Developed an Explosive Laden Unmanned Waterborne Vehicle: To Eliminate Liberation Tamil Tiger Elam (LTTE) Suicide Boat Attacks at Sea

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Abstract— *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 was introduced an elite and highly trained suicide carder to this special element to carry out attacks against Sri Lanka Navy (SLN) ships, by explosive-laden boats. Sri Lanka Navy, however, was faced with a unique challenge of a very different kind. The highly developed maritime guerilla warfare, which the SLN faces, had to be fought and won close to the enemy, at visual range, where speed and maneuverability were taken precedence over long-range weapons and endurance. Then, SLN was decided to build an unmanned waterborne vehicle (UWV), against suicide boat attacks of Liberation Tigers of Tamil Eelam (LTTE) without harming their men. This UWV was unique and operated at a wide range of both shallow and deep water, effectively. Further, it was fixed with 120 kg high explosive claymore minds and detonated remotely. The speed, maneuverability, and explosion impact of UWV were investigated by ramming it to the LTTE target. It was found that significant impact on an enemy by explosion and shock wave during the test. Consequently, LTTE suicide boat launching was 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 was introduced an elite and highly trained suicide carder 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 with 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 building up and identified a target by command vessel. Then, directed a bunch of smaller boats to approach the target vessel and attack from all around directions, and ensure to prevent it from fleeing the area. Subsequently, an explosive-laden boat was moving 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 with more than 40 knots, 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

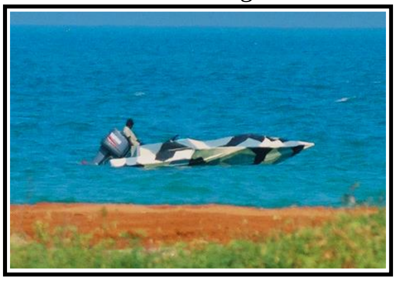


Figure 2. Explosive Laden Floating Device

SLN was realized that the bigger Dvoras were not enough to hunt down the smaller in size, very 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 from the time advancement in automation technology made such an idea a practical reality utility of such a vehicle capable of traveling 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 vehicles, 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 kind. The highly developed maritime guerilla warfare, which the SLN faces, had to be fought and won 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 homegrown 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.

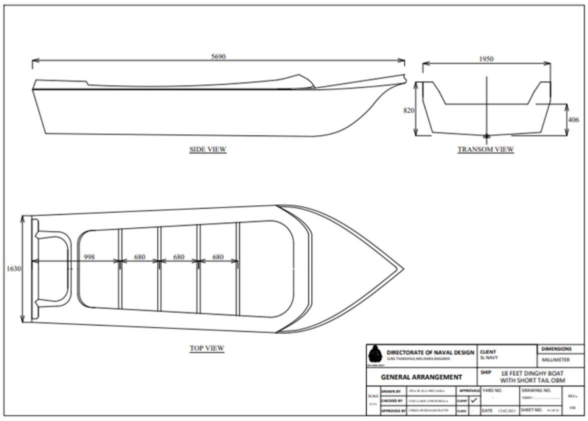
II. DESIGN FEATURES

Explosive Laden Unmanned Waterborne Vehicles (UWV).

A. Material Selection and Design of Hull

Fiberglass was chosen to make this arrow boat due to its low cost, lightweight, minimal elongations, and availability of experts and infrastructure facilities at SLN. Subsequently, the type of the hull was decided after conducting the number of trails, utilizing an 18-foot dinghy, 16-foot arrow boat, and 18-foot arrow boat with 200 kg payloads. Eventually, a planning hull was selected for this UWV because 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. Since the stability of the 18-foot arrow, the boat is one of the very important criteria in this design, to destroy the enemy target 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 3. 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 (Sea State 1/3)	-	40 / 50 knots
e.	Actuating Mechanism	-	Hydraulic
f.	Remote Link (Handheld Communication Set)	-	VHF
g.	Remote Control Range (Max / Practical)	-	6/ 15 Nm

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 workshop 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 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 Angel

Trim angle is a very important aspect, fixing an OBM to the arrow boat and leads to maintaining the 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 was played a major role to correct the trim angle during the operation of the arrow boat figures 5 & 6.

Figure 5: Correct Trim Angle

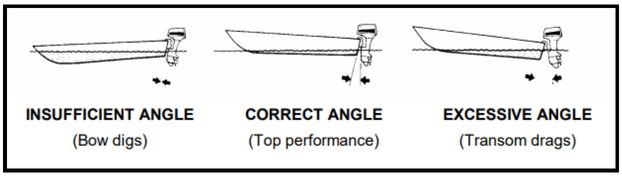
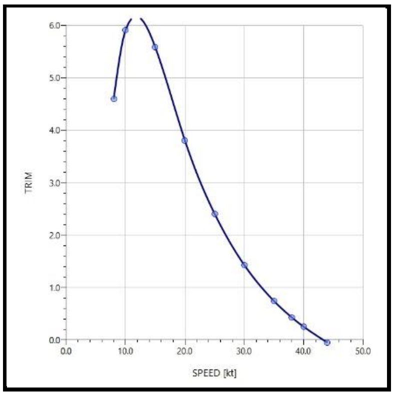


Figure 6: Characteristics of Trim vs Speed



E. Control System

The development process of this successful prototype had gone through long and arduous rigours, of seven failed models and many fundamental changes in the technological approach itself. To begin with, a purely mechanical control system based on an 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 the subsequent insight gained into the practicalities of such a development and with the lessons learned, the final prototype was based on an 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 harm 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 an 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 steerings as well as throttle control and was remotely controlled through a VHF link based on a handheld VHF communication set. The control was exercised by pressing the Power Transmitting Toggle (PTT) switch and the 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 limit 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 of speed.

Figure 7: Trim Pump

Figure 8: Wiring diagram of Trim Pump

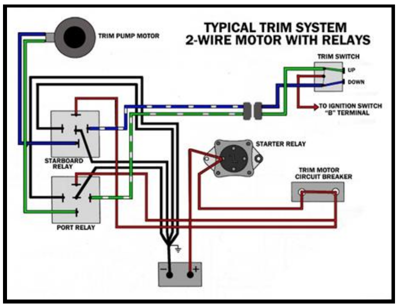


Figure 9: Prototype an explosive-laden unmanned waterborne vehicle (initial testing)

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 an abandoned merchant vessel called Fara III, which was grounded at LTTE controlled area at Pudumatalan. Subsequently, the operator has identified a distance to the target from the operating platform by 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 were to make further improvements of UWV.

Launching Platform

Special Boat Squadron (SBS) of SLN had 23-foot arrow boats which were operated more than 45 Knots 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

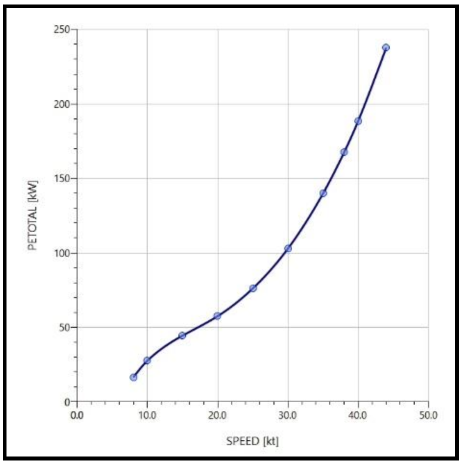
Sea trials were carried out using three different types of boats, different weight conditions, erratic capacities of OBM, and different sea states in table 2.

Table 2: Details of Sea Trails in Three different Models

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

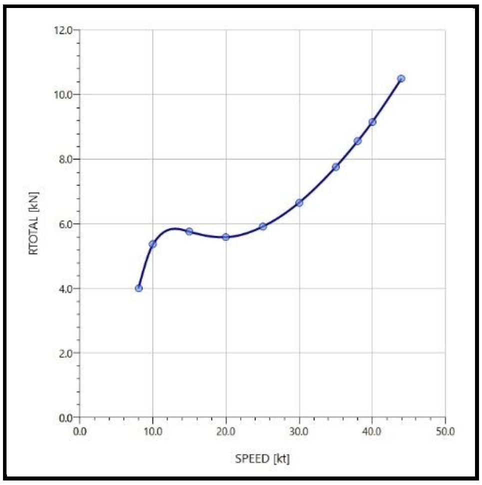
10/10/2007 12/10/2007 14/10/2007 15/10/2007					40 knots 48 knots 47 knots 48 knots 44 knots 43 knots 45 knots 48 knots	
13/11/2007 19/11/2007 25/11/2007 26/11/2007 02/12/2007 10/12/2007	18' Arrow Boat	420 kg (with high explosive)	75 HP	1-2 1-2 2 1-2 2-3 2	40 knots 40 knots 36 knots 41 knots 32 knots 37 knots	High speed, Taking small turning circle, steady and stable (bit unstable above seas state 3), operated 48 hrs and very reliable control system

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 peed 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.

Discussion

The mission was conducted in the daytime and completely visible weather conditions. This was the first time the explosive-laden UWV, used against an 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 lookouts, until the explosion.

Initially, 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 kts to 20 kts region that the arrow boat had maximum drag and that was why speed drop came into place in figure 14 &15.

IV. CONCLUSION

LTTE suicide boat launching was dramatically reduced. A remote-controlled unmanned waterborne vehicle was potent and can be used for a variety of tasks 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 the 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 (India) is currently performing as the Head of Department (Marine Engineering) and holds 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 on a number of occasions from the Commander of the Navy, HE the President of Sri Lanka for his innovation. Further, he was awarded the 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 to marine diesel engines and possesses a Masters's degree in Marine Engineering from Australian Maritime College, University of Tasmania, Australia.