Integrated Complex Advanced Robotic Unmanned System

Ground Control Station Interface (GCSI)

User Manual

Software: Version 0.2.0.3

Contents

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***

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.

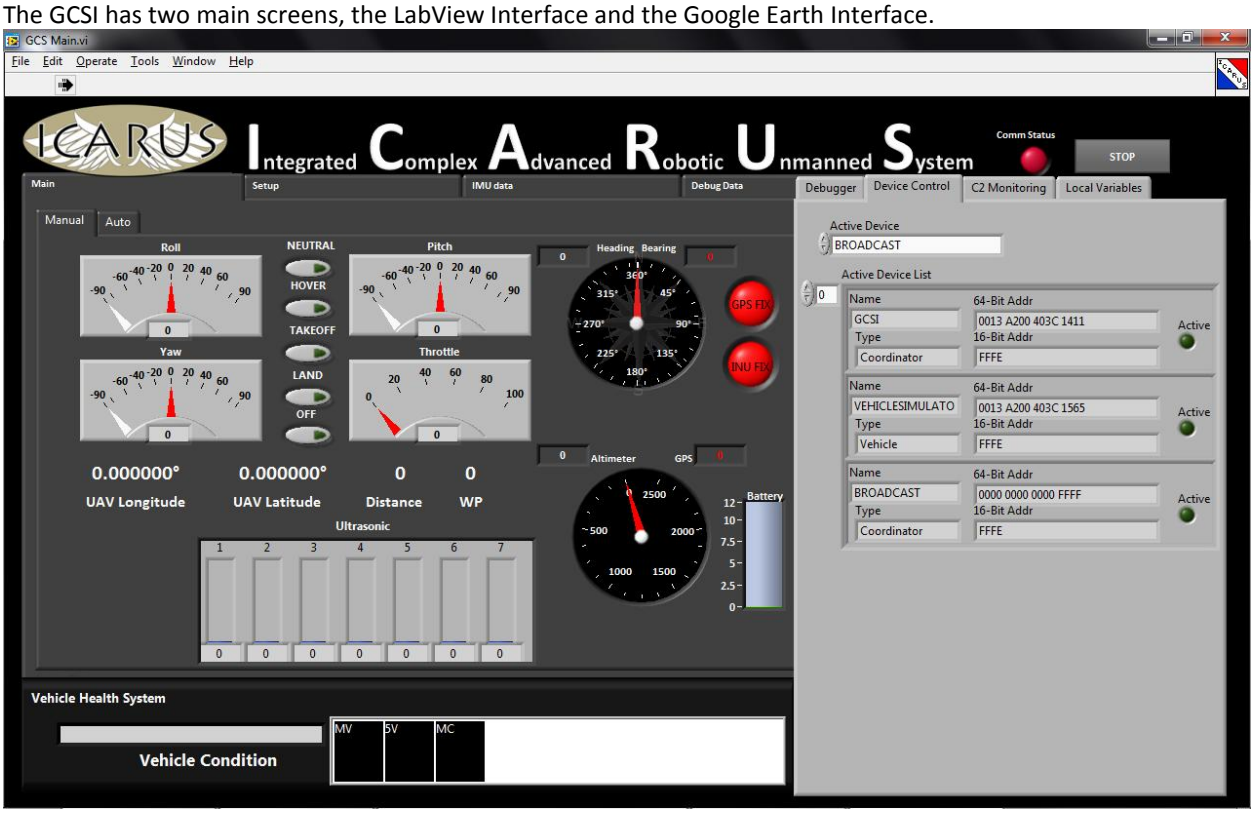

Figure 1: LabView Interface

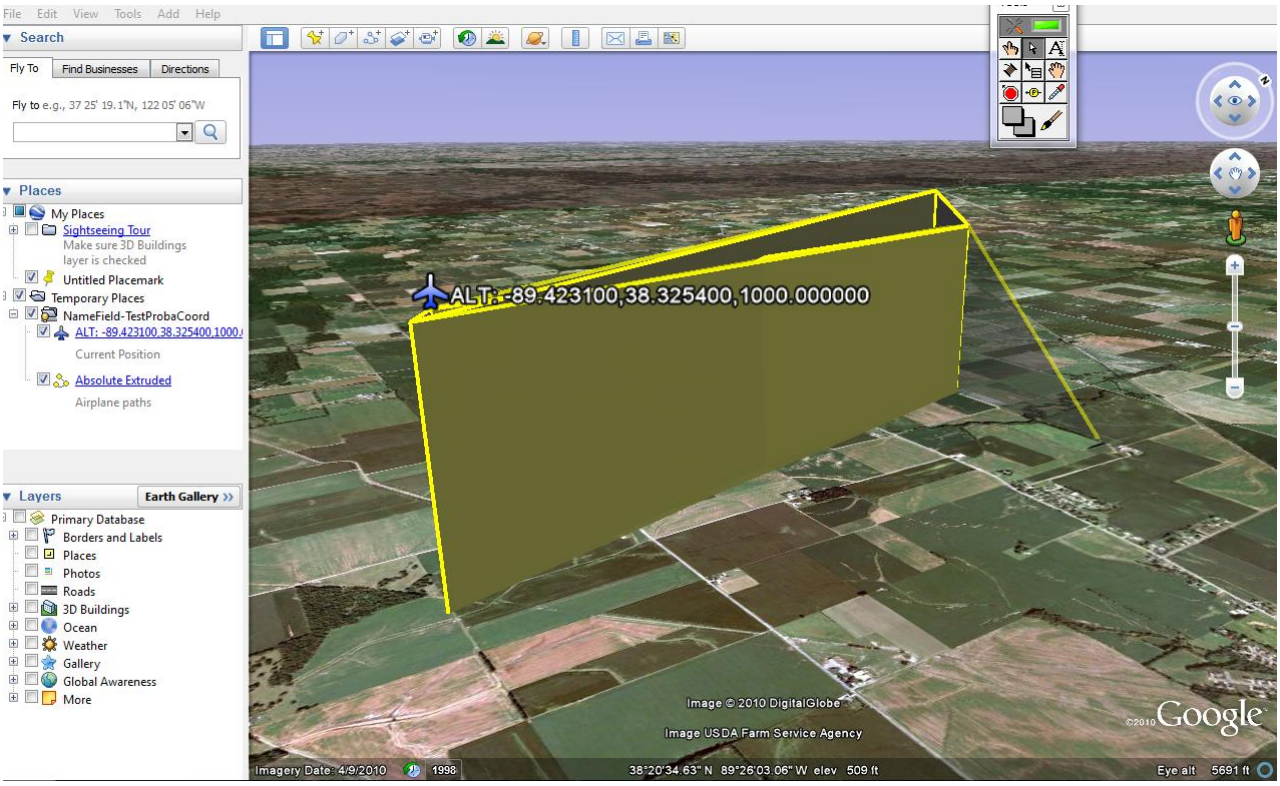

Figure 2: Google Earth Interface

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

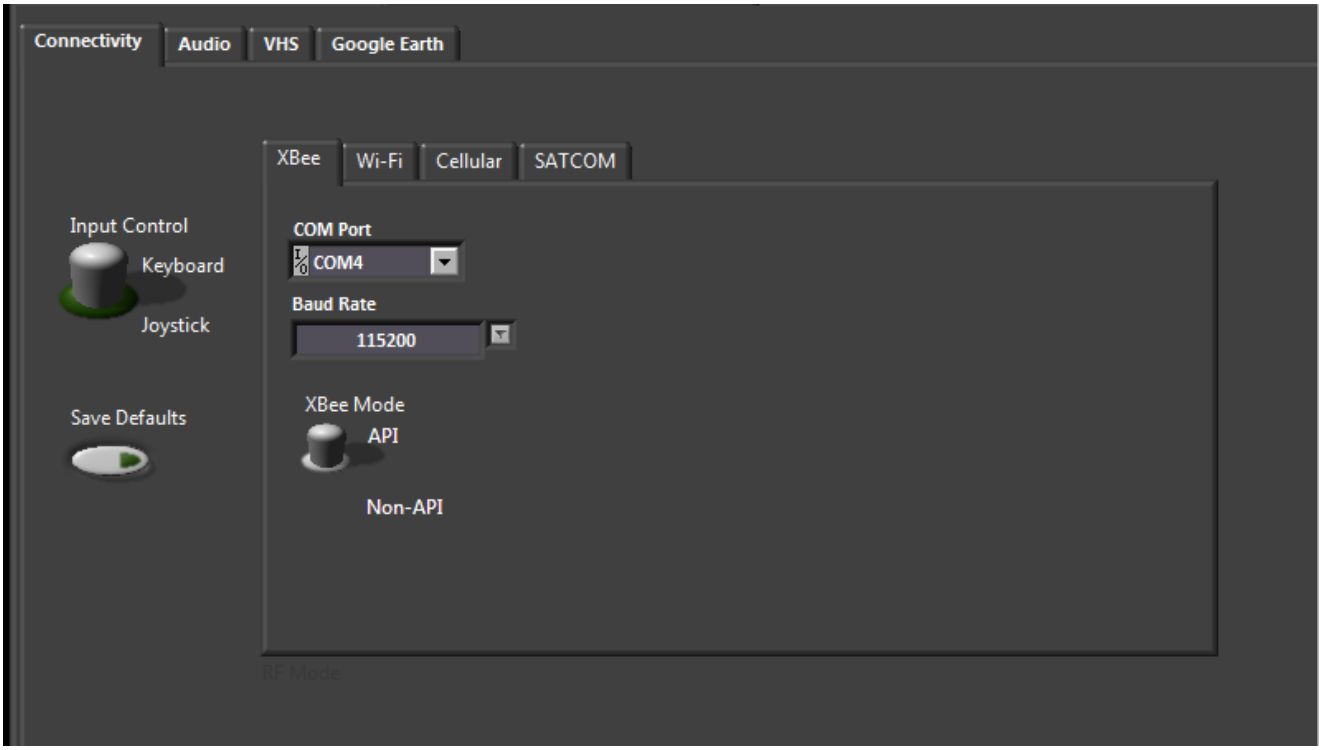

Figure 3: Connectivity Configuration Tab

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 Mode[4]
S: Enter HOVER Mode[5]
Z: Enter LAND Mode[6]
X: Enter TURN OFF Mode[7]

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 AssignXBeeID.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

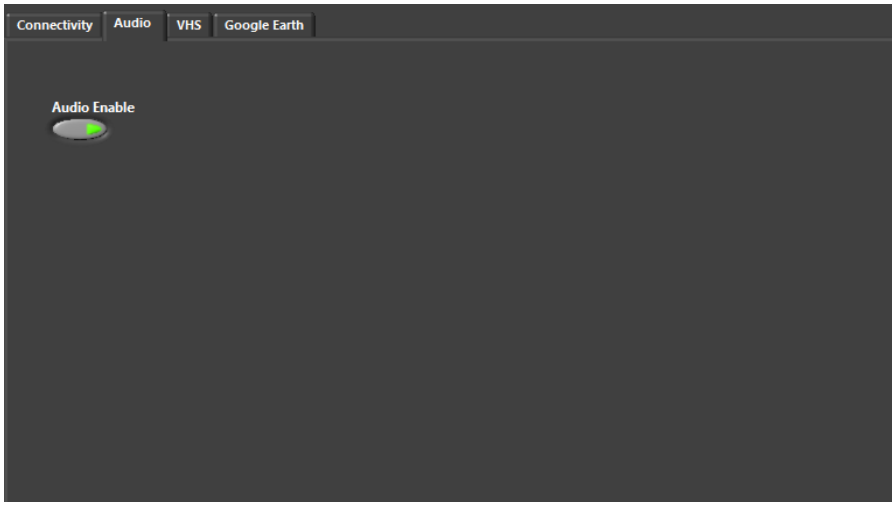

Figure 4: Audio Configuration Tab

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

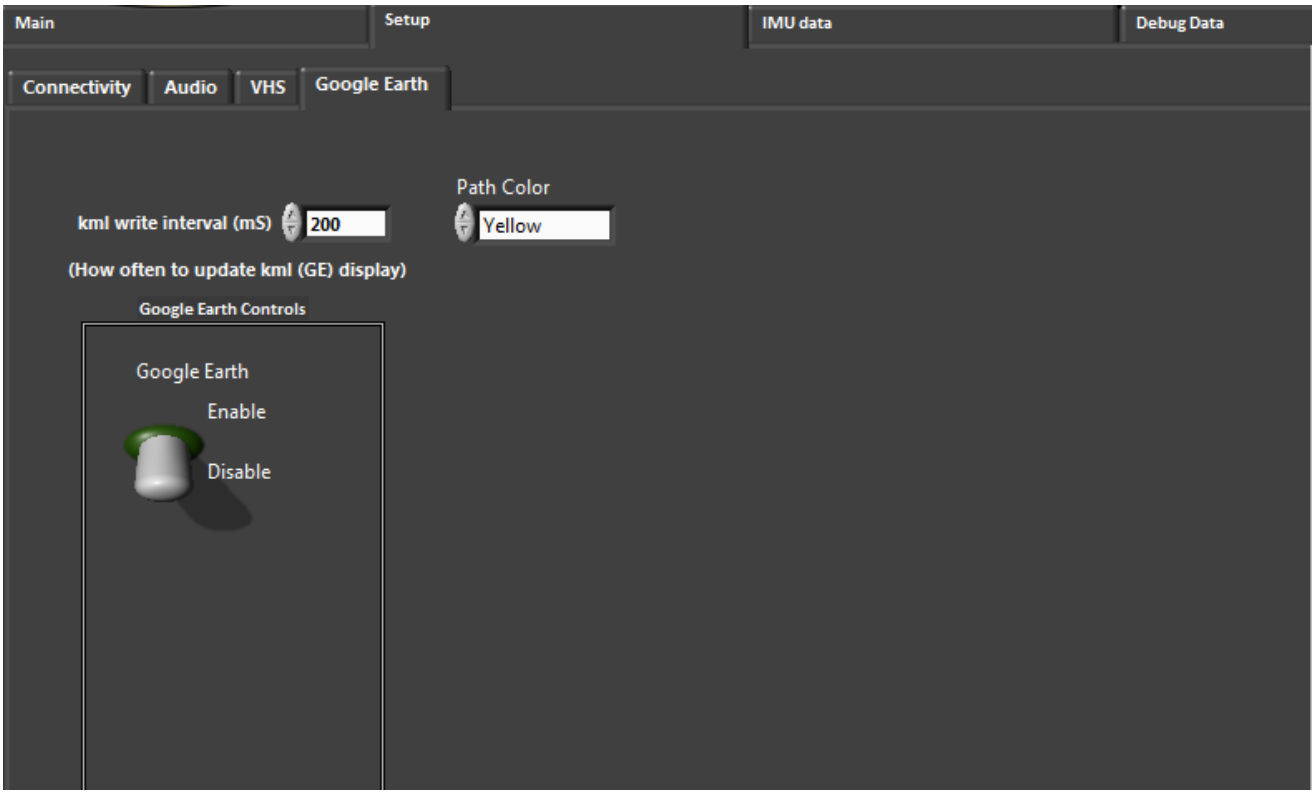

Figure 6: Google Earth Configuration Tab

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

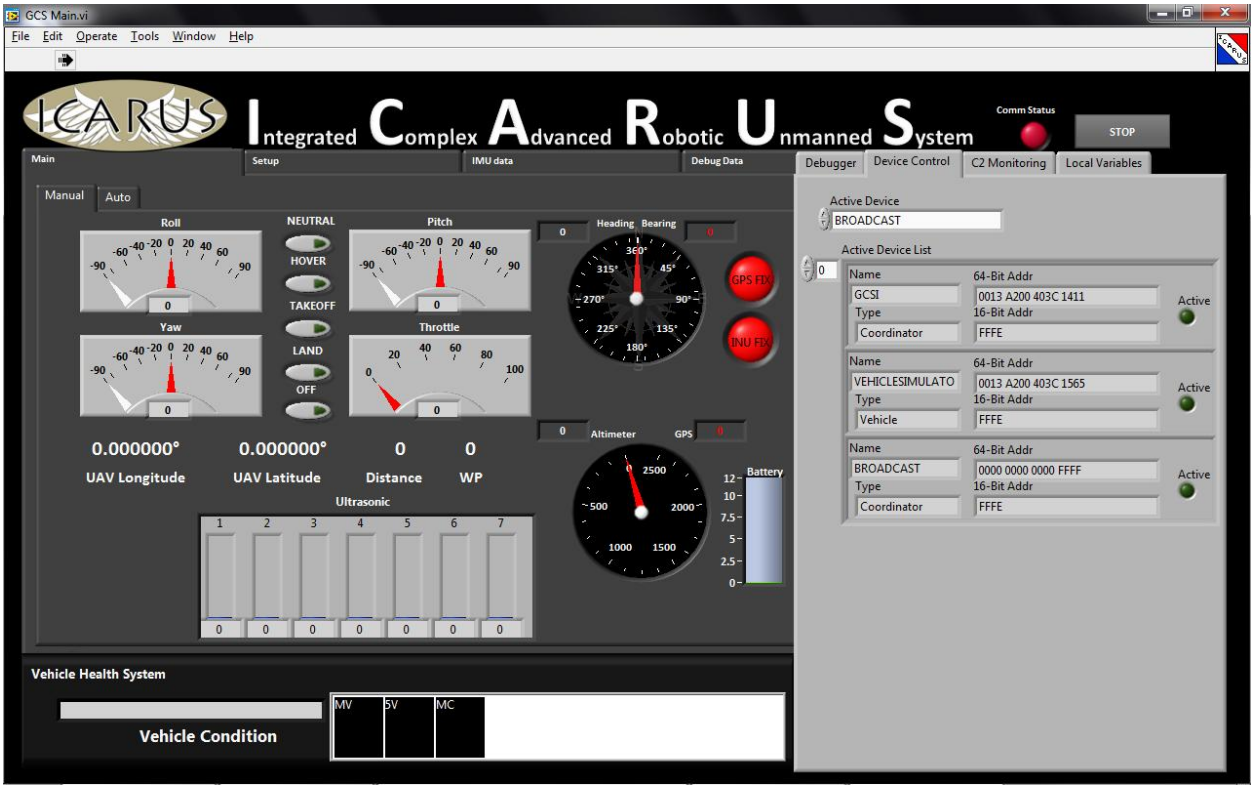

Figure 7: Manual Tab

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

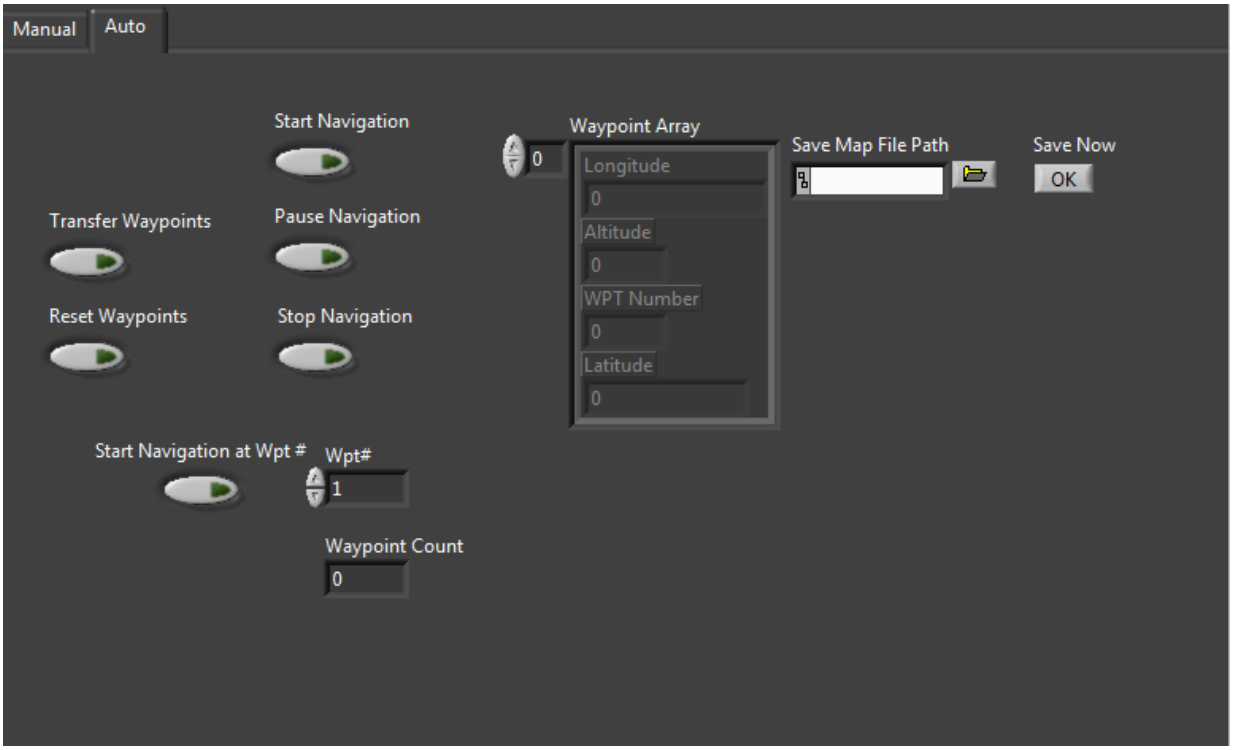

Figure 8: Autonomous Tab

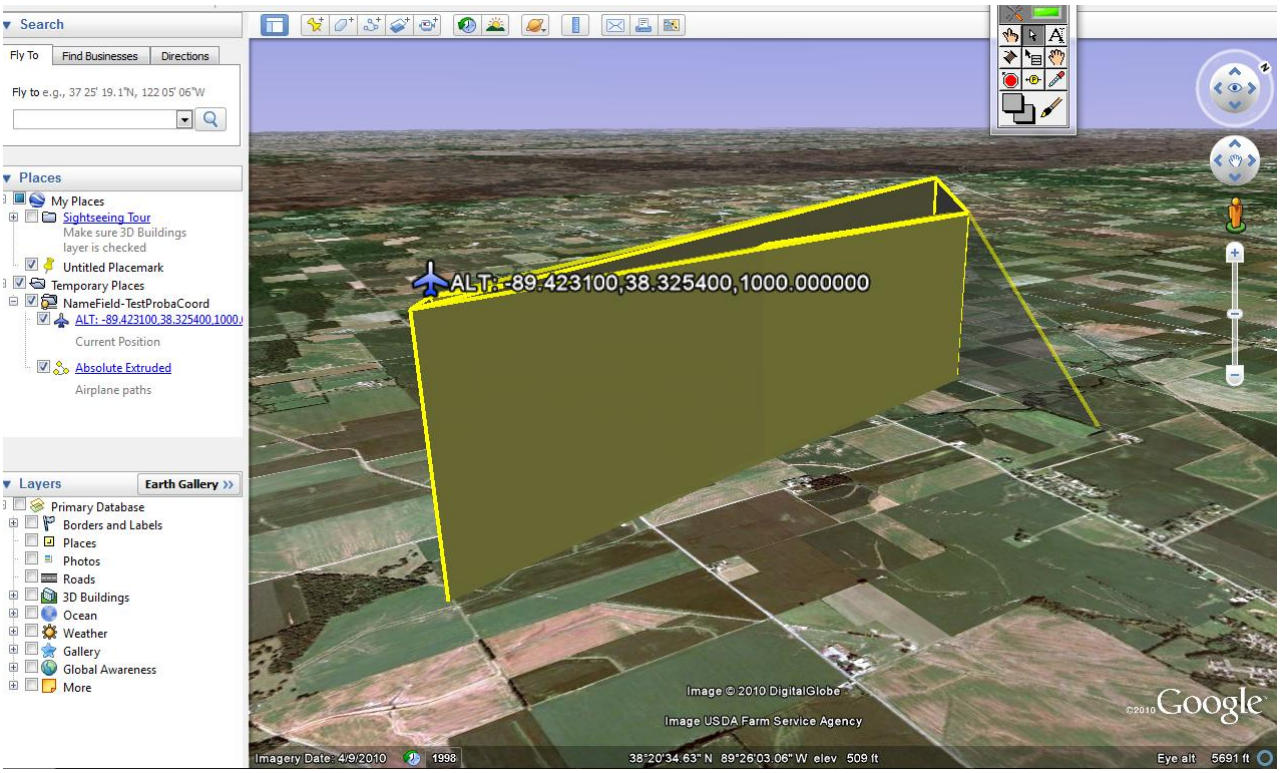

Figure 9: Google Earth Interface

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

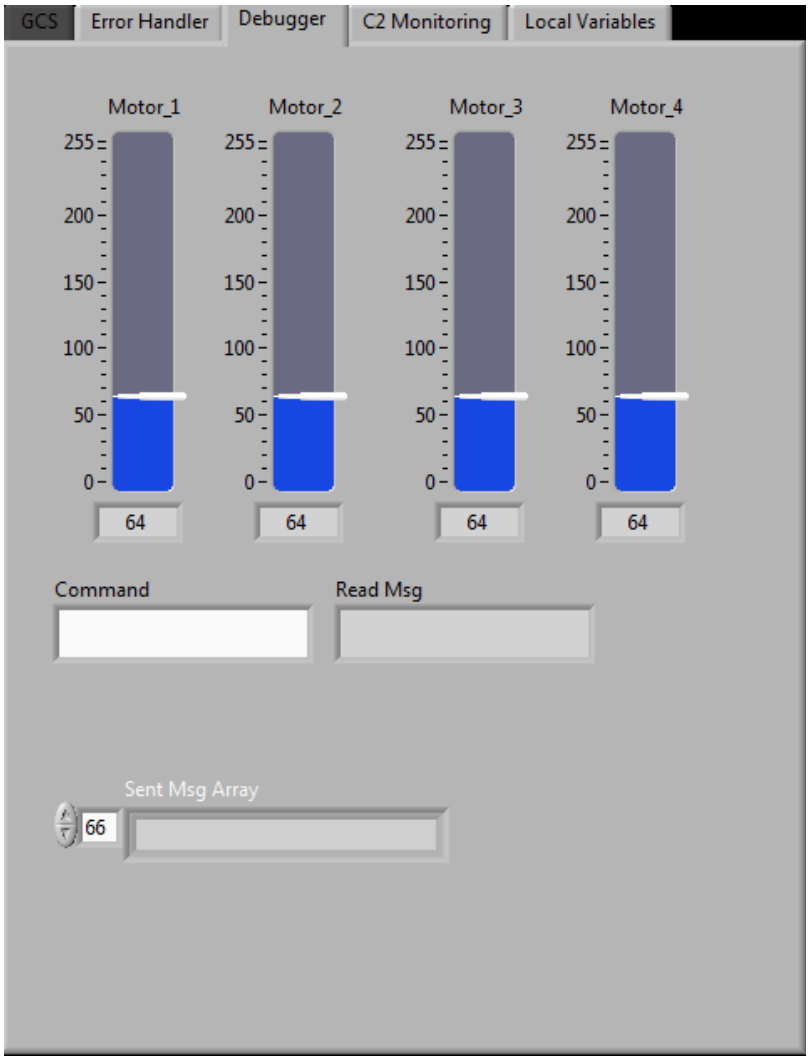

Figure 10: Debugger Tab

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

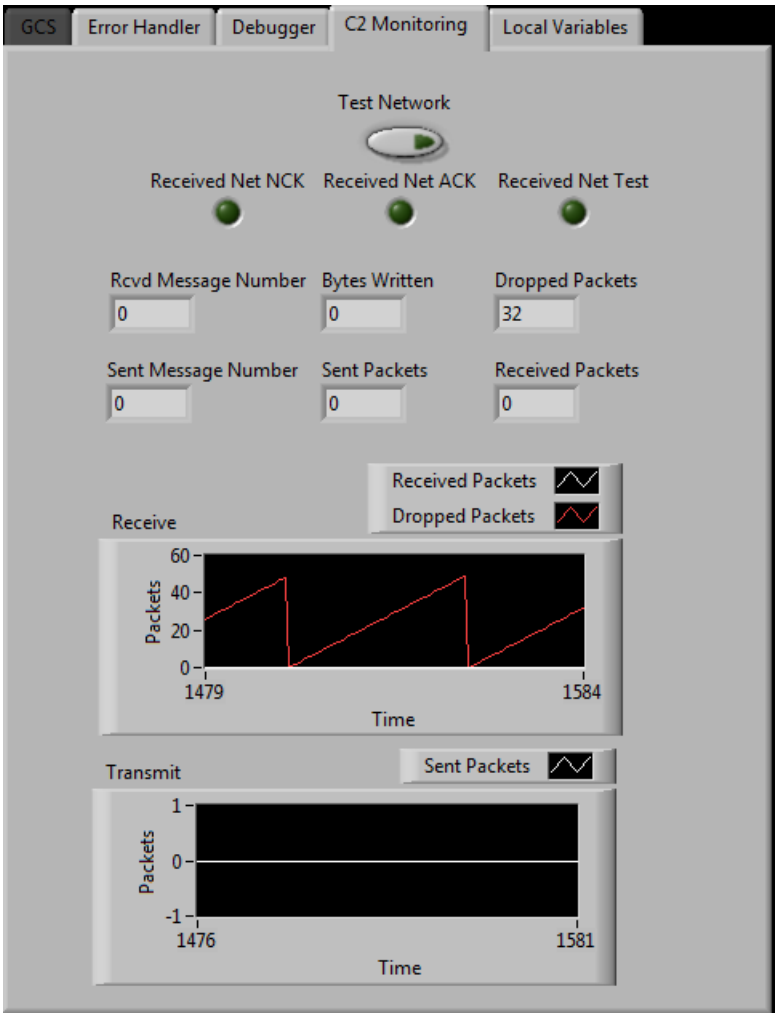

Figure 11: Command/Control Monitoring Tab

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

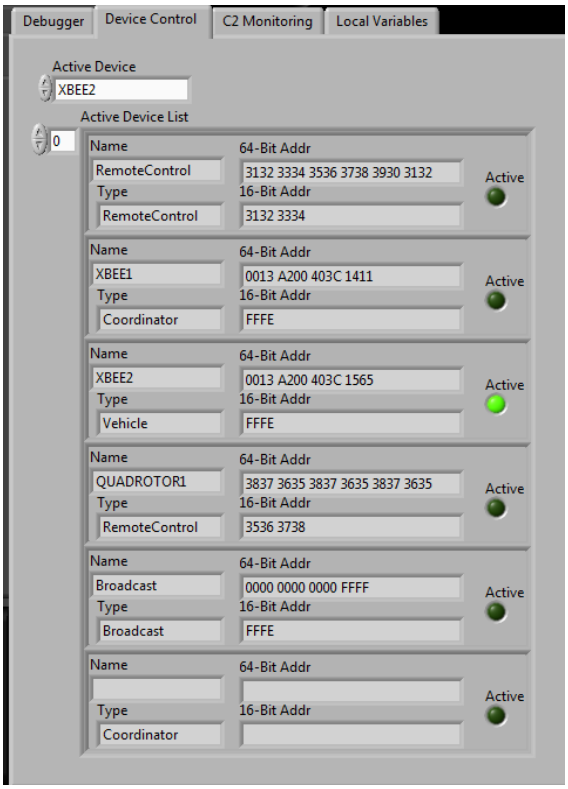

Figure 12: Device Control Tab

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 Procedures[9] 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 Procedures[10] 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.	• 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.	• 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.

Figures

Tables

Appendix