage (Gibbs 2006, p. 8). These variables can contribute to the prospect of a catastrophic event, responses to catastrophe and the nature of the artefact assemblage (Gibbs 2006, p. 10). The existence of responses to the threat phase can be compared and contrasted...
with the historic record, location of the site and the nature of deposition (Gibbs 2006, p. 10).

Gibbs recognizes different types of salvage operations. These are termed “opportunistic” and “systematic salvage”. Opportunistic salvage is defined as a short duration with intense focus on salvage of specific types of material where as systematic salvage occurs over extended lengths of time in order to recover as much of the cargo and structure of the vessel as possible (Gibbs 2006, p. 9). Gibbs also stresses the differences associated with sites that result from unintentional loss and those regarded as intentionally deposited. This concept is further expanded by Richards in his study of ship graveyards, but for sake of brevity will not be discussed here (Richards 2008).

Figure 2-3: Gibbs’ flow diagram of cultural factors affecting site formation (2006, p. 16).
Likewise, Jung (2009) identifies two types of salvage in relation to WWII sites located in Australia. These are termed “primary” and “secondary” salvage. Primary salvage is defined as operations undertaken by the owners or crew of the vessel (Jung 2009, p. 19), while secondary salvage occurs when individuals other than those who were directly involved at the time of loss recover items. This recovery generally takes place after a site is abandoned and relocated (Jung 2009, p.20).

Jung also incorporates Muckelroy’s description of continuous and discontinuous sites. Muckelroy defines a “continuous site” as one that is concentrated in a single self-contained area, whereas a “discontinuous site” is one that has been scattered and may be interrupted by sterile areas (1978, pp. 182-183). Site interpretation based on these concepts allows researchers to identify cultural activities that may have affected the site. Jung states for example that the presence of artefacts and personal objects inside a vessel may indicate that no secondary salvage has taken place (2009, p. 20). In contrast he also explores how sites may be raised, salvaged and moved to another location for discard. The archaeological signature for these sites is described as discontinuous due to the random deposits of material during the discard process (Jung 2009, pp. 22-28).

**Process Analysis as Applied to this Research**

Both historical and archaeological analysis of LVTs, the Battle of Saipan and the use of LVTs in Saipan will be conducted using the process approach. As identified in Chapter 1, certain research questions will be answered in relation to
answering how LVTs, and particularly the one under study, were modified based on pre-impact threats. Also of concern is how the particular LVT site being investigated came to be as it is today, particularly with regards to whether it was lost in battle at this location or was deposited there after the battle. Additionally, signs of possible salvage exist which raise questions about who conducted the salvage and at what stage did this salvage occur.

By using previous models of process analysis this thesis will explore those questions. Gibbs’s process model will be most useful in relation to pre-impact question of modification and behavior. The work of Muckelroy, Ward, Gibbs and Jung as they apply to loss and salvage also will be used to create a process model for better understanding the site formation of amphibious vessels.

Understanding the various cultural and environmental processes that may have influenced the formation of this archaeological site are key in determining the reason for the site’s location. By archaeologically examining the site and comparing this evidence to historic documents, disparities in the historic record may be identified and a greater significance for the LVT’s role in the battle obtained. Site signatures presented in the work of Muckelroy, Ward, Gibbs and Jung will be used to determine the site’s nature and the amount of salvage efforts conducted on it. This information will lead to understanding whether the LVT was catastrophically lost or intentionally deposited.

Process analysis has not been used to evaluate an archaeological site involving an amphibious vehicle. Thus, there is no model for what a salvaged verses un-salvaged LVT should look like or if a site was lost in battle or simply deposited in
the water post-battle. The amphibious nature of LVTs yields the possibility that the craft may have been catastrophically lost on shore and then discarded in the water.

The uniqueness of the LVT’s amphibious capabilities presents a challenge for site interpretation by the maritime archaeologist. Archaeological and historical research combined with process analysis can provide a more complete picture of the significance of LVTs used in the Battle of Saipan. The perceived threats to the vehicles by the Japanese defenders called for the vehicles to be modified prior to battle and process analysis has the potential to explore this course of action.

Process analysis of the LVT (A)-4 in Tanapag Lagoon will also help determine if this site was a catastrophic loss or deliberate discard. Historical research will provide an explanation concerning this site’s existence; archaeological research will provide insight into the modification and perceived weakness in vehicle design by those who operated them. By using the idea of pre-impact threat to evaluate the situation through the soldiers’ eyes it is possible to understand why these modifications were made. Finally through more historic research the significance of these modifications will be demonstrated through their adaptation to the design of later production models.
Chapter 3
History and Archaeological Literature Review
Introduction

“No AMTRACS no operation”

General Holland “Howling Mad” Smith

Modern amphibious warfare is not possible without the innovative technological advances made during WWII. The Solomon Islands campaign, in the Pacific, saw the need for new vehicles capable of delivering troops and cargo where traditional wheeled vehicles and boats were unable to travel. These vehicles needed to be capable of not only traveling through the water but also across shallow and sometimes exposed fringing reefs. The solution to this problem was the Amphibious Tractor also known as the Amtrac or Landing Vehicle Tracked (LVT) (Barker 2004, p. 3). This chapter will discuss the archaeological research, which has been conducted to date on LVTs and present a complete history of the LVT from its invention to its use in the Pacific, Saipan and afterwards.

Literature Review

Though much work has been done concerning submerged WWII sites, archaeological investigations of Amtracs have been mostly limited to resource inventory and site assessments. Thomas and Price (1980, p.33) mention a possible LVT in their Cultural Resources Reconnaissance Report for the Saipan Small Boat Harbor, Commonwealth of the Northern Mariana Islands, but do not mention any archaeological investigations beyond site identification. Carrell et al (1991) mention the location of a few LVTs during the National Park Service submerged cultural resource assessment of Micronesia; the LVTs were recorded
archaeologically, however Carrell acknowledges the fact that not much is known about LVT history concerning loss or disposal (Carrell 1991, p. 118).

Van Tilburg mentions several LVTs in *U. S. Navy Shipwrecks in Hawaiian Waters: an Inventory of Submerged Naval Properties* (2003). These LVTs may have been dumped after the May 1944 West Loch explosion, which destroyed equipment intended for the Invasion of Saipan. These LVTs are identified as LVT-1s and LVT-2s and are located in depths of water ranging from 1197-1200 ft (364.85-609.6 m) (Van Tilberg 2003).

In 2004, an LVT-4 was located buried on Guam. The site was interpreted as being an LVT that for some reason stopped running after making it to shore during the Invasion of Guam (Miller 2004). During reclamation projects in 1944 the LVT was used as landfill (Miller 2004). No mention of field expedient armor modifications was located.

In 2007 Steinberg investigated a submerged LVT-4 in Darwin Harbor, Australia. Archaeological investigation confirmed the site was a LVT and historical research revealed it was purchased as military surplus in order to act as a passenger ferry to Mandorah Beach. The LVT sank while being towed and never saw service as a ferry (Steinberg 2007, p. 9).

Southeastern Archaeological Research Inc. (SEARCH) conducted remote sensing surveys of Saipan’s western lagoons for cultural material relating to the Invasion of Saipan (Burns 2008, p. 84). The survey revealed an Amtrak in Tanapag Lagoon however no archaeological investigations were conducted by the group
beyond identification (Burns, 2008 p. 84). Parts of an Amtrac were also located in Garapan Lagoon with no further investigations conducted.

In 2009, Smith researched a LVT (A)-4 known to have been lost off of Stockton Beach New South Wales, Australia on 8 March 1954 at 02:00 (Smith et. al. 2009, p. 6: Smith and Ward 2009, p. 7). Five LVT (A)-4s were lost during a training exercise, however only one has been located (Smith and Ward 2009, p. 7). Historical accounts report that the weather took a turn for the worse, causing some of the LVTs to sink and others to capsize in heavy surf while trying to make it to safety. To date no work has been published concerning archaeological investigations of the known site.

Most secondary sources devoted to the Battle of Saipan only briefly mention the LVTs role during the invasion. These accounts refer to the vessels ferrying troops to battle before for the authors focus on the ground warfare (Brooks 2005, p. 136: Goldberg 2007, pp.57-75). Some accounts go into more detail by focusing on the negative aspects of the craft such as, it was a slow and cumbersome machine and the armor was considered too thin (Chapin 1994, pp. 1-2: Hardwood 1994, p.10: Rottman 2004, p.17).

Fortunately there are a few publications written by those who operated LVTs during times of war and saw first hand the unique capabilities the vessels possessed (Croizat 1992: Bailey 1976: Barker 2004). These primary sources point out that the flaws in the LVT’s design were not lost upon the crews who operated the machines and it is these crews’ ingenuity that led to the vehicles being modified (Mesko 1993:
These modifications directly influenced future LVT designs, thus assisting future troops in battle.

Works by Bailey (1976) and Barker (2004) give first hand accounts of LVT crews conducting modifications to LVTs before engaging in battle. This information led to a list of items to be investigated on the Tanapag Lagoon LVT (A)-4. Items such as boilerplate added to the upper and lower bow of the vehicle, as well as vision ports cut into the cab were mentioned in these sources. It was also learned that crews covered the upper deck portions of their vehicles with sandbags (figure 3-1). Sandbags helped stop bullets from penetrating the LVT and aided in preventing magnetic mines from being attached to the portions of the vessel that they covered.

Researching historical accounts of WWII produced a Master of Military Art and Science thesis by Matthew Boal entitled *Field Expedient Armor Modifications to US Armored Vehicles* from the U.S. Army Command and General Staff College (Boal 1994). Boal defines the modifications done by crews prior to engaging the enemy as “field expedient armor modifications.” In this study, Boal documents the crew level battle modifications of armored war machines, however no modifications to LVTs were noted.
Figure 3-1: Image showing expedient field modifications of using sandbags and extra armor around the turret top. (Photo: Department of Defense [USMC]).

*Roebling's Alligator*

As essential as the Amtrac was in the war effort it did not begin its career as a military vehicle. Donald Roebling designed the vehicle he called the "Alligator" for rescuing hurricane victims in the Florida Everglades (The United States Marine Corps Air-Ground Museum 1997, p. 3). Mr. Roebling began designing the Alligator in 1935 after witnessing the destruction and loss of life caused by a hurricane. He believed a machine capable of traveling through Florida's swamplands could save many lives.
Roebling constructed the Alligator with an aluminum hull, which greatly aided buoyancy. The vehicle was 24 feet long (7.32 meters) with a 92-horsepower Chrysler engine powering the tracks. The tracks mounted bolt on cleats known as grousers that acted as paddles in the water and provided traction on land. The original design of the grouser was a flat metal cleat that ran directly across the track. The Alligator was capable of a top speed of 25 miles per hour (40.23 Kilometers per hour (kph)) on land and 2 miles per hour (3.22 kph) in the water (Mesko 1993, p. 4).
Unhappy with the vehicle’s performance, Roebling began to modify his design. He experimented with different engines and stripped unnecessary weight from the vehicle and also varied the length and width of the Alligator. He found that the grouser design was the key to speed and efficiency in the water. Roebling’s third prototype featured a revised suspension that caused less drag in the water and the grouser was changed to a slightly curved shape that he mounted diagonally across the track. This new grouser design and revised suspension yielded a top speed of only 20 miles per hour on land, but speed in the water increased to 8.6 miles per hour. This revision of the Alligator caught national attention (Bailey 1986, pp. 37-38).

*Life Magazine* (Figure 3-3) ran an article featuring the Alligator in October 1937 (Life 1937, pp. 94-95). This article sparked an interest with the U.S. military and investigations into the feasibility of the vehicle’s use in military applications began. Initially Roebling was not interested in producing vehicles for the military, as he envisioned the Alligator for the purpose of saving lives. It took some convincing by military leaders that indeed his vehicle would be used to save lives of American soldiers and Marines who would be sent to war in the Pacific.
Figure 3-3: Life Magazine article featuring the Alligator. (Life Magazine 1937, p. 94).
Military production models of Roebling’s Alligator are commonly referred to as amphibious tractors, Amtracs and Landing Vehicle Tracked (LVT). The first production model was designated the LVT-1 by the military (Bailey 1986, p. 41). The LVT-1 design consisted of all steel construction and the driver’s cab was slanted back producing a lower profile. The vehicle was kept afloat by air contained in sponsons on both sides of the vehicle. It had a single propulsion system consisting of tracks mounted on the port and starboard sides. The tracks rotated on a rigid suspension system mounted around the sponsons. The engine used in the LVT-1 was a 150-horse power Hercules. The engine turned a drive shaft connected to the transmission, which rotated the drive sprockets that controlled the tracks. Steering the vehicle was accomplished through the use of two control sticks. The sticks operated the tracks independently, which gave the vehicle the ability to turn. By having one track moving forward and the other in reverse, the LVT was capable of turning in its own length. The tracks and suspension system were essentially the same as the Alligator and consisted of a rear drive sprocket mounted to the hull with an idler block mounted forward in the upper left portion of the hull. The idler block maintained tension on the track as it moved across the rigid suspension (Bailey 1986, p. 43).

After a series of tests and modifications to the construction of the Alligator, the Secretary of Defense awarded a contract to Roebling for an initial order of 100 LVTs in 1941, and quickly increased the contract to an additional 100 (Mesko 1993, p. 5). Once the vehicles reached military commands, crews realized that 200 LVTs
was not enough and additional orders were placed resulting in the production of 1,225 vehicles distributed to the Marine Corps, U.S. Army and Allied forces (Mesko 1993, p. 5). Roebling did not have the capacity for large scale manufacturing at his workshop, so he partnered with the Food Machinery Corporation located in Clearwater, Florida in order to meet the demand (Bailey 1986, p. 41).

The first alteration to the design specified by the military was in changing the all-aluminum construction to that of steel. Military thinkers did not believe aluminum to be a strong enough material for the harsh conditions of extended military use (Metz 1986, p. 4). Aluminum was also a relatively new material and fabrication processes were still being developed (United States Marine Corps Air-Ground Museum 1997, p. 6). Another change the military wanted was a new track design. It was thought the original track was not strong enough for continued use in seawater and sand (Bailey 1986, p. 59).

The LVT-1 was 21 ft. 6 in. long, 9 ft. 10 in. (2.77 m.) wide, and 8 ft. 2 in. (2.5 m.) tall (Bailey 1986, p. 43). It had the capacity to carry 4,500 pounds (2,041 kg.) of cargo 120 miles (193.12 km.) on land and 50 miles (80.47 km.) in the water (Mesko 1993, p. 7). Constructing the vehicle out of steel caused a reduction in speed due to the added weight. The all-steel LVT had a maximum speed of 12 mph (19.31 kph) on land and 6 to 7 mph (9.66-11.27 kph) in the water (Bailey 1986, p. 43).

The LVT-1 saw its first combat deployment during the Solomon Islands campaign (Metz 1984, p. 4). Originally intended as a logistical support vehicle solely for the delivery of cargo, military leaders quickly realized the versatility of these vehicles. At the landings on Guvutu-Tulagi, across from the main island of
Guadalcannal, military planners expressed concern about getting troops across the Fenaru River. The solution proved the versatility of the LVT. Engineers fabricated a bridge from scrap materials on board ship. The bridge was then mounted across the top of two LVT-1s. The LVTs carried the bridge to the river, pulled along side each other and acted as pontoons supporting the bridge while the initial assault force crossed (Bailey 1986, p. 53).

Being a new technology, the LVT-1 suffered from shortcomings in the design. One of these flaws was the track and suspension system (Mesko 1993, pp. 7-9). Overloading the vehicle combined with sand and seawater caused the bearings to seize, which meant the track was being drug around the track guides by the drive sprocket alone. Another serious issue was the slow speed of the amphibians. The Navy’s Bureau of Ships wanted the vehicle to obtain speeds of at least 15 miles per hour (24.14 kph) on land and 8 miles per hour (12.88 kph) in the water (Bailey 1986, p. 59).

_LVT-2_

Food Machinery Corporation reengineered the track and suspension system, which featured 11 rubber tires on rubber springs mounted to both sides of the vehicle at the bottom of the pontoons (Mesko 1993, p. 9). The track bearings were hermetically sealed to prevent sand and water from entering. The new design incorporated the front drive and power train of the M3A1 light tank, which allowed mud and other things to be discarded before the track links reach the drive sprockets. The new engine was more powerful and reliable than that of the LVT-1.
Four universal joints were also added to the driveshaft, which ran through the center of the cargo bay to prevent damage in the case of hull distortion (Bailey 1986, p. 59).

Perhaps the greatest contribution of the reengineering was the new grouser design. Food machinery Corporation tested over 100 grouser designs on model tanks and selected the best design (Metz 1984, p.4: Mesko 1993, p. 9: Bailey 1986, p. 57). The grouser chosen turned out to be a “W” shape (figure3-4). The new grouser did not cause lateral pressure and wear while in the water that the original grouser did (Metz 1984, p.4).

![Grouser Development](image)

*Figure 3- 4: Illustration of grouser design change. (Image: Mesko 1993, p. 12).*
The new design, designated the LVT-2 "Water Buffalo", was 26 ft. 2 in. (7.97 m) long, 10 ft. 8 in. (3.25 m) wide and 8 ft. 8.5 in. (2.66 m) tall (Mesko 1993, p. 11). Designers extended the bow, lowered the driver’s cab and lengthened the body giving the Water Buffalo a more streamlined appearance. It had a cargo capacity of 6,500 pounds (2,948.35 kgm) or 24 troops (Mesko 1993 p. 9). The 7-cylinder 200 horsepower Continental radial engine propelled the LVT-2 at a top land speed of 20 miles per hour (32.19 kph) and reached speeds of 7.5 miles per hour (12 kph) in the water (Bailey 1986, p. 59). There were mounts for one .50 caliber machine gun and four .30 caliber machineguns behind the cab and around the cargo area. Two thousand nine hundred and sixty-two LVT-2s were produced between 1943 and 1944 (Mesko 1993, p. 9). Early production models of the LVT-2 that were intended for assault purposes were fitted with armor kits to be welded on by the crews, however these models do not carry the armored (A) designation (Bailey 1986, p. 62; Mesko 1993, pp. 13).

**LVT (A)-2**

The manufacturer also produced later LVT-2 production models with armor around the cab and bow areas (figure 3-5). These LVTs were designated the LVT (A)-2 and were the first LVTs to receive the “A” designation signifying that they were armored. The armor around the cab was .5 in. (12.7 mm) thick and only .25 in. (6.35 mm) thick around the hull. Instead of plexiglass windows the armored version had an armored hatch that dropped down to protect the driver. Engineers fitted the top of the cab with two rotating periscopes to allow the driver to see while
in combat. Self-sealing gasoline tanks were also added to the assault version. The added weight of the armored versions caused a decrease in carrying capacity to 4,500 pounds (Mesko 1993, pp. 9-13). Food Machinery Corporation produced 450 LVT (A)-2s and delivered them to the Army.

Figure 3-5: Comparative drawing of LVT-1 and LVT-2. (Image: Mesko 1993, p. 9).
Logistics Involved with LVT Deployment

Marine troops were carried into battle aboard deep drafted troop transport ships (Grosvoner 1944, pp. 1-30). These ships also carried the traditional landing craft with the big forward ramp known as Landing Craft Vehicle, Personnel (LCVP) (Grosvoner 1944, pp. 1-30). The lifting arms on these transport ships were not strong enough to lift the LVTs so they were loaded aboard ships known as LSTs (Landing Ship, Tank). LSTs are shallow draft vessels with large bow doors that
allow the ship to pull into shallow water, open the bow doors, and have the vehicles they are carrying drive out (Grosvenor 1944, pp. 1-30). Marines climbed down cargo nets strung over the ships’ sides to LCVPs, which ferried them to the waiting LVTs. The whole deployment required two hours (Grosvenor 1944, pp. 1-30: Bailey 1986, p. 86).

**Tarawa**

The first combat use of the LVT-2 was in the Battle of Tarawa in the Gilbert Islands (Croizat 1992, pp. 88-89). The capture of the Solomon Islands gave the United States the ability to open an offensive drive through the islands of the Central Pacific. The Americans sought to capture the Northern Mariana Islands of Saipan, Tinian, and Guam effectively severing the Japanese main line of communications (Brooks 2005, p. 54). The first objective in this offensive was Tarawa Atoll and its airfields on Betio Island. Betio presented a new problem for the assault forces, a fringing reef with no known openings and subject to drastic tidal changes. If the tide was out traditional landing boats would not be able to deliver the troops ashore, thus leaving them stranded on the reef to wade across the lagoon under heavy enemy cross fire. This fact led to General Holland Smith, the landing force commander, telling Admiral Kelly Turner, the Amphibious Force Commander, “No Amtracs no operation” (Smith 1989, p. 20). This simple statement led to the LVT being deployed as an amphibious assault craft and with it came a significant change in how the Navy and Marines conducted amphibious operations.
LVT-1s and LVT-2s were both used in the invasions at Tarawa (Croizat 1999, pp. 96-97). The crews modified their LVT-2s in Samoa prior to being deployed to Tarawa (Croizat 1992, p.87). The modifications in Samoa consisted of mounting a 26 in. (66.04 cm) by 40 in. (101.6 cm) piece of 3/8 in. (.95cm) boilerplate to the front of the cab of the 50 LVT-2s. Crews also mounted a .50 caliber and two .30 caliber machineguns; one .30 caliber mounted near the stern of the vessel while the other two guns mounted just behind the cab (Bailey pg 84-91).

Seventy-five older LVT-1s from the 2nd AMTRAC Battalion located in New Zealand went through similar field expedient armor modifications prior to rendezvous in Tarawa. Armament of the LVT-1s included two .50 caliber machineguns mounted aft of the cab and one .30 caliber machinegun near the stern of the vessel. Armor plating measuring .25 in. (6.35 mm) thick were added to the sides and front of the cab along with a 1.5 ft² (45.72 cm²) armor plate attached to the inside of the cab to protect the driver (Bailey 1986, p. 84). Two large grappling hooks were also attached to the stern with the intention of being used to pull up Japanese defensive wire (Bailey 1986, p. 84) All of these modifications added weight to the LVTs and resulted in a reduction of speed.

LVT (A)-1

Food Machinery Corporation added a 37mm gun turret from the M5A1 Stuart light tank to the Water Buffalo, which resulted in the LVT (A)-1 (Mesko 1993, p. 21). Turreted versions of the LVTs are also known as Amtanks. In addition to the 37mm gun, the aft portion of the LVT (A)-1 possessed two gun tubs mounting a .30-caliber
machinegun each on scarf rings (figure 3-7). Later production models changed the ring mount to Mark 21 mounts and added a ball mounted .30-caliber machinegun in the cab at the radio operator’s seat. Food machinery Corporation produced 510 LVT (A)-1s in 1944 (Mesko 1993, pp. 21-24).

Figure 3-7: Comparative line drawing of LVT-2 and LVT (A)-1. (Image: Mesko 1993, p. 21).
**Marshall Islands**

The next step in stopping the Japanese expansion in the Pacific theater was the Marshall Islands (Croizat 1999, pp. 96-97). This island chain consists of many coral atolls all surrounded by shallow fringing reefs. LVT-2s and the new Amtank the LVT (A)-1 made their debut in the assault on the tiny islands of the atolls (Bailey 1986, p.106). The initial landings in Kwajalein Atoll at Mellu and Ennuebing Islands followed the same loading procedures as Tarawa, however for subsequent landings the plan changed to transporting troops in LCVPs over to the LSTs carrying the LVTs (Croizat 1989, p. 70). The troops then climbed up cargo nets strung from the sides of the ships where they would load into their assigned LVTs. Once loaded, the LST’s bow doors would open and the LVTs would make for the line of departure (Croizat 1989, p. 70).

The Marines continued to use their LVTs to gain control of the northern areas of Kwajalein Atoll while the Army worked their way through the southern portions of the atoll (Bailey 1976, p. 128). The Army used LVT-2s, LVT (A)-2s, and LVT (A)-1s to complete their objectives (Bailey 1976, p. 128). LVTs were then relegated to logistical duties after the initial invasion (Bailey 1976, p. 130).

**Mariana Islands**

The first objective in the Mariana Islands was securing the island of Saipan. A successful invasion of Saipan effectively placed the mainland of Japan within striking distances of U.S. B-29 bombers (Rottman 2004, pp. 7-8: Ministry of Defense 1995, p. 95). Japanese military leaders considered the Mariana Islands as their last
line of defense and fought to prevent the island from being seized by the Allies (Brooks 2005, pp. 101-226). As WWII continued, Food Machinery Corporation continued to redesign the LVT. New models were coming off the assembly line and Saipan would be their testing ground.

LVT-3 & LVT-4

Borg-Warner was awarded a contract to produce the LVT-3 but production problems delayed the LVT-3 from entering the war until the Okinawa campaign. The LVT-4 was the new cargo carrying design and was the same as the LVT-2 from the bow to the drivers cab. Engineers moved the engine from the rear of the cargo area to just behind the drivers seat (Metz 1984, p. 5). This move allowed the drive shaft to be run down the center of the cargo area and freed much needed cargo space. Designers incorporated a rear ramp to facilitate loading and unloading cargo (Mesko 1993, p. 14). The ramp also meant that troops no longer had to expose themselves to enemy fire while climbing over the sides. The redesign increased the carrying capacity by 2,500 pounds (1,133.98 kgm) allowing jeeps and 105 mm howitzers to be delivered. Food Machinery Corporation produced 8,351 LVT-4 Water Buffalos (Mesko 1993, p. 14). No armored versions were produced but armor kits were made available to forces to add and remove as missions dictated (Mesko 1993, p.m.14).
LVT (A)-4

Food Machinery Corporation also produced a new Amtank, the LVT (A)-4. The LVT (A)-4 is basically a LVT (A)-1 that has been slightly extended in order to mount a 75-mm howitzer turret to the top (Mesko 1993, p. 27). The turret of early production models possessed a single ring-mounted .50 caliber machinegun which designers later changed to two pintel mounted .30 caliber machineguns and added a ball mounted .30 caliber machinegun to the cab at the radio operator’s seat (figure...
These modifications became known as the “Marianas Model” but no change in model designation occurred (Mesko 1993, p. 30).

The high velocity round of the 37mm howitzer was effective against enemy armor but lacked the ability to destroy Japanese pillboxes and bunkers (Mesko 1993, p. 27: Collier 1949, pp. 54-55). The 75 mm howitzer provided a high trajectory, high explosive shell intended to destroy heavily fortified Japanese positions. This new artillery was welcomed by the troops, however it possessed a major flaw; the turret was not, thus covered making it vulnerable to enemy grenades and mortars. The lack of covering also left the turret machine gunner exposed to enemy fire making him a prime target (Bailey 1986, pp. 163-182).

Figure 3- 9: Comparative line drawing of LVT (A)-1 and LVT (A)-4. (Image: Mesko p. 27).
Crews began field expedient modifications to the early production model LVT (A)-4s as soon as they received them in preparation for the Invasion of Saipan (Barker 2004, p. 253). Modifications included: adding armor plating around the .50 caliber guns to help protect the gunner, adding .30 caliber co-axial machineguns to the cab in front of the radio operator’s seat and adding armor shields to the forward portion of the turret (Bailey 1986, pp. 163-168). All of these field expedient modifications had the goal of prolonging the life of the crew and the vessel.

*Saipan*

The island of Saipan is substantially larger than the atoll islands of the Gilberts and Marshalls. The larger geographic area called for a massive invasion force and the presence of fringing reefs demanded the use of LVTs. The assault plan called for the use of 600 troop-carrying LVTs preceded by 136 Amtanks (Rottman 2004, pp. 44-54). For this operation the troops were shuttled to LSTs carrying the LVTs six days before the invasion. This movement expedited forming the landing force on the day of the invasion. On the day of the invasion 47 LSTs assumed their positions near the fringing reef, 1,000 yards (914.4 m) from the line of departure (Chapin 1994, pp. 1-3). The LVTs disembarked and formed up at their respective landing zones with the Amtanks providing fire support from the sides. Four waves hit the beaches at timed intervals beginning at 0805 15 June 1944 (Rottman 2004, pp. 44-54). Rough seas capsized more than a few LVTs on the reef but the majority made it to shore (Chapin 1994, pp. 3-4: Rottman 2004, pp. 44-54).
The Amtracs were to reach their designated landing beaches and move 200 yards inland before unloading troops and then move further inland to what was called the 0-1 line (Chapin 1994, p. 4). This allowed the beaches to remain uncluttered for the arrival of subsequent waves of landing forces.

The rugged terrain of Saipan proved to be more than a challenge for the LVTs. Debris from previous air strikes and naval bombardments coupled with the rugged nature and thick forests of Saipan prevented the LVTs from penetrating to the planned 1200-1500yds (457-640m) inland (Rottman 2004 p. 51: Chapin 1994, p. 4). Most disembarked their troops on the beach under heavy fire.

After the initial assault, commanders employed cargo LVTs in a wide range of missions including: ship to shore supply delivery, evacuation of wounded to hospital ships, runs inland to supply dumps, assisting Underwater Demolition Teams with blasting a boat channel through the reef, fire fighting vehicles, and use as salvage vessels for pushing stranded landing craft off of the reef (Croizat 1953, p.46). Experiments with bridgehead ramps were also conducted by LVTs. These ramps consisted of iron supports with wooden decking chained to the top of a LVT. The LVT would pull up to a vertical shoreline of uplifted coral, unchain the bridge and back away (Croizat 1953, p. 46). The bridge would then slide off the front of the LVT and result in effectively widening a landing zone and permitting Amtracs to gain access to elevated beachheads. The invasion of Tinian saw the successful use of this landing method (Rottman 2004, pp. 47-84).

After securing the landing beaches, the Second Marine Division moved north along the western beaches taking control of Garapan before they met the Army's
27th Infantry Division. LVT (A) -4s from the Marine’s 2nd Armored Amphibian Battalion were used as artillery to destroy Japanese guns located near the water in the taking of Garapan (Chapin 1994, p. 28). After capturing Garapan, the Second Marine Division was placed into reserve status and the Army and continued to push beyond Garapan and northward through Tanapag Harbor to Tanapag where they were to meet up with the Fourth Marine Division (Rottman 2004, p.68). At this point it is noted that some amphibious tractors were sent for maintenance and repairs in preparation for the amphibious assault on Tinian (Bartholomees 1948, pp. 7-8). The salvaging of LVT components is not specifically mentioned, but it is reasonable to assume that the LVTs that were not capable of being repaired were stripped of all usable parts in order to repair other LVTs to operational status.

*Gyukysai*

On the night of 7 July 1944 General Saito, the commanding officer of the Japanese troops on Saipan, ordered a large-scale banzai attack. It is rumored that this attack was actually an act known as a *gyukysai* (Brooks 2005, p. 217). *Gyukysai* literally means, “breaking the jewel” and this is a reference to the three virtues of Japanese culture:

1) The Sword symbolizes true wisdom of decisions made decisively.

2) The Mirror represents the ability to see things, as they are good or bad in order to recognize true justice.
3) The Jewel characterizes the Japanese belief that they see themselves as gentile and pious people (Brooks 2005, p.217).

Breaking the jewel for all intents and purposes meant all Japanese regardless of age, sex or social standing must embrace a viciousness that would make the Emperor unbeatable against all odds. The Emperor himself is the only one who can order a gyukysai. However, General Saito told his forces that there was no longer a distinction between Japanese civilians and the Japanese military, implying the gyukysai had been ordered and all Japanese on the island where being ordered to fight the U. S. invaders (Brooks 2005, p. 217).

During the days leading up to the gyukysai, LVT (A)-4s are noted in historical documents to have provided artillery support during the taking of Garapan prior to U. S. forces moving onto Tanapag (Chapin 1994, p. 28). LVT use becomes unclear in the hours leading up to the final Japanese assault. The U. S. forces on Tanapag Plains could hear the gathering of people in the darkness singing songs and shouting while drinking sake (Chapin 1994, p. 31). At 03:55 on July 7, 1944 the Japanese mounted an attack on the U. S. positions just south of Tanapag (G2 1944, p. 50, Headquarters Fourth Marine Division 1944, p. 35).

Low on supplies, some Japanese armed themselves with knives tied to sticks and in some cases just pointed sticks (Bartholomees 1948, p. 6). The Japanese gathered in the tree line and complex network of trenches forward of the Americans position which offered cover and concealment from U. S. machine gun posts. The main group of Japanese attacked utilizing the approach route of a narrow gauge
railway that ran parallel to the beach through Tanapag Plains (Headquarters 106 Infantry 1944, p.23). This allowed them the ability to distribute the greatest amount of people in the quickest time possible to effectively overrun the U. S. lines. The goal of every Japanese solider that day was to take 7 U. S. lives for every Japanese death (Brooks 2005, p. 217). The U. S. positions were quickly overrun in the chaos (Headquarters 106 Infantry 1944, p. 22). The battle between the two opposing forces was in such close quarters that bodies of the Japanese dead piled up in the fields of fire of U. S. machine gunners and in some cases spilled into their positions (Chapin 1994, pp.32-33). Hand to hand combat quickly became necessary as U. S. troops fell back to more secure positions south towards Garapan (Chapin 1994, p. 34). U.S. forces were pushed back 3,000 yards (2,743 meters) before they were able to hold off the last of general Saito’s defenders. Most of the fighting ended by 11:30 on 7 July 1944 however combat operations continued throughout the day (Rottman 2004, p. 68). In the end 4,311 Japanese were found dead although some of these are accounted for from previous U. S. bombardments. A total of 451 U. S. troops were dead and 594 wounded in the battle (Rottman 2004, p. 68). It should be noted that official accounts and other historic accounts differ on the dates of this attack, probably due to the location of authors who wrote about the subject on either side of the international dateline.

The Role of LVTs During the Battle of Tanapag Plains

LVTs had been pulled off the front lines prior to the attack for maintenance and general repairs before the planned invasion of Tinian. It is unclear if the LVT
(A)-4s were included in this maintenance or if they continued in their role as mobile artillery supplementing the traditional artillery batteries and fighting in the swamplands where the mud was too thick for traditional tanks. What is clear through the historic documents is that LVTs were called upon to deliver supplies and ammunition to the troops fighting on the front lines of Tanapag Plains by approaching from the water directly to the front lines (Bartholomees 1948, pp. 8-13). They also evacuated casualties via water from the area of the attack to medical stations on return trips (Bartholomees 1948, pp. 11-13). The LVT’s ability to travel through the water allowed it to come within reach of the front lines, without drawing much enemy fire, and provide desperately needed relief.

The location of the LVT (A)-4 in Tanapag Lagoon, near where this battle took place, may indicate that LVT (A)-4s were being used on or near the front lines and after being destroyed it was disposed of just off shore. However, specific historic documentation has not been located at this time to lend support to this speculation. It is possible that the LVT (A)-4 was simply disposed of in a random location after being disabled in another battle and heavily salvaged.

The Invasion of Maniagassa (Managaha) Island

On 13 July 1944 U. S. forces staged what is described as a miniature amphibious landing on Maniagassa (now Managaha) Island in Tanapag Lagoon (Bailey 1976, p. 180). The island is approximately 250 meters wide by 300 meters long, surrounded by shallow reefs and located just outside the shipping channel to Tanapag Harbor. The island contained an element of Japanese soldiers and Korean laborers, thus
posing a threat to American shipping. The soldiers were manning the island’s three 120mm guns, which had been knocked out of action in previous U. S. bombardments (Rottman 2004, p. 69). Prior to the invasion, the tiny island was bombarded with naval artillery (Bailey 1976, p. 179). The soldiers on the island had been ignored until the main Japanese defenses on Saipan were eliminated. Marines from the sixth Marine Division attacked the island utilizing 5 LVT (A)-4s leading the way for 25 LVTs (Bailey 1976, p. 180). The battle lasted less than an hour (Bailey 1976, p. 180). Once the Island of Saipan was declared secure, LVTs were used to clear caves that could only be reached by water (Chapin 1994, p. 8).

*LVT Use After Saipan*

The Amtracs and Amtanks of the Marines and U.S. Army continued to prove their usefulness throughout the Marianas campaign, the Caroline Islands, Philippines, Iwo Jima and Okinawa (Croizat 1989, pp. 69-76). LVTs continued to benefit from design improvements for the duration of WWII in the Pacific. Not long after World War II ended the Armed Forces called the LVTs to battle in Korea (Croizat 1999, pp.82-75). This time the military called upon the LVT (A)-5 (figure 3-10).

The LVT (A)-5 is a version specifically designed to address the major problems of the LVT (A)-4 (Mesko 1993 p. 31). The LVT (A)-5 incorporates all of the modifications seen in LVT (A)-4s such as bow mounted machine guns and two machine guns mounted on the turret. The manufacturer raised the sides of the open turret and added view ports to both the turret and cab in order to help protect the
crew inside (Mesko 1993, p. 31). The turret was enclosed and incorporated a
gyrostabilizer to improve firing from the water, a major issue with the LVT (A)-4
(Mesko 1993, p. 31). LVTs were used again in the Vietnam War (Croizat 1989, p.
75).

Due to the continued struggle to improve this versatile machine, what began
as a humble cargo carrier is now the U. S. military’s Amphibious Assault Vehicle
(AAV-7A1) formerly known as the LVT-7 (Bailey 1986, pp. 244-266: Croizat 1989,
pp. 70-76: Croizat 1999, pp. 74-74).

Figure 3-10: LVT (A)-5 early and modified versions. (Image: Mesko 1993, p. 33).
Chapter 4
Methodology
Introduction

This chapter outlines the data collection techniques employed in the investigation of the LVT (A)-4 located in Saipan. The original location of the site will be addressed as well as events that led to the site becoming the focus of this particular study. Methodology concerning the archaeological survey and historical research will be outlined and a discussion of the ability to obtain information using process analysis is also explained.

Locating the Site

Southeastern Archeological Research Inc. (SEARCH) originally located the site of this LVT during an archaeological remote sensing survey in 2008 (Burns 2008, p. 84). SEARCH was under contract with the CNMI Historic Preservation Office (HPO) to conduct geophysical surveys to locate submerged cultural material in Saipan’s western lagoons. Photographs were taken of the site and a GPS coordinate was collected; no further investigations beyond target identification were conducted.

Initial Investigations

In July 2009, archaeologists from Flinders University conducted initial site investigations on the LVT (A)-4 to assess the feasibility of including the site in a WWII maritime heritage trail. This work was conducted in partnership with not-for-profit organization Ships of Exploration and Discovery (SHIPS), to which the National Park Service provided funding through a grant under the American
Battlefield Protection Program. Saipan’s Historic Preservation Office (HPO), Coastal Resource Management Office (CRM), and Department of Environmental Quality (DEQ) provided support in the form of survey equipment and boats. The remainder of equipment and staff were provided through Flinders University.

The investigation consisted of an initial 30-minute evaluation dive on the site. Divers photographed and noted key features, while searching for unexploded ordinance and other potential hazards to prospective trail visitors. The site evaluation also identified likely natural and cultural threats to the site and possible locations for permanent moorings. The marine ecology of the site and nearby reefs was also noted in order to determine the site’s ability to attract visitors. Researchers also noted a Japanese “pillbox” or gun emplacement on the shore directly to the east of the site location.

Archaeological Methodology

The site was visited once more in July 2009. Once all potential site evaluations were completed, it was agreed that the uniqueness of the site warranted further investigation. An hour long dive was conducted using basic maritime archaeological recording methods of baseline offsets, triangulation and trilateration to collect data including overall dimensions and possible cultural adaptations. Researchers took photographs of the entire site and a detailed sketch of the site was produced. A 65.62 ft. (20m) circle search was also conducted in order to determine if the site was isolated or associated with other cultural features. The dive was a nonintrusive survey with no cultural material being removed or disturbed.
Historical Research

In-depth historical research was conducted concerning WWII in the Pacific, and more specifically amphibious warfare and the use of LVTs. Web pages were used to collect initial data to be confirmed by other sources. Secondary data was collected from numerous published historical sources including books and military peer-reviewed journals. Primary sources were located at the Combined Arms Research Library (CARL), which is assessable online. CARL possesses a digitized library of documents concerning most U. S. wars both historic and modern. These documents range from declassified military plans, orders, journals and after action reports to monographs and masters theses concerning all aspects of warfare.

All documents and notes on documents were compiled into a research database utilizing EndNote software (Thomson Reuters 2009). The database serves as a digital library by organizing all sources alphabetically. Bibliographic information for each source was manually entered and EndNote allows for the attachment of files or URLs of the source as well as images, keywords and research notes for quick reference. Once this step was complete, materials were searchable by scrolling through the library or by using a keyword search. Organizing information in this way allows for use in future research and complete access to source materials.

Primary documents concerning the Battle of Saipan describe in detail how the battle was fought and the terrain the troops encountered. This information was used to evaluate the LVT (A)-4 site in Tanapag Lagoon through process analysis. Troop movements and obstacles concerning these movements are described in
numerous historic accounts and detailed maps are provided as well (Headquarters Fourth Marine Division 1944: Gugeler 1945: Bartholomees 1948: Adams 1950: Bailey 1976: Croizat 1992). These maps were used to demonstrate the dynamics of the battlefield and how terrain influenced the use of LVTs.

Perhaps the most important primary source for understanding potential processes that may have affected this site is the Department of the Army's *Technical Manual for LVT (A)-4s* (1951). This manual gives instructions on the operation, maintenance, armament, storage and the destruction of the vehicle to prevent enemy use. Of particular interest are the guidelines for the evacuation and/or destruction of essential parts once an LVT is disabled in combat. These procedures include descriptions of how to dispose of the LVT by means of sinking, burning, demolition and gunfire.

One important secondary source concerning WWII was a Master of Military Art and Science thesis by Boal entitled *Field Expedient Armor Modifications to US Armored Vehicles* from the U.S. Army Command and General Staff College (Boal 1994). In this study Boal documents the crew-level battle modifications of armored war machines. No modifications to LVTs were noted in this work, however it gave credibility to the idea that this LVT possessed battle modifications.

Works by Bailey (1976) and Barker (2004) give first hand accounts of LVT crews conducting field expedient modifications to LVTs as preparations before engaging in various battles across the Pacific. This information led to a list of items to be investigated on the Tanapag Lagoon LVT (A)-4. Items such as boilerplate added to the upper and lower bow of the vehicle as well as vision ports cut into the
cab were noted. It was also learned that crews covered the upper deck portions of their vehicles with sandbags. Vehicle modifications were not just limited to the exterior, some crews covered their radios with ponchos and they rolled condoms over the microphones as makeshift waterproofing (Barker 2004, p.7).

Figure 4-1: Image showing expedient field modifications to early model LVT (A)-4 consisting of sand bags, .30 cal. bow machine gun and extended armor around 75mm turret. (Photo: courtesy of Kathleen Dale).

For the purpose of this study, features are listed as anomalies observable on the LVT. In some cases a feature may represent an area of missing armor plates rather than listing each individual plate. Degradation and damage to the site as well as modifications are also listed as features. The features are numbered on the site plan for ease of reading.
Continued Archaeological Investigations and Methodology

In February 2010 archaeologists from Flinders University and SHIPS conducted further investigations at the site. The purpose of this survey was to record the site in detail in order to complete an accurate scaled site plan, record field expedient modifications and possible evidence of salvage and gather any additional data that may yield clues as to why this LVT is in its present location. In order to expedite this process, scaled drawings of a LVT (A)-4 were scanned from *World War II AFV Plans: American Armored Fighting Vehicles* (Bradford 2007, 80-81). The existing portions of the site were then traced from the images on to mylar and attached to slates so divers could more easily and accurately record what they were seeing.

![Example of line drawing from Bradford 2007](image)

Because the scaled drawings and the vehicles were constructed in the Imperial system of measurement all data was recorded in feet and inches. A
baseline consisting of a fiberglass reel tape was attached to the deck of the vehicle across the top of the port track. Offsets, elevations and declinations were taken to features along the baseline using a fiberglass reel tape and a fiberglass-folding ruler. Elevations and were also taken to the seabed. This information was intended to not only record the site in its present condition but also aid with monitoring the site and the environment in the future.

A total of three dives were completed on the site during the February 2010 investigation. These dives were nonintrusive and limited to what was visible above the sediment level. No cultural material was removed or disturbed. To aid in measuring armor plating a caliper was used to gauge the thickness of existing armor plates. All measurements were recorded and their location noted on the prepared slates.

After each dive the slates were transposed into field journals. The data was then used to produce detailed scale drawings and a site plan. All features of the site will be categorized and evaluated based on archaeological and historical data. Photographs taken during both the July 2009 and February 2010 investigations will be used to evaluate and interpret the site as it appeared when the research was conducted.

In preparation for photographs, archaeologist created photographic scales and north arrows out of available materials. One-half inch (1.27 cm) PVC piping was wrapped with black electrical tape at 50 cm intervals to create a 2-meter photo scale. North arrows were cut out of a plastic cutting board and weighted with .5 lb (.23 kg) lead fishing weight taped to the underside. A professional photographer
commissioned through SHIPS took photographs as well as a few divers with personal cameras. The photographer was mainly concerned with composition in order to present the site beautifully to the public. Archaeologists pointed out key features to be photographed. Confusion led to the photo scale not being present in all of the feature photographs and the north arrow not being present. All of the features were recorded photographically.
Chapter 5
Analysis
Introduction

This chapter will discuss the archaeological data collected during the July 2009 and February 2010 investigations of the LVT (A)-4 site in Tanapag Lagoon, Saipan. Findings will be explained using a combination of photographs, tables and site plans. A brief explanation of possible site formation processes will be presented using process analysis.

Location

The site is located in Tanapag Lagoon on the northwestern side of Saipan, Commonwealth of the Northern Mariana Islands (figure 5-1). The site is submerged in 2 - 10 ft (.61 - 3.05m) of water roughly 3,280.84 ft (1000m) from shore. The LVT is situated in a sandy area on the outside edge of a large patch reef. This area of the lagoon is home to numerous tropical fish and rays as well as sea turtles, hard and soft corals and other marine flora. The site is presently being colonized by some of these marine species.

Figure 5-1: Image of Saipan survey area circled in yellow. (Image: Google Earth. Date accessed 10 March 2010).
July 2009 Findings

In July 2009 archaeologists from Flinders University conducted an initial site investigation on the LVT (A)-4 in Tanapag Lagoon. The objective of these investigations was to locate and identify key features to be used in determining the exact production model of Amtrac. Key LVT features noted were the shape of the grouser, the overall length and breadth of the site, the drive sprocket, suspension, drive shaft, bow towing ring, windscreen and turret. After the inspection, historical research determined that the Amtrac in question is an early production model Landing Vehicle Tracked (Armored)-4.

The early production LVT (A)-4s are recognizable by the semi-closed 75mm Howitzer turret with a single .50 caliber machinegun scarf ring on the rear (Mesko 1993, 30). Also, the towing ring on the bow is mounted horizontally while late production models have a vertical towing eye through which a large shackle is secured (Department of the Army 1951, 6-8). The windscreen of later production model LVT (A)-4s possessed 2 viewports whereas the early models had a single armored hatch for the crew to secure during battle operations. Also the early model LVT (A)-4s did not come equipped with a .30 caliber machine gun port in the bow. This information allowed archaeologists to identify of field expedient armor modifications done in response to pre-impact threat assessments.
**February 2010 Investigations**

The purpose of the February 2010 investigations were to record the LVT (A)-4 in finer detail in order to complete an accurate scaled map of the site, to determine if more field expedient modifications were present, to record the extent of salvage operations undertaken and to gather any additional data that may yield clues as to why this LVT is in its present location. Features noted during this survey included any areas that appeared to be damaged (holes), modified (anything not in the original design) and evidence of salvage (evidence of missing components, cut marks). These data are reflected in the LVT site plans (figure 5-4).
Figure 5-3: Port side profile of LVT (A)-4 in Tanapag Lagoon. (Image: Arnold 2010).

Figure 5-4: Plan View of LVT (A)-4 in Tanapag Lagoon. (Image: Arnold 2010).
Feature 1

One of the most obvious features of the site is the absence of almost all of the armor plating across the deck, cabin, tracks, and engine room (figure 5-6). The top and port side of the armored driver's cabin is also missing as well as most of the starboard side of the cabin. After conducting a 360-degree non-disturbance circle search out to 65.62 ft (20m) around the site none of the armor plating or any other cultural material was located.
**Feature 2**

The 75mm turret has settled into the below deck space underneath it. The LVT (A)-4’s superstructures support the turret in combination with lateral support beams, transverse beams and a rear transverse bulkhead, which act to elevate the turret above the driver’s cab in operational LVT (A)-4s. Upon further investigation, it was noted that the lateral superstructure support frame on the port side has sheared off and settled inside the below deck space (figure 5-7).
The starboard side frame is bent downwards in an arch from the bow to the stern and sheared off where it is supposed to connect to the aft transverse bulkhead (figure 5-8). The declination of the starboard lateral support was recorded from the aft transverse bulkhead to the point where the bow plating meets the support (table 1). It was discovered that the vertical supports for the superstructure are bent in a
“U” shape in the forward section and missing towards the aft portion (figure 5-9). It was also found that the transverse support beams and transverse bulkhead are collapsed under the turret (figure 5-10).

Figure 5-8: Photo demonstrating the Starboard Lateral support outlined in yellow with 2m scale. (Photo: courtesy of Ships of Exploration and Discovery).
Table 1: Starboard Lateral Support Declination From the Aft Transverse Bulkhead to the Point Where the Bow Plating meets the Lateral Support.

<table>
<thead>
<tr>
<th>Baseline</th>
<th>Declination</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.51ft (2.9m)</td>
<td>22.44in (57cm)</td>
</tr>
<tr>
<td>10.17ft (3.1m)</td>
<td>22.44in (57cm)</td>
</tr>
<tr>
<td>10.83ft (3.3m)</td>
<td>20.05in (56cm)</td>
</tr>
<tr>
<td>11.48ft (3.5m)</td>
<td>20.05in (56cm)</td>
</tr>
<tr>
<td>12.14ft (3.7m)</td>
<td>19.69in (50cm)</td>
</tr>
<tr>
<td>12.80ft (3.9m)</td>
<td>18.50in (47cm)</td>
</tr>
<tr>
<td>13.50ft (4.1m)</td>
<td>16.93in (43cm)</td>
</tr>
<tr>
<td>14.76ft (4.5m)</td>
<td>10.24in (26cm)</td>
</tr>
<tr>
<td>15.42ft (4.7m)</td>
<td>6.30in (16cm)</td>
</tr>
<tr>
<td>16.10ft (4.9m)</td>
<td>3.54in (9cm)</td>
</tr>
<tr>
<td>16.40ft (5m)</td>
<td>1.20in (93cm)</td>
</tr>
</tbody>
</table>

Figure 5-9: View of bent vertical support outlined in yellow with 2m scale. (Photo: courtesy of Ships of Exploration and Discovery).
Figure 5-10: Collapsed transverse bulkhead outlined in yellow under turret. (Photo: courtesy of Ships of Exploration and Discovery).

Feature 3

Four large holes were identified in the lower portion of the bow (figure 5-11). The open areas appear to correspond to the bow’s superstructure. The holes were plotted using triangulation from the still present portions of the bow and added to the site plan. The existing plating was gauged with calipers in order to determine if the LVT crew had performed the field expedient modification of adding boilerplate to the hull. The lower hull plating thickness ranges from $\frac{3}{8}$ in (9.52
mm) to 5/8 in (16 mm).

Figure 5-11: View of holes in bow. (Photo: courtesy of Ships of Exploration and Discovery).

Feature 4

The upper portion of the bow exhibits a hole directly in front of the driver’s cabin (figure 5-12). The existing metal around this perforation was gauged using calipers. The thickness of this metal is 5/8 in (16 mm). The hole is of an indeterminate nature but may be evidence of the use of a cutting torch, indicating secondary salvage.
**Feature 5**

A coaxial mounted .30 caliber machine gun port is present in the windscreen of the driver’s cabin (Figure 5-13). This gun port is located in front of the radio operator’s seat. The coaxial mount is 11 in² (27.94 cm²) at its base and tapers to 6 in² (15.24 cm²) around the gun port. This is an armament feature that was not included in LVT (A)-4 design until after the Battle of Saipan.
Other than the front windscreen, the cabin structure is almost completely missing. The front windscreen possesses a .30 cal. coaxial machine gun mount (figure 5-13) and an armored hatch cover in front of the driver’s seat (figure 5-14). The top of the cabin area is missing just aft of where the armored covering should meet the windscreen (figure 5-15). The interior of the cabin has been stripped of all nonessential machinery, but the driver’s side still possesses the driver’s seat, steering controls and instrument panel containing the engine gauges *in situ* (figure 5-16). There are no other instruments or electrical panels present. The transmission is *in situ* along the centerline of the cabin. The compass of the vehicle, which mounted to the top of the transmission housing to the right of the driver, is also missing. The radio operator’s area is in total disarray and the radios and
connecting wires are missing. The .30 cal. machine gun is not present. Hoses from the transmission and a pile of debris lay where the radio operator's seat was once located. There also appears to be damage to the hull panels forward of the radio operator's station, which allows one to see out of the bow through Feature 3.

Figure 5-14: Concreted armored hatch cover located at driver's seat. (Photo: courtesy of Ships of Exploration and Discovery).
Figure 5-15: Overview of cab area. (Photo: courtesy of Ships of Exploration and Discovery).

Figure 5-16: View of instrument panel through the steering controls. (Photo: courtesy of Ships of Exploration and Discovery)
Feature 7

Large holes are present in the pontoons on both sides of the vehicle (figure 5-17). These holes are located just aft of the forward step pockets and penetrate through the pontoon to the interior of the craft (figure 5-18). The holes are 25.59in (65cm) in height from the sediment level and 13.79in (35cm) at their widest point. The metal plating of the pontoons is solid with little sign of corrosion.

Figure 5-17: Overview of portside pontoon with large hole. (Photo: courtesy of Ships of Exploration and Discovery).
Feature 8

The turret is basically an empty shell, it has been stripped of its 75 mm Howitzer, all of the fire controls and all of the manual and electrical turret traversing controls (figures 5-19, 5-20, 5-21). What is most significant about the remains is the addition of 3/4 in (19.05 cm) armored plating around the .50 cal. machinegun scarf ring. The armored shield is arranged in a semi-closed octagonal shape with one opening of the shield around the mount for the .50 cal. machinegun at the stern. A larger opening is at the forward center of the scarf ring. It appears that the armor shielding did not allow for the machine gun to move freely and would rely on the movement of the turret to engage enemies. The armor shield consists of four armored panels 11 in (27.94 cm) high. The lengths of the panels vary; on the port
side one panel is 14.5 in (36.83 cm) long and the other is 12 in (30.48 cm) long and the starboard side of the shield consists of a 14 in (35.56 cm) long panel and an 11 in (27.94 cm) long panel. Another point of interest on the turret is an apparent corroded machine gun mount on its port side (figure 5-22).

![Figure 5-19: Detail of turret traversing gears. (Image: Department of the Army).](image)

![Figure 5-20: Modified armored shield outlined in yellow and possible machinegun mount outlined in red. (Photo: courtesy of Ships of Exploration and Discovery).](image)
Figure 5-21: Detail of modified armored shielding. (Photo: courtesy of Ships of Exploration and Discovery).

Figure 5-22: Detail of possible machinegun mount. (Photo: courtesy of Ships of Exploration and Discovery).
**Feature 9**

The engine compartment of the vehicle is void of almost all machinery other than the radial engine (figure 5-24). Hoses, pumps, filters, vents, generators, air cleaners and oil coolers are all missing (figure 5-23). Additionally, there is a great deal of sediment located in the compartment; other components may be located beneath this sediment layer. The engine is mostly covered with sediment, and only three of its cylinders are exposed. The cylinder heads and valve covers have been removed and are filled with sediment. Two exhaust mufflers are *in situ* along the transom however their flexible hoses are missing. It is reasonable to assume the engine components were either salvaged or deliberately dismantled to prevent further usage.

*Figure 5-23: Detail of LVT (A)-4 engine as it appears installed. (Image: Department of the Army).*
Feature 10

The splashguards of this LVT are missing and the fender bracket around where the splashguards should be located appears to have been cut (figure 5-26). The bracket should be a triangular shape and mount to the transom and around the back of the splashguards to the outside of the track cover (figure 5-27).
Site Formation

Historical research reveals that LVTs were used in this area during two separate fighting engagements. The first mention of LVT use in this area was during the last banzai charge of the Battle of Saipan on 7 July 1944. During this battle LVTs used the waters of Tanapag Lagoon as an avenue of approach and exit. This avenue
allowed the machines access to the core area of the battle in order to deliver supplies and evacuate casualties (Bartholomees 1948, pp. 10-13). The second mention of LVTs operating in this specific study area is on 13 July 1944 when U.S. Marines conducted a small scale amphibious assault on what is now Managaha Island in Tanapag Lagoon. Sources state 5 LVT (A)-4s escorted 25 LVTs to the island (Bailey 1976, p. 180: Rottman 2004, p. 69). LVT operations in this area were undoubtedly not limited to these two actions however no other specific mention of LVTs in this study area have been located at this time. No historic sources have been located that mention the catastrophic loss or disposal of any LVTs in this portion of the lagoon.

Conclusion

This chapter has established the archaeological findings of this investigation. Through archaeological recording and historical research it has been determined that this Amtrac is an early production model LVT (A)-4 based on the turret design, windscreen and towing eye. Historical sources have produced evidence that LVT crews did routinely modify their vehicles before combative actions and it appears that the archaeological evidence supports this activity. Historic research has also linked LVTs activities to this study area however it remains to be determined if this LVT was one of those involved in the two missions within this area.

The next chapter will discuss possible explanations for the modifications based on the required tasks of the LVT (A)-4 crews. Process analysis will illustrate
the perceived necessity of battle modifications and possible reasons for the site’s formation.
Chapter 6
Discussion
Introduction

The purpose of this chapter is to discuss further the archaeological features described previously and how process analysis is used to examine the natural and cultural factors contributing to the site’s formation. Key processes such as pre-impact threat phase and salvage operations will be used to explain the occurrence of specific archaeological features and will be examined and contextualized through historical documentation.

Pre-Impact Threats, Strategies and Assessments As Identified in the Historic Record

In order to clearly demonstrate the need for and use of amphibious landing craft in the Battle of Saipan, it is necessary to first identify the pre-impact threats, strategies and assessments of the U.S. forces. The U.S. invaded Saipan from the western side of the island (Ministry of Defense 1995, p. 3) and in doing so positioned itself to intercept Japanese counter attacks and resupply efforts. This decision was based on intelligence reports that gave a good indication that the Japanese fleet was near the Philippines to the West (Ministry of Defense 1995, p. 125). Additionally, the U.S. learned through aero-reconnaissance that Saipan’s western beaches were not as heavily fortified as the rest of the island (Goldberg 2007, p. 22). Earlier air and naval bombardments eliminated the threat from key areas on the western side of Saipan, such as aircraft standing by on airstrips and large caliber weapons located on Managaha Island. However, the beaches chosen for the invasion possessed a fringing reef roughly 1500 meters offshore of the chosen landing sites. This reef was far too shallow for traditional landing boats to
cross and would have left the invading troops completely exposed while walking toward the beach under concentrated enemy fire.

The answer to the problem of getting the troops to shore without completely exposing them to the enemy was the Landing Vehicle Tracked (LVT). This piece of technology had been tried and tested from the opening stages of WWII in the Pacific beginning with the invasion of the Solomon Islands and proved itself to be a vital piece of equipment in the campaigns leading up to Saipan’s invasion (Bailey 1976, pp.53-211). Now in its fourth generation of production, the LVT would prove its worth once again.

The fringing reef and lagoon were not the only features of the terrain. The western beaches contained Japanese fortifications in the form of reinforced concrete bunkers containing artillery and machine guns and dense vegetation further inland. Additionally, range markers were located throughout the lagoon to aid Japanese artillery and mortar crews to rapidly and effectively fire on the arriving U. S. forces (Adams 1950, pp.10-12, Goldberg 2007, p. 55). These factors obviously influenced the decision to culturally modify LVTs by means of field expedient modifications.

*Overcoming Threats and Creating Strategies through Technology and Modification*

The shallow fringing reef demanded the need for amphibious vehicles. The Landing Vehicle Tracked (Armored)-4 (LVT [A]-4) was designed specifically to destroy Japanese reinforced bunkers in response to the pre-impact threat phase of planning the operation (Mesko 1993, p. 27). Because U.S. air and naval bombardment ceased once the landing vehicles neared the beach, the LVT (A)-4s
provided the only close-in, large caliber weapons support for the troops arriving behind them (Barker 2004, p. 4). These amphibious tanks led the way in front of the waves of landing forces coming ashore.

Because these vehicles had the job of being the first in the line of enemy fire, it is no wonder that the crews operating them chose to modify their vehicles for better protection. Crews learned from previous battles in the Pacific theater that LVTs were lightly armored. However, the manufacturer never corrected this weakness due to buoyancy requirements at sea and speed requirements on land. It is noted historically that the LVT crews regularly added sheets of steel boilerplate to the bows of their craft because the armor was so thin coral would regularly puncture it while crossing shallow reefs (Barker 2004, pp. 253-254, Mesko 2004, pp. 27-28). Also documented is the fact that the armor was incapable of preventing small caliber rounds from penetrating to the interior of the vehicle (Bailey 1976, p. 168). This fact is acknowledged by the adoption of a policy to carry wooden plugs for the purpose of shoring any holes while the vessel was underway (Bailey 1976, p. 168). The addition of sandbags across the deck also added a layer of extra protection for the men inside (Barker 2004, pp.253-254).

Modifying the bow armor by adding boilerplate (Feature 3) and sandbags lowered the vehicles profile in the water, which would cause the LVTs to take on water in rough seas. On land these modifications caused a reduction in speed, which made the already slow moving vehicle an easier target for the enemy. Given the trade off of speed and reduced freeboard for added protection, these modifications indicate that the crews were more concerned with protecting themselves from
enemy fire then maneuverability. The lower silhouette in the water caused by the addition of weight from the added boilerplate meant less target area to the enemy. LVT (A)s were never intended to replace traditional tanks, therefore the reduction in speed on land may have seemed a reasonable exchange.

The original design of the LVT (A)-4 called for a semi-closed 75mm turret with a single .50 cal. machine gun mount on the stern (figure 6-1). It has also been noted that crews added improvised armor shields (Feature 8) around the .50 caliber machinegun mount built into the turret. This response to pre-impact threat analysis addressed the fact that the machine gunner was all but completely exposed to enemy gunfire (Mesko 1993, p. 27). Therefore this shielding is a definite attempt at self-preservation. The addition of an armor shield around this machine gun mount seems appropriate considering the fact this vehicle was intended to lead an assault on a well fortified beach (Barker 2004, pp.253-254). The operators were prolonging the life of the crew and as a result prolonging the life of the vessel by welding steel plates around the .50 cal. gun mount.

Another perceived problem with the original design of the LVT (A)-4 was that there was no machinegun in the bow of the craft (Mesko 1993, p. 27). A bow machinegun added to the maximum firepower of the vehicle on targets in the path of the invasion force. By adding a .30 caliber coaxial machine gun port to the area in front of the radio operator’s seat, the crew effectively increased their ability to bring enemy targets under fire therefore decreasing the vulnerability of the LVT (Mesko 1993, p. 27). The addition of a coaxial-mounted .30 cal. machine gun (Feature 5) allowed the radio operator the ability to defend the vehicle from an enemy frontal
attack. The position of this weapon also enabled the radio operator to administer suppressive fire while storming a given beach. The addition of a coaxial-mounted .30 cal. machine gun to the bow of the LVT (A)-4 appeared on the later production models perhaps as a direct result of the modifications made by LVT crews in Saipan. Increasing the firepower of the vehicle aided in increasing its lifespan by lessening the enemy’s opportunity to shoot at it.

The U.S. military also established guidelines on what to do in the event an LVT was knocked out of battle. The Army’s technical manual for LVT (A)-4s outlines the proper steps for the evacuation of equipment usable by the enemy and destruction of the vehicle to prevent enemy use (Department of the Army 1951, pp. 565-569). The processes of primary salvage are outlined in this manual by indicating what type of equipment should be evacuated or destroyed and the processes of discard and abandonment are described by various means.

“Marianas Model”

![Comparative image of early and late production LVT (A)-4.](Image: Mesko1993 p. 30)
Archaeological Evidence of Field Expedient Armor Modifications and Salvage Efforts

The LVT (A)-4 located in Tanapag Lagoon demonstrates cultural modifications made at the crew level. It is reasonable to assume that the crews operating these machines were the first to notice design flaws and set about modifying the LVTs in order to compensate for the lack of armor and armament prior to the amphibious assault on Saipan in response to threat phase evaluations. These features undoubtedly influenced on the design of later production models of LVT (A)-4s nicknamed the “Marianas Model”. Flaws in the original LVT (A)-4’s design led to the incorporation of new features to the vehicle.

Figure 6-2: LVT (A)-4 site in Tanapag Lagoon diagram of features. (Image: Arnold 2010).
Armor plating missing from the site (Feature 1) may be a result of salvage prior to or after disposal of this LVT. It is unlikely the armor plates would have deteriorated under natural conditions or floated away. The 20m-circle search did not reveal any cultural material related to this or any other wreck signifying this is a continuous site due to the lack of a debris field. If the LVT in question was the victim of enemy action while underway in the lagoon, it is reasonable to assume that there would be debris associated with a catastrophic event scattered around the site.

The lateral supports, stanchions and transverse bulkhead (Feature 2) demonstrate signs of severe stress. The starboard stanchions have bent causing the starboard lateral support to arch downwards towards the turret, while the port lateral support is sheared off completely. It is unclear if this is evidence of battle damage, intentional destruction during the disposal process or if the turret collapsed upon itself due to deterioration. The severity of damage to the superstructure is observable both fore and aft of the turret.

The transverse bulkhead and associated support beams were located collapsed under the turret. Thus it is possible that over time the weight of the turret and degradation of the structural supports caused the collapse. Another possible reason for the collapse is outlined in the Army's technical manual for LVT (A)-4s. This manual describes that during the process of disposal one should place a “3-pound charge against the right fuel tank between the engine and bulkhead” (Department of the Army 1951, p. 568). This disposal method may have caused the
bulkhead to collapse under the turret and result in the lateral supports giving way under the weight of the turret.

The actual gauged thickness of the lower bow plating (Feature 3) is 5/8 in (15.88mm). In contrast, the thickness of the lower bow plating of the LVT (A)-4 as it came off the assembly line was 1/4 in. (6.35mm) (Department of the Army 1951, p. 15). The hole discovered in the upper bow (Feature 4) area was gauged to be 5/8 in (15.88mm). The manufacturer’s specifications for the armor plating on the upper portion of the bow was 1/4 in (6.35mm) (Department of the Army 1951, p. 15).

These gauged thicknesses of the armored plates on the lower portion of the bow indicate an added layer of protection that can be categorized as pre-impact modification due to a perceived threat. If the original specification of 1/4 in (6.35mm) armor plating is added to the historically documented practice of adding 3/8 in (9.53mm) boilerplate to the lower portion of the bow, the sum of the combined thickness equals 5/8 in (15.88mm). It is reasonable to assume that the range of measurements may be due to the deterioration and/or battle damage to the vessel. Nevertheless, based on the manufacturers’ specifications, the bow of this vessel appears to have been modified by adding extra steel however. The reason for the holes being present is unclear. The hole in the upper bow is an irregular shape. Some possible explanations are damage due to explosion or a very quick cutting job during salvage operations to access gear inside the cabin.

The above and port side of the drivers cabin (Feature 6) is completely missing. It can be assumed that a direct hit by enemy ordnance would cause severe damage to a vehicle of this construction, but the archaeological signature of this site
suggests intense salvage efforts. If this were the site of a catastrophic loss it would be reasonable to assume that some of the heavier vehicle fragments would be located on or around the site as indicated by Muckelroy’s process model (Muckelroy 1978, p. 158). Additionally, the characteristics of metal damaged by ordinance included jagged, rough and inconsistent edges. The LVT displays none of these characteristics in this area.

The missing areas of the cab may have been cut away for easy access in order to salvage machinery. The lack of superstructure and upper deck plates may indicate removal for salvage purposes prior to disposal. The lack of equipment present in the cab may also indicate intentional disposal after salvage. The removal of all usable items from a vehicle being disposed of is outlined in the Army’s technical manual for LVT (A)-4s (Department of the Army 1951, pp. 565-569). The manual also states that a “2-pound charge be placed on the left side of the transmission as far forward as possible” during disposal (Department of the Army 1951, p. 568). Being that this manual dates to 1951, it may be possible that these guidelines were not in place during the Battle of Saipan. If true, the charge may have been placed on the right side of the transmission or a hand grenade may have been tossed into the cab and landed in the radio operator’s seat. This may account for the holes in the starboard lower bow and the general disarray of the radio operators’ station. Interestingly, the fact that the steering controls and instrument gauges are in situ may be indication of disposing the vehicle while under its own propulsion.

If the holes in the pontoons (Feature 7) were located at the step pockets they could be argued to have occurred due to degradation. However the step pockets are
intact on both sides of the vehicle with minimal signs of deterioration. Because the holes are not located in what could be considered a weak point in the pontoon and the step pockets are present, it is reasonable to conclude that the holes are a deliberate indication of either discard or battle damage. These holes may have been caused by placing explosives inside the pontoon or possibly by large caliber weapons. Both of these methods of the vehicle disposal process are outlined in the Army's Technical Manual for LVT (A)-4s. The manual indicates that the discard of an LVT by means of demolition requires that a 2-pound charge should be placed at the center of the tracks and that the charges should be connected by detonating cord (Department of the Army 1951, p. 568). Discard by gunfire is outlined by firing all available weapons at the engine compartment, suspension and armament in the order specified. (Department of the Army 1952, p. 569). Again the archaeological signature of the site points to deliberate discard.

The turret (Feature 8) has been stripped of the howitzer, sighting optics, traversing mechanics and firing controls. The evacuation of these items during the disposal process is explicitly stated in the Army's Technical Manual for LVT (A)-4s. “All items of sighting and fire control equipment, including such items as periscopes, telescopes, and binoculars, are costly, difficult to replace, yet relatively light; hence, whenever practicable, they should be conserved and evacuated rather than destroyed. In the event of subsequent abandonment, the equipment will be completely destroyed, all optical elements and mountings smashed and firing tables, trajectory charts and inflammable items burned” (Department of the Army 1951, pp. 565-569).
The possible machine gun mount on the port side of the LVT’s turret may have been added in order to compensate for the lack of mobility of the .50 cal. machinegun due to the addition of the field expedient modified armor shield (figure 6-2). Late production LVT (A)-4 models did away with the .50 cal. machinegun mounted on the rear of the turret and replaced them with two .30 cal machineguns mounted on both sides of the 75mm turret. If this possible mount were used to support a machinegun it would be a threat phase cultural modification and is a direct link between expedient armor modifications and the development of later production models.

Figure 6-2: Early model LVT (A)-4s with square modified armor around .50 machine gun turret and what appears to be a .50 machine gun mounted to the port side of the turret.

(Photo: courtesy of Kathleen Dale).
The lack of equipment present in the engine compartment (Feature 9) may be due to deterioration processes over time. It is possible that the rubber engine components have decomposed, however the valve covers and cylinder heads would have to be manually removed. It is unknown if their removal occurred prior to or after this vehicle was sunk. The lack of machinery suggests that this LVT’s engine compartment was stripped of all usable parts. The Army’s technical manual for LVT (A)-4s does not specifically state how to disable an engine during disposal. However, it does state that a boat be brought along to the site of discard to pick up the crew if the LVT is under its own power. If this vehicle was disposed of under its own power the engine would have to be intact in order to operate.

The missing splashguards (Feature 10) may offer further evidence of salvaging every usable part from the LVT. The fender assembly appears to have been cut in order to easily remove the splashguards on both the port and starboard sides.

**Conclusion**

The design of the LVT (A)-4 is what Gibbs (2006) describes the creation and modification of a new vehicle in answer to pre-impact knowledge gathering. This LVT (A)-4 shows signs of pre-impact threat modification due to the perceived risks associated with its mission objectives. The extent of processes related to physical deterioration is not known at this time. If any organic or rubber materials were present at the time of sinking they would have most likely decomposed. Most of the existing steel is still solid and shows little sign of degradation.
The lack of materials in or around the site suggests salvage processes, however it is unknown to what extent primary and secondary salvage occurred (figure 6-6). The evacuation of all vehicle elements usable by the enemy prior to disposal is outlined in the Army’s technical manual for LVTs (Department of the Army 1951, pp. 565-569). The Army’s technical manual for LVT (A)-4s proper process for disposal appears to have been followed in most cases. There is evidence of evacuation of equipment (Features 1, 4, 6, 8, 9, 10), possible damage by gunfire (Features 3, 7) and/or possible damage by explosives (Features 1, 2, 3, 7). One discrepancy is that the manual calls for a craft to be dumped at a depth no less than 50 ft. (15.24 m). The depth at which this site is located allows easy access for anyone with a shallow draft vessel to access the site. This might be explained by the distance from shore having been deemed far enough to prevent recovery, or the LVT may have been dumped after the island was secured. An alternative is the vessel may have been under its own power during the disposal process, accidentally flooded en route and was simply abandoned. The method of disposing of an LVT by sinking while under its own power is outlined in the Army’s Technical Manual for LVT (A)-4s with a note of caution: “If a drain plug must be removed from underneath the vehicle, this method of destruction can be undertaken only if the distance the vehicle has to travel to reach the necessary depth is not too great” (Department of the Army 1951, p. 567).

Historic sources do not mention the destruction or disposal of LVTs in or around Tanapag Lagoon, which limits the ability to tie this particular LVT (A)-4 to a specific action. Unfortunately no serial numbers or other forms of identification
markers were located on this vessel, which hinder the ability to tie the vehicle to a specific U. S. military unit for further research. According to local divers, several LVTs are located north where the reef meets the island on the west coast. These LVTs are rest at a considerable depth of water (roughly 98-164ft [30-50 m]) and may have been pushed over the reef edge as part of a disposal project. Future investigations of disposed LVTs in Saipan should include the investigation of these LVTs to compare them with this LVT site.

A model based on previous models of sunken shipwrecks has been created as a part of this research in order to demonstrate some of the possible scenarios concerning the site formation process of the LVT (A)-4 in Tanapag Lagoon.

Figure 6-5: Flow chart showing possible scenarios concerning the LVT (A)-4 in Tanapag Lagoon. (Image: Arnold 2010).
Figure 6-6: View of site from starboard side. (Photo: courtesy of Ships of Exploration and Discovery).
Chapter 7
Conclusion
Introduction

This chapter will discuss the implications of this study as it relates to the original aims and research questions stated in Chapter 1. The main and subsidiary questions will be answered using the historical and archaeological evidence uncovered in this research. Additionally the future research potential of this and other LVTs will be discussed.

How Were LVT (A)-4s Used in Saipan?

Historical research shows that LVT (A)-4s preceded the landing force, effectively placing them first in harms way. LVT (A)-4s were the only artillery support the invading troops had once they neared the shoreline until traditional tanks could be deployed in later landing waves. Once ashore they acted as mobile artillery and helped capture strategic targets such as the town of Garapan. LVTs acted in a variety of roles such as command posts, logistical vehicles and rescue vehicles. They were able to approach and evacuate battlefields in ways that were unavailable to traditional vehicles. This capability greatly enhanced the U.S. ability to attack Japanese defenders and to defend themselves from counterattacks.

Perceived weaknesses in the original design specifications led the LVT crews to modify their vehicles. During the pre-impact threat phase, these modifications were deemed necessary in order to prolong the lives of the machines and the crews who operated them. The modifications of LVTs have been documented historically and now archaeologically giving insight into how LVT crews viewed their machines
as vehicles of war. The perceived weaknesses in previous LVT models directly influenced their predecessors on the battlefield.

At the time, the Battle of Saipan saw the largest use of LVTs in combat. Both the troop carrying LVT-4 and the Amtank LVT (A)-4 were introduced for this battle attesting to the attention given to pre-impact considerations by those planning the operation. The archaeological evidence presented by the LVT (A)-4 in Tanapag Lagoon indicates that its crew not only considered pre-impact threats, but also modified their vessel accordingly.

How and Why did the LVT Crews Modified their Vehicles for the Battle of Saipan?

In response to perceived threats during the pre-impact phase, cultural actions in the form of field expedient battle modifications were carried out. Historic records have shown that the coral heads of fringing reefs were capable of penetrating the unmodified bow armor of LVTs. Likewise small caliber rounds were capable of penetrating LVT armor. This knowledge, combined with the intelligence gathered concerning the Invasion of Saipan, would have been considered during pre-impact threat assessments. These considerations influenced the LVT crews leading the amphibious assaults to modify their machines in reaction to these threats with extra steel plates to better preserve and protect their craft and themselves while attempting to accomplish their missions. Even with the added protection of steel plating, it was necessary for the LVT crews to carry wooden plugs in order to patch holes while under way at sea.
The exposed .50 cal machine gunner would certainly want more protection while assaulting the enemy. Likewise, the addition of extra weaponry would be welcome on the battlefield. The study of field expedient armor modifications suggests self-preservation to be the common motive behind the crews’ actions. This attitude is clearly reflected in the archaeological remains of the Tanapag Lagoon LVT (A)-4.

*How Are These Modifications Reflected in the Archaeological Record?*

Pre-impact field expedient armor modifications in the form of added weaponry and armor shields are easily observable on the LVT (A)-4. Archaeological research has identified the addition one .30 cal. coaxial machine gun in the bow of this LVT (A)-4. Another probable machine gun mount is attached to the port side of the turret, which would have added considerable firepower and protection for the vessel. Perhaps the most obvious modification to this LVT (A)-4 is the addition of an armor shield around the .50 cal. machinegun on the rear of the turret.

Field expedient armor modifications such as adding steel plating to the bow of the vessels in order to increase the protective armor have been discussed historically. The practice of adding boilerplate to the bow of the craft has been archaeologically documented by gauging the existing bow plates on both the upper and lower bow of this LVT (A)-4 and comparing this to historic sources detailing the manufacturer’s design specifications.
What is the Significance of LVTs During the Invasion of Saipan as it Relates to the Development of the LVT as a Machine of War?

Lessons learned in previous battles established that the 37mm turret of the LVT (A)-1 was ineffective on Japanese fortifications. The LVT (A)-4 was a pre-impact threat response introduced specifically for the Battle of Saipan and was designed with a 75mm Howitzer for the purpose of destroying Japanese weapon emplacements and fortifications. These vessels mark a change in time concerning the equipment and supplies of U.S. forces during WWII. Historical research has shown LVTs to be the only amphibious vehicles capable of delivering large amounts of troops to shores sheltered by shallow fringing reefs. Likewise, these vehicles provided the only concealment to the invading forces. LVT (A)s were the only artillery support the invading forces received once the landing parties neared the shoreline before traditional tanks could be deployed to the beaches.

The study of field expedient armor modifications made to LVTs used in the Battle of Saipan as they relate to the process of pre-impact threat assessments presents the basis for understanding the degree of modification standardization between units and services, by both the U.S. and other nations. These modifications have presented insight into the mindset of those operating LVTs. These modifications have also illustrated a direct influence on the seriation of later production LVT models.
Site Formation Possibilities

Following the process model established by Muckelroy (1978), the archaeological signature of this site demonstrates that it has been heavily salvaged. There are no heavy pieces of metal in or around the site and no ammunition of any kind, spent or unspent was located. The site appears to have been subjected to primary salvage due to the lack of machinery, electronic devices and weapons as outlined in the Army's Technical Manual for LVTs. It is unclear how much, or if any secondary salvage has occurred. To date no historic records have been located, which tie this site to any actions of use, disposal or loss. It is reasonable to assume that this LVT was damaged in battle however; it is not known if this damage occurred on shore or in the water at its present location. The lack of debris field suggests that this LVT (A)-4 was not damaged at its current location, but discarded after salvage efforts occurred elsewhere.

It appears that the 1951 Army technical manual describing the proper disposal of LVTs was followed (although dated later, there was likely an earlier version)(Department of the Army 1951, pp. 565-569). All sensitive equipment and weapons were removed and the vessel was sunk. The inability to acquire an LVT technical manual preceding 1951 makes it unclear if the disposal methods were set forth prior to the invasion of Saipan. The deliberate disposal of this craft could have provided the basis for the guidelines set forth in the 1951 Army manual.
Future Research Potential

The LVT is a specialized machine that has been largely ignored by researchers. Future research may shed light on the extent of LVT modification occurrence in WWII battlefields across the Pacific and Europe and the standardization of these modifications between individual units of both the U.S. and other nations. This research has the potential to document the crew level threat responses that influenced the evolution of the Landing Vehicle Tracked from the humble beginnings of a humanitarian rescue vehicle to amphibious military supply craft to amphibious assault vehicle and even to its modern counterparts.

More research on these machines may also lead to a discernable pattern concerning catastrophic loss as compared to intentional disposal. By recognizing the signatures of both types of sites a more complete model can be produced to aid in interpreting future LVT sites.

LVTs were used during WWII in the Pacific on many different islands. The LVT also received limited use in Europe. These machines were leased to Allied countries and may have received expedient modifications by these nations’ soldiers. A study of how each model of LVT was modified for use during wartime may potentially yield more information about how the craft became such a diverse war machine and offer insight as to how the seriation of the vehicle was influenced by those using the vessel. Further, more information regarding the importance of LVTs during amphibious invasions can be gained by studying the terrain in which they were used to investigate local use and response to conditions.
Conclusion

The LVT (A)-4 site in Tanapag Lagoon is significant for its role in the U.S. victory of the Battle of Saipan during WWII. LVTs contributed to saving lives during invasion operations by ferrying troops to shore under heavy fire and evacuating the wounded from areas of intense fighting to ships waiting at sea. The unique capabilities of these vessels allowed allied forces the ability to utilize new strategic methods in warfare.

The field expedient armor modifications of this particular LVT are significant because they reflect the mindset of individuals responding to pre-impact threat processes during WWII. The difficulty of the missions and the design limitations the crews of these vehicles were confronted with are reflected in the archaeological record. Extensive field expedient armor modifications for the sake of self-preservation were deemed necessary by LVT crews in order to accomplish the many tasks they faced.
References


London: Ministry of Defence.


