

# Design of Railway Tracking and Speed Monitoring System Based on Global Positioning System (GPS) – Embedded Microcontroller

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**Abstract**— *The density of the population in Indonesia has an impact on the density of population activity. This does not deny that the population of Indonesia is very dependent on transportation to facilitate human activities. One of the transportation that is often relied on by the community is the train. In the project entitled "Design Railway Tracking and Speed Monitoring System Based on Global Positioning System (GPS) - Embedded Microcontroller" Discussing the development of desktop applications that are able to provide information in the form of the location of realtime train and safety status of the speed of the train. This system uses GPS as a latitude reader, longitude and speed in realtime. With the ability of GPS devices that have an accuracy rate of up to 14 m and an error rate for speeds ranging from 1.1% - 2.4%. Then the Real GPS data will be processed by the Visual Studio and composed with the database. So that it can provide output in the form of safety status of the train in the form of maximum speed and status of the train (safe or overspeed/danger) with additional warnings in the form of mp3 flames during overspeed status. Speed monitoring testing is carried out by Real Tracking Route of Jombang Station - Madiun Station on the Sri Tanjung train, while to monitor railway tracking can be done anywhere.*

**Keywords**— *GPS, Tracking, Desktop Applications, Information Systems, Databases.*

## I. INTRODUCTION

The Indonesian state is a country with a very dense population. The more dense the population, the more dense the activity of the population. This does not deny that the population of Indonesia is very dependent on transportation to facilitate human activities every day. One of the land transportation that is often relied upon by the community is the train. They tend to prefer trains for various reasons, including the comfort offered, quite affordable financially and is considered a solution to the problem of congestion because it has its own path (Maulidin et al., 2021). One of the main variables that affect the train trip is the maximum speed that has been permitted when passing or entering a certain path. As explained in the Government Regulation of the Republic of Indonesia Number 72 of 2009 concerning Traffic and Railroad Transportation Article 21A regulates that the maximum speed of the train is determined based on "the lowest maximum speed between the maximum speed of the capability of the path and maximum speed of railroad facilities". Limitation of the permitted maximum speed is carried out for various reasons including an effort to prevent unwanted things that are very likely to occur when the train

traveled, both in the form of a single accident or a collision between two trains (Setiawan M, 2016).

In traveling, the speed of the train was only known by the train cabin officer, namely a machinist and assistant machinist. While officers who are at the station or train operating control center can only monitor the train in the form of position or location. This does not rule out the possibility that a machinist will violate the speed of the train that has been permitted for some reason. As happened on September 24, 2009, there was a single accident that resulted in the overthrow of 18 train cars at Lawang Station, Malang and claimed one casualties. The accident occurred due to the train exceeding the specified speed. Where the machinist should arrange the train with a speed of 50 km/h to 60 km/hour (www.detiknews.com).

In 2013, Carol. L Schweiger in the journal "Implementation of a Real Time Passenger Information System on Bus" conducts research by installing a system on public transportation and the server is installed at the company's location centrally. Vehicles operating will be integrated with GPS to get Latitude and Longitude. Carol explained that the GPS system will run in realtime according to the movement of the automatic train rate and the speed display in real time (Carol. L Schweiger, 2013). In addition, in building an embedded system, a microcontroller is needed. In 2020, AT Wibowo in the journal "Design of Android -Based Motorized Vehicle Security Systems", utilizing GPS technology and IoT technology that is connected with applications on motor vehicle security systems. By utilizing GPS as a coordinating point of the vehicle location and controlled by a microcontroller in the form of Arduino Atmega which can later be connected to the application and can display the position of the vehicle (Wibowo, Adi Tri, 2020).

Based on the problems and references from the above research, the project entitled "Design Railway Tracking and Speed Monitoring System Based on Global Positioning System (GPS) - Embedded Microcontroller" can be used as a solution to increase security in railroad trips. Making railway tracking is a system created for officers who are in the operational center in order to monitor the location and speed of the train that is operating, while for the desktop application railway speed monitoring system is intended to help officers in the train cabin obtain information in the form of maximum speed that must be regulated When at a certain coordinates during the train trip. The safety system lies in the information on the screen if the overspeed train and the mp3 flame as a warning. This study

begins with GPS as a latitude, longitude and speed reader that will be sent to Arduino Uno first before being processed on the Visual Studio application found on the PC/Laptop. The information displayed is the maximum speed of the train while at a certain coordinate point and the status and flame of the MP3 as the output of the input. This desktop application is an effort to increase vigilance to avoid things that are not desirable.

## II. METHODOLOGY

### A. System Diagram

The system block diagram for the Speed Safety System Railway Project is shown by Figure 1.

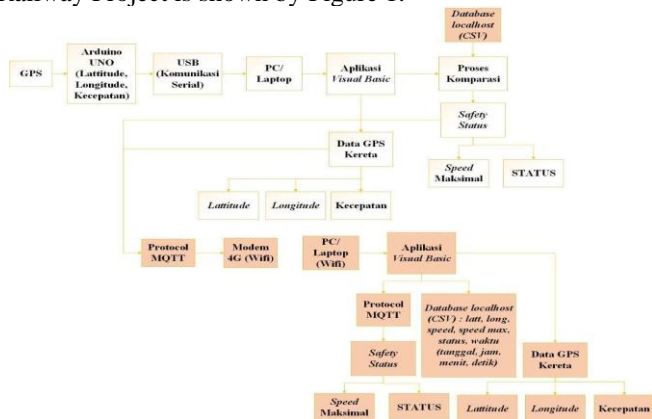


Fig. 1. System Block Diagram

#### Explanation of the System Block Diagram

1. GPS as a reader of the coordinates in the form of latitude and longitude and read the train speed and then sent to Arduino Uno.
2. Arduino Uno receives data from GPS to be sent to the Visual Studio application found on a PC/Laptop.
3. To connect Arduino Uno to a PC/Laptop, a serial communication is needed in the form of a USB. Rotary encoder is used to calculate the length of the filament produced by the extrusion process based on the number of spins on the roller.
4. On a PC/Laptop, it must be installed visual studio software for the Speed Safety System Railway Project.
5. The software used is Visual Studio with the 2015 version. Where the software will take GPS data.
6. Inside the PC/laptop there is already a database/data referries in the form of latitude, longitude, and maximum speed limit.
7. After the GPS data and the reference data are successfully read, there will be a comparison process. A fan is a device used to reduce heat around the nozzle to keep the temperature stable.
8. After the comparison process is complete, the software will display output in the form of safe status safety or danger/overspeed.
9. When the train is in danger/overspeed conditions, the MP3 will be ON with "Kecepatan Overspeed".
10. The MQTT protocol is a rule or function contained in a computer network, which is used to send and receive data. For the server used

<http://www.hivemq.com/demos/websocket-client/> with the topic train\_speed\_system.

11. A 4G (Wifi) modem is used on the PC/Laptop to keep the PC/Laptop online.

### B. Software Design

This section will be explained about the flowchart of software design from the Speed Safety System Railway using the 2015 version of Visual Studio.

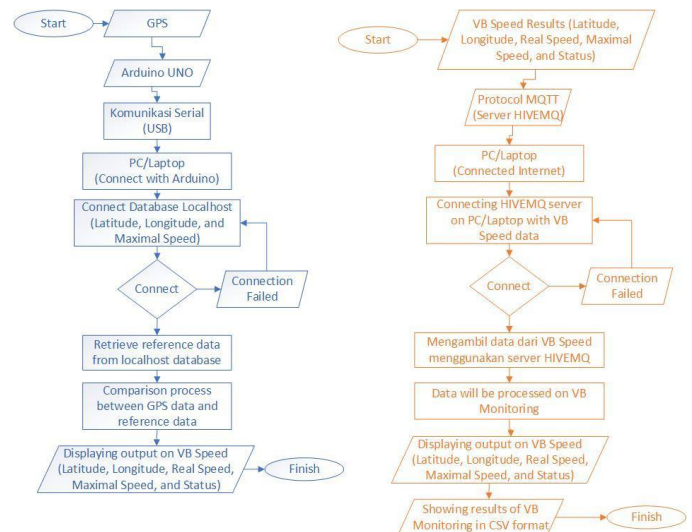


Fig. 2. Software system flowchart

### C. Display Design

Display Application Desktop Railway Speed System is needed to beautify the appearance. This can be a design/edit user on the visual studio display design page. Here is the display on the Desktop Railway Speed System application when the program hasn't been run.

#### a. VB Speed display design



Fig. 3. VB display design on the desktop railway speed safety system application

#### Explanation

- 1) On the left, there are several labels containing GPS data, Latitude, Longitude, the speed of the realtime train that is read by GPS devices, as well as hours/time.
- 2) In the middle, there is a label with several data grids in it. The data is a reference data/database that the researcher has input in the project script first.

3) On the right, there are several labels that contain maximum speeds when the train is at a certain point, the status resulting from the comparison process, as well as MQTT data (data to be sent and received by the HiveMQ server).

*b. VB Monitoring display design*

In VB Monitoring, 2 displays will appear, the first display displays GPS point maps (tracking) and the second display displays the logging data sent by VB Speed. To monitor the position of the train using display tracking and to monitor latitude, longitude, speed and time data using display data logging. Save the position, speed and time data of the train while it is right, there are several labels that contain maximum speeds when the train is at a certain point, the status resulting from the comparison process, as well as MQTT data (data to be sent and received by the HiveMQ server).



Fig. 4. Logging Data Display



Fig. 5. Tracking Display

III. RESULT

This section will be explained about the results of testing the Railway Speed Safety System project. The testing included testing GPS data collection in realtime, testing the addition of reference data/databases in the Desktop Visual Studio application, testing system safety status and MP3 on, the process of sending data from VB Speed to VB Monitoring using an external server, and the process of storing data logging.

*a. Validate reading of GPS device coordinates with readings by gmaps.*

For the validation of the accuracy level regarding the reading of the latitude and longitude of the GPS device, researchers do 5x comparisons as stated in table. From 5x experiments, the accuracy of the accuracy of the reading point of the coordinates of the GPS device reached 9 m to 20 m, with an average of 14 m.



Fig. 6. Evidence and how to calculate the distance (m) between GPS data and GMAPS

TABLE 1. Validation test result Lat, long between the GPS module and Google Maps

Position	Device GPS		Google Maps		Difference (m)
	Latitude	Longitude	Latitude	Longitude	
Kistia's house	-7.603052	111.529026	-7.603036	111.529068	9
Campus 1 PNM	-7.647699	111.526916	-7.647699	111.526916	11
Campus 2 PNM	-7.612281	111.510905	-7.612164	111.510809	20
Madiun Station	-7.619216	111.523933	-7.618836	111.524382	17
PG Great Rejo	-7.605838	111.531500	-7.605928	111.531442	13
<b>Average difference</b>					<b>14</b>

*b. Test results showing "AMAN" conditions.*

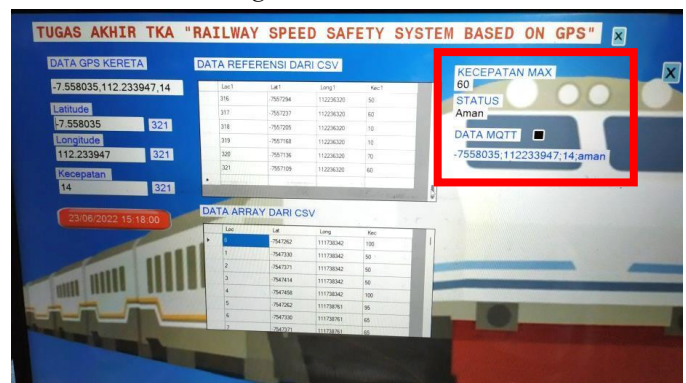


Fig. 7. Testing with "AMAN" conditions.

The picture above is the result of testing the real tracking of the train route Jombang Station - Madiun Station with output safety status indicates safe conditions. That is because the desktop application has received GPS data that is read when passing Latitude (321), Longitude (321) in the database. Then the train speed in realtime is read 14 km/h while the maximum speed limit is 60 km/hour. Which means the train speed is less than the maximum speed of the train that has been determined, so that it produces output in the form of conditions "AMAN".

*b. Test results showing overspeed/bahaya conditions.*

The picture below is the result of testing the real tracking of the Jombang Station - Madiun Station with Safety Output Status indicates the condition of Overspeed/Danger. That is because the desktop application has received GPS data that is read when passing Latitude (285), Longitude (240) in the database. Then the train speed in realtime reads 68 km/h while the maximum speed limit is 50 km/hour. Which means the train speed exceeds

the maximum speed of the train that has been determined, so that it produces output in the form of overspeed/bahaya conditions.

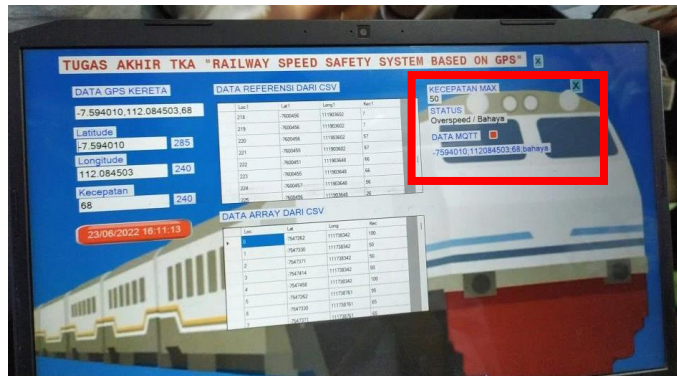


Fig. 8. Testing with overspeed/bahaya conditions.

c. Scripts for mp3

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If lat_long = i AndAlso speed_gps > speed_csv(i) Then
Label17.Text = speed_csv(i)
Label18.Text = "Overspeed / Bahaya"
status_kecepatan = "bahaya"
My.Computer.Audio.Play("D:\TUGAS AKHIR\Train Speed System\MP3\ovvr.wav")
    
```

Fig. 9. Script as an additional mp3 command on during overspeed / danger.

In the picture above, there is a script as an order so that the mp3 (which is lower in red) can turn on if the train status is in the overspeed / danger condition as in the expected design. Audio must be converted into WAV format so that it can be taken by visual studio software.

d. HIVEMQ External Server Testing

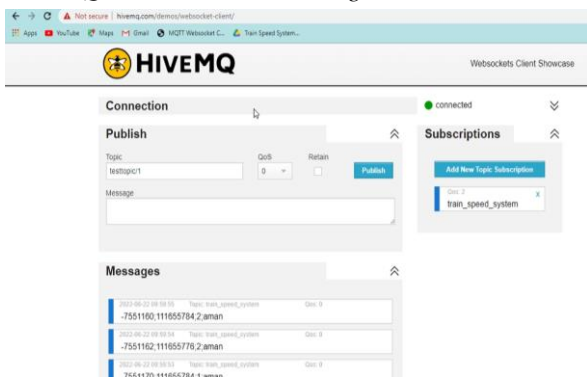


Fig. 10. VB Speed Data Sent to the Broker

Based on the tests that have been carried out, there are several obstacles so that the data sent from VB Speed is not sent to VB Monitoring. Due to poor internet connection in some areas, brokers cannot connect, and the author assumes that the external server was down for a while. This causes the VB Speed data cannot publish data to the broker, so the HIVEMQ broker cannot update the data regularly every 1 second. Lost data can be known when the data in the data logging has been exported to csv data and is visible at the time the data is displayed.

e. Program Testing on VB Monitoring

Based on the tests that have been carried out on VB Monitoring, both displays are functioning as desired. However,

because there are constraints on the internet connection, it affects the system's work while it is operating. Because when the internet connection is disconnected the broker cannot receive data from VB Speed so that VB Monitoring does not get data and affects the updated data on the data logging display and when the data is not updated then the tracking display does not update the position of the train while it is operating. In the data logging display there is an export csv feature, this feature serves to save logging data into csv data.



Fig. 11. Test Results on Display Data Logging



Fig. 12. Test Results on Display Tracking

IV. CONCLUSION

Based on the design and testing that has been carried out in the thesis "Design Railway Tracking and Speed Monitoring System Based on Global Positioning System (GPS) - Embedded Microcontroller" can be drawn as follows

1. Desktop applications are able to receive GPS data in the form of latitude, longitude, and train speed in realtime every second by setting interval on the visual studio software that has been designed.
2. Desktop applications can retrieve data from the database which is then used for a comparative process between GPS data and reference data so that the software is able to display safety status information from two conditions, namely "AMAN" and "overspeed/bahaya".
3. The system can display or visually convey information to the Operational Center in the form of position, speed, status, and time when the train is operating in real time.
4. The online tracking system using a broker is able to monitor the position of the train in real time with auto refresh on the tracking display every 1 second.

5. The csv database is capable of displaying the history of train journeys based on data records from the exported data logging display.

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