



COMPLETE MONITORING OF GROUND CONTROL SYSTEM FOR HIGH SPEED UAV

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ABSTRACT

Ground control system (GCS) was developed as tools to analyze a special purpose high speed UAV that capable of flying up to a minimum speed of 300 km/h, and this speed will continue to be improved for the next project. Using Hardware in the Loop Simulation (HILS) method between XPlane flight simulator and Labview as programming tools, all of attitude conditions, position in Google map and health monitoring of UAV can be monitored. Including setting the PID control and way points for auto pilot system can also be set easily. Making it easier for the pilot or the researchers to directly analyzing the current condition of the UAV maneuvers. Since all parameters are displayed in a user friendly views. In Hardware in the Loop Simulation (HILS), data communication is done using UDP / User Datagram Protocol to ensure that the data transfer will not interfere with monitoring / analysis conducted by the researchers, because this GCS has been extremes tested using F22 Raptor fighter up to speed of 514 m/s (about Mach 1.5) in the simulation. And more than that, the real data communication has also been carried out using the data telemetry system TX-RX for the high speed UAV is being developed. With these results, developed a universal GCS that capable of being used for the purposes of any kind UAV research, ranging from a low speed of 80 km/h to 400 km/h at this time. This GCS can display all the parameters that required by the researcher according to the parameters provided by XPlane for the UAV development.

Keywords: ground control system, universal ground station.

1. INTRODUCTION

In general, Ground Control System (GCS) has the function as monitoring and control of a flying vehicle [1]. Many development projects of GCS directly linked to development of fix wing UAV or multi-rotor's control systems itself [2-3] and this UAV usually is a low speed propeller UAV, with a maximum speed 120 km/h [4].

GCS development that discussed in this paper, also using UAV that developed for a specific purpose. This UAV usually call RKX-200TJ, have length 2.15 m, wingspan 1.6 m, cruising speed 250 km/h, and will be increased speed up to 350 km/h next year. So, for the analysis needs required a comprehensive monitoring to the overall attitude datas or anything else associated with stability when maneuver, navigation, achievement way points and other data related to the critical speed of UAV.

In addition to monitoring RKX-200TJ, would be maked universal GCS. It means, as long as there are modeling that made in flight simulator, in this case is XPlane, all of parameters vehicle will be able to process and analyzed as closely as possible, with add visual monitoring for the researchers. Thus the development of universal GCS would be important for the successful development of any vehicle in the future.

2. RESEARCH SCOPE AND SIGNIFICANCE

The development of the GCS is expected to be more optimal, with several adjustments based on the needs of general users, the pilot of the UAV, and other analysis requirements for research. As a result, the GCS has more graphical features by highlighting on user interface features.

1. Displaying coordinate position on Google map and altitude historically.
2. Displaying vehicle attitude in graphic interface to help pilot in driving the vehicle.
3. Displaying vehicle health status.
4. Displaying vehicle attitude historically to make analysis.
5. Enable to have some different settings for several purposes, such as offline map setting, commu-nication setting, file path location to save file etc.
6. Enable to make waypoints setting.
7. Enable to display many input and output data to and from XPlane for various types of UAVs and research purposes.

The GCS is also developed to fit into some vehicle models, including high speed flying test bed, UAV and some other types of flight vehicle, with different protocols.

3. METHODOLOGY

Before conducting a real flight test, GCS development is mainly assisted by flight simulator XPlane, both are connected in close loop using HILS (Hardware in the Loop Simulation) [5-8] as showed in Figure-1 below. With XPlane [9-11, 14], it is possible to conduct a test using various types of vehicle, from low-speed type such as aero-modeling aircraft to fighter type (F22 Raptor) with speed more than Mach 1.5.

During the development of the ground station, several computer languages has been used, such as Visual Basic, C++ to LabView 12, considering its simplicity in



the development and its easy communication with existing hardware.

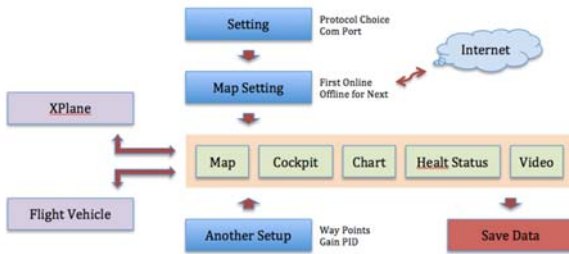


Figure-1. Hardware in the loop simulation (HILS).

The combination between XPlane and Labview using UDP (user datagram protocol) [12] enables multiple test flights of a vehicle and has the function of GCS in real time. And also tested using radio telemetry system which connects between UAV and GCS.

4. RESEARCH PROCESS

In order to realize universal GCS, as mentioned in the point II above, GCS has following features:

A. Easy parameters setting

The first step required in this GCS is communication setting, such as setting com port and baud rate; file save setting including directory path for filtered data and row data; and choosing the protocol to be used. This protocol is very closely related to the model data, there is can be shaped ASCII data or binary / HEX data. And also provides setting the original coordinate as a reference for the calculation range of vehicle during flight, as shown in Figure-2 below.



Figure-2. Parameter setting.

B. Map setting

In map setting, it is equipped with zoom feature, center of coordinate, size of map and map format (roadmap, mobile, satellite, terrain and hybrid), as shown in Figure-3. Reading of the Google map can be done once

only, when the first booting and save the downloaded map into a folder in the specified directory. This offline map display is selected to avoid unavailability of internet connection in the area during vehicle launch. So it can download some maps while in a good location for expected maps to be used later.

All parameters are combined into an address in Google map. If there is an internet connection, the map displayed will fit the intended setting, by using IwebBrowser provided in Labview.

Referring to the setting of coordinate center and zooming, range of longitude and latitude could be calculated (left and right of longitudinal also up and down of latitude), so the coordinate of GPS can be plotted in the map.

In the bottom side, user can select the map file to be used and type of the map (bmp or jpg). Figure-4, illustrated how the process of displaying and setting the google map image in labview.

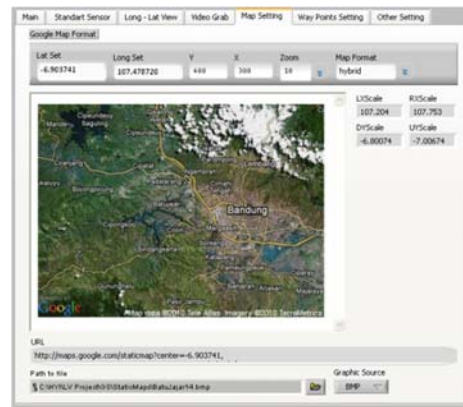


Figure-3. Map setting.

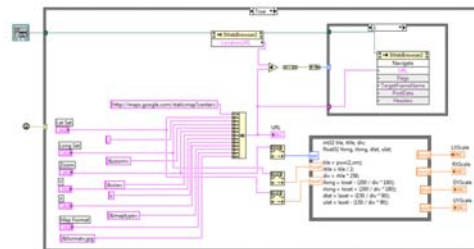


Figure-4. Map setting program in the LabView.

C. Monitoring position and altitude of vehicle

To help user and to make easier monitoring, the coordinate position is displayed on Google map offline, as shown by Figure-5. In addition to mapping coordinates, there are also displayed in numeric coordinates including the altitude in a historical chart.

Within this window, it is also shown the coordinate and altitude settings associated with the nearest waypoint. GPS and attitude data of the vehicle is read via



serial and separated by commas. The order of data displayed is as following:

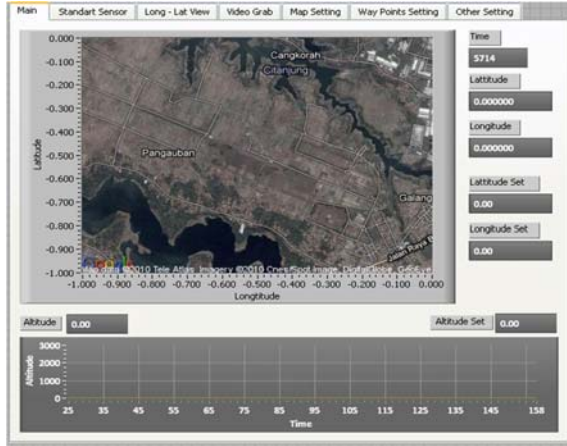


Figure-5. Overlay coordinate position on Google map.

1. GPS / attitude data reading through RS-232 with its standard protocol setting.
2. Detection of ASCII character length per line.
3. Detection of header data
4. Separation of data per comma
5. Conversion of data from 'lon lat' to 'degree'
6. Display on Google map

The facility of Labview gives assistance in displaying GPS data as flight path vehicle online on XYGraph with map background, which has been set. The looping of the previous data may be displayed historically with flight vehicle overlay on map. Figure-6 is a program to obtain serial data from GPS and parsing it.



Figure-6. Data processing.

D. Vehicle cockpit

To give pilot assistance in flying the vehicle, there is a cockpit display mode indicating vehicle attitude on flight, as seen in Figure-7. The display also features data of roll, pitch, yaw, altimeter and air speed. The two latest sensors are measured by pressure sensor.

The collaboration with ActiveX as the object of Labview front panel allows all attitude data displayed more attractive because of the presence of data in numeric format.

ActiveX cockpit display is developed using other software such as Visual C, Visual Basic or other software that support the creation of ActiveX. Furthermore

LabView can directly call and use it as a component part of this cockpit display (Figure-8).

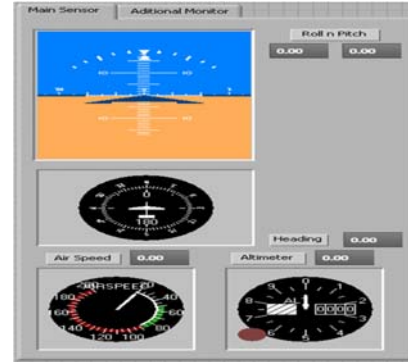


Figure-7. Vehicle cockpit model.



Figure-8. ActiveX in LabView.

E. Historical chart

When researchers need to analyze the flight attitude of vehicle in real time, they can use the function of analyzer. Knowing the flight condition will also influences the stability level of the vehicle. The display also shows data of roll, pitch yaw, alpha (angle of attack), beta (side slip angle), speed XYZ, and anything that is needed to be displayed. The display (Figure-9) can be seen in a historical chart.

Displaying data in Waveform chart is the standard format provided by Labview. The display of this chart is very user-friendly for the researchers, who normally have not much expertise in programming.

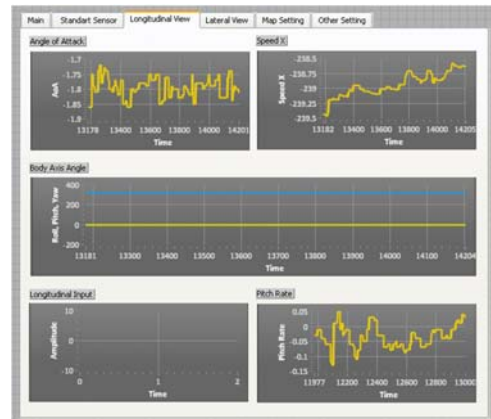


Figure-9. Historical chart for analysis.



F. Health monitoring

Displaying vehicle health status is also given, for example is the battery status and the speed vehicle while flying. Battery monitoring is necessary to avoid the out of control of the vehicle due to power loss.

Also the speed monitoring conducted to compare the results of measurements speed by GPS or pitot cube as a speed sensor. In the same way can also be designed to display other required data as a means of monitoring.

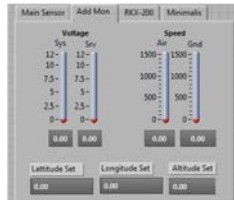


Figure-10. Health monitoring.

G. Waypoints setting

Besides data reading format, the GCS is also equipped with waypoints setting for auto pilot [13, 15] purposes that will guide for the vehicle in determining its flight path. The waypoint data consists of longitude and latitude coordinates altitude and air speed.

The ease in determining waypoint is also provided by GCS. Users only need to click in some location in the map, and automatically the flight path will be displayed, including the waypoint coordinates (Figure-11).

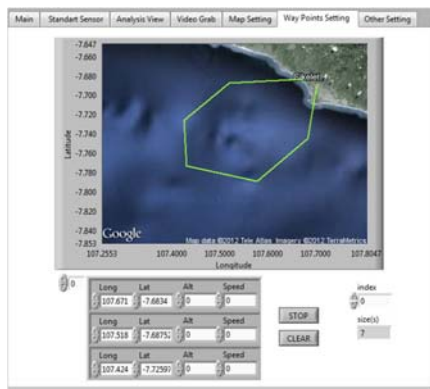


Figure-11. Waypoints setting.

Moreover, there is a function provided to make direct conversion from the real coordinate of longitude and latitude into a point data on screen, by using Event Structure in Labview. The procedure is as follows:

- 1) When the mouse moves, no action is available.
- 2) When mouse down and followed by mouse up, the data will be saved in array and will be displayed in the referred map.

- 3) Resetting waypoints can be done by pushing the button "Clear" which means activating the mode 'clear', or clearing the array.
- 4) And the data in array is the data that will be sent as the waypoints to on-board processor of the vehicle via telemetry.

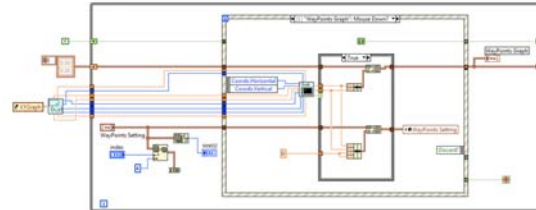


Figure-12. Waypoints program in LabView.

H. Universal ground control system

The system has been developed can also be used for many types of UAVs and many research purposes. During the UAV models that are created using Plane Maker, then all the UAV output variables (roll, pitch, yaw, speed, etc) will be displayed freely as needed for stability analysis of the UAV or analysis for specific research purposes.

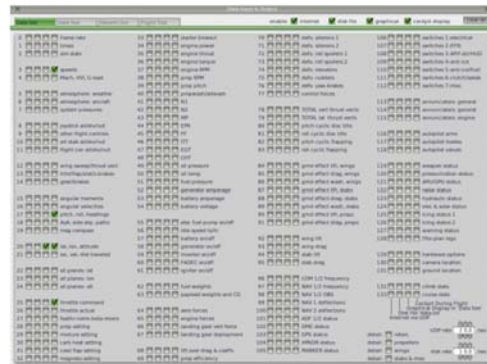


Figure-13. Setting Input / Output Data XPlane.

Similarly, can be sent the data that serves as a data input XPlane like aileron, elevator, rudder, throttle engine, landing gear etc. So, this universal GCS will greatly assist researchers in the development of special or new types of UAVs by making use of all the XPlane facilities and easy to display a lot of data provided by LabView (see point E above).

5. GCS TEST

Several tests have been conducted for different related models of data, ASCII or HEX. For ASCII model, flight test data can be obtained from the flight simulation XPlane. So, it can be assumed that the approach of data collection via XPlane is the same use as flight monitoring on vehicle when flying.



Another test has also been completed by receiving data in HEX format, which is sent by another system in UAV development (Rainbow Electric). Protocol binary / HEX data is developed in the matrix 30 bytes x 5 columns of data for the dynamic needs of the entire data during flight.

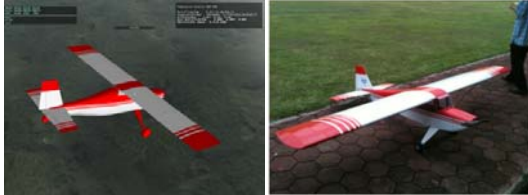


Figure-14. Simulation by HILS and real Rainbow Electric.

Also tested in the simulation under HILS, the high speed UAV, RKX-200TJ that flying at speeds 400 km/h.



Figure-15. Simulation by HILS and real RKX-200TJ.

In other words, all features in GCS can function well. And in actual Rainbow flight test, this GCS has been connected with telemetry system directly. But only works 1 way, that is from Rainbow to GCS with data transmit speed 38, 400 bps. To make it 2 ways it is still not successful. So, PID gain settings for stability are still down in the ground before the Rainbow flown.

6. CONCLUSIONS

Based on results on the development of GCS above, there are several points to be concluded:

- 1) The usage of LabView as a software for developing GCS really is helpful and simple. The tendency to hardware and the ability to make user-friendly displays make it easy for users, researchers and pilots.
- 2) Developed GCS can be used for analysis in the development of high-speed or special purposes UAV to provide completed parameters input and output using combination between XPlane and Labview.
- 3) Universal GCS have developed can be used to analyze the UAV from a low speed 80 km/h until 400 km/h under HILS.

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