Design and Development of Onboard control system for Autonomous Marine Surface Vehicle (AMSV)

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Abstract : Department of defense and harbor protection mission are interested in the use of unmanned marine surface vehicles for various military and civilian services. The mission of Autonomous Marine Surface Vehicle (AMSV) can be divided into subtasks and all possible applications of AMSV can be executed with Ardupilot open source platform called Mission Planner. In this work, open source autopilot board called APM2.5 (ArduPilot Mega) board is used for vehicle operation and autonomous control on the surface of the water with minimal human interaction. Raspberry Pi camera is used as FPV (First Person View) camera for live-video streaming on a webpage. The developed system provides three modes of operation autonomous, semi-autonomous and manual control mode. This AMSV can be automatically controlled remotely onshore using Mission Planner and also change entire system for manned control (catamaran) with minimum alteration in emergency situations. Fun-Yak Boat is used as a lifeboat for inshore or coastal activities and provides ultimate safety in the sea. The expected capabilities and functions of this system are autonomous navigation, environmental measurements and observations, obstacle avoidance, data logging and two-way communications via 3DR Telemetry. The developed AMSV can be used for rescue operation in the military system.

IndexTerms - **Autonomous Marine Surface Vehicle; Autopilot; APM2.5; autonomous navigation, Mission Planner, FPV;**

I. INTRODUCTION

The autonomous vehicle is a most trending topic in robotics system like Autonomous Ground Vehicle, Autonomous Aerial Vehicle, Autonomous Marine Surface Vehicle and ardupilot board APM2.5 is commonly used as base controller Autonomous Underwater Vessels. With minimal human interaction autonomous vehicle perform its work remotely. For a vehicle to be self-sufficient, it must have the capacity to explore and perform capacities autonomously, without outside help or control (Fausto Ferreira *et al*, 2012).

This paper involves the design and development of an Open source based Autonomous Marine Surface Vehicle (AMSV), which can efficiently and reliably provide critical information, vital to the execution of various tasks in complicated marine environments. The basic common component for unmanned surface vessels is boat, propulsion system and control board. The control board used in this system is APM2.5 (Ardupilot Mega) which is master controller of this work. AMSV can be deployed in water under hostile situations, like water being contaminated by nuclear, biological or chemical agents and in rough weather and regularly monitor the vehicle status and sensor status from sea shore (Jianhua Wang *et al*, 2009). System is built with open source autopilot controller is equipped with Global Positioning System (GPS) and other sensor modules for path planning and environmental monitoring (SyedaIqra Hassan *et al*, 2017).

To execute a variety of mission that is planned, the marine surface vehicle needs a robust, reliable, accurate and adaptable navigation, guidance and control (NGC) system which provides seamless switching between automatic and manual control mode (W Naeem *et al*,2008). During emergency situation, the open source controller and electric outboard is dismantled from a marine surface vehicle and fixed it into any catamaran and can start working in short period of time.

II. SYSTEM OVERVIEW

The work involves the design, development and fabrication of an Open source based Autonomous Marine Surface Vehicle (AMSV), which can efficiently and reliably provide critical information, vital to execution of various tasks in complicated marine environments. AMSV can be deployed in a water body even under hostile situations, such as water contaminated by nuclear, biological or chemical agents and in rough weather. System is built with open source autopilot controller equipped with Global Positioning System (GPS) and other sensor modules for path planning and environmental monitoring. To execute variety of mission that are planned, marine surface vehicle needs a robust, reliable, accurate and adaptable navigation, guidance and control (NGC) system which provides seamless switching between automatic and manual control mode.

During emergency situations, the open source controller and electric outboard is dismantled from marine surface vehicle and fixed onto any catamaran and can restart working in short period of time. The boat which is operated with autopilot board is

called as arduboat or autonomous marine surface vehicle (AMSV). The few basic components for all unmanned surface vehicles are a boat or hull, a propulsion system, GPS and various kind of computer control system. To achieve required features additional sensors and sampling equipments are used upon AMSV with these basic components. The ardupilot board APM2.5 commonly used as base controller for arducopter, ardurover and arduplane.

APM 2.5 used for controlling light-weighted boats by driving brushless motor. In this project, APM 2.5 is used for controlling propulsion system of the small boat which is driven by linear actuator and high torque servo motor. In AMSV project, electronic components which are mainly dependent on power supply (batteries). Since it is operating on marine surface, it is obvious that if there is any problem (or complete discharge of batteries) in power supply the whole system stops working. To overcome this problem, proper power management should be maintained. For this project, AMSV system which will control power supply wirelessly using open source software Mission Planner. So system can be manually arm/disarm when it is required.

III. SYSTEM DESIGN

Integration of Fun Yak 2.8 Boat, motor and open source controller (Ardupilot) board delivers an Autonomous Marine Surface Vehicle (AMSV). Figure1 shows block diagram of AMSV, it consists of onboard controller called APM (ArduPilot Mega) board , GPS for navigation and surveillance, telemetry, power module and motors. In this project AMSV Electric components divided into two parts, one is power unit and other is control unit. For each unit separate LiPo batteries are used.

APM2.5 board is used as a base controller to control both propeller and rudder of the AMSV through ESC (Electronic Speed controller) or motor driver. GPS module connected to APM2.5 via GPS port for navigation. The electric outboard motor consist throttle for speed control of propeller and rudder for direction controlled using joystick used when AMSV operated in manual mode. The Raspberry Pi camera is used as FPV camera for surveillance. 3DR Telemetry is used to provide wireless communication with ground station. The complete block diagram of AMSV is as shown in Fig.1.

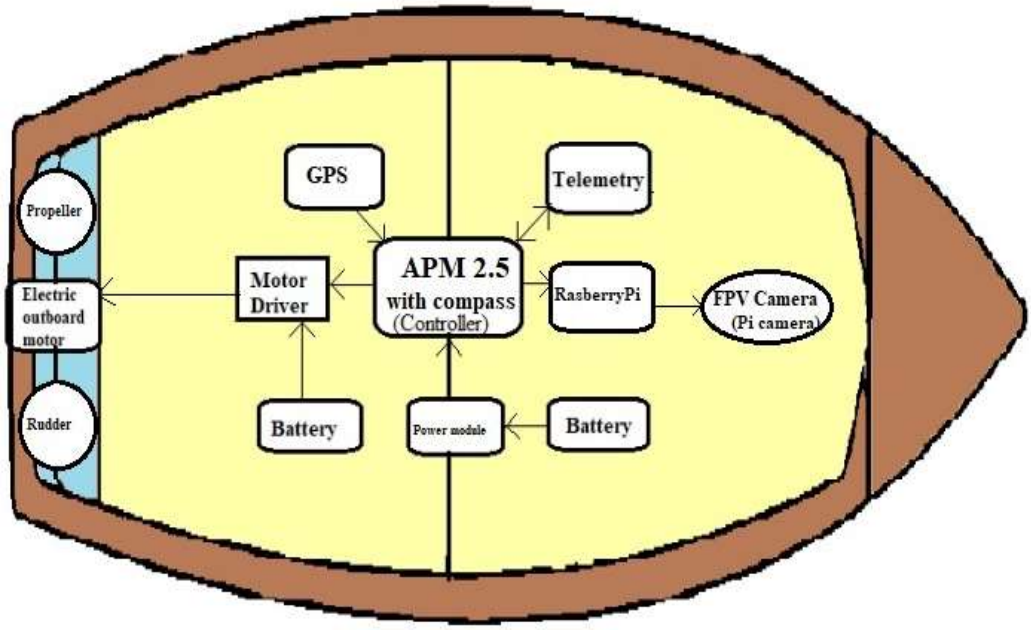

Figure 1: Block diagram of Autonomous Marine Surface Vehicle (AMSV)

Figure 2: Ground station control (GCS) system

Ground control station communicates with AMSV via wireless 3DR radio telemetry. The Ground Control Station (GCS) includes mission planning ardupilot open source software, 3DR telemetry to provide wireless communication with remote AMSV and joystick for remote control of AMSV as shown in Fig. 2. Live video streaming on webpage is done using raspberry pi camera for surveillance.

3.1. Hardware Requirement

The basic hardware requirement for unmanned surface vehicles are boat, motor and controller. In this work, fun yak 2.8 boat and electric outboard motor is used which is shown in Fig.3. Onboard boat components as shown in Fig.4 includes APM2.5 board with in-built compass used as open source ardupilot software in which all components are connected to achieve particular tasks such as GPS for navigation, 3DR radio telemetry for wireless communication with GCS.

Figure 3: Boat with Electric Outboard Motor.

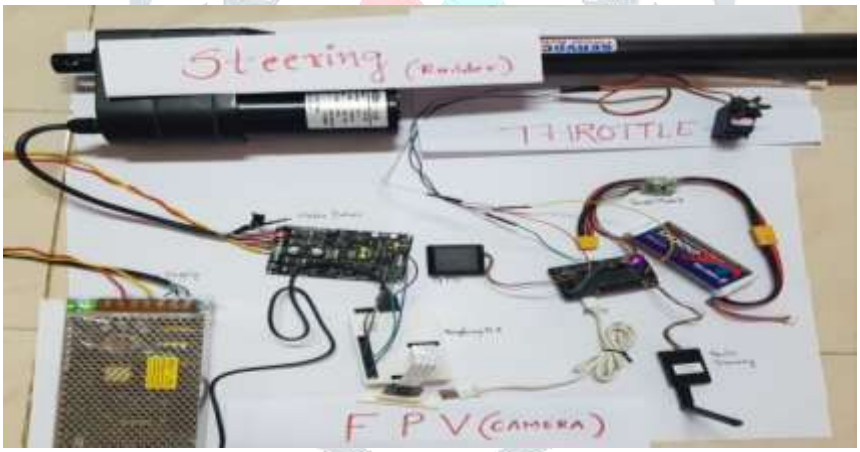

Figure 4:On-board boat components

Figure 5: Ground control station with joystick

12 inches DC linear actuator used as steering for direction control of electric outboard and high torque servo motor used as throttle to speed up and rotate propeller. The linear actuator and servo motor are driven by APM 2.5through motor driver and

ESC. Joystick connected to the mission planner will control steering, throttle and APM board arm/disarm to provide semi-autonomous mode. Figure 5 shows ground control station with joystick communicates with APM2.5 board via 3DR telemetry transceiver.

3.2. AMSV Control Modes

In this work, AMSV can be controlled in three modes as shown in Fig.6, such as autonomous, semi-autonomous and manual control mode.

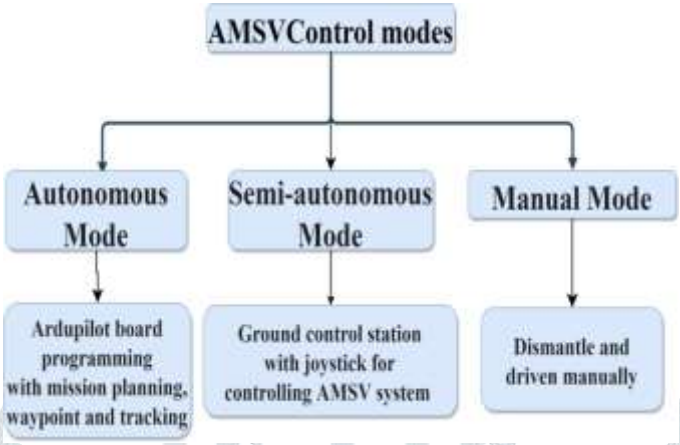

Figure 6: Supporting control modes for AMSV

Autonomous mode: The boat is driven automatically by waypoint path planning and tracking done in mission planner on Ardupilot board programming.

Semiautonomous mode: The boat is remotely controlled by joystick using mission planner at GCS.

Manual mode: In emergency situation, dismantling controller system and driven manually as normal boat.

IV. RESULT

During onboard development of this system, AMSV is tested in three modes of operation in Centre for System Design lab National Institute of Technology Karnataka, Surathkal. In each mode of operation, AMSV electric outboard motor throttle and steering movement is controlled using servo and linear actuator. During AMSV On-board testing, steering (linear actuator) is tested using the motor driver and servo motor tested using servo motor tester. The complete AMSV onboard setup and GCS is as shown in Fig.7. The AMSV's electric outboard motor propeller and the rudder is controlled by movement of servo motor shaft and rotary-linear motion of linear actuator respectively, in which both servo and linear actuator motions are controlled by APM2.5 using PWM signal. Power management is done by arming/disarming APM2.5 board remotely when required.

Semi-autonomous control mode testing is done using the joystick. The configuration of AMSV is done in mission planner. The raspberry pi 3 and its camera used as FPV camera for live video streaming on webpage and Mission planner is efficiently configured to achieve required tasks which are shown in Fig.8 and Fig.9 at Ground Control Station system.

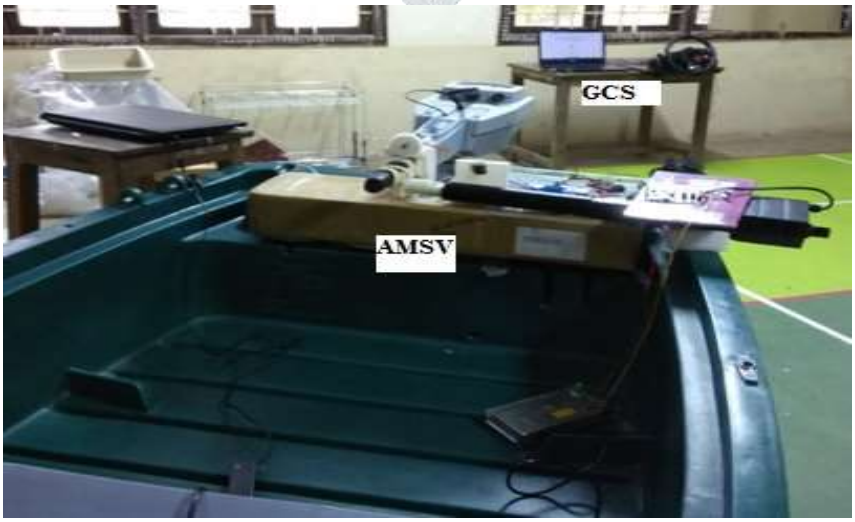

Figure 7: AMSV Final Setup and Testing in CSD Lab NITK.

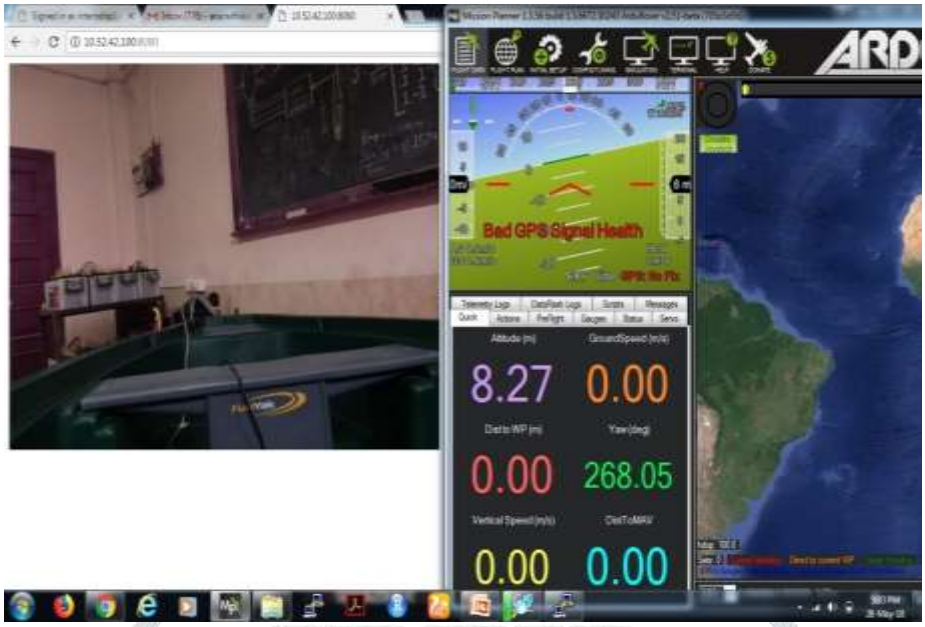

Figure 8: Mission Planning And Live Video Streaming On Ground Control Station.

Figure 9: Live video streaming on web page using raspberry pi camera

V. CONCLUSION AND FUTURE SCOPE

The autonomous marine surface vehicle that can be used for real-time application has been successfully tested in Centre for System Design, NITK Surathkal. The outcome of this project is deployment of an open source Autonomous Marine Surface Vehicle and is integrated during emergency civilian applications for rescue operations. Marine surface vehicle installation can be done in few minutes in any weather condition. The Vehicle can operate in three modes of operation such as Autonomous, Semi-Autonomous and Manual mode. During the emergency situation, the Open source controller and electric outboard motor can be dismantled from the marine surface vehicle and fixed it into any catamaran and can restart working in a short period of time. With the global positioning systems becoming more compact, unmanned vehicles are becoming affordable and turning up to be versatile.

Higher bandwidth wireless data systems also become the source to the rapid growth of unmanned marine surface vehicle. Many scientific and military operations get benefited because of AMSV (Autonomous Marine Surface Vehicle). AMSV can herald a new era of ocean observing. AMSV is becoming a recognized technology for application to fulfill an emergency mission and holds potential for further research and development. This project will be helpful for the civilian applications for rescue operations.

VI. ACKNOWLEDGMENT

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