Developing an Explosive Laden Unmanned Waterborne Vehicle to Eliminate Liberation Tamil Tiger Elam (LTTE) Suicide Boat Attacks at Sea

MCP Dissanayake

Department of Marine Engineering, Faculty of Engineering, General Sir John Kotelawala Defence University, Sri Lanka

dissanayakemcp@kdu.ac.lk

Abstract— The LTTE was one of the most ruthless terrorist groups, which had operational sea capabilities. In the early 1980s, the LTTE formed a naval wing called sea tigers. Subsequently, the sea tiger leader introduced an elite and highly trained suicide carders to this special element to carry out attacks against Sri Lanka Navy (SLN) ships, using explosive laden boats. The Sri Lanka Navy, thus, was faced with a unique challenge. The highly developed maritime guerrilla warfare, which the SLN faced, had to be fought and won in close proximity to the enemy, at visual range, where speed and manoeuvrability took precedence over long-range weapons and endurance. Then, the SLN decided to build an unmanned waterborne vehicle (UWV), to counter suicide boat attacks of the LTTE without harming its own men. This UWV was unique and operated at a wide range of both shallow and deep waters effectively. Further, it was fixed with 120 kg high explosive claymore mines that could be detonated remotely. The speed, manoeuvrability, and explosion impact of UWV were investigated by ramming it to the LTTE target. It was found that significant damage to the enemy was done by the explosion and shock wave during the test. Consequently, the LTTE suicide boat launching dramatically reduced.

Keywords*: *Sri Lanka Navy (SLN), Unmanned Waterborne Vehicles (UWV), Unmanned Arial Vehicle (UAV), Rapid Action Boat Squadrons (RABS).

I. INTRODUCTION

The LTTE was one of the most ruthless terrorists, which consisted of operational sea capabilities. In the early 1980s, LLTE has formed a naval wing, called sea tigers. Subsequently, the sea tiger leader introduced elite and highly trained suicide carders to this special element to carry out attacks against Sri Lanka Navy (SLN) ships, by explosive laden boats. Initially, the SLN was suffered heavily and tried to make counter attacks by available resources. Further, the SLN fleet was upgraded by supreme boats with new technologies, as per proposals of expert fighters on board SLN ships. Though it was not enough to evade the LTTE suicide boat attacks and SLN was losing their boats during sea battles against the enemy.

The Sea Tigers were designed and developed a new tactic called "wolf pack" attacks. In these attacks, the formation was gradually built up and identified a target by command vessel. Then, directed a bunch of smaller boats to approach the target vessel and attack from all directions, and ensure to prevent it from fleeing the area. Subsequently, an explosive laden boat was moved towards the target with a cover of the larger command vessel and rammed the target by losing a single Black Tiger, in this mission. Generally, two types of boats were utilized against SLN, one was stealth craft which was operated at high seas atmore than 40 knots speed, another type was Explosive Laden Floating Device that was used at shallow water against SLN patrol craft,

Figure 1. Liberation Tamil Tiger Elam suicide boat

Figure 2. Explosive Laden Floating Device

SLN realized that the bigger Dvoras were not enough to hunt down the smaller in size, vary fast moving, shallow water operating and highly maneuvered LTTE suicide boats. Therefore, SLN elite force, Special Boat Squadron was testing out smaller versions of boats against LTTE suicide boats, though it was not fully succeeded.

An unmanned vehicle that can be controlled remotely has been a matter of military curiosity. Advancement in automation technology made such an idea a practical reality of such a vehicle capable of travelling in air or water. where the terrain obstruction does not interfere with the line of sight control has been of particular significance. Thus the development of unmanned vehicles for military use has been progressing at a fierce pace all over the world during the last few decades. Though, development of unmanned aerial vehicles has outpaced their waterborne counterparts due to their distinctive usefulness for surveillance waterborne unmanned vehicle, on the other hand, could not make the same place for itself in a maritime arena that is predisposed towards airborne surveillance, long-range weapons and prolonged endurance. A scenario for which waterborne unmanned vehicle is intrinsically not suited. Therefore, worldwide, the development of remotely controlled unmanned waterborne vehicles (UWV) is restricted for roles such as target boats, mine clearance vehicles, deep sea submersibles, etc. (Ebken J, Bruch M, Lum J 2005).

Sri Lanka Navy, however, was faced with a unique challenge of a very different kinds. The highly developed maritime guerilla warfare, which the SLN faces, had to be fought and won in near close to the enemy, at visual range, where speed and maneuverability were taken precedence over long-range weapons and endurance. Therefore, the utility of UWV was of special consequence for SLN. Naturally, as the challenge faced by SLN was very unique and unprecedented in technologically developed parts of the world, the expertise needed for such an enterprise had to be home grown rather than imported.

The UWV was primarily designed to mislead the LTTE boats during sea battles. A secondary purpose of the UWV was to use it as the first line of the battle and avoid human casualties. The main objective of this research project was to stop LTTE suicide attacks by operating and triggering this UWV with a safe distance, and minimum damage to the SLN during sea confrontations.

II. DESIGN FEATURES

Explosive Laden Unmanned Waterborne Vehicles (UWV).

A. Material Selection and Design of Hull

Fiberglass was chosen to make this arrow boat due to low cost, light weight, minimal elongations, and availability of experts and infrastructure facilities at SLN. Subsequently, type of the hull was decided after conducting number of trails, utilizing 18-foot dinghy, 16-foot arrow boat and 18-foot arrow boat with 200 kg pay loads. Eventually, a planning hull was selected for this UWV considering the fact that ability to push through the water and skim across the water's surface. According to preliminary design, construction of the 18-foot arrow boat was begun with the fabrication of a hull in figure 1. Since stability of the 18-foot arrow boat is one of the very important criteria in this design, to destroy the enemy targets by ramming without hindering the mission. The length of the arrow boat is restricted to 18' and maximum breadth is curtailed with 5' 3". The height is 2' 7" with both sides angled out, at an angle determined from the difference in the beam and bottom widths of the hull in figure 2. Fabricating a transom is vital, and considered as the back panel of an arrow boat hull. Consequently, the angled sides are generating additional depth to the planning hull and an increase in the displacement. Therefore, it leads to enhance the capacity of the arrow boat to accommodate a heavy load of explosives to destroy the enemy target with surprise.

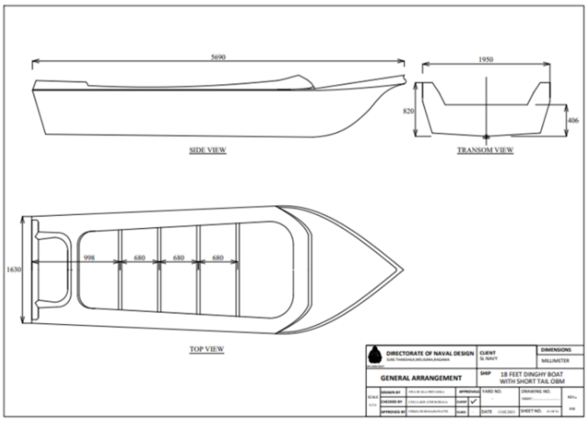

Figure 3. Detail Design of 18' arrow Boat

Salient Features

a.	Type of Boat	- Arrow (18')
b.	Propulsion Plant	- 75 HP OBM
c.	Pay Load Capacity	- 150 Kg

d. Max Speed - 40 / 50 knots (Sea State 1/3)
e. Actuating Mechanism - Hydraulic
f. Remote Link - VHF (Handheld Communication Set)
g. Remote Control Range - 6/ 15 Nm (Max / Practical)

B. Propulsion System

Short tailed 2-stroke, 75 HP Outboard Motor (OBM) was chosen as a propulsion system for this arrow boat due to easy handling in shallow water, to achieve maximum speed, destroy the enemy target with surprise and availability of work shop facilities within SLN in Table 1. In this context, many options were had with SLN to select suitable engines for the designed arrow boat. Both inbuilt engines and separate propulsion systems or inbuilt engines and water jet systems are generally used for this kind of water borne application, to achieve design speeds.

Table 1: Selecting the right size hp for outboard motor for this 18' arrow boat

Motor HP	Boat length (feet)	Boat length (metres)
2hp – 10hp	8' – 12'	up to 3.5m
5hp – 15hp	8' – 14'	up to 4.2m
9hp – 20hp	11' – 16'	up to 4.5m
20hp – 40hp	13' – 18'	up to 5.0m
40hp – 75hp	14' – 20'	up to 5.5m
90hp – 140hp	16' – 25'	up to 6m +

Figure 4. Short tailed 75 HP Outboard Motor

C. Selection of Correct Propeller

Propeller size is expressed with two numbers, diameter and pitch, with diameter always stated first. The diameter is two times the distance from the center of the hub to the tip of any blade. Smaller prop diameters generally go with smaller engines, or with fast high performing boats. Therefore, in this context, a smaller size propeller was fixed with 75 HP OBM as per guidelines of Yamaha Manufacturer to meet SLN requirements such as speed and surprise (Savitsky, 2003). In addition, Rake is the degree that the blades slant forward or backward in relation to the hub. Rake can affect how water flows through the propeller, which can make a difference regarding boat performance. Aft rake helps to lift the boat's bow, decreasing the hull's wetted surface area and improving top end planing speed. Eventually, SLN decided to take enemy targets by using UWV within the 2 nm range to dodge enemy swam attacks.

D. Trim Angle

Trim angle is a very important aspect, fixing an OBM to the arrow boat and leads to maintain stability of the vessel. Further, it depends on the vessel's handling characteristics, the size of the outboard, the sea, and loading conditions. In this design, the trim pump played major role to correct the trim angle during the operation of the arrow boat figure 5 & 6.

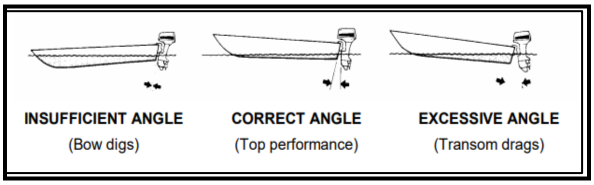

Figure 5. Correct Trim Angle

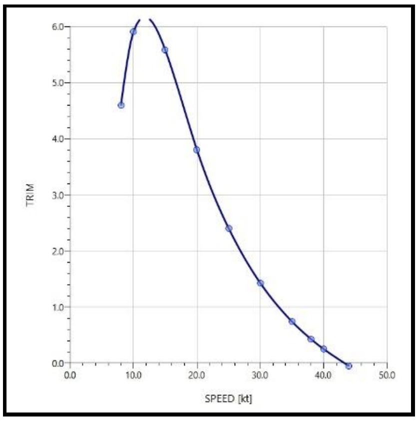

Figure 6. Characteristics of Trim vs Speed

E. Control System

The development process of this successful prototype had gone through long and arduous rigours seven failed model tests and many fundamental changes in technological approach itself. To begin with a purely mechanical control system based on automobile window winding mechanism was tried. Though, due to inconsistent performance and lack of robustness this approach had to be abandoned. Eventually, a hydraulic actuating system assembled from a discarded hydraulic mechanism of Out Board Motor (OBM) was found to be suitable and was successfully integrated into a functional remote control aggregate. After developing a reliable control system, an initial scaled down model with only steering control (Without throttle control) was developed and tried on a 23' FGD. With subsequent insight gained into the practicalities of such a development and with the lessons learnt, the final prototype was based on a 18' Arrow Boat which is powered by a 75 HP OBM. The steering system was developed, utilization of trim pump and both port and starboard could be achieved maximum up to 30o, without harming to the stability of the UWV. Similarly, the speed control mechanism was incorporated with another trim pump and hydraulically controlled the acceleration and retardation during the experiment. The trim pump was powered by 24 DC and ensured to keep the batteries, fully charged throughout the test (Ford, D.W. and Juve, E.K., Nautamatic Marine Systems Inc, 1996). A steering system was very special in this UWV and hydraulically operated with the utilization of additional trim pump, that was actuated by VHF signals and associated with fluid communication through a hydraulic cylinder, that connected to the OBM (Treinen, K.J., Amerling, S.J. and Fisher, B.L., Brunswick Corp, 2001). Then, the prototype model had both steering as well as throttle control and was remotely controlled through a VHF link based on handheld VHF communication set. The control was exercised by pressing the Power Transmitting Toggle (PTT) switch and quantum of control signal was determined by the duration for which the PTT was pressed. For differentiating between different types of commend, different channels of the communication set were used. It may be pertinent to mention that the remote control circuit had been exclusively developed for this requirement and was quite different from a normal remote control toy. While, the vehicle could be remotely controlled up to a range of 15Nm, practical difficulties of sighting and precise control limits the useful range of remote control to 6 Nm. The prototype model was operating with a dummy load of 120 Kg but could carry and payload up to 150 Kg. the prototype had been extensively tried a sea and can travel up to 40 knots speed.

Figure 7. Trim Pump

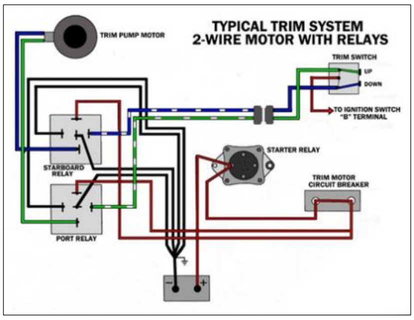

Figure 8. Wiring diagram of Trim Pump

Figure 9. Prototype an explosive laden unmanned waterborne vehicle (initial testing)

F. Test Procedure

The UWV was fixed with 120 kg of high explosive and amalgamated with a trigger mechanism to carry out explosion by VHF communications. An operator was on board another arrow boat at sea and selected the target as abandon merchant vessel called Fara III, which was grounded at LTTE controlled area at Pudumatalan. Subsequently, the operator was identified a distance to the target from the operating platform by a radar and prepared the UWV for the assigned task. Then, the UWV was operated at speed of 40 knots, at seas state 1-2 and reached the target within 5 minutes and carried out the attack by ramming. This complete operation was observed by the Unmanned Arial Vehicle (UAV) and recorded all the events to make further improvements of UWV.

G. Launching Platform

Special Boat Squadron (SBS) of SLN had 23 foot arrow boats which were operated at more than 45 Knots speed with high maneuverability. Therefore, SLN decided to strengthen SBS boats with one or two Explosive Laden UWV for missions against LTTE.

Figure 10: Special Boat Squadron Launching Pad

Figure 11. Launching Unmanned Waterborne Vehicle at Sea

Figure 12. Moving Unmanned Waterborne Vehicle to the LTTE target

Figure 13. Unmanned Waterborne Vehicle was rammed into the Fara III

III. RESULTS AND OUTCOMES

Sea trials were carried out using three different types of boats, different weight conditions, erratic capacities of OBM, and different sea states in table 2.

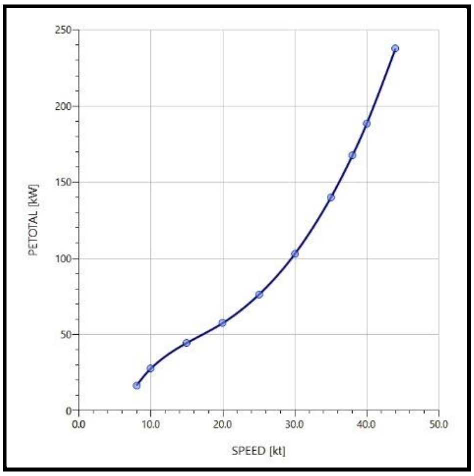

Figure 14. Comparison of Power vs Speed

Power of OBM and speed of boat were calculated at sea state 1-2 figure 14.

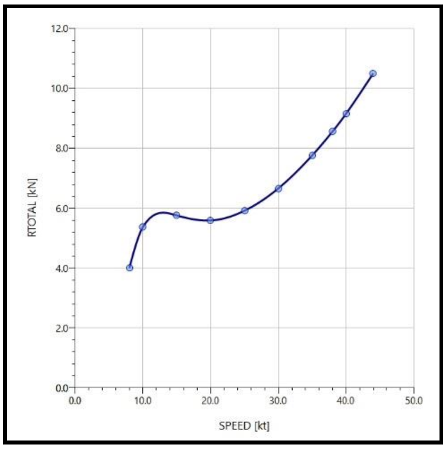

Figure 15. Comparison of Resistance vs Speed

Arrow boat hull resistance and speed were calculated at sea sate 1-2 figure 15.

A bearable level of noise and bit vibration was generated during the UWV operation. The UWV was steady at sea state 1-2 with a speed of 40 knots. The hydraulic control and data acquisition systems were produced very reliable outcomes. The maneuverability of UWV was very high and reached the target accurately. The explosion impact was immense and Fara III was parted into two pieces.

IV. DISCUSSION

Table 2. Details of Sea Trails in Three different Models

Date	Type of Boat	Weight	OBM	Sea State	Speed	Remarks
23/03/2007	23’ FGD	500 kg	25 HP	1-2	12 knots	Less speed, taking large turning circle, stable, operated 16 hrs and very reliable control system
24/03/2007				1-2	11 knots	
26/03/2007				1-2	12 knots	
07/04/2007	23’ FGD	600 kg	75 HP	1-2	23 knots	Moderate speed, Taking large turning circle, stable, operated 64 hrs and very reliable control system
08/04/2007				2	20 knots	
19/04/2007				3-4	15 knots	
23/04/2007				1-2	24 knots	
24/04/2007				2	19 knots	
27/04/2007				2	18 knots	
16/05/2007	16’ Arrow Boat	420 kg	75 HP	1-2	34 knots	High speed, Taking small turning circle, steady and stable, operated 108 hrs and very reliable control system
17/05/2007				2-3	28 knots	
20/05/2007				3	20 knots	
03/06/2007				1-2	34 knots	
06/06/2007				2	24 knots	
12/06/2007				2	24 knots	
20/06/2007				3	19 knots	
09/07/2007				1-2	33 knots	
10/07/2007				2-3	26 knots	
12/07/2007				1-2	35 knots	
20/07/2007				2-3	27 knots	
16/08/2007	18’ Arrow Boat	280 kg	75 HP	1-2	48 knots	High speed, Taking small turning circle, stable (bit unstable above seas state 3), operated 146 hrs and very reliable control system
19/08/2007				1-2	48 knots	
23/08/2007				1-2	47 knots	
25/08/2007				2	43 knots	
02/09/2007				1-2	49 knots	
14/09/2007				1-2	48 knots	
22/09/2007				1-2	48 knots	
25/09/2007				3	41 knots	
26/09/2007				3-4	39 knots	
28/09/2007				3	40 knots	
29/09/2007				1-2	48 knots	
02/10/2007				1-2	47 knots	
06/10/2007				1-2	48 knots	
10/10/2007				2	44 knots	
12/10/2007				2	43 knots	
14/10/2007				2	45 knots	
15/10/2007				1-2	48 knots	
13/11/2007	18’ Arrow Boat	420 kg (with high explosive)	75 HP	1-2	40 knots	High speed, Taking small turning circle, steady and stable (bit unstable above seas state 3), operated 48 hrs and very reliable control system
19/11/2007				1-2	40 knots	
25/11/2007				2	36 knots	
26/11/2007				1-2	41 knots	
02/12/2007				2-3	32 knots	
10/12/2007				2	37 knots	

The mission was conducted in day time and completely visible weather conditions. This was the first time the explosive laden UWV, used against enemy target. Further, it was created an utter panic state for sea tigers, and ended up with a disastrous situation. Moreover, this low profile UWV could not detect by the enemy radars or look outs, until the explosion.

Initialy UWV was at rest, the weight of the arrow boat was stayed entirely by the water in which it's sitting, known as "static buoyancy." Subsequently, the arrow boat started to move forward through the water, speed created hydrodynamic lift. Eventually, more power was applied, lift increased, and reduced wetted area and thus reducing drag. At this point, the boat was said to be "planing" and steadily reached up to 45 kt. In addition, 12 knots to 20 knots region that the arrow boat had maximum drag and that was why speed drop came into place in figure 14 &15.

V. CONCLUSION

LTTE suicide boat launching was dramatically reduced. A remote controlled unmanned waterborne vehicle was potent and can be used for a variety of task ranging from benign use as target boats to an offensive platform. One of the most potent uses of this platform could be to match the suicide boat tactics of the enemy during sea confrontations. The remote control boats with explosive payload could be made part of 'Rapid Action Boat Squadrons' (RABS) and unleashed in the form of a swarm attack on an unsuspecting enemy at a decisive moment during the battle. This only envisions one of the many such scenarios where an unmanned vehicle could be effectively used without putting the valuable human resource in harm's way. Therefore, possibilities of potential use are many and are only limited by creative imagination rather than the limitation of the hardware.

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AUTHOR BIOGRAPHIES

Cmde (E) MCP Dissanayake, CEng (IEI), Associate Member (IESL), Fellow (FRINA) is currently performs as the Head of Department (Marine Engineering) and hold 2 No's patents for his research papers published so far. He is an inventor and published 06 No's publications on Brackish Water Reverse Osmosis application, Fan Boat Building and Oscillation Water Column, Ocean Wave Energy Converter. He was the Director in Research & Development at Sri Lanka Navy and has received commendations in number of occasions from the Commander of the Navy, HE the President of Sri Lanka for his innovation. Further, he was awarded with prestigious, Japanese, Sri Lanka Technical Award for his own developed low-cost Reverse Osmosis Plant, to eliminate Chronic Kidney Disease from Sri Lanka. Moreover, he has vast exposure on marine diesel engines and possesses a Master's degree in Marine Engineering from Australian Maritime College, University of Tasmania, Australia.