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AUTONOMOUS UNDERWATER VEHICLE DESIGNED TO BE USED IN ANTISUBMARINE WARFARE

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Abstract: *In this paper we have realized a study which has as a main objective the creation of an underwater target needed for the ASW drills with ships from Romanian Navy Forces. This underwater autonomous vehicle will be obtained by SET53 torpedo modification. The study is focused on: redesign some critical torpedo subsystems, fitting hidroacustic sensors on the torpedo, testing and evaluation of the modified subsystems.*
Key-words: *underwater vehicle, torpedo, ASW drills*

1. INTRODUCTION

We propose a systems analysis of a low cost expendable target that can be deployed from surfaceship during a training exercise to emit a wide range of acoustic signals while maneuvering at a wide range of speeds in a complex pattern representative of an evading diesel electric submarine. The device will have a full range of detection, emission, echo-repeat, logging, and communicating functions, as well as the full capability to inter-operate with sonar. The target will be realised by making SET 53 torpedo modification. The proposed effort will analyze the component subsystems to determine their requirements and capabilities, as well as analyzing available alternatives for meeting system requirement, including evaluating technology currently being developed in other Navy programs to leverage those effort to provide a more effective device, development of which can also entail less risk, time and money. The result of Phase I effort will enable Phase II fabrication and testing of a prototype device.

2. SIMILAR SYSTEMS

Expendable Mobile ASW Training Target, the **MK39 EMATT** is designed to replicate the sounds and movement of a diesel submarine. Work in deep or shallow water, vary the EMATT’s speed and passive tonal levels, watch the target automatically maneuver in response to active sonar echoes by changing course, depth and speed.

Using a vital naval asset, such as a submarine, to act as a target in ASW training is extremely cost-inefficient and resource-consuming. **AUV62-AT** replaces the conventional submarine role. It is intended for ASW operator training and onboard sonar and command system check-up.

Figure 1 EMATT system

The AUV62-AT can follow pre-programmed routes or be navigated online by the operator using radio communication or the underwater acoustic link. The AUV62-AT vehicle can be easily configured as an Artificial Target using a Payload Module with a Noise Transmitter and an Echo Transponder. It is therefore used to resemble a true Submarine for operator training, as well as onboard ASW sonar and command system check-up. The AUV62-AT can follow pre-programmed routes or be navigated online by the operator using radio communication or just the underwater acoustic link. The operator can therefore not only change the speed, depth and course of the vehicle, but also alter the acoustic performance or select another pre programmed route. The AUV62-AT can operate in several different modes to comply with the desired training conditions.

Figure 2 The AUV62-AT system

The **CALAS** training Target is a Reusable Light Weight Autonomous Underwater Vehicle. This target optimizes the sonar operator training at sea under real conditions. The underwater navigation capabilities of the CALAS together with its realistic acoustic performance make this target an ideal answer to ASW training requirements in shallow and deep water. The CALAS Target is designed to train sonar operators on any kind of platform: helicopter, ASW aircraft, surface ship and submarine. This target may also be used with training involving torpedoes. The target performs pre-programmed three-dimensional kinematic patterns that do not require any external run time control. The acoustic behaviour of the CALAS target is based on the replica of the real active sonar signals and on radiated signals simulating a noise sound source.

Figure 3 The CALAS system

3. PROPOSAL FOR SET53 TORPEDO MODIFICATION

In this paper we have realized a study which has as a main objective the creation of an underwater target needed for the ASW drills with ships from Romanian Navy Forces. This underwater autonomous vehicle will be obtained by SET53 torpedo modification. The study is focused on: redesign some critical torpedo subsystems, fitting hidroacustic sensors on the torpedo, testing and evaluation of the modified subsystems. The main modifications are:

- Torpedo speed will decrease from 29 knots to 6-12 Knots;
- Torpedo battery will be changed in order to get a longer operational time ;
- Some hidroacustic sensors will be fitted on the torpedo.

In this paper we will analyze how the hydrodynamic behavior of the torpedo will change if torpedo speed decrease from 29 knots to 6-12 knots. We will study the speed decrease effect in vertically plane. We made a 3D model of horizontally torpedo rudders and using CFD software we determined the forces which are produces in rudder planes for different speed values and different attack angles. The 3D model of the rudder can be shown in following picture.

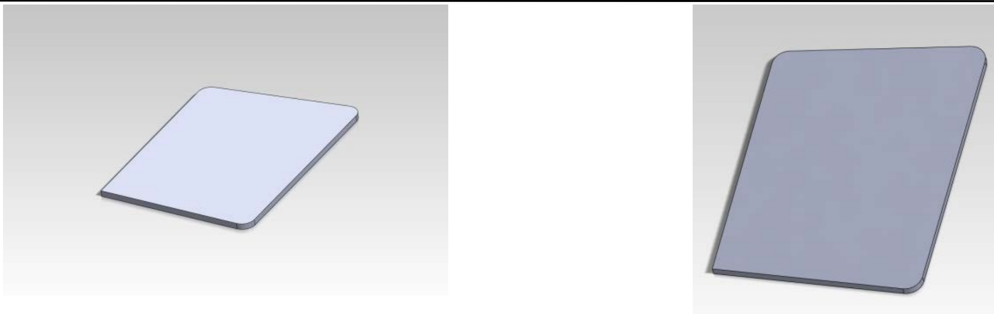

Figure 4 The 3D model of torpedo horizontally rudder

Figure 5 The overall dimensions of rudder

We used CD Adapco STAR CCM software for simulations and forces determinations. We made simulations for the following conditions:

- Torpedo speed – 29 Knots, 12 Knots, 6 Knots;
- Rudder attack angle – 0^0, 15^0, 20^0, 30^0, 45^0;
- Water density – 1000 Kg/m^3;
- Water dynamic viscosity - 0.001141 Pa-s;
- The flow is turbulent, turbulence intensity – 0,1;
- Model of turbulence – k – ω;
- Rudder area – 0,04701 m^2.

For the simulations we made the following steps:

- Create a domain and put the rudder inside;

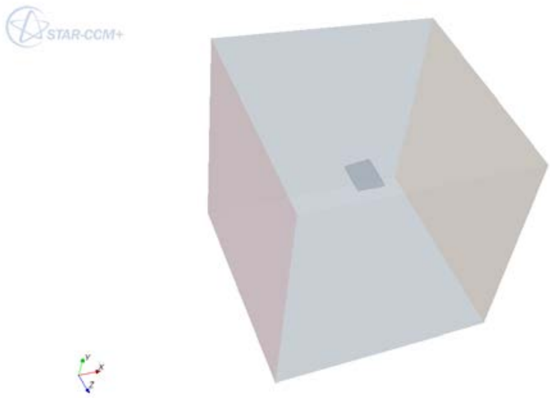

Figure 6 Rudder domain used for simulations

- Create a mesh for domain and rudder;

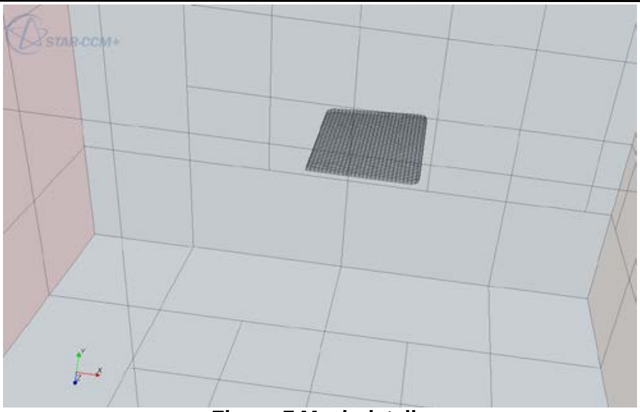

Figure 7 Mesh details

- Setting the initial conditions: torpedo speed, rudder attack angle;
- Setting the stopping criteria for simulation – the simulation will end after 1000 iterations;
- Make calculations and results analyze.

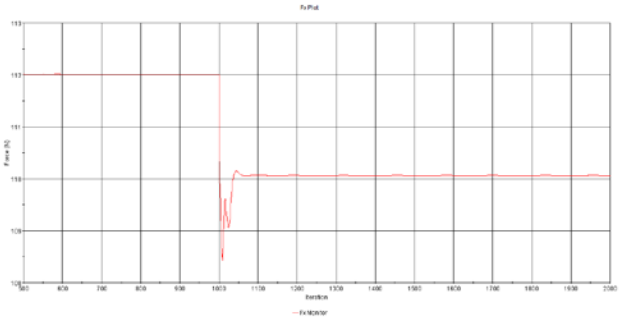

Figure 8 Results for F_x calculations

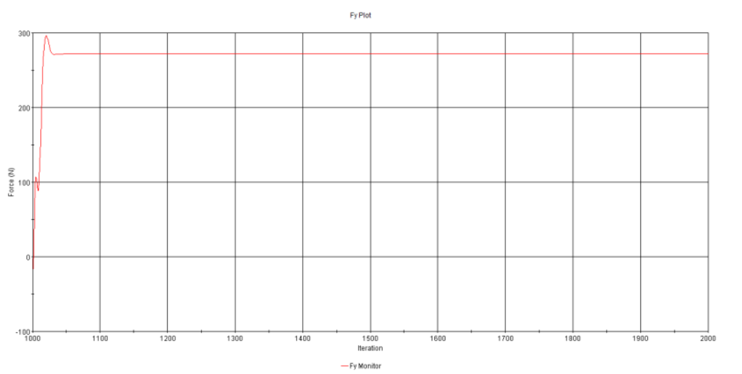

Figure 9 Results for F_y calculations

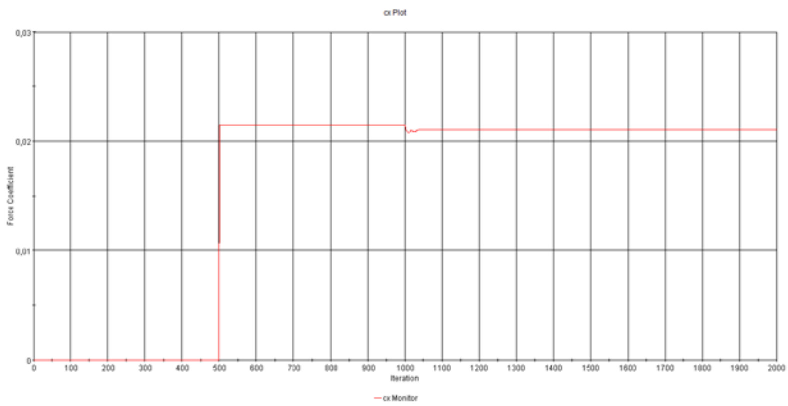

Figure 10 Results for force coefficient calculations

The results for all simulations which we have made are in the next table:

Table 1

Simulation	Torpedo speed (knots)	Rudder attack angle (degrees)	Fx (N)	Fy (N)	cx
1	29	0	112, 009	0	0,021407
2	29	15	110,057	271,78	0,021024
3	6	0	4,976	0	0,00951
4	6	15	4,881	11,689	0,000933
5	12	0	28,397	0	0,005427
6	12	15	27,882	68,07	0,005329
7	12	20	27,197	94,968	0,005198
8	12	30	26,104	167,672	0,004989
9	12	45	20,487	197,101	0,003915

We can see the first effect of speed decrease from 26 Knots to 6 Knots, the F_y force will decrease dramatically from 271,78 N to 11, 689 N, so the torpedo maneuvering capabilities in vertically plane will be seriously affected. In order to compensate this, we have two options: redesign rudders or modify the maximum attack angle of torpedo rudder. First solution will conduct as to bigger rudders, and for this reason the solution couldn’t be accepted because we intend to use the same launcher for the modified torpedo. So, we have to adopt the second solution – increase de maximum rudder attack angle from 15^0 to 30^0. We made simulations for angles of attack between 15^0 and 45^0. We decided to use a 30^0 attack angle. Increasing attack angle up to this value, will not conduct to significant bigger value for F_y.

4. CONCLUSIONS

ASW training is obtained most effectively when air, surface and subsurface platforms and their ASW SONAR crews train in the operational environment in which they would be asked to locate enemy submarines. Training against live submarines is costly and most often not available. Mobile ASW training targets fill this critical training asset. To effectively counter current and future underwater or undersea threats Naval forces must be trained with new and sophisticated technology that simulate real world conditions and scenarios.

In this paper we tried to identify the step necesarees in order to obtain an ASW target from a SET53 torpedo. The process of modification must have the folowing phases:

Phase I

Development of a new target propulsion system that can reach a sprint speed of 6 to 12 knots is necessary and vital. Sprint speed capability on training targets provide tactical training advantages while also emulating more realistic and dynamic maneuvers of todays’ modern submarines.

The SET53 torpedo is designed to be launched from ships and his dimensions are : length – 7800 mm, diameter – 534,4 mm.

The deficiency in the current propulsion system is tied to two (2) main components; the custom built plumb batteries pack that generates 82,5Volts and 570 A for the operation of the electronics system and DC motor. The innovative challenge of this modification lies in the design, development, and integration of a new propulsion system (high efficiency motor and energetic and safe battery) that allows the SET53 torpedo to operate hydrodynamically stable in depth, heading while achieving a sprint speed of 12knots and a sustained variable speed of 6 to 8 knots.

Phase II

The torpedo should be fitted with hidroacustic sensors, in order to simulate noise for different types of submarines and some equipments need it to make the torpedo to follow a specific path.

Phase III

Testing and functional evaluation for new and modified equipments.

Phase IV

Transmitting the technology for Navy use.

With an improved propulsion system that provides increased energy and power for longer and more sustain periods; new hidroacustic sensors the modified SET53 torpedo has viable commercial application in areas of underwater data collection, oil samplings and other containments from waterways, oceanography, and profiling.

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