ROVBus: A Modular Electronics Backbone For Flexible ROV Capability Integration

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***Abstract*— This paper presents "ROVBus," a communications framework tailored to custom ROV development, that enables plug-and-play interconnection of various component tools via a unified communications bus. The flexibility provided by this approach enables easy custom tooling for various ROV frameworks and allows them to be tailored to a range of applications. The paper will describe the ROVBus system architecture at a block diagram level and will explore how this system architecture can be used to quickly adapt a common ROV backbone on a project by project basis. Successes and challenges in achieving the desired flexibility and rapid development will be discussed.**

***Keywords*— subsea tooling; modular component architecture; custom ROV platform**

I. Introduction

Underwater applications present an extremely diverse set of challenges. Though off-the-shelf Remotely Operated Vehicles (ROV's) often act as a good platform for deploying job specific tools, for certain tasks, operational restrictions may prohibit the use of a standard ROV, necessitating the development of a project specific vehicle or tool.

But the cost of a complete vehicle design makes this economically unfeasible for many projects. And the time required for a custom design is a significant barrier. Development of an entire system from scratch for every project would result in unacceptably long project lead times and prohibitive costs.

Following several years of experience designing custom ROV's, SeaView Systems has undertaken the development of a robust, modular underwater robotic control system, called "ROVBus," upon which multiple application blocks can be developed and deployed. Using ROVBus, the development of a new vehicle can be done at much lower cost, can allow easy reuse of previous module development, reduces inventory requirements by allowing flexible reuse, and can be accomplished much more rapidly while still maintaining a high quality of service.

This paper explores the capabilities and design considerations in creating ROVBus and presents some of the applications that have been built on th ROVBus framework.

II. ROVBus: A Platform for Underwater Tooling

ROVBus employs either a single board micro-controller or an industrial PC for remote control, fiber optic telemetry, and another micro-controller driving custom daughter-boards for control of:

- Brushless DC thrusters
- Linear actuators
- Tracks
- Other subsea tooling
- Dimmable LED lights
- Heading, pitch and roll inputs
- Sonar and auxiliary power control
- HD video control and monitoring
- Leak detection
- Other components

The block diagram in Fig. 1 shows the components of an example ROVBus system used for the control of a robotic underwater crawler system. By utilizing existing ROVbus PCBs development time and cost can be greatly reduced over a bespoke system without any sacrifice in functionality.

The use of ROVBus enables components to be stocked and paired with logic boards so that they can be readily deployed on any ROVBus enabled platform. This results in much improved efficiency when configuring custom vehicle frames or swapping out tooling for a frame that is to be deployed for different target aplications.

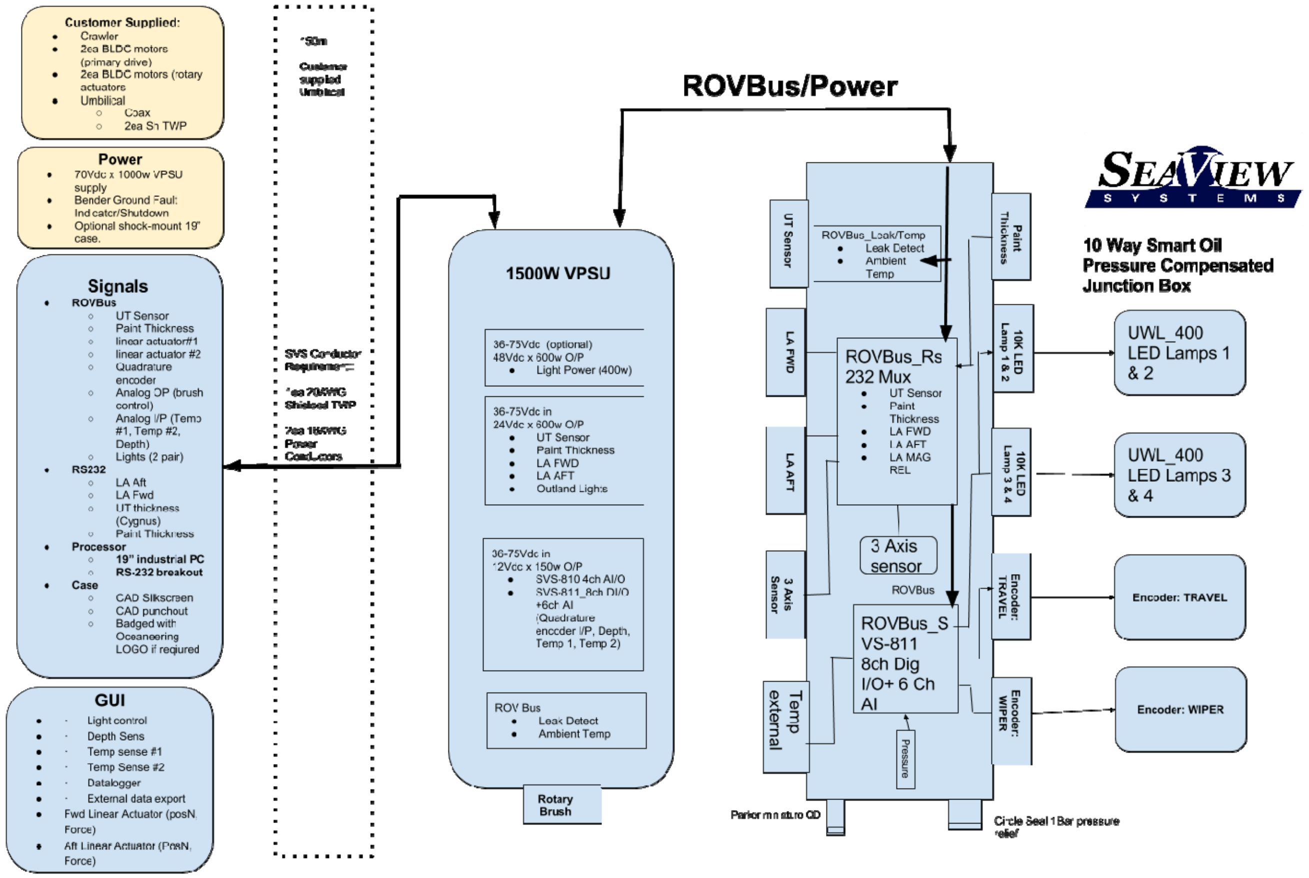

Fig. 1. The components of an example ROVBus system used for the control of a robotic underwater crawler system.

Specific features of existing ROVBus cards include:

- Analog I/O
- Digital I/O
- PWM Control
- On-board leak detection
- On-board temperature sensor
- Quadrature Encoder I/P
- Tacho I/P (frequency counter)

ROVBus devices are controlled using simple ASCII control characters. Proof of concept may be performed by controlling devices using a terminal program. Once the hardware is proven, control code may be rapidly developed as required.

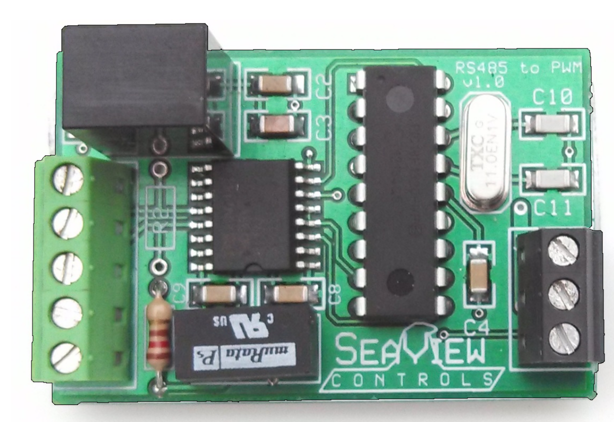

Fig. 2. A sample daughter board used to control LED lights.

Fig. 3. An ROVBus compatible daughter board mounted within an LED light casing.

By driving each of these components via a port-identified controller board, the individual components can be treated as plug and play elements. The components of ROVBus are shown in the diagramatic representation of an example system, a subsea crawler for detecting unexploded ordnance.

Another advantage to this system is that all of the components can be driven by a standardized graphical interface that con be easily modified to reflect the components present in any specific implementation.

III. ROVBus as Used in ROV Systems

A couple of examples of the diversity of applications that have been developed using ROVBus are shown below. These will be presented in more detail in the full paper including both design considerations as well as the use of these vehicles in the field.

One of the initial applications using ROVBus is called "Smart Grapple" which is shown in Fig. 4. Smart Grapple uses ROVBus to allow the remote operation of a grappling tool. By incorporating thrusters, video cameras, lights and sonar, as well as positioning and orientation systems, the Smart Grapple allows a user to either visually guide the grapple or, in extreme low visibility conditions, to use the grapple purely based on sonar.

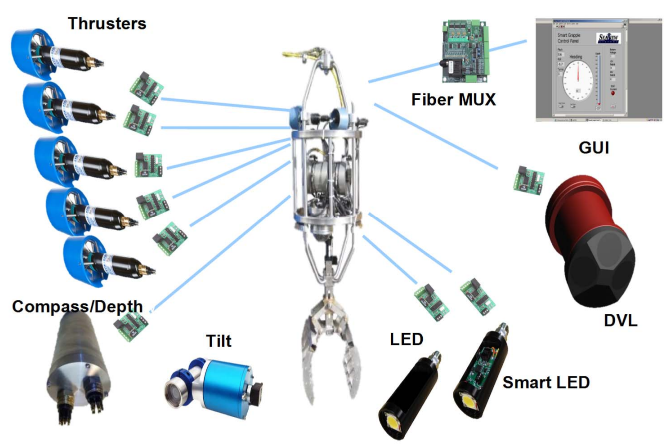

Fig. 4. Smart Grapple was implemented using the ROVBus to manage positioning and grapple control as well as imagingwith interchangeable components that can be easily deployed and tailored to the target environment

By connecting each of these components to the ROVBus backplane for control, they can readily be integrated with the overall system design. The equipment required for this application is very dependent on the deployment envirvonment, especially visibility conditions. If a subsequent deployment requires different components, say for example, replacing a sonar with an HD video controller, the changes required to the system are minimal as the control logic is already in place.

Another example of a custom vehicle is an articulating ROV dubbed "Chiton" (shown in Fig. 5) that uses ROVBus as the control backbone for thrusters, cameras and survey equipment. In the case of this vehicle, it also includes actuators that pull the ROV body from its flexed mode (designed specifically to penetrate a narrow point of ingress) into a rigid body capable of efficient transit once it has passed the point of entry to the survey target. As with the more common components such as thrusters, the ligament actuators can be readily incorporated as nodes on ROVBus and system integration work for their control is greatly reduced.

Once the vehicle has passed through the narrow opening, it tightens a set of ligaments to become a rigid body capable of performing a full survey in a tunnel penetration of about 5km.

Another application for ROVBus is a robotic crawler for unexploded ordnance (UXO) detection in high energy littoral environments such as surf zones. In this application a combined Analog/Digital I/O card is embedded into each of two Hydraulic Propulsion Units used to drive two hydraulic drive circuits (one port and one starboard). The units monitor the speed of each HPU in order to provide synchronous control of port and starboard tracks. Other features include onboard leak detection and temperature sensing.

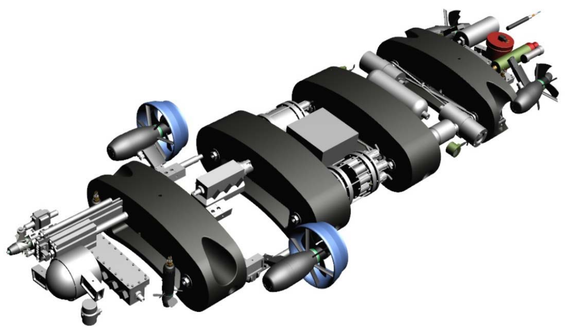

Fig. 5. The “Chiton” vehicle design with ROVBus connected elements

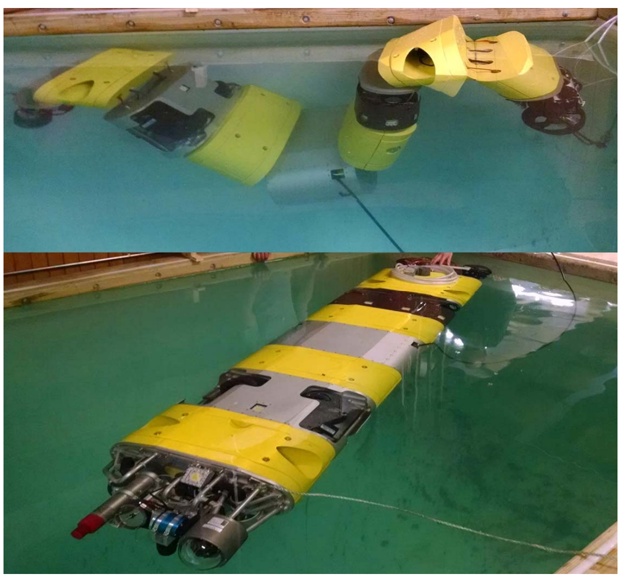

Fig. 6. The “Chiton” vehicle showing the vehicle flexed and extended

IV. Conclusion and Directions For Future Work

A couple of examples of the diversity of applications that have been developed using ROVBus have been described in outline. Design considerations as well as details about field deployment, successes and challenges with completed vehicles designed around ROVBus, new projects that are underway, as well as highlighting possible future applications will be presented.

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