Communication System Between the ROV and the USV's "Edredon" Control Post

Sustav komunikacije između ROV-a i zapovjednog mjesta USV-a „Edredon“

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Summary

One of the tasks carried out by the operator from the Command Post (land or ship), who controls the unmanned surface vehicle (USV „Edredon") is the protection of critical marine objects (ports, ships, container terminals, etc.). This task is often carried out by using a remote operated vehicle type ROV (unmanned underwater vehicle). This vehicle is transported on board the USV at the site of the planned underwater reconnaissance area. When USV reach the scheduled location, the USV operator switches to remote control of the ROV vehicle. The article discusses solving the problem of remote control of the underwater vehicle ROV from Command Post. The operator uses the Launch and Recovery (L&R) system on the USV to control the ROV ditching process from the USV deck. It then controls the movement of the ROV vehicle under water (images from cameras and data from sensors placed on the vehicle ROV are transmitted via USV to the Command Post). After completing the task, the ROV vehicle is lifted aboard the USV, which carries out the next task.

KEY WORDS
unmanned surface vehicle
unmanned underwater vehicle
remote control

Sažetak

Jedan od zadataka operatera na zapovjednom mjestu (kopno ili brod) koji kontrolira bespilotno površinsko vozilo (USV „Edredon") je zaštita ključnih morskih objekata (luka, brodova, kontejnerskih terminala itd.). Taj se zadatak često obavlja uz pomoć daljinski upravljanog vozila ROV (bespilotna ronilica). Ovo vozilo se prevozi na USV-u (bespilotnom površinskom vozilu) do mjesta planiranog podvodnog područja izviđanja. Kad USV stigne na predviđeno mjesto, USV operater prelazi na daljinsko upravljanje ROV ronilicom. U članku se govori o rješavanju problema daljinskog upravljanja ROV ronilicom sa zapovjednog mjesta. Operater koristi sustav porinuća i povlačenja (L&R) na USV-u za kontrolu procesa odbacivanja ROV-a s palube USV-a. Potom kontrolira kretanje ROV-a pod vodom (slike s kamera i podaci sa senzora postavljenih na ROV-u šalju se putem USV-a na zapovjedno mjesto). Nakon dovršetka zadatka, ROV vozilo se podiže na USV i prelazi se na sljedeći zadatak.

KLJUČNE RIJEČI
bespilotna površinska vozila
bespilotna ronilica
daljinsko upravljanje

1. INTRODUCTION / *Uvod*

One of most important tasks fulfilled in the construction project of the Polish version of an unmanned surface vehicle were: providing the capability for the use of the USV to transport an underwater vehicle UUV (Unmanned Underwater Vehicle) of the ROV type, the remote control of that vehicle by operator, and the transmission of images from cameras placed on the ROV to the Command Post (ship or land) [2, 3]. Therefore it was necessary to solve the problems of wireless remote control of the underwater vehicle and the cameras installed on it as well as the data transmission from additional sensors placed on the vehicle to the Command Post. The intended effect was achieved by replacing the cable link between the ICC (Integrated Control Console) and the OCU (Operator Control Unit) with the radio link on the USV to send control signals and images from video and optoelectronic cameras installed on the USV to the Command Post [1].

The objective of the ROV integration with the USV was, therefore a remote control by an operator from the ROV vehicle Command Post and the reception of images and data from sensors placed on board of LBV200-4 being reported to the Command Center.

A purchased system of underwater vehicle consists of three main parts:

- the ROV LBV200-4 vehicle,
- the central control unit ICC (Integrate Control Console),
- the URS150-FOV cable line.

Figure 1 The view of the vehicle and the Command Post (container)
Slika 1. Vozilo i zapovjedno mjesto (kontejner)

Source: own materials

Figure 2 The set of the system of the underwater vehicle UBV200-4
Slika 2. Sustav ronilice UBV200-4

Source: Manufacturer's instructions

The LBV200-4 vehicle is directly connected by the cable line with the drum. In the drum a conversion of optical signals (sent by fiber optic) into electrical signals: Ethernet and video is being done. The drum with the cable line is directly connected to the control unit of the ICC.

The control unit of the ICC includes:

- The monitor that displays a picture from video cameras placed on the vehicle,
- The vehicle control unit OCU (Operator Control Unit),
- Led indicators of system operation states,

Figure 3 The control unit of the ICC (Integrate Control Console)
1. The AC power connector of the control unit ICC, 2.. The input of video signal from the ROV vehicle, 3.The power connector for ROV's engines, 4. The data transmission connector (RS232), 5. The video signal output.

Slika 3. Upravljačka jedinica ICC (integrirane upravljačke konzole)
1. Priključak za izmjeničnu struju upravljačke jedinice ICC, 2 . Ulaz video signala s ROV vozila, 3. Konektor napajanja za ROV-ove motore, 4. Konektor za prijenos podataka (RS232), 5. Izlaz video signala.

Source: Manufacturer's instructions

- The on/off switch with protection,
- The power module of brushless motors of the LBV200 vehicle.

Control of the vehicle LBV200-4 is done using the manipulator OCU shown in Figure 4.

Figure 4 The OCU Manipulator
Slika 4. OCU Manipulator
Source: Manufacturer's instructions

The operator using the manipulator is able to control the ROV vehicle and to change the parameters of the devices mounted on its board.

The central unit of the ICC collects also data from additional devices installed on the ROV vehicle. In the purchased solution there are data sent from: the Blue View sonar, probes to measure physic-chemical parameters of the marine environment, and underwater navigation system USBL.

2. THE REMOTE CONTROL OF THE ROV UNDERWATER VEHICLE / *Daljinsko upravljanje ROV ronilicom*

Together with the vehicle there is the operator console with a 15" color monitor, and a set of manipulators (Figure 2) provided by the Teledyne SeaBotix Company. The joystick is used to control the movement in the horizontal plane, that is forward and backward and turn right and left, while the knob is used to control the submerging. The other controls shown in Figure 4 and Figure 5 are used to control the movement of the camera, switching its lights, the switching on the power, etc. To send commands to the vehicle and receive information from the sensors the serial port is used.

Figure 5 Operator console LBV 200-4
Slika 5. Konzola operatera LBV 200-4

Source: Manufacturer's instructions

In order to carry out the remote control of the underwater vehicle from the land mobile Command Post container a number of possible hardware configurations was considered:
- doubling the control equipment on the USV vessel unit and in the command container device simulating the of local work;
- recognizing the optical signals used in the cable line, decoding them and sending via radio connectivity to the command container;
- the placement of the ICC on the USV platform, removing the OCU manipulator to the Command container and sending the video images with the help of the USV video server.

From the three above mentioned possible solutions, the one where the ICC is placed on the USV platform (Figure 6), the OCU manipulator is moved to the Command Post, and sending video images with the help of video server from ROV to USV were chosen. The ICC control unit installed on the USV platform was integrated with existing radio communications solutions and network systems. The flowchart of the developed solution is shown in Figure 6.

Figure 6 Location of the ICC on the USV board
Slika 6. Položaj ICC-a na ploči USV-a
Source: own materials

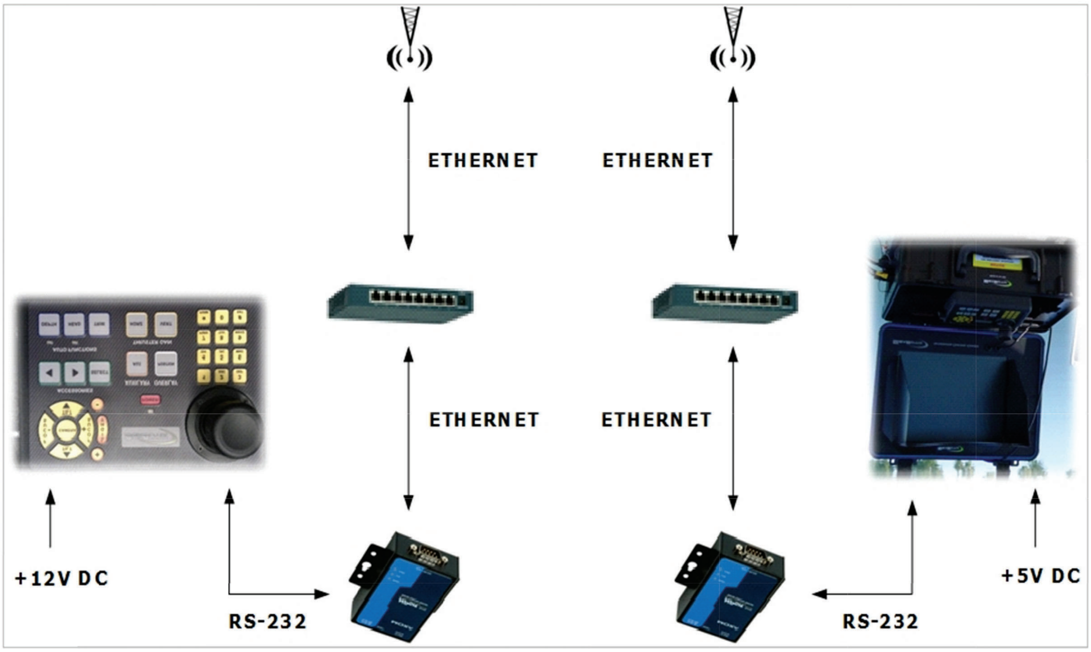

Figure 7 The block diagram of the ROV remote control

Slika 7. Blok dijagram daljinskog upravljača ROV-a

Source: own materials

Connecting cable ICC - OCU was replaced with the transmission channel compliant with Ethernet standard (Figure 7).

For this purpose, the conversion of control signals sent between the ICC and the OCU from the serial transmission to Ethernet with the MOXANPort 5150A converters was used. The scheme of testing post is shown in Figure 8.

Figure 8 The test post

Slika 8. Testno mjesto

Source: own materials

The RS-232/Ethernet Moxa converter (Figure 9) used in the system creates the bridge between the serial interface and Ethernet network.

Figure 9 NPort 5150A Converter

Slika 9. Pretvarač NPort 5150A

Source: own materials

The transmission is bi-directional, regardless of the configuration mode of the converter.

3. SENDING IMAGES FROM THE ROV TO THE COMMAND POST / *Slanje slika s ROV-a do zapovjednog mjesta*

An image from the cameras installed on the submarine vehicle is converted into optical signals and using optical fiber, which is part of the cable line, passed to the drum, where they convert the analog signal (fig.10). To upload an image from the cameras to the command post (Command Center) the installed on the USV video server, in the form of a PC, with a multi input video card (under the previous phase of the work of the USV protected free lines cards video for use by the ROV) was used.

Figure 10 The Cable line drum with the optical signals to electrical signals converter
Slika 10. Bubanj s kabelima s pretvaračem optičkih signala u električne signale

Source: own materials

An analog video signal from the ICC through a coaxial cable terminated with the BNC connectors was connected to a free input of a video card installed in the PC, working as a video server. That device provides the conversion from analog image to digital form, encoding of the video stream using "ffmpeg" and the transfer of data frames using the UDP protocol. So formatted packets of data are transmitted by the AirSpan WiMax radio connection and get to the PC located in the Command Post.

Figure 11 The structure of remote control system of an underwater vehicle by the operator from the mobile Command Post USV
Slika 11. Struktura sustava daljinskog upravljanja ronilicom kojom upravlja operater iz mobilnog zapovjednog mjesta

Source: own materials, [2], [3]

Figure 12 The USV "Edredon", the mobile command post and the system of launch and recovery of the underwater vehicle ROV LBV200-4.
Slika 12. USV „Edredon", mobilno zapovjedno mjesto i sustav porinuća i povlačenja ronilice ROV LBV200-4.

Source: A. Miłosz, AMW Gdynia

4. CONCLUSION / *Zaključak*

Each country's task is to safeguard an adequate level of safety of critical marine objects. Recently, great attention has been paid mainly to the dangers of the underwater environment. The current trend will ensure in the future the total security of land, water and underwater critical infrastructure. In securing underwater critical infrastructure, it is important to provide cooperation between USV and UUV (ROV). Equipping USV with underwater monitoring systems is one of the easiest ways to solve the problem. The detection and identification of explosives, chemical, biological or radioactive materials significantly increases the safety of protected objects and coastal areas . For this reason, the issue raised in the article is timely and necessary. The task of cooperating unmanned surface and underwater vehicles greatly enhances the possibilities of operation of both vehicles (synergy process). Tests carried out by the remote control vehicle type ROV, which can be quickly moved to different locations using the USV, have increased its operationality. This study also showed the elements of the system that need to improve. One such element is the L&R system of the ROV vehicle from the USV vehicle.

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