ABSTRAK

NAHDIYIN ASHABULJANAT. Rancang Bangun Prototipe *Autonomous Surface Vehicle* (ASV) Untuk Patroli Perairan Berbasis IoT Dan Kendali *Waypoint*. Dibimbing oleh ROZEFF PRAMANA dan RUSFA.

Patroli keamanan dan pengawasan wilayah perairan secara konvensional masih menghadapi berbagai keterbatasan, terutama terkait dengan tingginya biaya operasional dan keterbatasan jangkauan pemantauan pada area perbatasan. Metode pengawasan manual ini kurang efisien untuk dilakukan secara berkelanjutan dalam menjaga keamanan maritim dari berbagai potensi ancaman atau pelanggaran. Kondisi tersebut menuntut adanya inovasi teknologi yang mampu melakukan pengawasan secara mandiri, aman, dan efisien. Oleh karena itu, diperlukan sebuah sistem patroli maritim otomatis yang andal, berbiaya rendah, serta dapat dipantau dari jarak jauh secara *real-time*.

Penelitian ini bertujuan untuk merancang dan mengimplementasikan sebuah prototipe *Autonomous Surface Vehicle* (ASV) berbasis ESP32 sebagai solusi modern untuk patroli dan pengawasan maritim di perairan perbatasan Kepulauan Riau. Sistem navigasi otonom pada kendaraan ini menggunakan sensor GPS NEO-M8N dan kompas digital CMPS12 untuk mengeksekusi misi *waypoint* secara mandiri. Pengawasan visual dilakukan melalui kamera CCTV berbasis algoritma *deep learning* YOLOv8 untuk deteksi objek secara *real-time* serta *Internet of Things* (IoT) diterapkan menggunakan jaringan 4G LTE untuk sinkronisasi data telemetri pada antarmuka web, serta dilengkapi mekanisme *safety stop* berbasis sensor ultrasonik HC-SR04 untuk menghindari tabrakan otomatis.

Berdasarkan hasil pengujian, nilai *Root Mean Square Error* (RMSE) pada sensor HC-SR04 berhasil ditekan hingga 0,71 cm melalui kalibrasi regresi linear, yang mengaktifkan sistem *safety stop* secara instan untuk menghentikan laju kendaraan saat rintangan terdeteksi pada jarak < 3 meter. Stabilitas orientasi arah juga ditunjukkan oleh kompas digital CMPS12 dengan rata-rata *error* berkisar antara 2° hingga 4° terhadap kompas kalibrator. Empat geometri lintasan (lurus, persegi, segitiga, dan *zigzag*) pada pengujian berhasil dieksekusi dengan baik meskipun dipengaruhi gangguan arus air. Selain itu, deteksi terhadap manusia (*person*) dan kapal (*boat*) berhasil dilakukan oleh model YOLOv8, yang sekaligus memicu indikator visual serta alarm peringatan dini. Pengujian konsumsi daya mencatat daya sebesar 218 Watt pada beban maksimum, sehingga baterai LiPo 13.000 mAh mampu menyediakan waktu jelajah selama 53 menit.

Secara keseluruhan, prototipe ASV yang dikembangkan mampu menjalankan fungsi navigasi otonom dan pemantauan objek secara stabil. Integrasi kendali *waypoint* dan pemantauan berbasis IoT ini diharapkan dapat berkontribusi dalam meningkatkan keandalan serta efisiensi pengawasan wilayah perairan di masa depan. Sistem ini juga dirancang untuk meminimalkan risiko keselamatan personel serta menekan biaya operasional patroli konvensional. Dengan demikian, otomatisasi pengawasan keamanan yang cerdas dan modern pada wilayah perairan perbatasan berpotensi nyata untuk disolusikan oleh sistem yang diusulkan.

Kata kunci: *Autonomous Surface Vehicle* (ASV), *Internet of Things* (IoT), *waypoint*, *safety stop*, YOLOv8.

ABSTRACT

NAHDIYIN ASHABULJANAT. Design and Construction of an IoT-Based Autonomous Surface Vehicle (ASV) Prototype with Waypoint Control. Supervised by ROZEFF PRAMANA and RUSFA.

Conventional maritime security patrols and surveillance face various constraints, particularly related to high operational costs and limited monitoring coverage in border areas. This manual surveillance method is inefficient for sustainable implementation in safeguarding maritime security against potential threats or violations. These conditions demand technological innovations capable of conducting independent, safe, and efficient surveillance. Therefore, a reliable, low-cost, automated maritime patrol system that can be monitored remotely in real-time is required.

This study aims to design and implement an ESP32-based Autonomous Surface Vehicle (ASV) prototype as a modern solution for maritime patrol and surveillance in the border waters of the Riau Islands. The autonomous navigation system on this vehicle utilizes a NEO-M8N GPS and a CMPS12 digital compass to independently execute waypoint missions. Visual surveillance is performed through a CCTV camera driven by the YOLOv8 deep learning algorithm for real-time object detection. In addition, the Internet of Things is implemented using a 4G LTE network to synchronize telemetry data on a web interface, which is also equipped with an HC-SR04 ultrasonic sensor-based safety stop mechanism to avoid automatic collisions.

Based on the test results, the Root Mean Square Error (RMSE) value of the HC-SR04 sensor was successfully suppressed to 0.71 cm through linear regression calibration, which instantly activates the safety stop system to halt the vehicle when an obstacle is detected at a distance of < 3 meters. Directional orientation stability was also demonstrated by the CMPS12 digital compass with an average error ranging from 2° to 4° against the calibrator compass. Four trajectory geometries (straight, square, triangular, and zigzag) during testing were successfully executed well despite being affected by water current disturbances. Furthermore, multi-object detection of humans (person) and boats (boat) was successfully performed by the YOLOv8, which simultaneously triggered a visual indicator and an early warning alarm. Power consumption testing recorded a power of 218 Watts under maximum load, enabling the 13,000 mAh LiPo battery to provide a cruising endurance of 53 minutes.

Overall, the developed ASV prototype is capable of executing autonomous navigation functions and object monitoring stably. The integration of waypoint control and IoT-based monitoring is expected to contribute to improving the reliability and efficiency of maritime surveillance in the future. The system is also designed to minimize personnel safety risks and reduce conventional patrol operational costs. Consequently, the smart and modern automation of security surveillance in border waters has a real potential to be resolved by the proposed system.

Keywords: Autonomous Surface Vehicle (ASV), Internet of Things (IoT), waypoint, safety stop, YOLOv8.