



Integrated Complex Advanced Robotic Unmanned System

Ground Control Station Interface (GCSI)

User Manual

Software: Version 0.2.0.3

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Description

The GCS Interface is a fully featured and Open Source tool for enabling the use of multiple ground and aerial vehicles in a useful and expandable package. The GCSI is programmed primarily in National Instruments LabView, a graphical programming language. Some of the many features of the GCSI include:

Table 1: GCSI Features

| |
|---|
| Vehicle Health System helps monitor Vehicle |
| Debugger Mode helps in Vehicle development |
| Intelligent Error Handler deals with ICARUS defined Error Codes and informs User |
| Save Map files for later analysis |
| Manual Control (keyboard/joystick) of any ground or aerial robotic vehicle. |
| Autonomous Control of any ground or aerial robotic vehicle. |
| Google Earth real-time continuous mapping of robotic vehicles. |
| Multiple communication network types (XBee, Wi-Fi ¹ , Cellular ² , SATCOM ³). |
| Audio Feedback |
| Various Sensors Reporting |
| User Configurable |
| Monitor Communication Status |

Software Roadmap

The GCSI Software is going through a development process to provide advanced features while being maintained in a usable and tested state.

Table 2: Software Roadmap

| Version | Capability | Explanation |
|----------------|-------------------------------------|--|
| 1.0 | Manual Control | Manual Control of the Vehicle. |
| 1.0 | Network Initialization | Network initialization using 3-way handshake. |
| 1.0 | Error Display | |
| 1.0 | Basic XBee API Mode | Send to specific device, show status of all receiving devices. |
| 1.0 | Autonomous Control | Plot waypoints, transfer to Vehicle, show path in Google Earth. |
| 2.0 | Google Earth with Multiple Vehicles | Able to display different tracks for different Vehicles in Google Earth. |
| 2.0 | RF Modes | Able to select different RF modes. |
| 2.0 | Video Feed | Display Video Feed from Vehicle. |
| 2.0 | Advanced XBee API Mode | Includes 16-bit addressing, mesh networks, RSSI indicators. |
| 2.0 | User Configuration | Includes Google Earth icon configuration. |

Requirements

Software Requirements

The GCSI requires the full LV Run-Time Engine 8.6.1 for your Operating System. Current Operating Systems supported by LV:

¹ Currently Not Supported.

² Currently Not Supported.

³ Currently Not Supported.

Table 3: LV Supported Operating Systems

| Operating System | Run-Time Engine Link |
|--------------------------------------|---|
| Windows (2000,XP,Vista,Vista x64) | http://joule.ni.com/nidu/cds/view/p/id/1244/lang/en |
| Linux | http://joule.ni.com/nidu/cds/view/p/id/1246/lang/en |
| Mac | http://joule.ni.com/nidu/cds/view/p/id/1245/lang/en |

NOTE: All Development has been performed in a Windows environment. While LV may be compatible with other Operating Systems, the GCSI in no way guarantees interoperability with other Operating Systems.

Google Earth (GE) is available for free download [here](#).

GCSI Hardware and Software Recommendations

Besides the requirements listed in the [Software Requirements](#) Section, the following are Recommendations for optimal performance and capability with the GCSI.

Table 4: Hardware and Software Recommendations

| Recommendation | Justification |
|-----------------------|--|
| 2 Displays | Optimal simultaneous viewing of LV and GE Interface's. |
| Serial Port | Used for Communications. If no Serial Port is available, GCSI Software will be able to use USB Port. |
| Joystick | Easier Manual Control of Vehicle. |
| Basic RF | XBee Radio's are suggested: Supported Devices . However, any drop-in wireless radio will work (using the XBee Non-API Mode). |

ICARUS System Requirements

Communications

The GCS Interface requires at least one of the following Communications Networks to exist:

Table 5: Communications Network Requirements

| Communication Network | Status |
|------------------------------|---------------------|
| XBee | Supported |
| Wi-Fi | Not Supported (yet) |
| Cellular | Not Supported (yet) |
| Satellite Communications | Not Supported (yet) |

For information regarding the implementation of the ICARUS Communications Protocol, see Appendix A1: ICARUS Communications Protocol Guide. The ICARUS Communications Protocol must also be followed, which can be found in Appendix A2: ICARUS Communications Protocol Specifications.

Bug Reporting and Feature Requests

As this software is currently in BETA Release, please use the following link to report any bugs or features that you feel are absent from the software:

<http://code.google.com/p/robot-chopper/issues/list>

Installation

1. Download and Install the Labview Run-Time Engine for your Operating System (See [LabView Software Requirements](#))
2. Download and Install the Google Earth Client.
3. Restart Computer.
4. Download, Unzip and Execute the most recent version of the GCS Interface:
<http://code.google.com/p/robot-chopper/downloads/list>

Overview

The GCSI has two main screens, the LabView Interface and the Google Earth Interface.

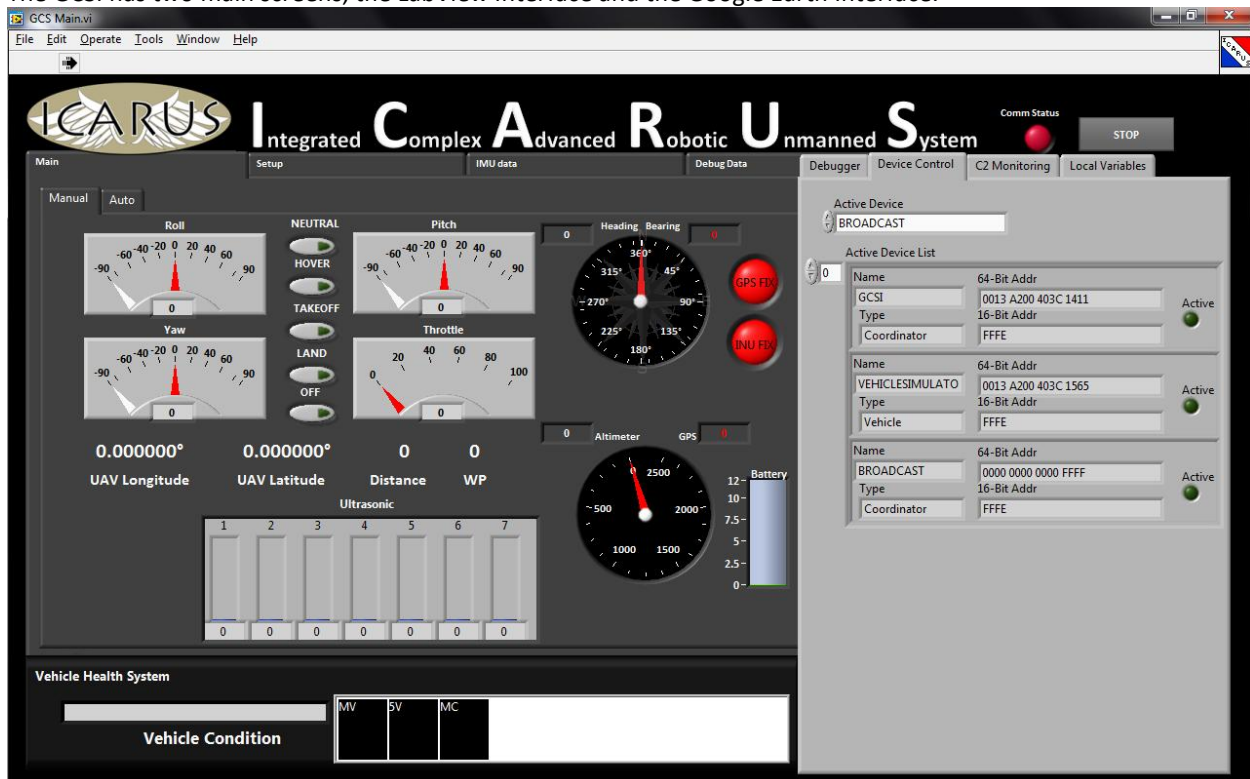


Figure 1: LabView Interface

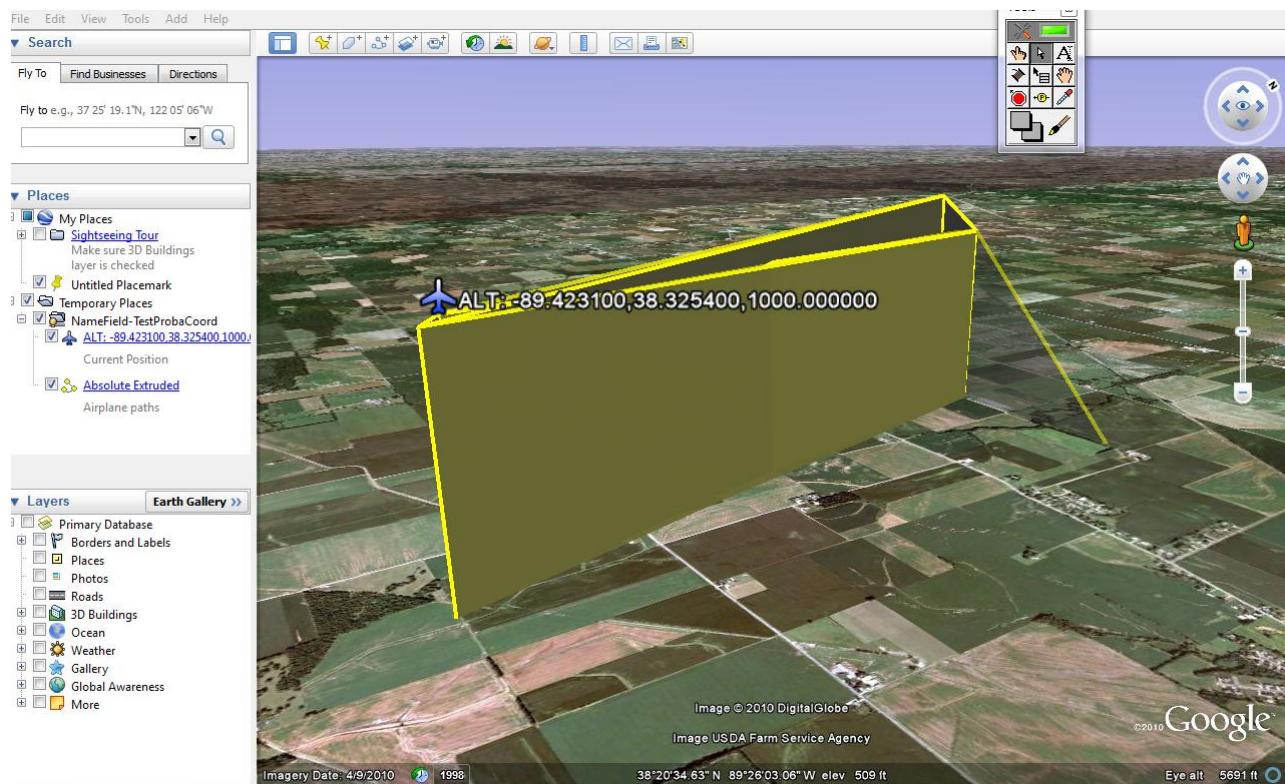


Figure 2: Google Earth Interface

The LabView Interface is required for Manual and Autonomous Control. The Google Earth Interface is optional for Manual and Autonomous Control, but is required for Waypoint designation. As the Google Earth Interface uses a large amount of system resources and can directly affect the communication network, during Manual Control it is suggested to keep the Google Earth program closed.

Configuration

Setup Tab

Connectivity Tab

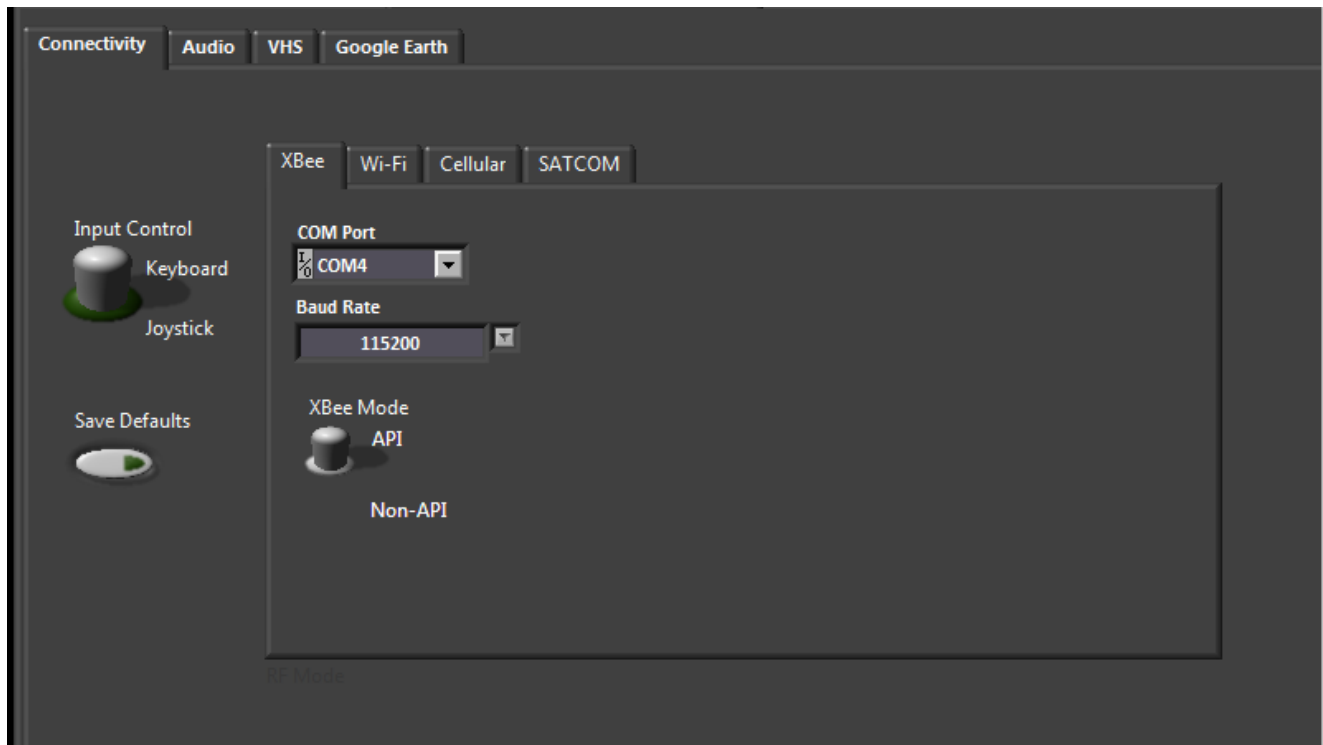


Figure 3: Connectivity Configuration Tab

Controls/Indicators

1. Input Control: Select between Keyboard and Joystick.

Keyboard Controls:

UP: Pitch Down

DOWN: Pitch UP

LEFT: Roll Left

RIGHT: Roll Right

<: Yaw Left

>: Yaw Right

-: Throttle Decrease

BACKSPACE: Throttle Increase

W: Enter TAKE OFF Mode⁴

S: Enter HOVER Mode⁵

Z: Enter LAND Mode⁶

X: Enter TURN OFF Mode⁷

2. Save Defaults: Save Default Options. Includes:

Google Earth Enable, XBee API Mode, Baud Rate, Audio, Vehicle Health System

⁴ See System Documentation

⁵ See System Documentation

⁶ See System Documentation

⁷ See System Documentation

Wireless Tab

XBee

The GCSI Software will default to XBee, Non-API Mode with no COM Port specified.

Non-API Mode:

The Non-API Mode of the XBee acts as a transparent UART, whatever is sent out to the transmitting XBee is received at the receiving XBee. There are limitations to the Non-API Mode, one of which is the ability to transmit to different XBee Radio's at different times without going into the Command Mode of the Radio. If more than 2 XBee Radio's are desired for operation at the same time, API Mode should be used.

Initial Configuration

1. Select COM Port
2. Select Baud Rate (115200 bps default)

API Mode:

The API Mode of the XBee acts as a way to send UART data to a specific XBee Radio, and the receiving XBee Radio will report the UART data along with the Sender's address. More information on the XBEE API Mode can be found [here](#).

Initial Configuration

1. Connect XBee Radio to Computer.
2. Open the [X-CTU Utility](#).
3. Select the appropriate Baud Rate and Port. (XBee default is 9600 bps, No Flow Control, 8 Data Bits, No Parity and 1 Stop Bit.
4. Click Enable API.
5. Click Modem Configuration
6. Click Read.
7. Open AssignXBeelD.exe
8. Select the File Location for idlist.txt which should already be created.
9. Click Load From File.
10. Using the Up/Down arrows, go to the next undefined Device (or overwrite changes to a device not used).
11. User Name, type the Name of the Device. This text will be how you choose from different devices in the GCSI.
12. Define a Type. This is not important with GCSI ver .2 but will be used in higher versions.
13. Under the 64-bit Addr field type the SH and SL values from the X-CTU Utility.
14. Leave the 16-Bit Addr field blank.
15. Steps 1-14 will need to be accomplished for each XBee Radio on your network.
16. Click Save and Quit.

Usage Instructions

1. Open the GCSI.exe
2. Select the COM Port of the XBee connected to your computer.
3. Select the appropriate Baud Rate
4. Click the switch to activate API Mode.
5. Under the Device Control Tab, click Active Device to select from any Device on your Network.

Wi-Fi

Currently not supported.

Cellular

Currently not supported.

SATCOM

Currently not supported.

Future Expansion

Audio Tab

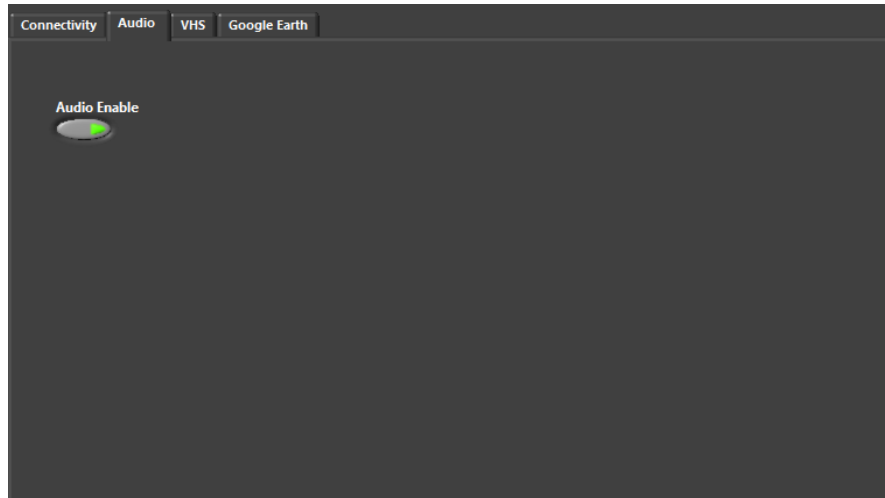


Figure 4: Audio Configuration Tab

Controls/Indicators

1. Audio Enable: Enables/Disables Audio.

Future Expansion

1. Control different Voice.

Vehicle Health System Tab

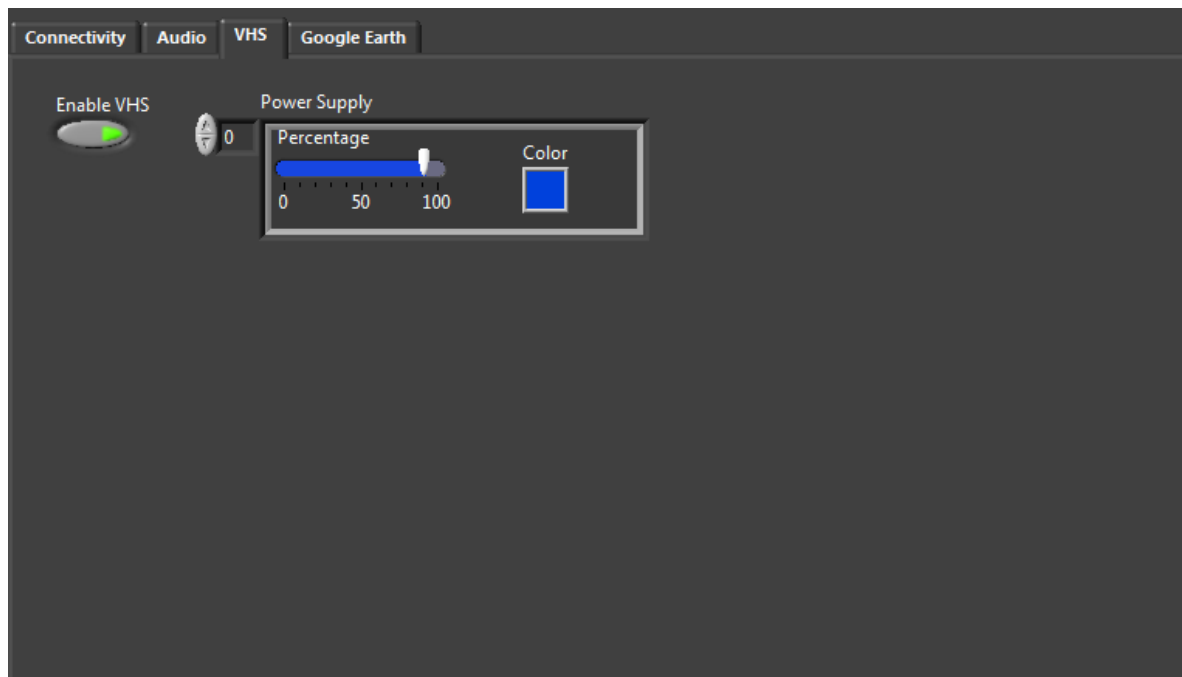


Figure 5: VHS Configuration Tab

Controls/Indicators

1. Enable VHS: Enables/Disables VHS.
2. Power Supply: Configures different parameters for different levels for every Power Supply parameter (Main Voltage, Main Current, 5V Supply)
 - a. Percentage: Sensor value must be over this value.
 - b. Color: Displays as this Color.

Future Expansion

1. Configure other parameters and colors.

Google Earth Tab

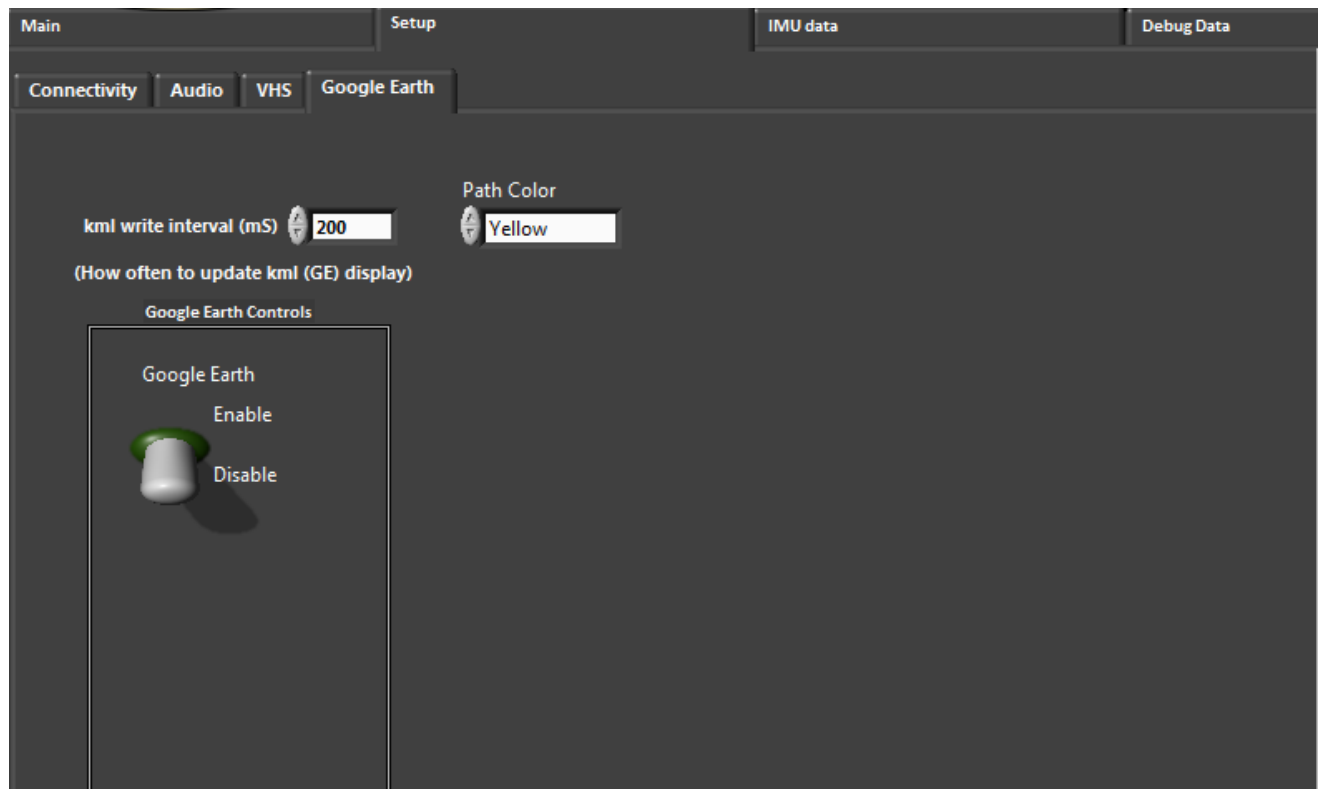


Figure 6: Google Earth Configuration Tab

Controls/Indicators

1. kml write interval (mS): How often the KML file used by Google Earth is updated, in milli-Seconds.
2. Google Earth Enable/Disable: Controls whether or not Google Earth is opened on startup of GCSI. Use to improve communication speed during Manual Control.
3. Path Color: Path color of Vehicle path in Google Earth. Current colors supported: Yellow,Blue,Gray.

Future Expansion

1. Select different Vehicle Icons, Waypoint Icons, Path Colors for multiple Vehicles.
2. Google Earth Enable/Disable closes Google Earth if currently running.

Operation

Main Tab

Manual Tab

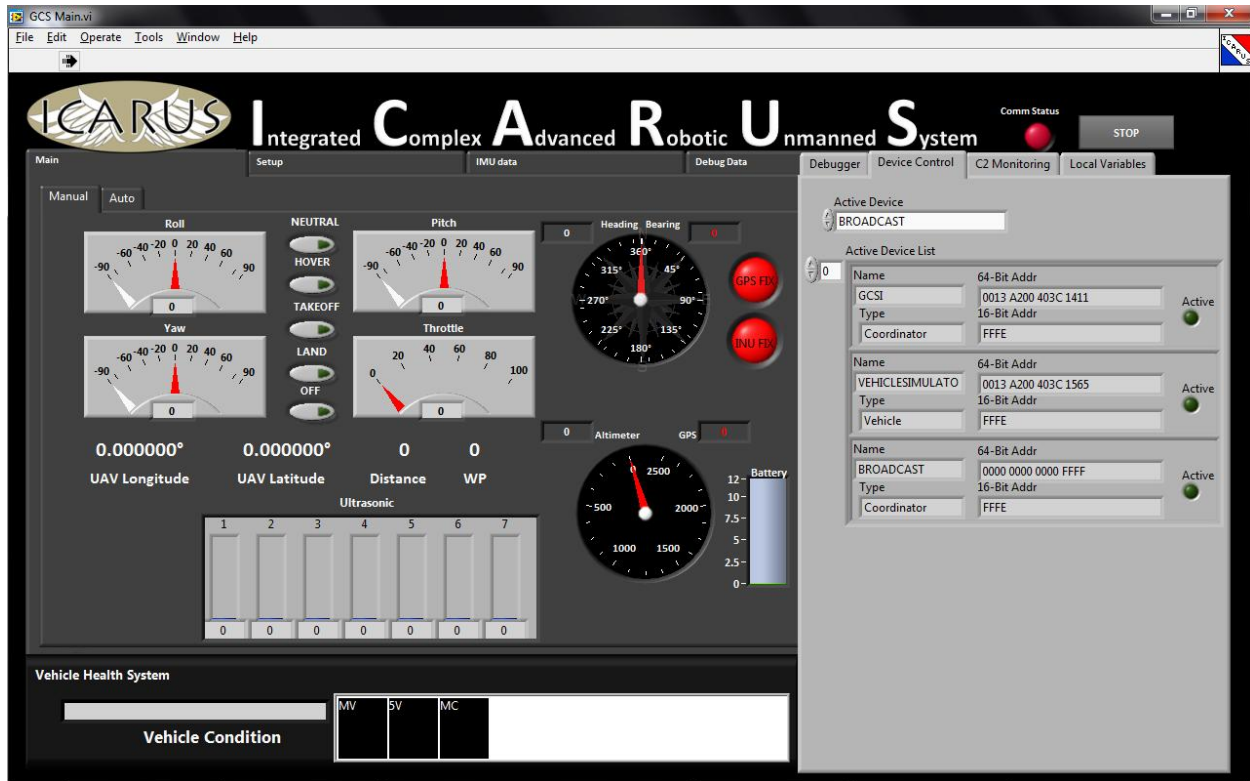


Figure 7: Manual Tab

The Manual Tab displays Sensor readings and other data reported from the Vehicle

Controls/Indicators

1. Course/Bearing Gauge
 - a. Bearing: The compass angle of the Vehicle with respect to its next waypoint.
 - b. Heading: The compass angle of the Vehicle with respect to Magnetic North.
2. Altitude:
 - a. Altitude over Datum: Altitude reported by GPS Device
 - b. Altitude over Ground: Altitude reported by other Sensors, such as barometric or distance sensors.
3. Ultrasonic: Each Ultrasonic sensor reports how far away it sees an obstacle, in inches.
4. Battery: Battery Voltage, maximum is 12V.
5. GPS FIX: Indicates receiving GPS Position Data.
6. INU FIX: Indicates receiving INU Orientation Data.
7. Pitch/Roll/Yaw: Indicates INU Orientation Data for each Axis.
8. Throttle: Controls Vehicle Throttle.
9. UAV Latitude/Longitude: GPS Position Data.
10. WP: Current Waypoint Objective.
11. WP Distance: Distance to Next Waypoint, in feet.

Future Expansion

Autonomous Tab

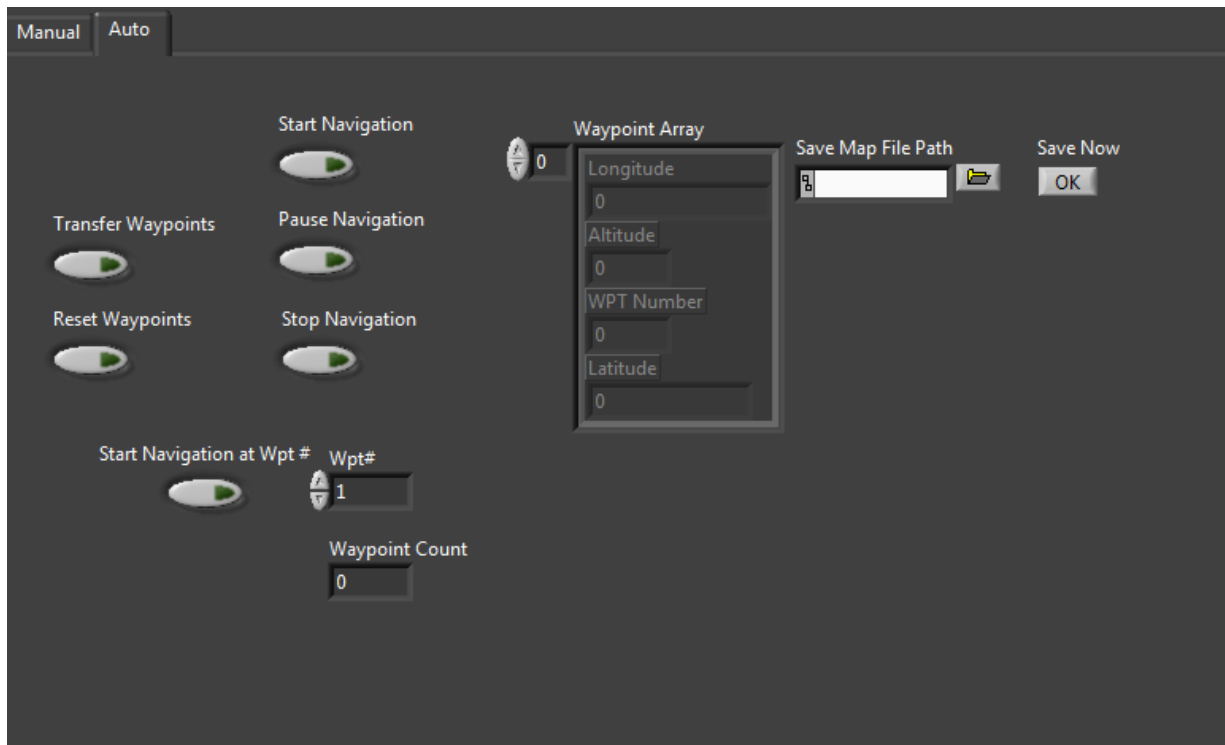


Figure 8: Autonomous Tab

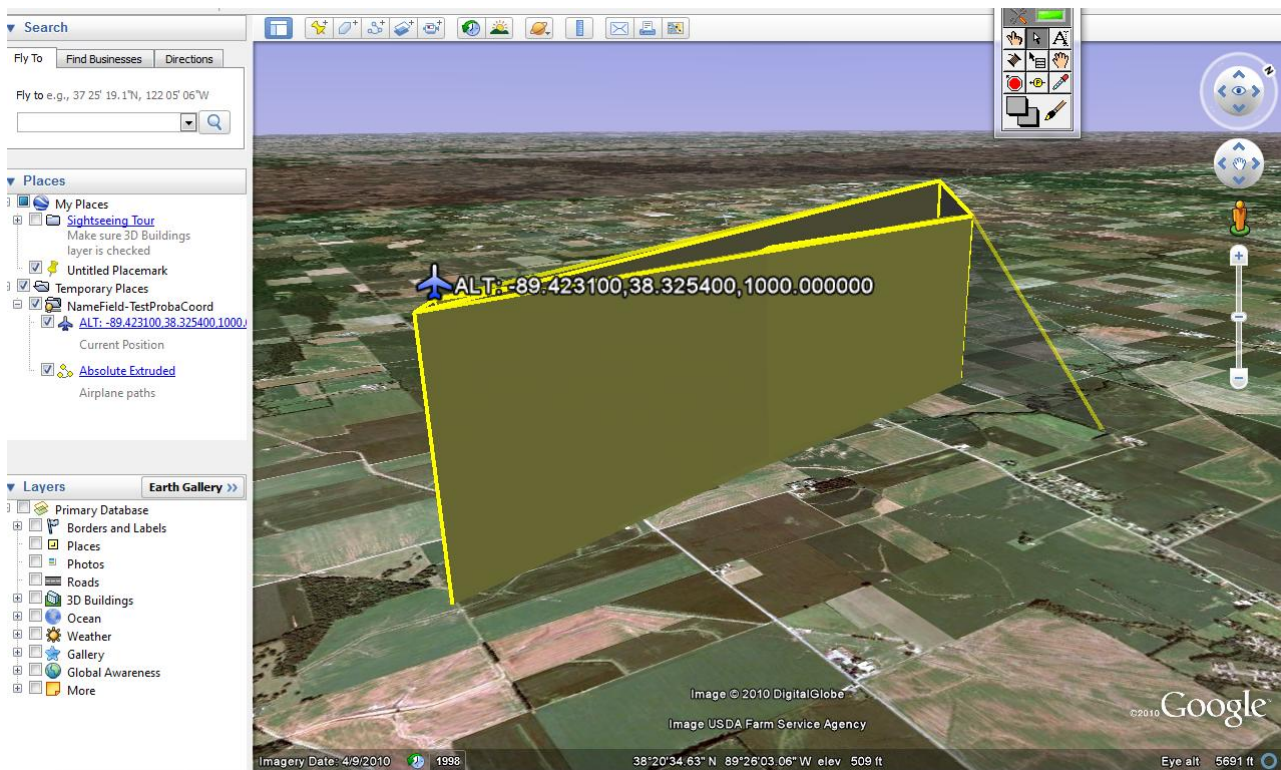


Figure 9: Google Earth Interface

The Google Earth Interface is used to create Waypoints and to mark the current and past position of the Vehicle(s)⁸.

To Create a Waypoint, Right-click anywhere on the map.

To focus in on the Vehicle, click on the Vehicle Icon in the Places Toolbar on the Left.

Controls/Indicators

1. Transfer Waypoints: Transfer Waypoints to Vehicle.
2. Reset Waypoints: Reset Waypoints on Vehicle and Google Earth Interface.
3. Start Navigation: Command Vehicle to start autonomous navigation from Waypoint 0.
4. Pause Navigation: Command Vehicle to Pause current autonomous navigation.
5. Stop Navigation: Command Vehicle to Stop autonomous navigation.
6. Start Navigation at Wpt#,Wpt#: Command Vehicle to start autonomous navigation from selected Waypoint Number.
7. Waypoint Count: Total number of Waypoints.
8. Waypoint Array: Displays all Waypoints.
9. Save Map File: File Path to save Map.
10. Save Now: Save current Map to File. This File is a KML file that can be used by Google Earth, without having to use the GCSI Software.

⁸ Only 1 Vehicle currently supported.

Future Expansion
Side Tab
Debugger Tab



Figure 10: Debugger Tab

Controls/Indicators

1. Motor_1-4: PWM signals sent to Speed Speed Controller's.
2. Command: ICARUS Communications Protocol Message sent to Selected Device.
3. Read Msg: ICARUS Communications Protocol Message received.
4. Sent Msg Array: Stores up to the last 256 messages sent to facilitate re-tries

Future Expansion

Command/Control Monitoring Tab

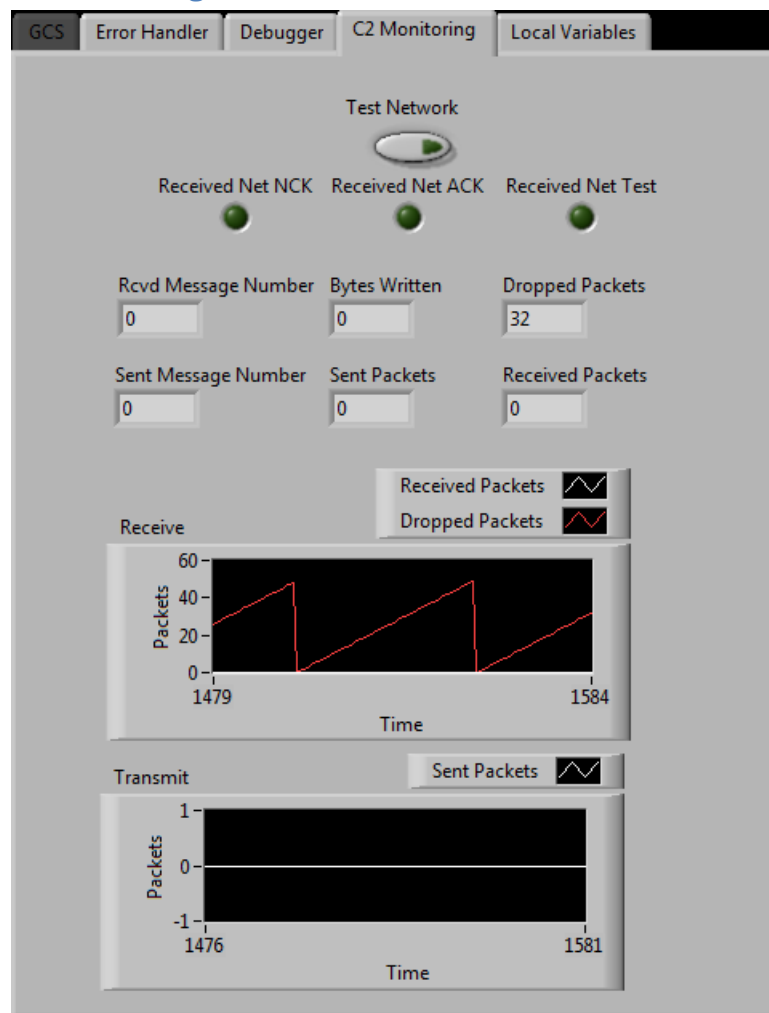


Figure 11: Command/Control Monitoring Tab

Controls/Indicators

1. Test Network: Initializes Network Test process. Turns off when Network Test is completed.
2. Received Net NCK: Received ICARUS Communications Protocol Message \$NET,NCK
3. Received Net ACK: Received ICARUS Communications Protocol Message \$NET,ACK
4. Received Net Test: Received ICARUS Communications Protocol Message \$NET,TEST
5. Rcvd Message Number: Sequence Number of Received Message.
6. Sent Message Number: Sequence Number of Transmitted Message.
7. Bytes Written: Bytes written on Active COM Port.
8. Sent Packets: Number of Packets sent over 1 second period.
9. Dropped Packets: Number of Packets dropped over 1 second period.
10. Received Packets: Number of Packets received over 1 second period.
11. Receive: Graphical form of Items 9 and 10.
12. Transmit: Graphical form of Items 8.

Future Expansion

Device Control

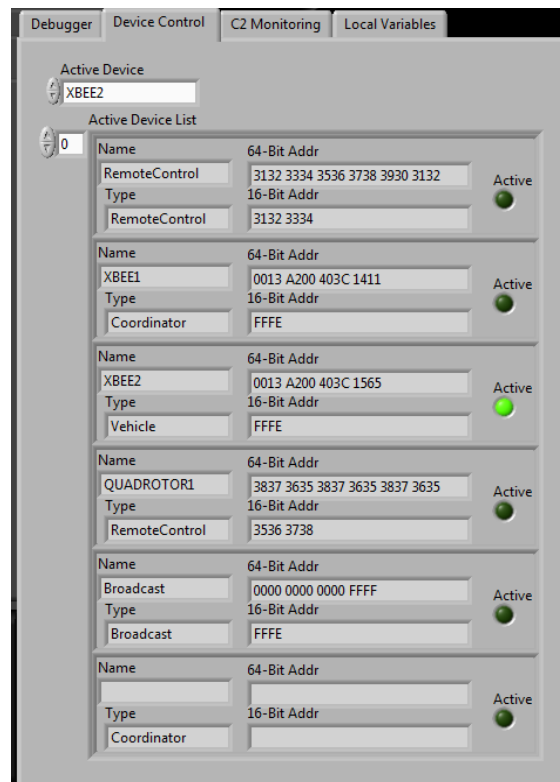


Figure 12: Device Control Tab

Controls/Indicators

1. Selected Device: Choose Device to send/receive Manual Packets and send Autonomous Packets to.
2. Active Devices: Lists all Devices defined on Communication Network and their status.

Future Expansion

Bottom Tab

Vehicle Health System Tab

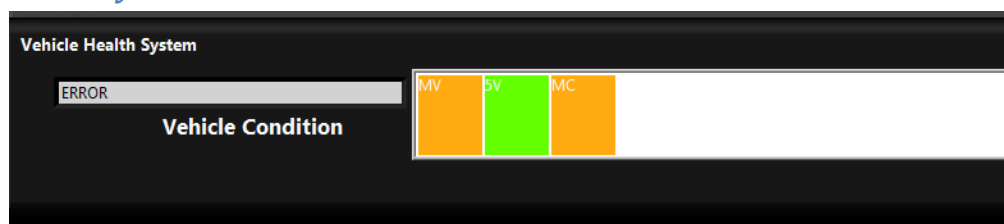


Figure 13: Vehicle Health System Tab

Controls/Indicators

1. Vehicle Condition: Provides overall status of Vehicle. Conditions Include:
 - a. NORMAL:
 - i. Battery Voltage Nominal.
 - ii. No Error Codes.
 - iii. Main Current Nominal.
 - b. LAND SOON:
 - i. Battery Voltage decreasing. Land soon before Batteries are too low to land Vehicle safely.
 - c. NO COMMUNICATIONS:

- i. No communication with Vehicle.
 - ii. Lost communication with Vehicle.
 - iii. A large number of are Packets being received but are not recoverable.
- d. EMERGENCY LANDING:
 - i. Vehicle was being flown but due to the following reasons, EMERGENCY LANDING Procedures⁹ have been implemented automatically.
 - 1. No Communications for X Seconds.
 - 2. Battery Voltage < X and Altitude over Ground > X.
 - 3. Pitch,Roll,Yaw,Throttle or Altitude over Ground uncontrollable.
 - 4. Loss of Critical Components: Primary Controller, GPS.
- e. EMERGENCY RECOVERY:
 - i. Vehicle was being flown but due to the following reasons, EMERGENCY RECOVERY Procedures¹⁰ have been implemented automatically.
 - 1. EMERGENCY LANDING Procedure not appropriate or not possible.
 - 2. No Communications for X Seconds.
 - 3. Battery Voltage < X and Altitude over Ground > X.
 - 4. Pitch,Roll,Yaw,Throttle or Altitude over Ground uncontrollable.
 - 5. Loss of Critical Components: Secondary Controller, Main ESC's.

Future Expansion

⁹ See System Documentation.

¹⁰ See System Documentation.

Frequently Asked Questions

System Performance

Development and Testing for the GCSI was performed on a HP Laptop with Windows 7 64-Bit, 2.2 GHz Intel Core 2 Duo with 4 GB of RAM and a second display. Testing was also performed on a Dell Laptop with Windows XP 32-Bit, 2GHz Intel Core 2 Duo with 2 GB of RAM.

Troubleshooting

Table 6: Troubleshooting Symptoms and Fixes

| Symptom | Fix |
|--|---|
| When starting GCSI Software, it immediately stops running. | <ul style="list-style-type: none">• The GCSI Software requires at least one Communications method specified. Configure a Communications method in the Connectivity Tab. |
| The Manual Tab doesn't display any information. | <ul style="list-style-type: none">• Open a Terminal Program (such as Hyper Terminal) using the correct COM Port and Baud Rate. If no data appears, make sure the Vehicle is turned ON. If data appears, close the Terminal Program and proceed.• If using the XBee API Mode, make sure to select the correct device. |

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Appendix

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- A2: [ICARUS Communications Protocol Specifications](#)
- B1: [Source Code](#)