2016 MATE INTERNATIONAL ROV COMPETITION

EXPLORER CLASS

TECHNICAL REPORT

KOCAELI UNIVERSITY

UMUTTEPE YERLESKESI, IZMIT

KOCAELI, TURKEY

TEAMMATES of LUCKY FIN

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ABSTRACT

This documentation belongs to Mate ROV 2016 Turkey competition's winner Lucky Fin team. This team consists of seven students and one mentor which are from the Department of Electronics and Communication Engineering at Kocaeli University. Team members work on systems of hardware and software. The first time when vehicle will attend to competition, main purpose is to take HD videos in small areas with controlled manoeuvre. The number one priority is safety while designing and working on security provisions.

Vehicle's body made by PVC. ROV has four motors. There're four cameras on it. One of them is inside the tube. Two of them are mounted above vehicle. The last one is on the robotic arm and controlled with robotic arm. There're three servo motors on robotic arm. Controlling of vehicle is done using a joystick. There're some sensors like compass, leakage sensor, temperature sensor and pressure sensor. The electronic card has a BeagleBone Black (BBB) which is a single board computer of Texas Instruments, motor drivers, servo drivers, power circuits, sensor drivers and communication circuits. BBB runs control software which is written using C++ programming language.

Graphical user interface (GUI) is written using C# programming language. The telemetry that an operator might need of is shown on GUI.

The vehicle's designed for maximum 150 meters depth and tested under pressure of 15 bars. The robotic arm is able to move in two dimensions and to grip objects in the third dimension.

The vehicle costs about $5000.

Figure 1 - **ALL MEMBERS of LUCKY FIN TEAM**

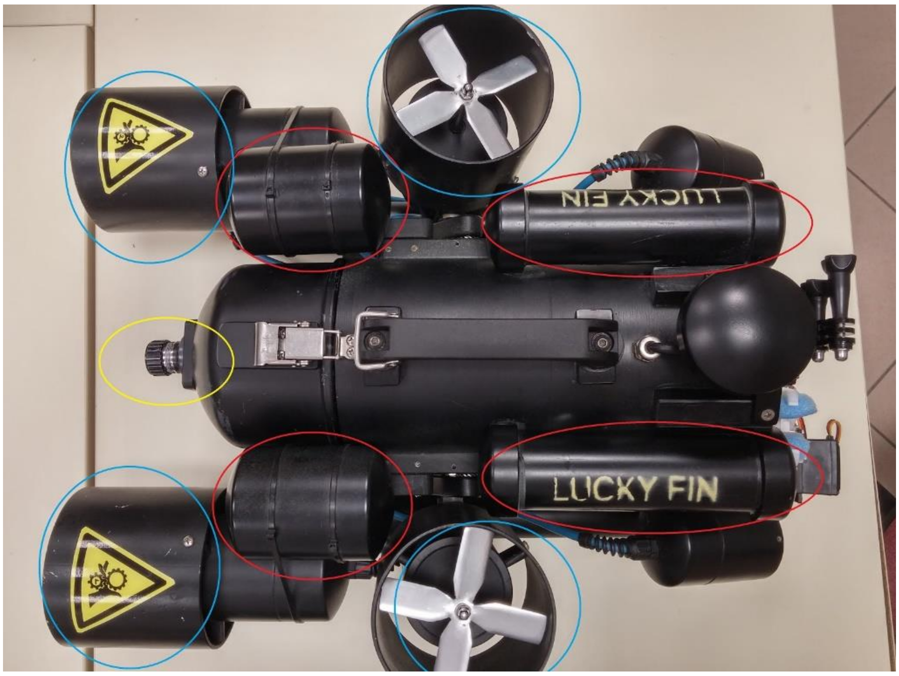

Figure 2 – **TOP VİEW**

Vehicle's body made by PVC as it is shown in Figure 2. To take safety precautions some labels are sticked on the body where might be dangerous parts such as thrusters. The tubes circled in red in the Figure 2 provide neutral buoyancy of the ROV. There are four thrusters circled in blue in the Figure 2. Two of them are for vertical movements and the others for horizontal movements. The thrusters are controlled by generating pulse with modulation signals which are generated by Beaglebone Black which is used on the electronic board as a brain of the ROV. In the Figure 2 the area circled in yellow is the cover of the communication cable's connector.

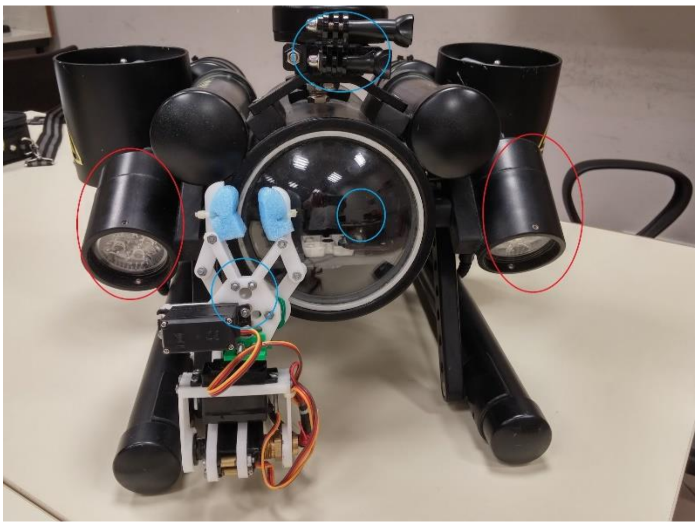

Figure 3 – **FRONT VİEW**

There're four cameras on the ROV shown in the Figure 3 circled in blue. One of them is inside the tube. Two of them are mounted above vehicle. The last one is mounted on the robotic arm and it can be controlled with the robotic arm. There are two LEDs shown in the Figure 3 circled in red.

There're some sensors in the main tube which contains the electronic card like a compass, a leakage sensor, a temperature sensor and a pressure sensor.

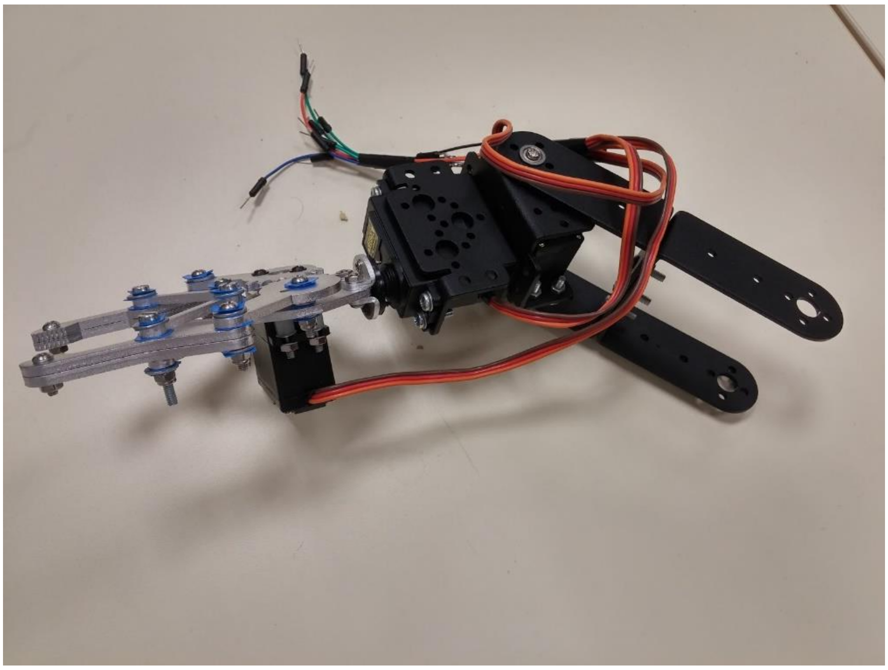

Figure 4 - **GRIPPER**

The robotic arm which is in the Figure 4 is able to move in two dimensions and to grip objects in the third dimension. There're three servo motors on robotic arm. It is controlled by generating pulse with modulation signals which are generated by the programmable real time unit in BeagleBone Black.

SAFETY

For Kocaeli University Underwater Society safety is the number one priority in all aspects of work and operation. Our group always takes a proactive approach to ensure members follow safety protocols and that they work safely in all environments. All employees are required to be familiar with standard lab and shop safety protocols including safety equipment locations, emergency exit routes, and dress requirements. Our vehicle's first aim to help divers in dirty places which is unhealthy and also our target is to measuring pollution, carbon ratio , temperature and etc. if we effect to another chippy that mean we failed. Employees are advised on safety procedures specific to the pool environment before remotely operated ROV operations begin. So while we were working on our project we define our security steps and we follow them. Our steps are;

All Lucky Fin products are designed and developed with a focus on proactive safety. Lucky Fin has a number of built-in safety features including:

- Over current protection
- Emergency stop switch
- Curved, smooth edges on ROV
- Thruster shrouds
- ROV power isolated from topsides control module
- Warning labels on moving or exposed energized equipment

Figure 5 – **TEAM MEMBERS, Safety**

Our group has developed a series of operational checklists (see Appendix A) which detail protocols for safe ROV operation. Pre-flight protocols include electronic and water ingress testing while post-flight protocols include the surface shutdown of all ROV systems. Launch and recovery is accomplished by a two-person team and takes advantage of handles on the ROV ensuring a safe transition to and from the water. While the ROV is in operation, members of the deck crew are required to wear closed-toe footwear, personal flotation devices, and safety glasses. All checklists indicate potential safety risks to operators. By diligently following safety practices, no serious or loss-of-time injuries have occurred in preparation for this contract. With every new opportunity, our group strives to further its focus on safety.

DESCRIPTION of CHALLENGES

Difficulties that we met during preparation for competition

- Water proofing servo
- Burnt servos due to over current
- Pressure measurement errors
- ADC calibration errors
- Joystick errors
- Power problems of thrusters
- Water leakage through cable
- Buoyancy of control tether
- Buoyancy and balance of the ROV
- Viewing angle of the misplaced camera

DESCRIPTION of SKILLS GAINED

The most important achievement we've had is to learn how to react to a problem in the group. The second most important subject is water proofing the ROV. We design PVC housing for water proofing the thruster motors. Water proof couplings are used for the cable of external components.

Thruster motors are vertically and horizontally located for better power performance and number of motors is limited by four in order to low power consumption. We designed our ROV's body like oval. At the same time we got help from physic theorems for ROV's general structure.

To make servo motors water proofed, we filled grease inside them. In the software side code which is for servomotors are limited for do not draw over current. To do cable of communication which is for servo motor's water proof, we filled spaces with adhesive.

To provide neutral buoyancy, we calculated the amount of water that overflows due to vehicle's bulk. When the ROV doesn't dip, we add weights on it. At the same time, to provide neutral buoyancy for communication cable, we calculated the amount of water that overflows due to cable's bulk and we add floating material.

We added extra cameras because of adherent robotic arm blocked to the cameras view.

We learned about dynamic movements of thruster motors. Due to dynamic movements, we experienced about power management.

DESIGN RATIONALE

ROV BODY DESIGN

Our primary purpose in designing ROV is to get high quality videos from underwater and smooth manoeuvres of the ROV in small area.

Neutral buoyancy and stability adjustments are realized proper positioning of thrusters and floaters. High resolution video camera with large sight of view is used for visualisation of the robotic arm movements, attached in front of ROV. Spherical polycarbonate window is used to resist high pressure under water. The body of ROV is designed as compact as possible to achieve better dynamical movements. The thrusters are positioned two sides of ROV and back side to achieve minimum power consumption. The warning signs on ROV are placed to the locations where they easily can be seen. The colour of the signs selected yellow to be able to seen underwater best.

SOFTWARE CONTROL of ROV

Graphical User Interface (GUI) is designed for the controlling the motion of our ROV, collecting valuable information underwater and status of the ROV electronics. The software is developed using C# development environment. In GUI user can configure selected properties of control software and select communication port, activate joystick properties, visualize orientation of ROV and determine the depth of ROV operation.

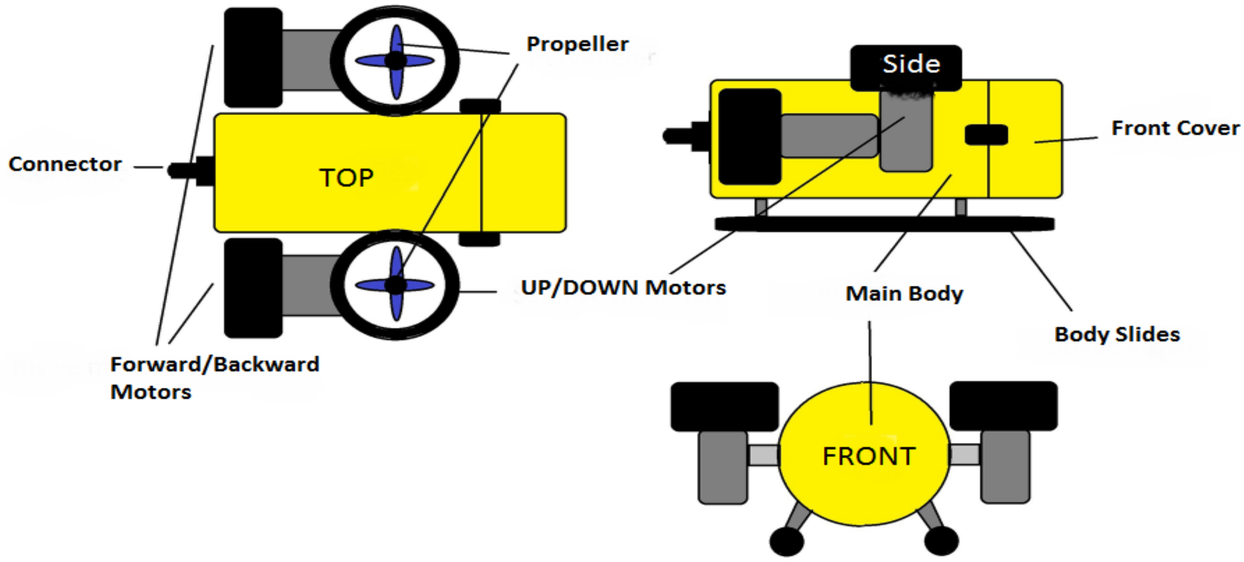

Figure 6 - **VEHICLE CAD**

ELECTRONIC DESIGN

Electronic control card of our ROV is placed into a PVC tube to achieve maximum pressure endurance. In electronic control card, four DC/DC converter power circuits are used to convert DC 48V to DC 12V. Three of the DC/DC converters are used for DC thruster motors power supply each driving two DC motors. The last DC/DC converter is used for the rest of electronic circuits power supply. All the convertor are current limited DC/DC converters and protected by 10A fuses.

CONTROL SOFTWARE

The software for Lucky Fin consist of two parts which are for the client and the ROV. The GUI software which runs on the client side (Windows OS) was written using the Microsoft .NET Framework and C# programming language. The reason for choosing this language is because it is simple to design and to develop a graphical user interface (GUI) and is easy to find external libraries such as Avionic Instruments Control. The second software which runs on the ROV was written using C++ programming language and assembly instruction set of Texas Instrument's Programmable Real Time Unit (PRU) which is one of the microprocessors in BeagleBone Black.

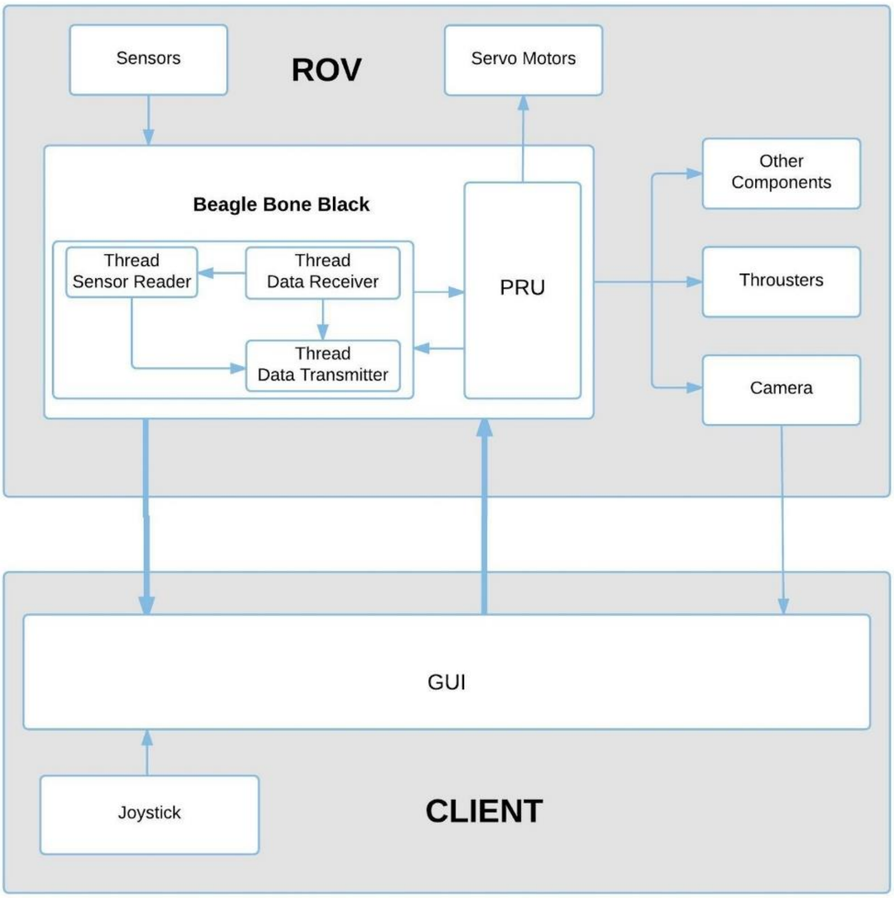

Figure 7 - **SOFTWARE BLOCK DIAGRAM**

The GUI software was designed to operate the ROV via a joystick controlled by an operator and to monitor the ROV's basic movements and conditions with a camera. The GUI periodically transmits specific data packets to the ROV; that means commands to the ROV and it periodically receives specific data packets coming from the ROV which contains the sensors data and information about the ROV to update the GUI.

The ROV software receives specific data packets coming from the GUI to execute these data packets as commands and sends specific data packets to the GUI to inform it. A software written using assembly instruction set of Texas Instrument's PRU is integrated into the ROV software to generate pulse width modulation (PWM) signals for the servo motors. By this PRU code the signals are generated with more stability and more sensitivity because of the real time microprocessor (MCU) in the PRU. The communication between this PRU code and the C++ code is done using a shared memory which is used PRU's MCU and BeagleBone Black processors. The C++ code uses thread structure to handle processes like receiving data from the GUI and sending data to the GUI and reading sensors data at the same time. Three thread functions are used for this purpose as it is shown in the figure 9. The main thread function is the data receiver thread function. This function receives data coming from the GUI then processes the commands hidden in the packets. The function also works with the other thread functions co-ordinately.

BUDGET

Budget	Value	Description	Source
Display	$ 650	4xFull HD cameras, 1xMonitor	Sponsor
Tether	$ 150	1x100 meters communication cables	University
Sensor	$ 250	1xPressure sensor	Sponsor
Sensors	$ 1000	1xcompass, 1x Temperature sensor	University
Servomotors	$ 60	3xservomotor	Sponsor
Motors	$ 200	4xthruster	University
Manufacturing Materials	$ 800	Materials for ROV fabrication	University
Control Card	$ 250	PCB Manufacturing, mounting, electronic component	University
Control Computer	$ 90	BeagleBone black	Sponsor
SMPS	$ 200	4x48 to 12V 10A	Sponsor
Power connector	$120	6 pıns water proof	Sponsor
Power leds	$ 120	2x12 watt	University
Material Processing	$ 750	Mechanical construction	Sponsor
Joystick	$ 60	Wireless Logitech	University
Others	$300	Carrying case and tools	University
Total	**$5000**		

DISCUSSION of FUTURE IMPROVEMENTS

One of the problems that we have determined as a team; the angle view of ROV's camera is insufficient for under water. Therefore it causes some difficulties during tasks for pilots. In this case the solution is the help of multiple cameras by attaching video processor on Lucky Fin. Video signals coming from cameras will be transferred over a single cable to the monitor. We will use waterproof housing to keep outer cameras. Also new ports will be provided for the cameras on the body. The new ports also will be tested in order to avoid water-leakage. By using the multiple-video on a single monitor, the pilot will be able to perform the tasks easier.

Another problem that we have encountered is that faulty connections in the design of Lucky Fin's control board. The control card on the Lucky Fin has a very large size so we plan on a new design which is smaller size. Large size of the control card occupies a big place on the board. Designing only a new control card won't be enough to make Lucky Fin safer and more stable if some extra controls aren't considered such as controlling of current limit and enhancing the leakage sensor.

One of our plans is to make Lucky Fin run autonomous by image processing. An example scenario would be like that Lucky Fin will be following a diver who has a coloured object in his hand and move by the instructions which the diver gives with the object.

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- **MET Engineering**
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APPENDIX A – SAFETY CHECKLIST

PRE FLIGHT SAFETY CHECKLIST

- ELECTRONICS ENCLOSURE IS SEALED
- NO ELECTRONICS WIRES ARE EXPOSED
- UNDERWATER CONNECTIONS ARE SEATED
- TETHER IS UNTANGLED AND SECURED
- CONTROLS IN OFF
- PERSONNEL ARE CLEAR FROM ROV
- ALL ELECTRONICS HAVE POWER
- THRUSTER RESPOND TO CONTROLS
- EMERGENCY STOP SYSTEM TESTED

LAUNCH AND RECOVERY SAFETY CHECKLIST

- DECK CREW WEARING PFDS
- DECK CREW WEARING CLOSED TOE SHOES
- DECK CREW WEARING EYE PROTECTION WHEN REQUIRED
- TWO PEOPLE LAUNCH CREW READY
- LAUNCH ROV
- LAUNCH TEAM CLEAR FROM ROV
- DECK CREW READY TO RECEIVE ROV
- ROV CONTROLS LOCKED ONCE IN RECOVERY AREA
- RECOVERY ROV FROM WATER AND PLACE ON DECK

POST FLIGHT SAFETY CHECKLIST

- ROV POWERED OFF
- TETHER DISCONNECT
- ALL SYSTEM POWERED OFF

APPENDIX B – ROV's BLOCK DIAGRAM

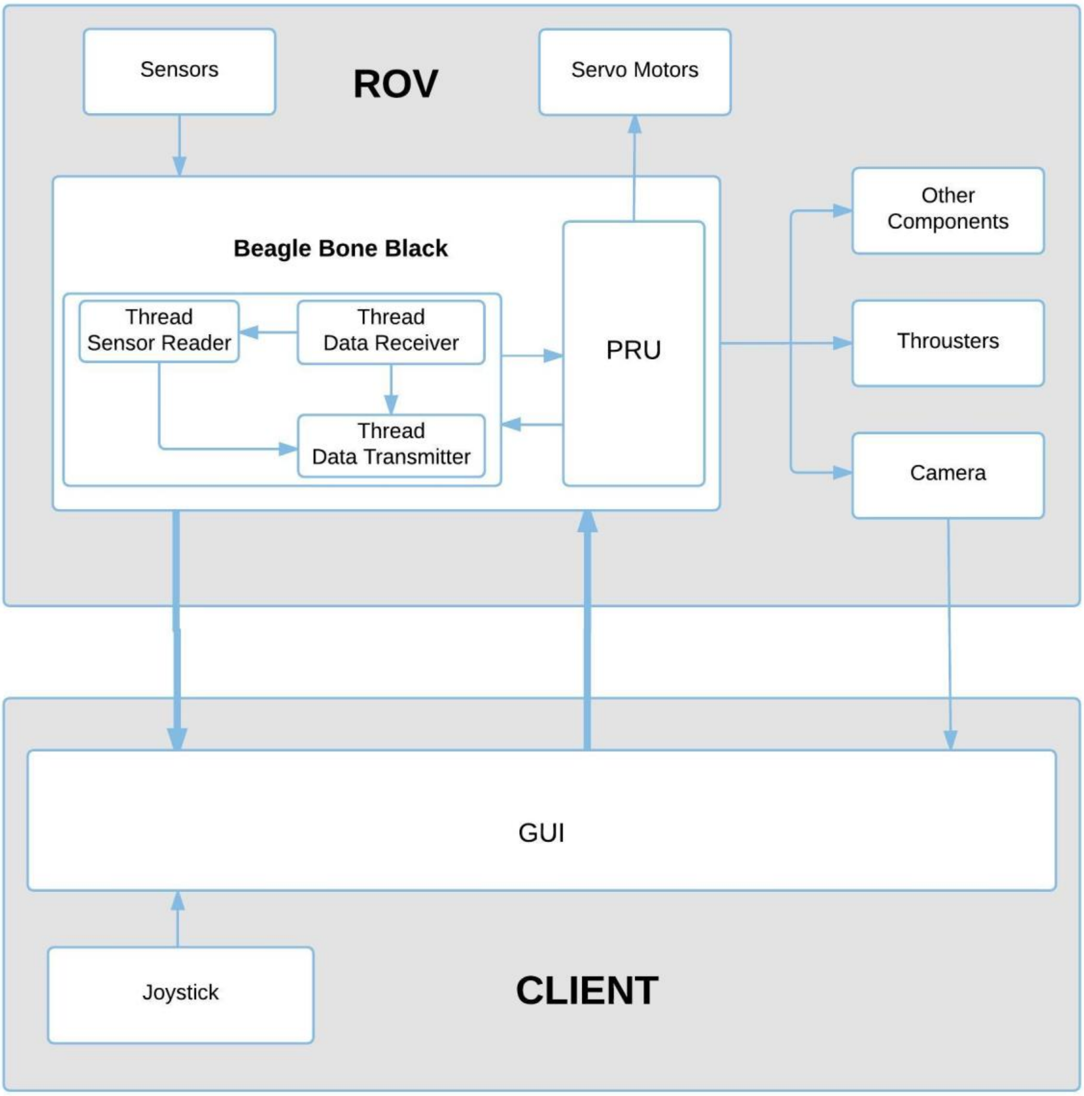

Figure 8 – **SOFTWARE BLOCK DIAGRAM**

APPENDIX C- SID

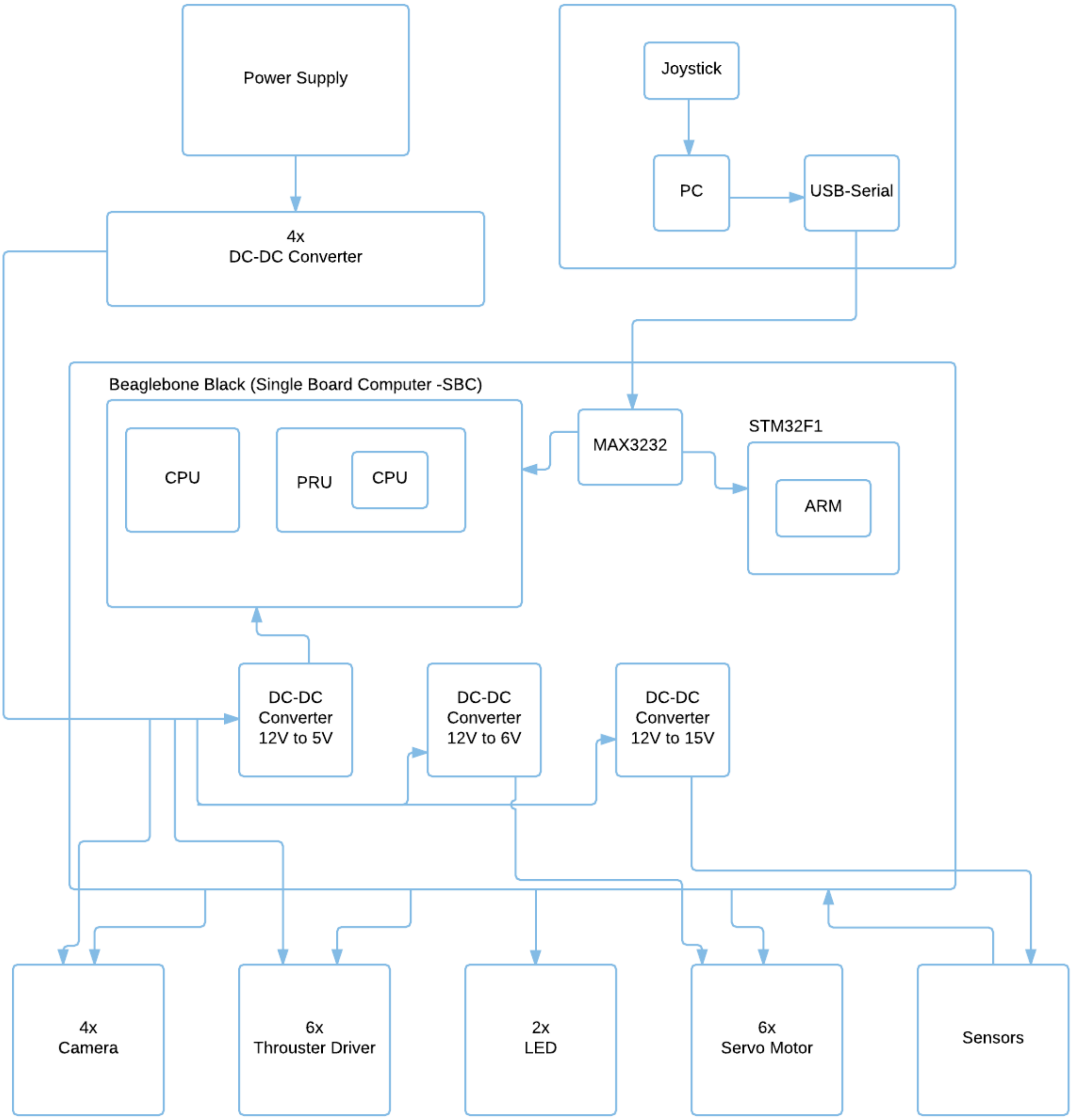

Figure 9 – **CONNECTION DIAGRAM OF THE ROV**