Mine counter vehicles for Baltic navy

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TADEUSZ KUBATY
Chief of Underwater Systems
Polish Navi Headquarters, Logistics Departamen
Ul. Pulawskiego 7,
81-912 Gdynia Poland
tel. 48 58 626 32 34
email: tkubaty@mw.mil.pl

LECH ROWIÑSKI
Department of Underwater Technology
Faculty of Ocean Technology and Shipbuilding
Technical University of Gdansk
80 952 Gdansk, Poland
Tel. 48 58 347 1907, email: rowinski@pg.gda.pl

Abstract:

During two great wars of last century Baltic waters were mined extensively by all navies acting in the area. Some of the mines were never recovered. This can also happen in future. This is a reason for counter mine forces in Polish Navy. For some time new technologies are being introduced. Naval mine neutralisation technology is very cost sensitive. Two mine counter systems presented, were developed with this constraint in mind. While total operational costs depend strongly on mass and dimensions, remotely operated vehicles of the systems are comparatively small. Descriptions of the systems are followed by indication of important similarities that allow alternative use of the vehicles from platforms and consoles. Capability of joint operations is indicated and explained. Operators trainer that can be used to educate operators of both system is therefore a logic solution. This is based on computer simulation of images presented on console screens.

1. INTRODUCTION

Application of remotely operated vehicles for mine counter operation has been studied by Polish Navy since year 1980. Principally PAP104/Pingwin type vehicles were considered. However, high cost and intrinsic vulnerability of high mass vehicles, prompted idea of single shot solution. Following decision to adopt the conservative approach and co-operation with former DDR Navy proved to be a blind spot. Current approach to the subject is a low cost focused. It assumes wide application of commercially available components for a limited size vehicle. While mine disposal technology (not a vehicle technology) is not completely mature both remotely and autonomously powered vehicles were developed. The vehicles are multi purpose design. It mean use against all types of mines in broad range of local conditions. This is a reason why being comparatively cheap, both vehicle types are very far from cost target level, indicted by some naval sources at 5000 USD. It is result of a composition of technical means required meet high complexity the mission task.

2. TWO INDEPENDENT SYSTEMS THAT CAN WORK TOGETHER

UKWIA£ and SMCC systems are of somehow conservative design. It also true for the latter, as disposable technology finds its way to several navies. Common assumption for vehicles, that were build using different approach, is lowest feasible cost. For single shot vehicle low cost is obvious. Although UKWIA£ vehicle is a multi mission device basically, it can be easily destroyed by adequately fused mine. Low vehicle replacement cost is therefore of great advantage in the case of multi mission system too. Because of limited deck space of the ships, system sizes and masses were limited to a feasible minimum also.

UKWIA£ and SMCC system are delivered as sets, ready for installation, except for cranes used for launch and recovery. Ship mounted, universal cranes are currently used for this purpose.

Being so different, both the systems largely use same observation and navigation devices. Hardware and software used for system control are also very similar. This is because of great similarities in mission tasks and profiles. It allows to use common design of operator's console in both application. It also means that ship equipped with one of the system can be used to operate another one. However unique feature of UKWIA£ vehicle is its capability to transfer SMCC and launch it at required location. This offers capability to extend range of UKWIA£/SMCC system in specific tactical and environmental conditions.

3. COMMON CONSOLES AND OPERATOR TRAINERS

The similarities in system functions allow for use of almost the same hardware and similar software needed to remotely control of both types of vehicles. This substantially reduces development cost. Substantial savings are expected during exploitation due to limited inventory of spares and common skills required for maintenance It is also of great help in mission management and personnel training.

Console can be delivered as permanently installed or as portable set of cases. Both types of consoles are enclosure independent. This allows for easy modifications to answer specific platform limitations.

Vehicles are controlled by a pilot using one or two TV images. Important system status information are overlayed on one of TV images in graphical form. These are supplemented by sonar image and navigation data screens. All the screens are LCD type. Their size depends on particular requirements. 10" and 12" TFT LCD screens are currently in use. Single screen, multi window solution will be considered as alternative in future application.

Similarities found between both consoles have their culmination in case of common operator's trainer, developed to facilitate education and training of operators. Simplified trainer (a single device simulator) is built into all consoles installed on ship permanently. Operating mode of the console (as a controller or as a simulator) is selected from the control computer keyboard.

Real trainer is built using exact UKWIAL/SMCC console design. To allow computer simulation of all system functions, only two additional computers are added for virtual vehicle. One to simulate sonar head and one for second TV image. Standard console computers are used for other functions. In fact, it is also possible to install additional two computers mentioned above in ship mounted console, to obtain full simulation capability.

4. UKWIAL ROV

The UKWIA£ system is a typical cable supplied and controlled ROV. It can be used for majority of search, observation and manipulation tasks. However, delivery and location of mine disposal charges are its main applications. Open frame design of the vehicle and open control system architecture offers easy access to all components for maintenance, repair and modifications.

The Ukwia³ ROV system is composed of the following components:

1. Remotely Operated Vehicle

2. Operator Control Console

3. Power Supply Unit

4. Umbilical Cable

5. Umbilical Cable Winch

6. System container (optional)

The UKWIA£ vehicle is equipped with two TV cameras, obstacle avoidance/ imaging sonar and purpose designed manipulator arm. System capabilities can be easy expanded using extra tools and equipment.

High propulsion and manoeuvring capabilities are achieved by means of 6 thrusters arranged to obtain optimum performance. Four thrusters are used for propulsion in horizontal plane. Their thrust is vectored by computer controller. Two thrusters control vehicle movements in vertical. They are also used for zero pitch stabilisation. Thruster's nozzled screw propellers are powered by means of rare earth magnet synchronous AC motors. Planetary gears are built in between motors and propellers. This assures low weight of the thrusters and therefore weight of all the vehicle. Motors of the thrusters are oil filled and externally screened to reduce vehicle magnetic fields.

Vehicle is supplied with energy by an 500m umbilical. To reduce magnetic field and component weight, high voltage of single phase AC current is supplied from dedicated inverter. All data and TV signals, between ROV and deck control room, are transmitted using fibre optic technology. 4 multimode fibres are used for easy assembly, maintenance and expansion capability.

Vehicle movements are controlled by means of two displacement type joystickcs. Other system commands are inserted using a PC compatible, IP 66 protected membrane keyboard. Pilot work is aided by several auto piloting functions such as auto-heading, auto-depth and pitch stabilisation. Auto diagnostic functions are also built in into the system software.

UKWIA£ vehicle can be used to carry of almost all disposal charges available. Small charges (10g) such as Toczek B (CTM, Poland), Sting (Bae systems, UK) can be precisely placed using devoted manipulator with telescopic arm. It is 2,5m total length while extended, and 240° tiltable. Arm tilt and extension are executed by electro-mechanical drives. It contains B&W camera, used for detailed observation and aiming. While equipped with additional claws the manipulator can also be used to suspend cutting charges on mooring ropes and chains.

50kg charge deployment system consists of charge release and winch. Geared electric motor powers a screw ended rod that is compatible with an aye on a charge body. Toczek A (CTM, Poland), Damdik (Danmark) are equipped with appropriate device. Electrically driven charge winch is provided to allow a 50kg charge to be lowered from the vehicle hovering up to 4m above a bottom mine.

5. SMCC ROV

Self propelled Mine Counter Charges are used to identify and destroy naval mines located at least 300m from a launch point. Typical mission profile calls for destruction of a target detected by other means. Usually it will be detected by means of minehunter's bow sonar but approach to target introduced to data files is also likely.

SMCC is a torpedo like, small, remotely operated vehicle. It carries mine disposal equipment to detected and classified target. Training and reconnaissance version can be used in search for targets as well. While target is identified, by vehicle sonar and TV camera, a mine disposal equipment is used to initiate mine explosive. For typical chapped charge or SAP gun device aiming is required. This is achieved using SMCC manoeuvring abilities and laser aiming device. While properly aimed, the device is triggered by means of coded signal from operators console. Accidental triggering of a mine fuse means mission success also. It means high physical fields are premium rather than negative factors as in a case of multi mission vehicles.

If the disposal device fuse is not triggered by the operator during a set time, the vehicle computer neutralizes the fuse and is able to flood its pressure hull with sea water. In current software, the time iscounted from launch or arming of the SMCC, Sterilised vehicle drops on the bottom.

Mine counter mission consists of a few distinguished periods. It starts with a short launch phase followed by transition to target area. Constant tracking of SMCC position is critical in this phase. Tracking is accomplished by means of acoustic transponder/responder device fixed to vehicle body. It responds to ultra short base line navigation system or ships mine hunting sonar. Relocation phase in friendly environment lasts a few minutes. While struggling with strong currents it can take 15 minutes for the SMCC to reach a target. To facilitate operator in this phase, an automatic control procedure can be selected. This integrates data from tracking system, vehicle data regarding heading and depth and navigation data of the mission platform (ship). Together with environmental information (currents) these data allow for calculation of optimum path and vehicle parameters. Next mission phase, when mission target must be found using vehicle sonar, can be supported by automatic procedures to limited extent only. Auto heading and auto depth/altitude may be utilised, but manual control is compulsory in current state of system development. This is also true for the following identification and aiming phases of a mission.

SMCC vehicle is available in three versions. Armed versions A and B are a disposable, single mission devices. Version A is equipped with shaped charge. Version B is equipped with SAP projectile gun. Both versions are usually destroyed during mine disposal. Training and reconnaissance version of the SMCC (version C) is recovered, after a training or reconnaissance mission is finished.

Basic set delivered is composed of the following elements:

SMCC in transporting case	10 pcs (versions A and B)
SMCC in transporting case	2 pcs (version C)
Operators console	1 pc
Launcher in transporting case	1 pc
Launcher winch	1 pc
Launcher lifting cable	1 pc
Recovery net	1 pc
Hydroacoustic navigation system antenna	1 pc
Maintenance equipment set	1 pc
Spare parts set	1 pc

6. OPERATOR's TRAINER

The ROV simulation software of the trainer has been developed as a realistic training facility for MCM system operators. It was created with a few limitations assumed:

- The system and simulation software will be run on IBM compatible, off the shelf, industrial grade hardware preferably of the type used in real console.
- Computer simulator will use data from real ROV control system and simulation results will be presented using equipment that is utilised in real ROV pilot console.
- Modular software structure is to allow easy implementation commissioning and modifications.
- Lecture interface will allow easy modifications of environmental conditions, space

  geometry and geometry of structures both on the bottom as well as in water space.

A kernel of the simulation software is a ROV physics simulator, that calculates vehicle position and orientation changes. These are results of control commands, external influences and physical limitations. The ROV movement is further limited by space geometry and presence of virtual umbilical cable.

Specific feature of the software, is ability change of a vehicle geometry due to action of several components such as pan and tilt units and manipulators. Space geometry and environmental characteristics are defined around a vehicle. This includes water surface, bottom and structures. Optical and acoustical characteristics are defined for every geometrical element. Definition of environmental conditions regards range of features such as turbidity, current, day time. Local sediment disturbances and plankton presence are also introduced.

Data regarding current position and orientation in space together with data regarding space geometry and surface characteristics are used by specialised software modules to create images and information presented to an operator using dedicated displays, widows and other adequate means.

For effectiveness and simplicity only one graphical presentation software module is active in single piece of a hardware (computer). In fact, all the modules run the same software using different device simulation element. Modules are synchronized by one of them, indicated as a master.

Therefore, simulator is built using software/hardware modules in number required by an application and customer preferences. The modules are integrated using local Ethernet network. The same network is utilized to integrate simulator with external elements such as vehicle control computers, navigation computers and other devices required to make virtual reality close to real as much as possible. 8 modules are currently run the trainer system, including one dedicated to lecturer or training supervisor.

Principal feature of the software used for simulation is ability to generate required results in real time. Simulation step 1/30s takes to accomplish. This assures good perception of presented images by human operator.

Current space definition is limited to 400m x 400m area. Using space editor a training supervisor is able to customise ROV operational space. Basic operation required is to build bottom geometry. This is accomplished by simple self graphical tools similar to that used in drawing programmes. This is followed by location of objects and structures. Located objects can be oriented and partly buried in sediments. Extensive base of objects (mines, stones, coke cans) has been built for current application. This can be extended by introduction of any objects that can be defined by geometry, optical and acoustical characteristics. A dynamic behaviour (mathematical model) needs definition, if located object is suspended or can be moved on the bottom.

7.FUTURE DEVELOPMENTS

The technologies adopted for UKWIA£ and SMCC systems are not at their limits. To exploit these potentials further development of both systems is planned. Main subject of interest is wide area search. Base systems technologies will completely split apart. The UKWIA£ will be transformed into forward going sonar platform. With much greater power demand new vehicle will be even stronger united with a ship. As opposite, the SMCC is a good start for autonomous craft. Using the same battery type, it is feasible to consider ranges of 50km per dive, while advances in computing power of contemporary processors allows to built in adequate intelligence. New types of sensors are needed for both projects to be really effective.