Development of Simulation Control Trajectory Application for Movement Monitoring of Low-Speed Rocket

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ABSTRACT

Low-speed rocket is usually used as a research prototype for a high-speed rocket research. In its development, the rocket is equipped with two systems, namely the navigation system or commonly called GCS (Ground Control Station) is useful for monitoring the state of the rocket and the flight control system. In this research, the GCS application is used as a simulator for the rocket flight trajectory visualization which the data derived from the rocket flight test data log. Log data is an array which is containing the data processing from sensor such as accelerometer, gyroscope, magnetometer, compass and gps. Phase committed to processing the log data from flight test such as Parsing, Plotting and Data Visualization. The last step is testing the data visualization with the questionnaire to see the response from respondents about data visualizing from GCS applications that have been built according to Nielson's (2000) five aspects such as learnability, efficiency, memorability, errors and satisfaction. From the questionnaire test, it can be concluded the simulation application that is built has a value of a good reception by the respondent in a scale of 5 with mode 4

Key Words **:** GCS, *Data Visualization, Data Log, Parsing, Plotting*

1. INTRODUCTION

Current generation of guided missile development is very rapid, especially related to the rocket's ability to cruise at high speed, maneuvering difficult and a high level of precision targets. In terms of speed, the rocket is divided into two categories, namely the rocket at high speed which can cruise over 300 km / h and a rocket with a low speed that can be cruise under 300 km / h and usually used as a research prototype.

In its development, the rocket is also equipped with two systems that required in rocketry research, the navigation system or commonly called GCS (Ground Control Station) which is used for monitoring the state of rockets and flight control systems [1]. The visual of movement rocket is needed to monitoring the speed and the attitude of the rocket [2] that shown by GCS on computer devices. In addition, the rocket without the control system will be very dangerous when forced to fly because there is no control system that control the attitude of the rocket while cruising and unstable.

Development of monitoring applications with low speed movement of the rocket is related to previous research on the design of monitoring systems and stability control of the EDF rocket [13]. In previous research, monitoring application that is built to monitor the extent of rocket through the reading of the sensor data in real-time and still can not visualize and simulate the movement of a rocket. Thus, at the time of the rocket flight test, the rocket EDF researchers did not know the position and how the movement of the rocket. This issues make the recovery of the rocket after launch is sometimes difficult to do because the final position of the rockets is unknown. Recovery itself is a process of recovery of the rocket vehicle to a safe place after the flight test carried out.

This research will be built a trajectory simulation application form that will display a visualization of rocket flight trajectory from the starting point to launch until landed back on Earth with the input of the data log from rocket flight on GCS application in the hope of applications built to facilitate researchers rocket EDF to find out how the movement of the rocket from the starting point to help launch and recovery process after the rocket flight test carried out.

2. RESEARCH CONTENTS

2.1. GCS (Ground Control Station)

GCS (Ground Control Station) or GS (Ground Segment) is the transmitter-receiver in the earth station equipped with a computer device that is used to control or monitor the rocket and the spacecraft or payload that is being rolled [6].



Figure 1. GCS

2.2. *Trajectory*

Trajectory is the rute of the movement of an moving object at one time [7]. In each point on the trajectory consists of the value of the position, velocity, and attitude that can produce acceleration. Trajectory can apply to the object that has such speed satellite, land vehicles, ships, aircraft, and others. Examples trajectories encountered in the mapping world is the flight-path or the flight path of air that is required when using the mapping aircraft.



Figure 2. *Trajectory on flight-path*

2.3. *Serial Communication*

Serial communication is serial data transmission (data are sent one by one in sequence), so that the serial communication slower than parallel communication [12]. This communication requires only one line and cable, fewer than the parallel communication. In principle, the serial communication is communication in which data transmission is done per bit, or in other words, serial communications is one method of data communication in which only one bit of data transmitted over a cable strand at a particular time. Basically, the serial communication is a special case of parallel communication with a value of n = 1, or in other words, is a form of communication in parallel with the number of wires just one and only transmit one bit of data simultaneously. This can be compared with the real parallel communication in which n-bit data is sent along with the values generally $8 \leq n \leq 128$.

Serial data communication know two methods, namely synchronous and asynchronous. Sychronous method transmits multiple bytes or characters (or so-called data block or frame) before requesting Configuration rmasi whether the data has been received well or not. Examples of the use of the method contained in the serial synchronous data transmission keyboard. Meanwhile, the method of asynchronous data is sent one byte each shipment. Usually not required Configuration rmasi menerimaan data. Examples are the use of asynchronous serial UART (Universal Asynchronous Receiver Transmitter) used on the serial port (COM) of the computer. Of the two types of methods can be selected and carried out through program.

2.4. *Data Visualization*

Data visualization is the conversion of data into a visual format (table or graph) so that the characteristics of the data and relationships between data items or attributes can be analyzed or reported. Data visualization is one of the best technique and interesting for data exploration. Humans have the ability to analyze large amounts of information visually.

Data visualization can be defined as a variety of ways to create drawings, diagrams or animations with the aim of communicating a message or information. In general, visualization is used to aggregate the data in a very large number which then were presented with various models.

Monitor the movement of the rocket by utilizing the capabilities of the human eye through a GCS may provide a more useful information in detecting anomalies rocket motion. Based on these assumptions, data visualization through GCS be an alternative tool in monitoring the movement of a rocket.

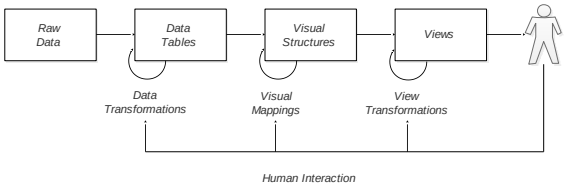


Figure 3. *Visualization data process*

a. *Raw Data is the data which will be processed.*

b. *Data Tables is the raw data that transformed into a structured data table which have*

multiple meanings represented through metadata.

c. *Visual Structures Structures is the data compiled transformed into a geometric model by choosing a basic geometric shapes such as points, lines and polygons and attribute data set.*

d. *Views is the geometrical data subsequently transformed into an image. This is done by looking at changes in scale, translate, zoom and graphical representation.*

2.5. VSPE

VSPE serve to help software engineers and developers to create / debug / test applications through the cable or use a serial port. Developers who develop software and is associated with a device installed in the computer via cable or serial port is usually limited to only a few number of ports on the computer. In fact, a growing number of ports currently testing the application, the better.

To overcome this, we can use VSPE (Virtual Serial Port Emulator). As the name suggests, this software is used to create a virtual port emulator. Thus, each of the user's computer can use up to 255 ports. With the help of this software, the process of manufacture, testing and troubleshooting will be easier.

Unlike the actual port that can only be used for the software or device, the virtual port is one port can be used more than one application. As for some of the features of this software, among others :

a. *Virtual device for the connector, the data splitter and the pair (pair).*

b. Connect a variety of devices.

c. Mode user devices include TCP Server, TCP Client, Serial Redirector, UDP Manager and Bridge.

d. Support the programming or scripting with the Python programming language.

e. Supports x86 processor architecture (32bit) and x86_64 (64bit).

f. There API (Application Programming Interface) for C and C ++ for application development directly.

g. *Available features for monitoring data usage.*

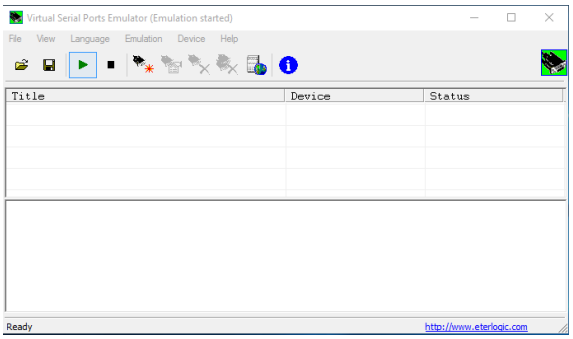


Figure 4. *VSPE*

2.6. *System Analysis*

Here is a system architecture that is built.

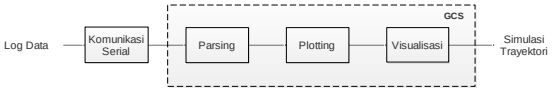


Figure 5. *System Architecture*

The new system will be built using the program input in the form of log data obtained from the rocket flight data processing. Log data will be transmitted serially.

2.7. *Input Data*

Input data that used in rocket flight trajectory simulation of this EDF, which logs data from flight test conducted with a .txt format that can be viewed on the sheet attachment. Here is the fixed data log data obtained from the sensor data processing accelerometer, gyroscope, magnetometer and GPS. Log data is used in the form of array data is separated by a space and sent via serial communications applications and subsequently in GCS data will be parsed, plotting and then visualized in accordance with the parameters required.

```
1 -4,82 -1,61 12,82 1 -10 25 493 694 612 6,99 -21,7 106 1018 -6,85428 107,6039505
```

Figure 6. *Input data*

The format of the input data from the data log is as follows.

a. The first digit is an index of data.

b. The second digit is the data up to the fourth accelerometer sensor on each axis X, Y and Z.

c. the fifth to the seventh digit is a gyroscope sensor data on each of the axes X, Y and Z.

d. the eighth to the tenth digit is a magnetometer sensor data on each axis X, Y and Z.

e. The eleventh digit is the data roll.

f. The second digit is the data twelve pitch.

g. Digit thirteenth is the data heading.

h. Digits fourteenth an altitude data.

i. Digit latitude fifteenth represents data (latitude).

j. *Digit sixteenth is the data longitude (longitude).*

2.8. *Process Analysis*

There are the following analysis processes.

a. *Log of data as input program incorporated into serial communication applications.*

b. *serial communication applications will send log data to the GCS.*

c. *At GCS, the log data will be through three processes, namely parsing, plotting and visualization.*

d. *The output of the program is a simulated rocket flight trajectory is equipped with sensor data and avionics instrument.*

2.9. *Serial Communication Process*

Log data is sent to the serial method after pairing connection process is a virtual port that is in the virtual port-pair can communicate. This communication will make connections between applications GCs with serial communications applications in order to form an array of data in the log data can be transmitted from the serial communications applications to GCS.

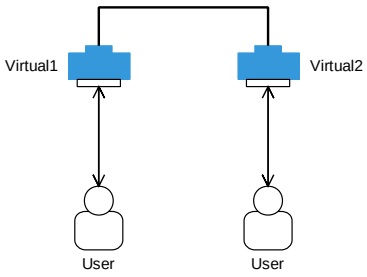


Figure 7. *Virtual port pairing*

2.10. *Parsing Data*

Separating character of logged data to divide the received data into the array variable sensor data. This process will help us in the next process, namely the data plotting.

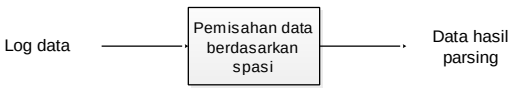


Figure 1. *Parsing data*

2.11. *Plotting Data*

Putting the data that has been parsed and adjust the sensor data variables that have been declared. The following block diagram plotting the data.



Figure 2. *Plotting data*

2.12. *Visualization*

Data visualization is done after the process of parsing and plotting. Data visualization application aimed at helping users to understand the information from the simulated trajectories presented in the form of GUI (Graphical User Interface).

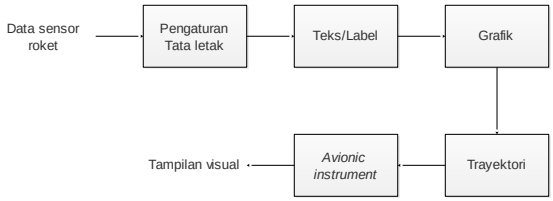


Figure 3. *Data Visualization*

2.13. *Interface Design*

Here is the interface design of the system built.

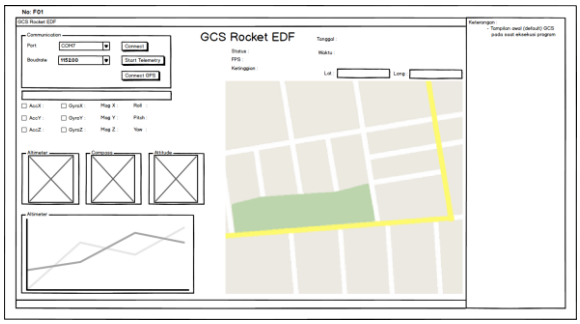


Figure 4. *Interface design*

Applications built GCS will display information in the form of a label / text of the sensor used, avionics instrument that consists of components attitude, compass and altitude, altitude graph and folders to visualize the trajectory of movement of a rocket.

2.14. *Interface Implementation*

Following implementation of the interface design application interface is built.



Figure 5. *Interface implementation*

2.15. *Data Visualization Testing*

Tests performed data visualization to see the user's response to the information from the simulation application trajectory is presented in the form of GUI (Graphical User Interface). This testing is done in the Lab Dirk UNIKOM in the form of a questionnaire consisting of ten questions were distributed to 20 respondents. At first, each respondent will be given some task or tasks that must be done prior to the application to be tested. The following tasks have to respondents do.

Table 1 . *Data Visualization Testing Task*

No.	*Task*/Tugas
1	*Pairing two ports for serial data communication with the application VSPE*
2	*Setting the application components such as the selection of the serial port, baudrate = 9600, data bits = 8, stop bits = 1, parity = none, handshake = none and click the connect button*
3	*Setting GCS application components such as the selection of port and baudrate = 9600. Then click the connect button, start telemetry and connect GPS*
4	*Back to the serial application, click the browse button to enter Gasibu log test data or Ledeng*
5	*Log data is sent via the serial application and data visualized on the application GCS*
6	Setelah pengiriman data dari aplikasi serial selesai, klik tombol disconnect GPS, stop telemetry dan disconnect pada aplikasi GCS dan klik tombol X pada pojok kanan atas untuk keluar dari aplikasi
7	*After sending data from application serial finished, click the disconnect button GPS, telemetry stop and disconnect the GCS application and click the X button at the top right corner to exit the application*

Once the task was given to the respondents, the next step to do is give the questionnaire to the respondent. The questionnaire consists of 10 questions given were sufficient to demonstrate the value of aspects of the testing data visualization according to Nielson (2000). Each question from the questionnaire aims to show the level of user acceptance, which will be assessed on a scale of 5 (the Likert scale). The questions given in this questionnaire are as follows.

Table 2. *Questionnaire Questions*

No.	Pertanyaan
1.	*Does the application interface GCS can be recognized from the beginning ?*
2.	*Do you know the file format of the log data used ?*
3.	*Are you able to send log data easily ?*
4.	*Is the information displayed on GCS in accordance with the format of the log data used?*
5.	*Is the text display is easy to read ?*
6.	*Are the components of the GCS can be understood ?*
7.	*Is the color design of the GCS comfortable to be seen ?*
8.	*Do GCS can help see the movement of the rocket ?*
9.	*Do GCS can simplify the process of recovery after a test rocket launch ?*
10.	*Are you able to remember the components and features of the application GCS ?*

Of the ten questions, each question has a separate section to represent every aspect of the testing data visualization according to Nielson (2000). These aspects include :

a. Learnability, describes the degree of user convenience to meet the task-task basis when they first saw or using a trajectory simulation applications.

b. Efficiency, describes the rate of speed in completing the task-task after learning the result of design.

c. Memorability, describes the degree of user convenience in using a good draft, after a certain period of use.

d. Errors, describes the likelihood of errors made by the user when using the trajectory simulation applications.

e. *Satisfaction, explain the level of user satisfaction in using simulation applications trajectories*.

Contributions questionnaire for each aspect of your test data visualization above can be seen in Table 3 below, where each attribute is indicated by the number of each of these attributes. And in the provision of the questionnaire, it has been described previously by researchers to respondents.

Table 3. *Plot of Data Visualization Testing Aspect*

No.	Pertanyaan	Aspek Pengujian Visualisasi Data				
		Learnability	*Efficiency*	*Memorability*	*Errors*	*Satisfaction*
1.	*Does the application interface GCS can be recognized from the beginning ?*					
2.	*Do you know the file format*					

	of the log data used ?					
3.	*Are you able to send log data easily ?*					
4.	*Is the information displayed on GCS in accordance with the format of the log data used?*					
5.	*Is the text display is easy to read ?*					
6.	*Are the components of the GCS can be understood ?*					
7.	*Is the color design of the GCS comfortable to be seen ?*					
8.	*Do GCS can help see the movement of the rocket ?*					
9.	*Do GCS can simplify the process of recovery after a test rocket launch ?*					
10.	*Are you able to remember the components and features of the application GCS ?*					

The explanation about the questions over the relationship of each attribute, has been described by the researcher to the respondents, with the intention that the respondent can fill out the questionnaire correctly and as expected.

After the distribution of questionnaires given to the respondent, then do a recap of the results of questionnaires that have been deployed. Results of testing the questionnaire recap data visualization can be seen on page appendix (Appendix D).

Here is a data visualization test results conducted on 20 respondents who describe the distribution of answers to each question are given in the questionnaire data visualization.

a. *84% of respondents said GCS applications can be recognized from the initial interface.*
b. *79% of respondents know the format of the log data used.*
c. *82% of respondents can send log data easily.*
d. *88% of respondents said the information presented in accordance with the format of the log data used.*
e. *89% of respondents said the existing text display is easy to read.*
f. *84% of respondents said the components of the GCS can be understood.*
g. *84% of respondents said the color design of the GCS convenient for viewing.*
h. *90% of respondents said GCS can help see the movement of the rocket.*
i. *90% of respondents said GCS can simplify the process of recovery after a test rocket launch.*
j. *80% of respondents could recall the components and features of the application GCS.*

Data visualization of test results above, it can be concluded that the trajectory simulation application that is built has a value of acceptance (acceptance) the good of the respondents in a scale of 5 to mode 4.

3. *CLOSING*

Based on the results of testing conducted trajectory simulation applications, it can be concluded that :

a. *Applications built to help scientists rocket EDF to see the movement of the rocket through visualization maps the trajectory of the component in GCS.*
b. *Applications that are built to facilitate researchers rocket EDF to make the process of recovery after a test rocket launch carried out.*

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