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The MAGIS Remotely Operated Vehicle Some design problems

INTRODUCTION

The offshore industry uses more and more technical facilities for penetration of the abyss. Unmanned vehicles, especially the remotely operated vehicles (ROV) play a key role in tasks performed underwater.

Procedure of building of the ROV system requires fulfilling detailed requirements of the user. There are also various technical and economical limitations which have to be taken into account by the designer and manufacturer. The problem of reliability and safety of the designed ROV system is of special importance.

Most of these problems were taken into consideration in design process of an underwater systems built at the Faculty of Maritime Technology as a result of R&D projects carried out by the Underwater Research Team. In the underwater system the MAGIS ROV has been applied .

In this paper configuration and main parts of the MAGIS ROV system, range of the system application and the design process of the ROV are shortly presented. Criteria affecting the project and some aspects of the ROV system's reliability are indicated.

CONFIGURATION OF THE MAGIS ROV SYSTEM

The configuration of the MAGIS ROV system is shown in Fig.1.
The system consists of :

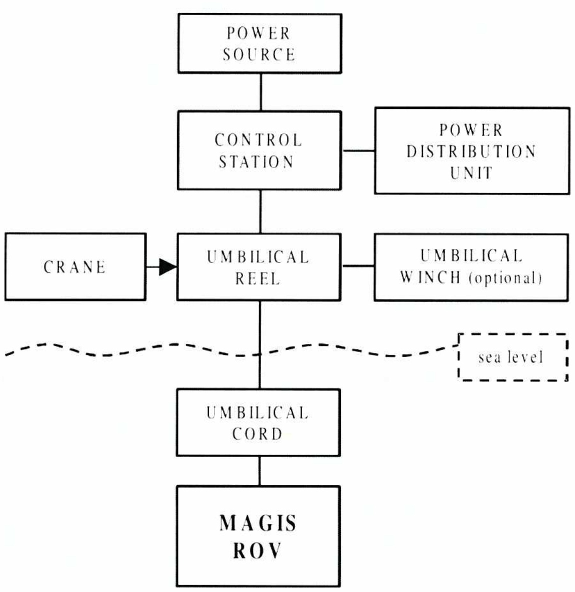

Fig.1. *Arrangement of the MAGIS ROV system*

- the vehicle which is connected to the surface control station by an umbilical cord stored on the reel
- handling system for control of the ROV
- launching system (by an external crane)
- power source and power distribution unit.

The MAGIS ROV is directly attached to the control station without any additional links. The configuration of the vehicle is presented in Fig.2.

The ROV system consists of several simultaneously developed sub-systems the main of which are as follows :

- structure and structural containers to accomodate the equipment carried by the vehicle
- energy supply sub-system : source of energy, power cabinet, umbilical cord
- propulsion sub-system (thrusters)
- vehicle control sub-system
- sub-system for vehicle navigation and positioning
- sub-system containing instrumentation, displays and data processing
- work equipment
- sub-system for launching and transport.

Technical description of the system is briefly presented in Table, [3].

Technical characteristics of the MAGIS ROV system

Parameter/sort of equipment	Technical data / device
Task site category	line or area site
Shape	spindle-like
Gabarites	2250 x 760 x 600 [mm]
Weight in air	125 [kg]
Operational depth	400 [m]
Speed forward	2.5 [m/s]
Number of propellers: longitudinal transverse+vertical	6 2 2+2
Umbilical cord	100 or 400 m in length optical fibres for numerically controlled signal transmission
Supply voltage	3 x 380 x 50 [V x Hz]
Basic equipment	colour video camera, black & white video camera, photo camera & strobe, lights 4 x 300 W, pan & tilt platform for one camera and 2 lights, magnetic compass, pressure draught gauge, two-function jaw manipulator, tracking system
Optional equipment	magnetometer, water sampling device, sounder for testing physical & chemical parameters of water
Deck devices	energy supply cabinet, two video monitors, computer with video overlay installed monitor, hand control console, mouse, keyboard

The main advantageous features of the MAGIS ROV system are as follows :

- working depth down to 400 m, (covering almost the whole Baltic Sea area)
- forward speed of 2.5 m/s which allows to operate in strong water stream
- spindle shape providing low resistance in water stream and high manoeuvrability

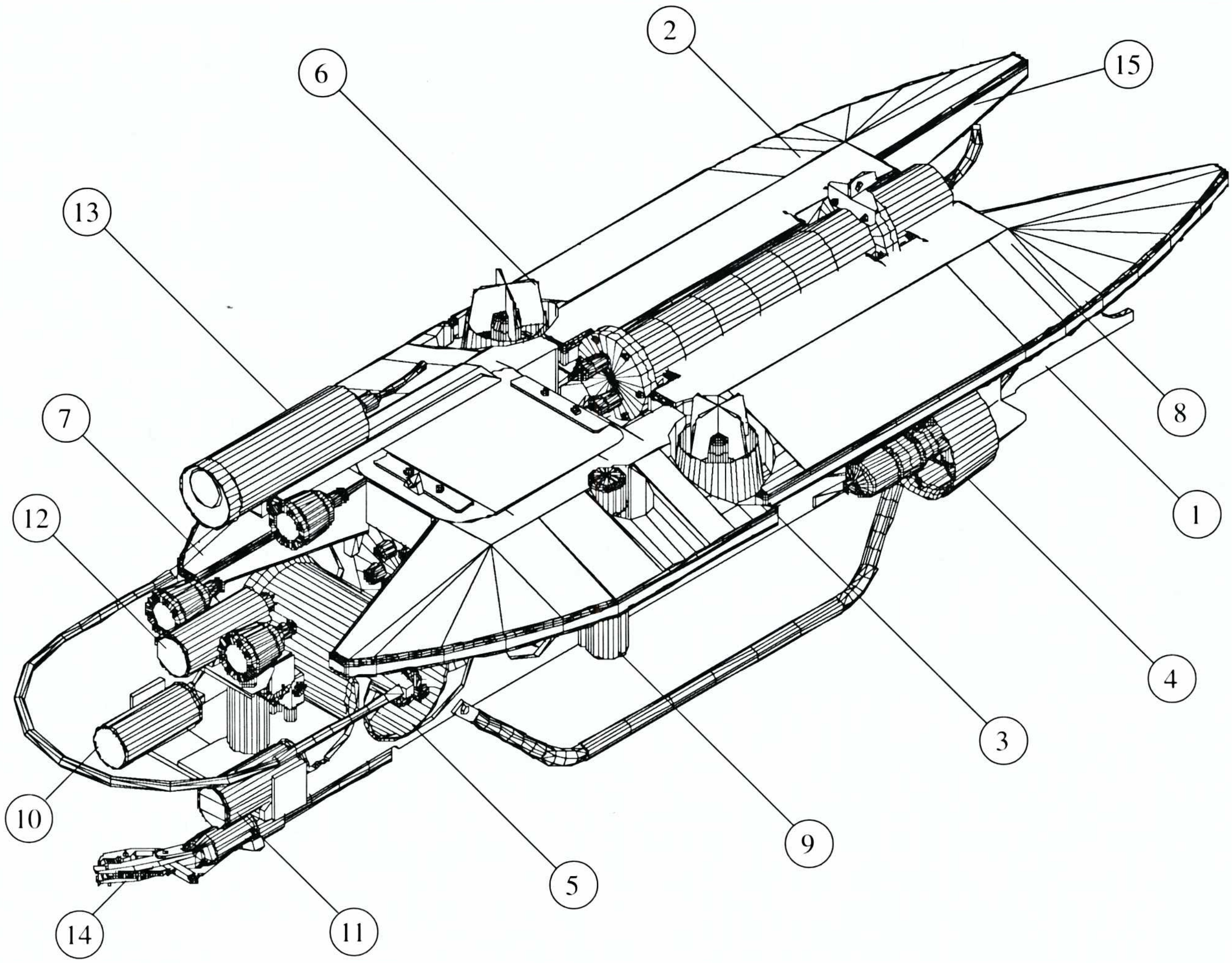

Fig.2. *Configuration of the MAGIS ROV*

1 - frame
2 - buoyancy unit
3 - container for electronic equipment
4 - longitudinal thruster
5 - transverse thruster (hidden)
6 - vertical thruster
7 - light
8 - compass (hidden)
9 - beacon
10 - photo camera
11 - strobe lamp
12 - colour tv camera + pan&tilt
13 - b&w tv camera
14 - manipulator
15 - umbilical cord
16 - measurement sonde (hidden)

- ➢ sophisticated equipment which allows to perform task with a great precision and to on-line measure different parameters with a great accuracy
- ➢ tracking system based on an ultra-short-base positioning system, providing precise description of vehicle position at the work site.

TASKS TO BE PERFORMED BY THE MAGIS ROV

Tasks assigned to the MAGIS ROV cover observation, inspection and water environment monitoring with the use of the equipment carried by the vehicle. The range of such investigations is as follows :

- observation of the abyss and bottom, searching for underwater objects
- inspection of underwater structures : hydro-technical constructions, pipelines, cables, oil and gas mining equipment
- monitoring of working parts of underwater appliances including those for sea-bed mining
- inspection of underwater parts of floating objects
- monitoring of physical-chemical properties of water
- biological investigations
- assistance during divers missions
- transport of diver's equipment.

DEVELOPMENT PROCESS OF THE MAGIS ROV

The development process of the MAGIS ROV was divided into three phases, [1] :

- ☑ ***the pre-design phase*** in which underwater vehicle missions were defined
- ☑ ***the design phase*** in which assumptions regarding performance of the tasks were developed with taking into account technological constraints
- ☑ ***the post-design phase*** when manufacturing and tests were realized. In that phase remarks regarding system performance were collected for the system design improvements in the future.

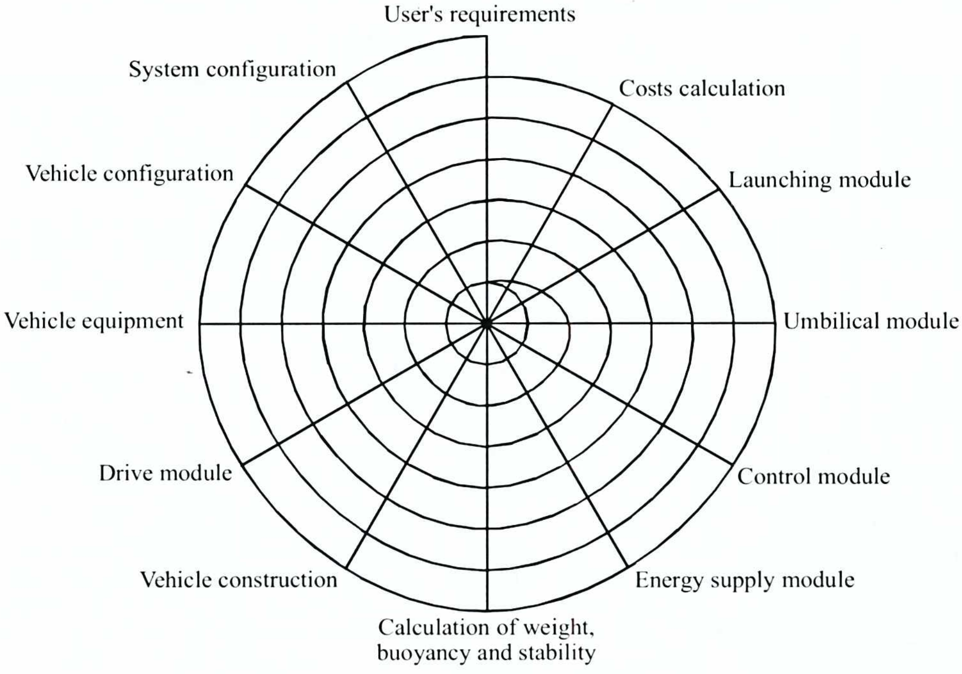

Fig.3. *Designing spiral of the remotely operated vehicle.*

Designing of the ROV was performed in accordance with the procedure characterized by the designing spiral shown in Fig.3, [2].

DESIGN CRITERIA

All the partners involved in the project submitted their design criteria. The most important criteria affecting the project were as follows :

usefulness of the system
minimum cost of the system
minimum weight or space of the ROV and its system
possible transport, storage and launching of the ROV system
design and operational features complying with the-state-of-the art.

RELIABILITY-RELATED STRUCTURE OF THE ROV SYSTEM

The reliability related structure determines dependence of reliability state of an object (usefulness state, uselessness state) on reliability states of its components [4].

The MAGIS ROV system consists of the following functional components : power, control , propulsion, vision, working, launching and other units. The system forms serial structure therefore a malfunction of each of its units affects the performance of the entire system (Fig.4).

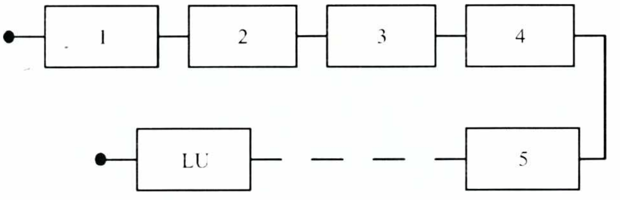

Fig.4. *Serial structure of the MAGIS ROV system*

1 - power unit, 2 - control unit, 3 - propulsion unit, 4 - vision unit, 5 - working unit, LU - launching unit

Each of the assemblies and units of the system, usually consisted of redundant parts, forms parallel structure, e.g. the vision unit composed of two tv cameras and multiple projectors (Fig.5). In such case a malfunction of any of the unit's parts would not lead to a malfunction of the unit and the entire system would be able to fulfil its assumed functions. It is very difficult to ensure a proper level of reliability for the ROV system. Hence it was found reasonable to identify the weakest components and to use them in redundant units to ensure a higher reliability level for the entire system.

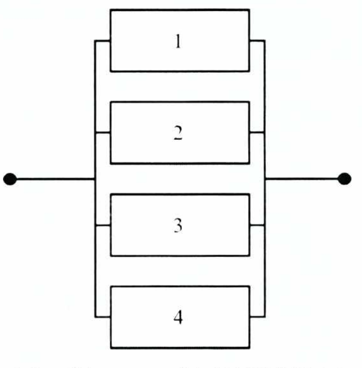

Fig.5. *Parallel structure of the MAGIS ROV vision unit*

1 - tv camera 1, 2 - tv camera 2, 3- reflector 1, 4- reflector 2

FINAL REMARKS

The field trials of the MAGIS ROV system confirmed that the system in question has been suitable for underwater investigations. Various tasks were successfully performed in co-operation with Polish maritime institutions. Important tasks performed in the year 2000 covered inspection of wrecks, ship hulls, piers and a part of Szczecin--Świnoujście waterway.

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