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DESIGN OF AUTOPILOT TANK PROTOTYPE MONITORING SYSTEM ON GROUND STATION USING GOOGLE MAPS

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ABSTRACT

Indonesia is one of the largest archipelago countries in the world. Therefore, it is necessary to safeguard the vital object especially within the border area of the (NKRI). The unmanned tank rides are one of the rides that can be used as combat rides on the battlefield in maintaining security and sovereignty (NKRI). Utilization of unmanned tank rides on the durability and defence functions of the nation can minimize casualties. In realizing the control system and monitoring of unmanned tank rides using the design build Monitoring system Autopilot Prototype Tank on the Ground Station using Google Maps. In this design defines the needs of the system on the ground station. The need for electronic maps to display the location of the prototype tanks on the system interface, using one of the Gmap.net program libraries or libraries that can be integrated with the C# programming language. The need for data transactions through UART, using the library or series of communication program libraries for this need. The need for prototype tank location indicator and waypoint location in the form of marker on map, using one of Gmap Marker function from library or program library Gmap.net. The need to describe a straight line between waypoint points, using the polyline function of the Gmap.net library or program library. The need to describe the area on the waypoint, using the circle function of the Gmap.net library or program library. Autopilot control of the prototype tanks that have been performed can be done well using Visual Studio 2012 programming. Monitoring system on the interface of the system that is made shows the system can run well, with the results of the system can display prototype travel to every waypoint made.

Keywords: Visual Studio 2012, Gmap.net, Prototype, Autopilot.

1. INTRODUCTION

1.1 Background

Indonesia is one of the largest archipelagic countries in the world. With these conditions, it is highly needed that troops are capable as law enforcement and can maintain the security of the entire sea area, namely the Indonesian National Army Navy. The Indonesian National Armed Forces itself has a lot of equipment of its equipment adjusting to the developing technology. Therefore, security is needed for vital objects, especially in the border region (NKRI).

Unmanned tank rides are one vehicle that can be used as a combat vehicle on the battlefield in maintaining security and sovereignty (NKRI). War should be avoided but the reality in many countries up to now is waging war as the final solution of a national problem. The use of unmanned tank rides in the nation's defense and defense functions can minimize fatalities.

Unmanned tank rides are controlled from the control center and can operate autonomously. This centralized control system uses wireless communication on radio and satellite frequency networks. Using a PC or laptop device an unmanned tank vehicle can be controlled in various control modes namely manual and autopilot control.

The location of the tank vehicle operation can be monitored on the monitor screen in an application interface that can run on the Windows operating system. In realizing the control and monitoring system of unmanned tank rides, the author tries to take this theme into a final project with the title Design of an Autopilot Prototype Tank Monitoring System on Ground Station Using Google Maps.

In this design research the alusista tank will be made in prototype or prototype form. The control and monitoring system that will be planned functions to monitor the prototype tank in manual control mode and autonomously, manual control uses a joystick that is connected to a PC or Laptop device and controls automatically based on the locations that have been determined in the application interface.

Determination of location based on earth coordinates presented in the application in the form of a 2-dimensional electronic map. Electronic maps designed in the form of interfaces were developed using the C # programming language, which is one of the programming languages available in Visual Studio 2012.

In addition to the control system, the planned system interface can monitor the location of the prototype tank on the map, all information relating to the sensor device integrated in the prototype tank can also be monitored. Information data obtained from the prototype tank, which are planned to be displayed on the system interface are:

a. The prototype tank's axis axis towards the earth is based on a compass sensor.
b. Yaw axis, pitch and roll prototype tank based on gyro sensor and accelerometer.
c. Battery capacity and usage based on current and voltage sensors.
d. The movement speed of the prototype tank is based on the rotary encoder sensor and GPS.
e. Coordinate the location of prototype tanks based on GPS sensors.

1.2 Formulation of the problem

In this final project problems need to be formulated, namely:

a. How do you make a system for determining the route of unmanned tank rides?
b. How to make a tank vehicle sensor information monitoring system?
c. How to make a tank vehicle sensor information monitoring system?

1.3 Research Objectives

The purpose of this study are:

a. Creating an interface system for determining the route of unmanned tank rides.
b. Create a monitoring system for sensors for unmanned tank rides.
c. Create a system to monitor the location of unmanned tank rides on an electronic map.

1.4 Research Benefits

The benefits of this research are:

a. As the application of the system to determine the route of the Alutsista tank on autopilot.
b. To monitor system acquisition data on Alutsista tanks.
c. As one of the solutions tracking the location of unarmed armaments tanks on PC and laptop devices.

1.5 Scope of problem

The boundaries of the problem of Designing the Autopilot Prototype Tank Monitoring System on Ground Station Using Google Maps are:

a. Using the Visual Studio C # 2012 programming language.
b. Using electronic maps as a medium for navigating unmanned tank systems.
c. Able to run tank rides manually or on autopilot.

2. LITERATURE REVIEW

2.1 Map

2.1.1 Map Definition

Map is a picture stating how the land, mountains, rivers and so on are located. Maps are representations of the real world. The existence of the real world will be more detailed using maps. So, it can be said that the map can provide a comprehensive picture of the environment and everything in it. All objects can be displayed on a map, both natural and man-made objects. Maps that provide these facilities are called basic maps (maps fetures).

2.1.2 Elemen Peta

a. Data Frame

Data frame is part of a map that displays data layers (data layer). This section is the most important and is the focal point of a map document.

b. Legend

The map legend is responsible for explaining all the symbols used in a map at each data layer. Besides legend also functions as a key. Describe in detail the various schematic drawings, symbols and categories contained in the map.

c. Title

The title of the map gives a brief description of the subjects in the map.

d. Scale

Scale is a comparison of the distance on the map with the actual horosontal distance on the terrain or field. The flat distance formula on the map is "Distance on Map X Scale = Distance on the Field. Map scale writing is usually written with non-line numbers (graphics). For example, Scale 1: 10,000, meaning that 1 cm of the map is equal to 100 m in actual terrain. The scale of the map determines the size and shape of the representation of the elements. The greater the scale of the map, the greater the size of the elements.

e. Border

It is a border on a map that helps users know the edge of a map clearly. By using borders, the placement of text on the map will also look neater.

f. Maps Overview

Overview Maps Especially when enlarged in an area, will help users to better understand the contents of the area in detail.

2.1.3 Digital map

Digital maps are maps in the form of digital data, whether in the form of vector, raster data, or a combination of both. The type of digital data itself usually consists of two types, namely:

a. Vector Data

Each natural detail is described as an entity in the form of a line with a certain direction (vector) or point. The area details are described as areas that are bounded by closed lines. A road detail, for example can be defined as a line entity.

b. Raster data

Data is divided into small plots, each of which has a specific character (color, intensity, pattern, texture). The size of the map depends on the resolution of the image which in this case depends on the original media (face of the earth, maps or photos) and the recording device (satellite, digital camera or scanner). Spatial analysis can be handled more easily with raster maps, but the cartographic side is not good and it is difficult to handle objects in the definition of lines (roads, rivers and vegetation boundaries).

c. Digitizing the map

To turn a paper map into a digital map, we can use a digitizer, which is an electronic device to trace images. Digitizer includes one type of pointing device in the form of a table or board, equipped with a pointer in the form of a mouse with crosshair crosses or a stylus pen. In addition to the digitizer, the digitization of the map can be done above the monitor layer or on-screen digitizing.

2.1.4 Definition of Geographic Information Systems

The definition of Geographic Information Systems (GIS) is always changing because GIS is a relatively new field of science and technology studies. Some definitions of GIS are: Geographical Information System (GIS) is a computer-based information system that combines elements of the map (geographic) and information about the map (attribute data) designed to obtain, process, manipulate, analyze, display and display spatial data to complete planning, processing and researching problems.

Geographical Information System (GIS) is a computer system used to capture, store, examine, integrate, manipulate, analyze, and display data relating to positions on the surface of the earth.

Geographical Information System (GIS) is a system that can support spatial decision making and is able to integrate location descriptions with the characteristics of phenomena found at these locations. A complete GIS includes the methodology and technology needed, that is, spatial data, hardware, software, and organizational structure. A Geographic Information System (GIS) is an organized collection of computer hardware, software, geographic data and personnel that are efficiently designed to obtain, store, update, manipulate, analyze and display all forms of geographic reference information.

2.1.5 Visual Studio 2012

Microsoft Visual Studio is a complete software (suite) that can be used to develop applications, both business applications, personal applications, or application components, in the form of console applications, Windows applications, or Web applications. Visual Studio includes compilers, SDKs, Integrated Development Environment (IDE), and documentation (generally in the form of MSDN Library). Compilers included in the Visual Studio package include Visual C ++, Visual C #, Visual Basic, Visual Basic .NET, Visual InterDev, Visual J ++, Visual J #, Visual FoxPro, and Visual SourceSafe.

Microsoft Visual Studio can be used to develop applications in native code (in the form of machine language that runs on Windows) or managed code (in the form of Microsoft Intermediate Language above the .NET Framework). In addition, Visual Studio can also be used to develop Silverlight applications, Windows Mobile applications (which run on the NET Compact Framework).

2.1.6 C # Programming Language

C # (C Sharp) is an object-based programming language used by Microsft .NET Framework. This programming language is a new programming language created by Microsoft which was developed under the leadership of Anders Hejlsberg who has created various programming languages including Borland Turbo C ++ and orland Delphi.

The C # language has also been standardized internationally by ECMA. Like other programming languages, C # can be used to build various types of applications, such as Windows-based applications (desktop) and web-based applications and web services-based applications.

2.1.7 NET Framework

Net Framework Is a software (Software) that is used primarily on Microsoft Windows Operating Systems. Net Framework is a work environment to facilitate the development and execution of various programming languages and library collections so that they can work together in running Windows-based applications. Generally, computers only have one language, namely (assembly), so when and develoved an application with language. Net computer will not understand the language.

Therefore, we need a software (translator) to be able to run it. No wonder some software can not run properly (error) on a computer if the language used is different. That's the point of using it. Net Framework as a translator of that language. This is the main function of. Net Framework is as a translator or executing a software that can be run.

Usually on an operating system in this case Windows is usually already present. Net Framework, but not necessarily the software is active and can be used, for that in some Windows operating systems the need to install/ activate manually.

3. RESEARCH METHOD

3.1 Research design

This type of research in this thesis is a system design research, which is a system on a PC or laptop device that is presented in the form of a system interface that can interact with users. Unmanned tank vehicle motion control unit in this final project uses a PC or laptop device, the system will be made an integrated system with the general functions of manual control, autopilot and monitoring.

To connect devices on Ground Station Control (GSC) with unmanned tank rides using radio telemetry communication. The functions of Ground Station Control (GSC) can be explained as follows:

a. Electronic map

It is a navigation map to show the location of a vehicle without getting up on a PC device.

b. Manual Control

The manual control function via a joystick device is converted to a PC via a USB connection

c. Autopilot control

The approval function on a itinerary with location points that must be visited.

d. Battery Monitoring Level

System interface in Ground Station Control (GSC) to provide information on battery voltage levels and current absorbed current in real time.

e. Monitor Wahana Tank Orientation

System interface on the Ground Station Control (GSC) to provide information on tank vehicle movements over yaw, pitch and roll movements.

f. Monitor Tank Speed

System interface at Ground Station Control (GSC) to provide tank vehicle speed information when moving.

3.2 Research procedure

To carry out the research properly, the preparation of steps to find the source of data and to research the design of the Data Transmission Building Between Exercise Smart Mine and Ground Station Using Lora includes research instruments, primary data, secondary data, as well as testing the validity and reliability of the data.

3.2.1 Time and Place of Research

The research location is a place or area where the research will be conducted. The research conducted by the author took place on the Moro Krembangan STTAL Campus in Surabaya. The time used in this study began in July 2019 until the end of December 2019.

3.2.2 Research Tools and Materials

Tools and materials needed to support this research process and system implementation.

a. Research Tools
The tools used in the study consisted of hardware and software.
1) Hardware
a) Laptop or PC with a minimum of CORE I3 RAM 4GB
b) Playstation analog joystick
2) Software
a) Visual Studio 2012.
b) Net framework 4.5

b. Research Materials
1) Visual Studio
The following Visual Studio data that need to be known before the process of making the system. Visual Studio can run on Windows 32- or 64-bit operating systems. The version needed in making this system is Visual Studio 2012
2) Operating System
The operating system on a PC or laptop device uses the Windows 7 operating system

3.2.3 Research design

Research Design Design of Autopilot Prototype Tank Monitoring System on Ground Station Using Google Maps by applying the stages of research, as follows:

a. Preliminary studies
Preliminary studies are study processes to obtain information about the research to be conducted.
b. Problem analysis
Problem analysis is a study to find out the causes of problems, as well as alternative solutions and later solutions to problem solving
c. Need analysis
Requirement analysis is one of the many critical activities in the software needs engineering process to understand the realm of problems of the current system and the realm of solutions of the system to be made

d. Design analysis
It is the process of selecting tools to analyze data, so that the formulation of the problem can be solved and the objectives can be proven. At this stage the writer must choose a data analysis tool that matches the data to be obtained in the field study.
e. Design.
Based on the study of the previous design analysis, the information in Figure 3.1 can be obtained. explains the flow of research to carry out the process of designing a Ground Station Control (GCS) system. unmanned tank rides and development steps.

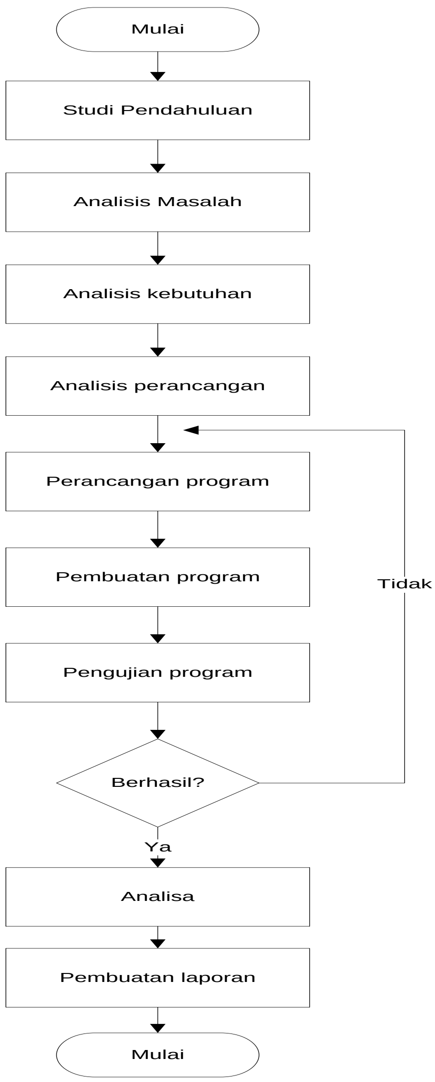

Figure 3.1 Research Flow

3.2.4 Data collection

In the research of Design and Development of Autopilot Prototype Tank Monitoring System on Ground Station Using Google Maps using data collection methods. The research will be conducted by the author, i.e. documentation, this method is carried out by collecting data from books, notes, and research results in relevant agencies regarding the Indonesian Armed Forces National Armed Forces Navy.

3.2.5 System planning

In research on the Design and Development of Autopilot Monitoring Systems on Ground Station Using Google Maps. The planned system is expected to be able to carry out all the functions and features described in the previous sub-chapter. To illustrate the functions contained in Ground Station Control (GCS), it can be illustrated in the overall system block diagram in Figure 3.2 below. In the system block diagram illustrates all functions that can be accessed by users in operating Ground Station Control (GCS).

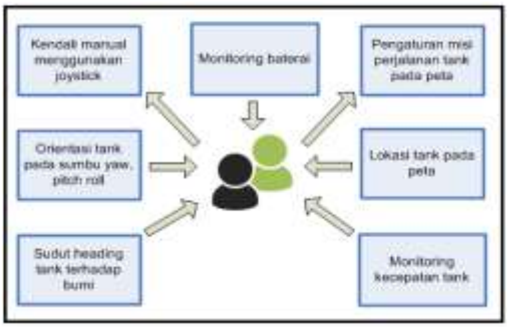

Figure 3.2 Ground Station Control (GCS) Block Diagram.

The system functions on the Ground Control Station (GSC), which consists of 7 main parts, namely:

a. Manual control uses a joystick that is to control the Prototype tank by manually using a remote control.

b. Monitoring orientation Prototype tank on yaw axis, pitch roll that is for monitoring.

1) Yaw axis: Is a movement of shaking his head or turning right and left.

2) Pivot axis: This is a nod or up and down motion of the nose of the plane.

3) Roll Axis: Is a rolling motion to the right and left on the Prototype tank.

c. The bow angle of the Prototype tank towards the earth is to monitor the direction or direction of the Prototype tank.

d. Battery monitoring is to monitor the capacity, voltage and current of the battery.

e. Prototype tank trip mission arrangement is to regulate or determine Waypoint points that are used as Prototype tank's travel path.

f. Monitoring the location of the Prototype tank on the map to monitor the position of the Prototype tank.

g. Prototype tank speed monitoring is to monitor the speed of the left and right wheel RPM and the speed of the Prototype tank.

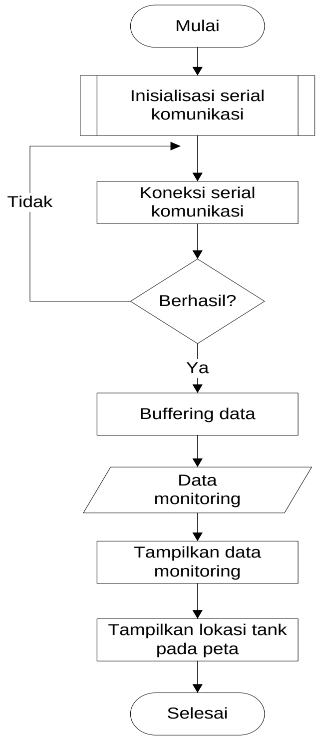

Figure 3.1 Diagram Alir Sistem Monitoring

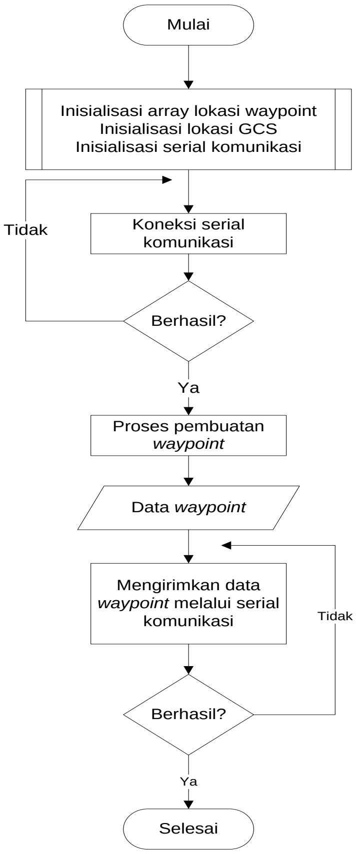

Figure 3.4 Flow Chart of Waypoint Making System

3.2.6 Data processing

Data processing is a process that the writer does after obtaining some information collected in the data collection process. The data obtained will be reviewed and become a reference in the process of design analysis and system design.

The method used in data collection is using the library method, which is a method for collecting materials or data relating to the theme of the discussion and problems from the source of the library. The sources in this study are divided into two, namely primary data sources (primary sources) and secondary data sources (supplementary sources):

a. Primary Data is the source of data obtained directly from the source, namely agencies related to the main weaponry system. The observation process was carried out by interviews with relevant parties of the Indonesian National Army Navy.

b. Secondary Data is the source of data collected from international journals and research papers that have been done before. And sources of literature or books relating to the object of research and other sources from the internet.

4. DESIGNING, IMPLEMENTATION AND TESTING OF THE SYSTEM

In this chapter the author will discuss the analysis and discussion of ground station control systems on prototype tanks. System analysis and discussion discusses the design that is made, its implementation or application and the testing of the system made will be explained in detail.

4.1 Design of Ground Control System in Prototype Tank

In designing controls on the Ground Control side, the authors conducted an analysis to obtain a system design that was in accordance with the objectives of the Prototype tank control of the Ground Station. In this design the author defines the system requirements at the Ground Control Station, so that steps can be determined in the realization of the system's goals. Definitions of requirements in this design can be stated as follows:

a. The need for an electronic map to display the location of the prototype tank on the system interface. There is a need to determine the prototype tank travel destination locations presented to the user interface in the form of an electronic map. To fulfill this need, the writer uses one of the library or libraries of Gmap.net programs that can be integrated with the C # programming language.
b. The need for data transactions via UART, so the authors use a library or serial communication program library for this need.
c. The need for a prototype tank location indicator and waypoint location in the form of markers on the map, the authors use one of the Gmap Marker functions from the library or library program Gmap.net.
d. The need to draw a straight line between waypoint points, the authors use the polyline function from the library or library program Gmap.net.
e. The need to describe the area of the waypoint, the authors use the circle function from the library or library program Gmap.net.

Based on the needs of the system, the writer can describe the software requirements based on the definition of these needs, namely:

a. Editor of the Visual Studio 2012 program on the Windows platform
b. Library or library of Gmap, net programs.

Software requirements that have been mentioned need to be installed on the Windows 8 OS platform (the author uses Windows 8 64 bit). For the editor of the Visual Studio 2012 program you can download the free or trial version on the link: https://visualstudio.microsoft.com/vs/older-downloads/.

Based on the system requirements, a general system design can be made as shown in Figure 3.2. It explains the system functions in the Ground Control Station, which consists of 7 main parts, namely manual control, Prototype orientation monitoring, Prototype tank bow angle, battery monitoring, travel mission management, location monitoring Prototype tanks on the map and monitoring prototype tank speeds.

4.2 Implementation

For the implementation of the Ground Control Station Prototype tank, some things that need to be prepared and done are as follows.

4.2.1 Electronic Maps

In programming the GCS (Ground Control Station) using the C # programming language, the important thing in adding electronic map features to the program interface is to add the reference program Gmp.net.dll. As shown in Figure 4.2 below. Gmap.net.dll is a library of programs that can be added as references.

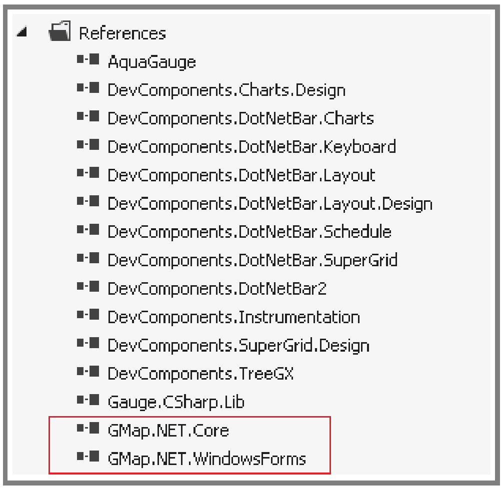

Figure 4.1 Reference Gmap.Net program.

Program references that need to be added in more detail, namely:

a. Gmap.net.Core, contains program functions that run behind the scenes.
b. Gmap.net.Window Forms, contains functions that can interact with users such as electronic map screens, marker icons, polylines and others.

After the author adds the Gmap.Net program reference, the writer can add the Gmap.net control to the program interface as shown in Figure 4.3. Gmap.net control is an electronic map component that can visualize maps in 2-dimensional mode. Gmap.net control can be set using several map providers options such as Google maps, bing maps, Cloud Made Maps, Latvian Maps and others.

Figure 4.2 Adding Gmap.net Control to the program interface

The first time the program is run, the electronic map needs to be set at the center point of the location, by arranging the map using the following program code, the location of the center point of the map is exactly at the STTAL Surabaya location.

```
gMapControl1.MapProvider =
GMap.NET.MapProviders.BingMapProvider.
Instance;
GMap.NET.GMaps.Instance.Mode =
GMap.NET.AccessMode.ServerAndCache;
gMapControl1.Position = new
```

4.2.2 Icon Marker

So that the location on can be indicated, then added one or more markers. Gmap.net Library has provided markers with several variants and colors that are selected or specified in Visual Studio programming. In the GCS system that is designed the author uses 3 types of markers, to identify the location of the GCS, waypoints, and waypoints that have been visited. To distinguish the waypoint by default the marker is green, after the point has been visited by the prototype tank, the marker at that point turns red.

To add a marker in the user interface using this program code.

```
int p = confg.objects.Markers.Count;
GMarkerGoogle cc = null;
if (p == 0){
MessageBox.Show("Please set GCS location
first!");
```

4.3 Testing

In this section, the system testing process that has been made will be explained to find out whether the system has been made to run well. The step-by-step testing process is carried out for analysis so that if a bug or error is found on the system it can be immediately repaired.

4.3.1 Testing of Gmap.Net Electronic Maps

To conduct electronic map testing on the C # program interface, the author defines the steps that must be taken before testing the program, namely:

a. Add the Gmap.net control component to the program interface.
b. Set the center point of the map location by setting the latitude and longitude variables.
c. Setting the map provider, the program created by the author defines several variants of the map provider used, shown in the following program code.

The following snippet of program code is used to make arrangements before the authors test the program created.

```
 "ArcGIS_DarbAE_Q2_2011_NAVTQ_Eng_V
5_Map","ArcGIS_Imagery_World_2D_Map"
,
"ArcGIS_ShadedRelief_World_2D_Map","
ArcGIS_StreetMap_World_2D_Map",
"ArcGIS_Topo_US_2D_Map","ArcGIS_Worl
d_Physical_Map","ArcGIS_World_Shaded
_Relief_Map",
"ArcGIS_World_Street_Map","ArcGIS_Wo
```

Set the center point of the map location using the following program code:

```
gMapControl1.MapProvider =
GMap.NET.MapProviders.BingMapProvider.Instance;
GMap.NET.GMaps.Instance.Mode =
GMap.NET.AccessMode.ServerAndCache;
gMapControl1.Position = new
GMap.NET.PointLatLng(-7.2199907,
112.7184928 );
```

Figure 4.4 follows the electronic map testresults:

Figure 4.3 Electronic map test results

From the test of Figure 4.4 if a marker is added at the STTAL location, the test results can be shown in Figure 4.5 below:

Figure 4.4 Electronic map test results with the addition of markers

In the electronic map testing that has been done the author uses a hybrid map china map, for further testing the author will use Google Terain Map, and the results of the electronic map test is shown in Figure 4.6 below.

Figure 4.5 Electronic map test results using Google Terain Map

Figure 4.6 Electronic map test results using Google Hybrid Map

Figure 4.7 Electronic map test results using Google Map

4.3.2 Testing Monitoring Data Display

Monitoring data is data sent by the Prototype tank to the Ground Station to be displayed in the form of numerical variables and visualization in the program interface. Monitoring data on the Ground Station is obtained through serial communication connected to the telemetry receiver. To be able to communicate with telemetry devices, the first step taken is to determine the port name and baudrate of the device and then press the connection button on the program interface. The following displays the data communication serial connection settings, shown in Figure 4.9.

Figure 4.8 Communication Serial Connection Settings

If the connection is successful then the connection display will change as shown in Figure 4.10 below.

Figure 4.9 Serial Connection Settings Successful Communication

The appearance of the program interface on the start page of the program after a successful serial connection is shown in Figure 4.11. In the main view of the program there are 4-tab control menus, which can switch interfaces according to menu features. These tabs include:

a. Mission planner, serves to organize the prototype tank mission.

b. Configuration, serves to set the radius of location identification per waypoint.

c. Manual control, serves to run the prototype tank in manual mode.

d. Log, serves to display the activities carried out by users of the program.

The mission planner feature as a whole can be displayed in Figure 4.11 below.

Figure 4.10 Interface Display Mission Planner Menu

In the mission planner menu view can be displayed in parts so that each function can be understood more clearly in the interface of this program.

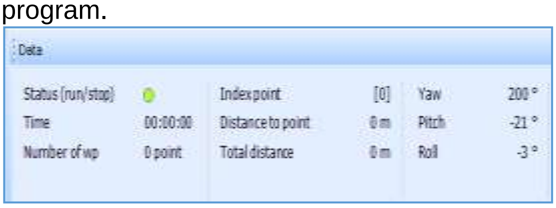

Figure 4.11 Display of the Mission Planner Data Menu Interface

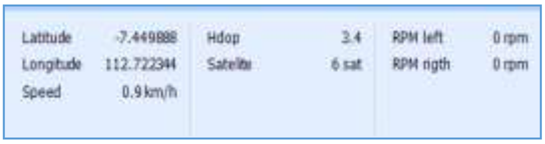

Figure 4.12 Mission Planner Menu Data Interface Display

The monitoring display on the mission planner's menu interface can provide information about the location of the prototype tank which is displayed in the form of an electronic map visualization presented in Figure 4.14 below.

Figure 4.13 Interface Display of Prototype Tank Locations on the Map

Visualization of the prototype tank is shown as a marker in Figure 4.14 in green, with the direction of the bow in accordance with the value of the compass data towards the earth. The location of the prototype tank is based on GPS data.

To display the visualization of instrument data in graphical form can be shown in Figure 4.15 below.

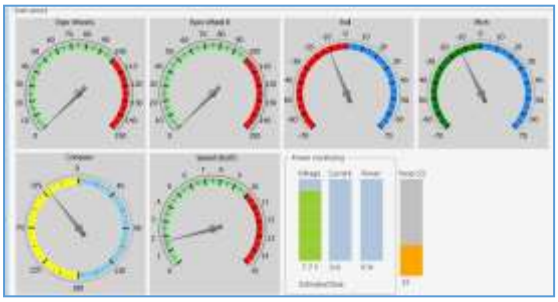

Figure 4.14 Instrument Interface Display

The instrument interface is a visualization of the data in Figure 4.12 and Figure 4.13 in the visual graph. The instruments presented are: left and right wheel rotational speed, prototype orientation in yaw, pitch and roll, ground speed in km / hour, battery level, current usage, power absorbed by prototype tank temperature.

4.3.3 Testing the Prototype Tank Full Manual Interface

To test the prototype tank manual control, the writer will switch the program interface to the manual control menu. To run the manual control, it is necessary to adjust the manual control mode in the on position. By changing the slider speed L and speed R can change the speed of the left wheel and right wheel prototype tank. If the value of speed L or speed R is positive, the prototype tank will move forward. If it is negative, the prototype will move backwards. Figure 4.16 is a display of the manual control interface.

Figure 4.15 Interface Display Manual Control Menu

4.3.4 Testing Waypoint Settings

To test the Waypoint settings on an electronic map on the C # program interface, the author defines the steps that must be taken before testing the program, namely:

a. Determine the starting location, by default the starting location is the GCS location, which is the starting point of the prototype tank's location
b. To determine the next destination point, the user adds the next point by double-clicking the location on the map as expected.

The following snippet of program code is used to set the initial location.

```
double lat = gMapControl1.Position.Lat;
double lng = gMapControl1.Position.Lng;
GMarkerGoogle markerHome = new GMarkerGoogle(new PointLatLng(lat, lng), confg.bmp);
GMap.NET.PointLatLng point = new PointLatLng(lat, lng);
markerHome.Position = point;
```

to test the 1 waypoint setting. The initial step taken is to determine the location of the Ground Station first, then add waypoint 1 by double-clicking the mouse on the destination location or using the addition of the waypoint location manually. Following is the display of the 1 waypoint setting interface shown in Figure 4.17.

Figure 4.16 Setting 1 Waypoint

The second test conducted by the author is to test 2 waypoints. By adding 1 more waypoint so that it becomes 2 waypoints by double-clicking the mouse on the destination location or using manually adding the waypoint location. Following is the display interface of the 2 waypoint settings shown in Figure 4.18 below.

Figure 4.17 2 Waypoint Settings

The third test conducted by the author is to test 3 waypoints. By adding 1 more waypoint to 3 waypoints by double-clicking the mouse on the destination location or using manually adding the waypoint location. Following is the display of the 3 waypoint interface shown in Figure 4.19.

Figure 4.18 3 Waypoint Settings

The fourth test conducted by the author is to test 4 waypoints. By adding 1 more waypoint to 4 waypoints by double-clicking the mouse on the destination location or using manually adding the waypoint location. Following is the display of the 4-waypoint interface shown in Figure 4.20 below.

Figure 4.19 4 Waypoint Settings

The fifth test conducted by the author is to test 5 waypoints. By adding 1 more waypoint so that it becomes 5 waypoints by double-clicking the mouse on the destination location or using manually adding the waypoint location. Following is the display of the 5 waypoint settings interface shown in Figure 4.21 below.

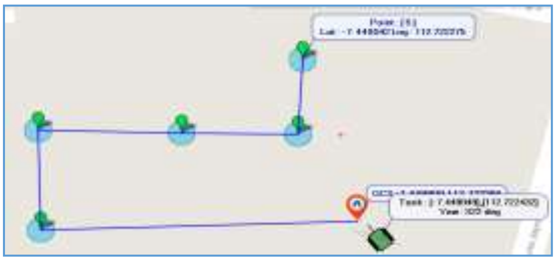

Figure 4.20 Setting 5 Waypoints

The sixth test conducted by the author is to test 6 waypoints. By adding 1 more waypoint so that it becomes 6 waypoints by double-clicking the mouse on the intended location or using manually adding the waypoint location. Following is the display of the 6 waypoint settings interface shown in Figure 4.22 below.

Figure 4.21 Setting 6 Waypoints

The seventh test conducted by the author is to test 7 waypoints. By adding 1 more waypoint to 7 waypoints by double-clicking the mouse on the destination location or using manually adding the waypoint location. Following is the display of the 7-waypoint interface shown in Figure 4.23.

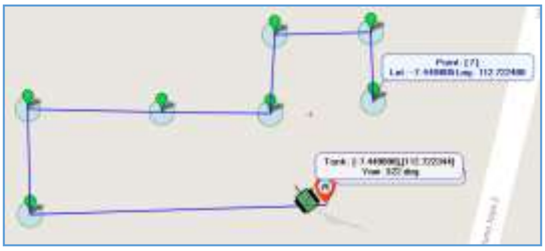

Figure 4.22 Setting 7 Waypoints

The eighth test conducted by the author is to test 8 waypoints. By adding 1 more waypoint so that it becomes 8 waypoints by double-clicking the mouse on the destination location or using manually adding the waypoint location. Following is the display interface of the 8 waypoint settings shown in Figure 4.24 below.

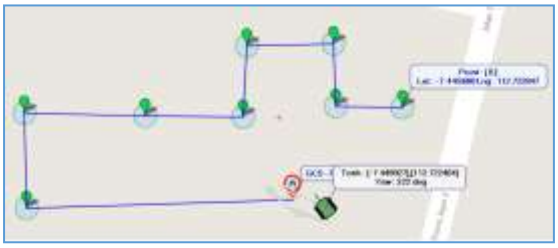

Figure 4.23 8 Waypoint Settings

The ninth test conducted by the author is to test 9 waypoints. By adding 1 more waypoint to 9 waypoints by double-clicking the mouse at the intended location or using manually adding the waypoint location. The following displays the 9-waypoint settings interface shown in Figure 4.25 below.

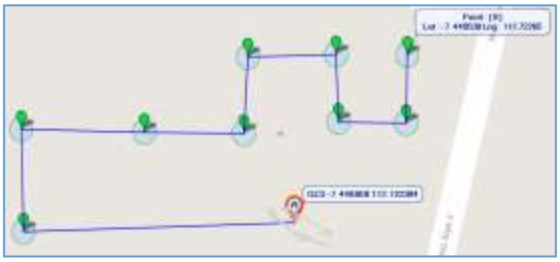

Figure 4.24 9 Waypoint Settings

With the formation of the waypoint that has been made and tested, the waypoint data can be displayed in the form of a list explaining the order on the trip route that has been set.

Waypoint list

No	Point	Latitude	Longitude	Distance (m)
1	[0]	-7.449927	112.721746	44 m
2	[1]	-7.449701	112.721741	24.9 m
3	[2]	-7.449708	112.722031	20 m
4	[3]	-7.449711	112.722265	16.2 m
5	[4]	-7.449542	112.722275	18.6 m
6	[5]	-7.449536	112.722483	14.4 m
7	[6]	-7.449685	112.722488	16.4 m
8	[7]	-7.449688	112.722647	11 m
9	[8]	-7.449538	112.72265	16.5 m

Figure 4.25 Waypoint List

The total distance and the number of locations that must be visited can be presented in the following Graph 4.27.

Data

Status (run/stop)		Index point	[0]
Time	00:00:00	Distance to point	0 m
Number of wp	10	Total distance	182 m

Figure 4.26 Waypoint Information

4.3.5 Autopilot Simulation Testing

This simulation is intended by the author to simulate the journey of the prototype tank on autopilot according to the specified waypoint. The simulation made will move ideally without interference, this simulation is used as an approach to autopilot motion on the actual device..

Figure 4.27 Tank Moving to Waypoint 1

Figure 4.28 Tanks Reach Waypoint 1 and Move to Waypoint 2

Figure 4.29 Tank Reaches Waypoint 3 and Moves to Waypoint 4

Figure 4.30 The Tank Reaches Waypoint 4 and Moves to Waypoint 5

Figure 4.31 The Tank Reaches Waypoint 6 and Moves to Waypoint 7

Figure 4.32 Tank Reaches Waypoint 3 and Moves to Waypoint 8

4.3.6 Testing the Prototype Tank Autopilot

This test aims to determine the autopilot system that was made at the Ground Station has been running well. To run the following autopilot system.

a. Connect the serial communication by setting the port name and baudrate.
b. Determine the location of the Ground Station.
c. Make a waypoint.
d. Upload waypoint data to the prototype tank.
e. Run the autopilot process

Autopilot testing activities carried out in the square of Sidoarjo, with 4 test scenarios. Following this is the interface of the autopilot program in the waypoint creation process, after 4 waypoints are created then a marker icon is displayed on the electronic map.

Figure 4.33 Display Process of Making 4 Waypoints

The next process is to run the autopilot process with the author clicking the star autopilot button, when the process is run the Prototype tank icon icon will move towards the waypoint location 1. To display the results of the prototype tank testing process towards waypoint 1.

Figure 4.34 Display of Prototype Tank Towards Waypoint 1

The Prototype Tank will continue the mission journey to the next point, waypoint 2. In this process the prototype tank will change direction according to the target waypoint. Following is the display of the prototype tank process towards Waypoint 2.

Figure 4.35 Display of Prototype Tank Towards Waypoint 2

The Prototype Tank will continue the mission journey to the next point, waypoint 3. In this process the prototype tank will change direction according to the target waypoint. Following is the display of the prototype tank process towards Waypoint 3.

Figure 4.36 Display of Prototype Tank Towards Waypoint 3

The next process is the prototype tank process has reached waypoint 4, which is shown in the following figure.

Figure 4.37 Display of Prototype Tank Arrives at Waypoint 4

5. CONCLUSIONS AND SUGGESTIONS

This section will explain conclusions and suggestions based on testing and analysis of the Prototype Tank Autopilot Monitoring System that has been carried out. The conclusion can be drawn from the system made, based on the results of testing the autopilot system.

5.1 Conclusion

a. The conclusions obtained based on the Autopilot Prototype Tank Monitoring System on the Ground Station Using Google Maps that have been made, can be mentioned, namely:
b. a. The application of electronic maps on the Autopilot Prototype Tank Monitoring System on Ground Station Using Google Maps, has been successfully carried out. Waypoint point markers can facilitate the user in determining the destination points in the process of making a prototype tank trip mission.
c. b. The implementation of Autopilot Prototype Tank control that has been done can be done well using Visual Studio 2012 programming that has been done by the author. The application of the communication system via the USB port and the application of the control system through the interface that has been made can run well, this is evidenced in the results of system testing.
d. c. Monitoring system on the system interface that is made shows the monitoring system can run well, sensor data and parameters of the autopilot control system can be displayed on the system interface with an update interval of 1000 ms or 1 second.

5.2 Suggestion

Based on the research results of the Autopilot Prototype Tank Monitoring System on Ground Station Using Google Maps that have been done by the author can be given advice for further system development. Suggestions that can be submitted are developing a Monitoring System by analyzing the determination of the nearest route. Methods that can be applied include, Ant Colony, Jikstra, Brute Force and others.

Suggestions in this development aim to improve the ability in the process of optimizing the mission of the trip, so that it can be obtained by the closest route.

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