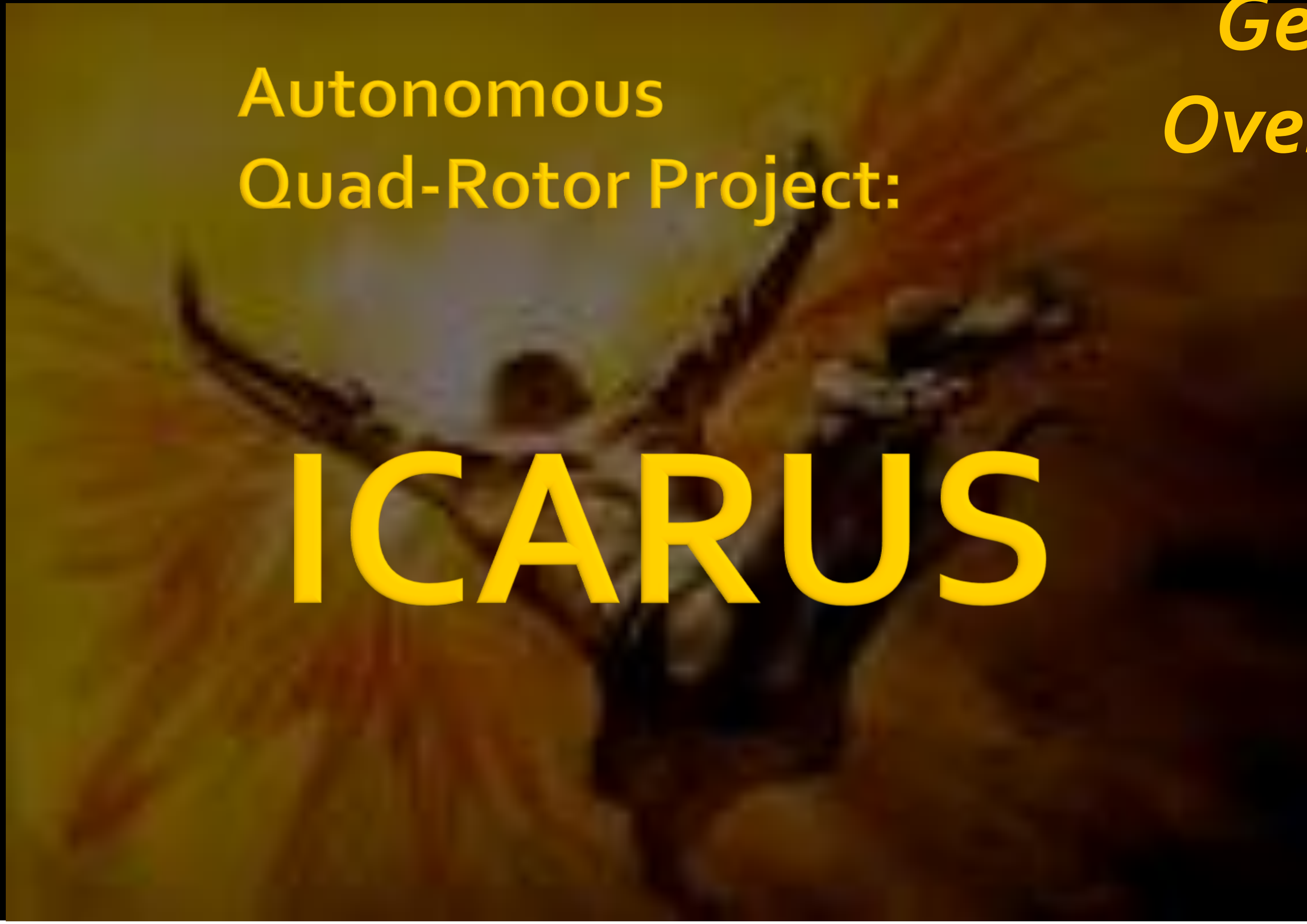
General Overview



Autonomous Quad-Rotor Project:

ICARUS

Integrated Complex Advanced Robotic Unmanned System

David Gitz, EE, ICARUS Lead Engineer

Core Team

- Ben Wasson
  - Masters Student
  - ICARUS Business Manager
- David Gitz
  - Electrical Engineer
  - ICARUS Lead Engineer
- Michael Welling
  - PhD Candidate
  - ICARUS Systems Engineer
- James Chaklos
  - Masters Student
  - ICARUS Test-Stand Engineer
- Steve Warren
  - Computer Engineer
  - ICARUS Communications Engineer

Satellite Teams

- Washington University UAV Team
- SIU-Carbondale ECE Lab Team
- SIU-Carbondale Senior Design (pending)
- Boeing ONE Group (pending)

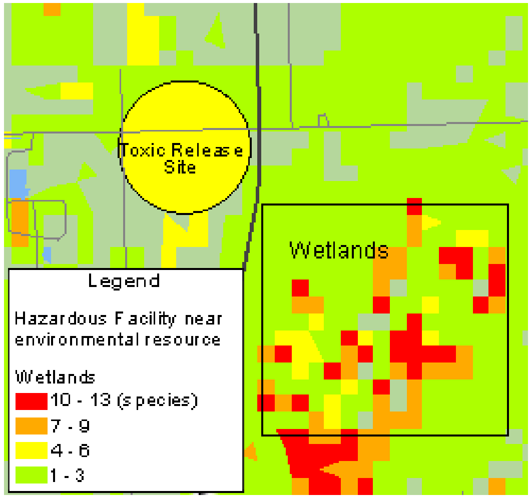
Topics:

- Applications
- The Future
- System Description
- Capabilities
- Competitor Analysis

Applications

Civil Inspection

Military



Environmental Research

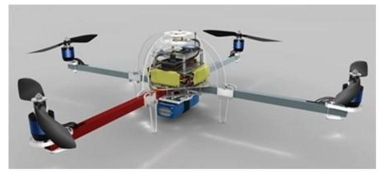
Law Enforcement

Residential Inspection

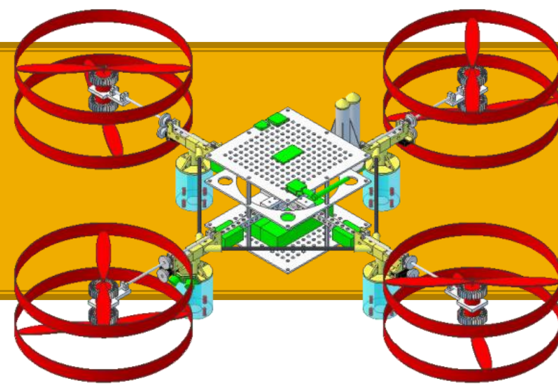
Future of Quad-Rotor's

V-22 Osprey
Bell Helicopter
Boeing Rotorcraft Systems
2007

PAST



ArduCopter



ICARUS

DraganFlyer v6

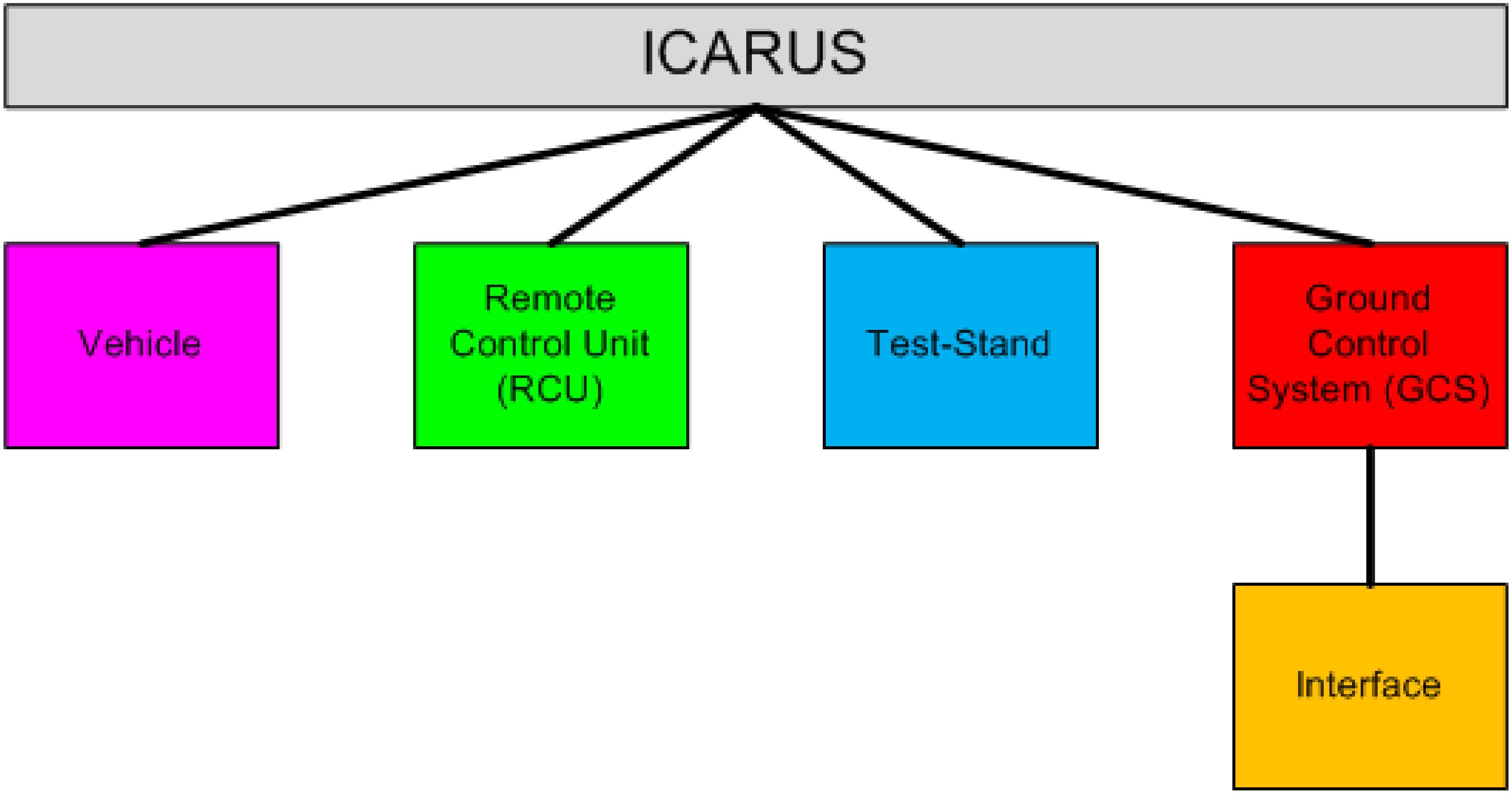
V-44
Bell/Boeing
Pending

FUTURE

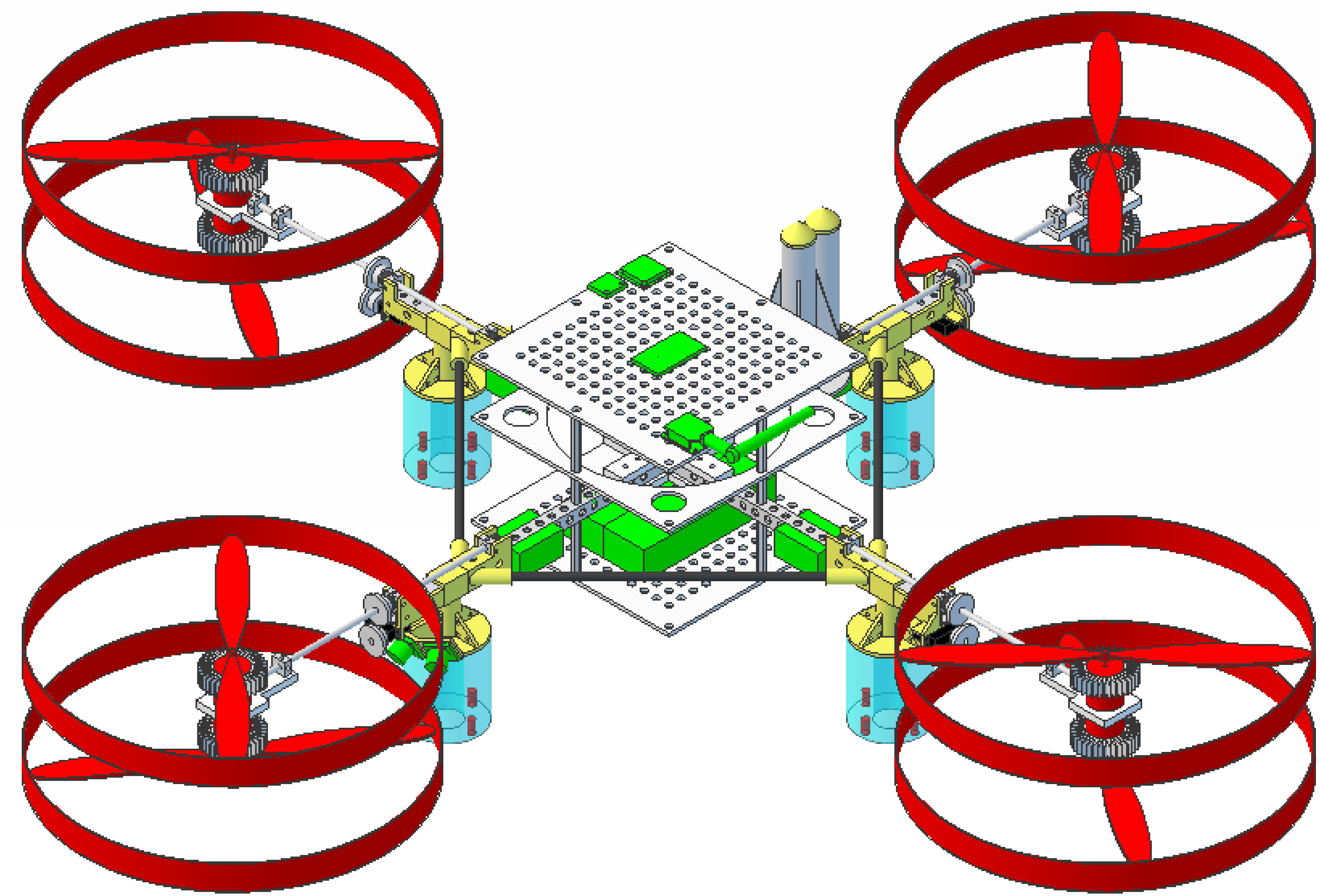
Competitor Analysis

System \ Capability	Advanced Hover	Automatic Takeoff/Hover/Landing	Autonomous Navigation	Manual Control	Calibration via Test-Stand	Vehicle Health System	Collapsible Frame	Configurable Payloads	Extended Range	Extended Flight Duration	Image Capture	Obstacle Avoidance	Swarm Autonomy	Terrain Following	Audible Vehicle Status	Video Transmission	WiFi Repeater	Wireless Airborne Programming	Wireless Charging other Systems
ICARUS ver 2	X	X	X	X	X	X	-	F	F	F	F	F	F	F	F	F	F	F	F
ICARUS ver 1	-	X	X	X	X	X	-	-	F	F	F	F	F	F	F	F	F	F	-
ArduCopter	-	X	X	X	-	-	-	-	-	-	-	X	-	X	-	-	-	-	-
AR Parrot Drone	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-
Dragan Flyer VI	-	X	-	X	-	X	X	X	X	-	X	-	-	-	-	X	-	-	-

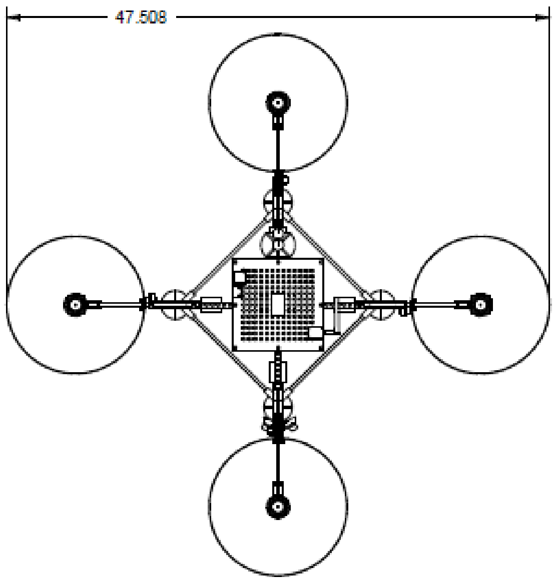
System Description

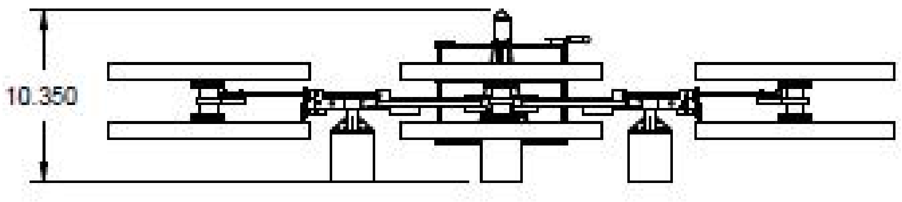


Vehicle



Vehicle

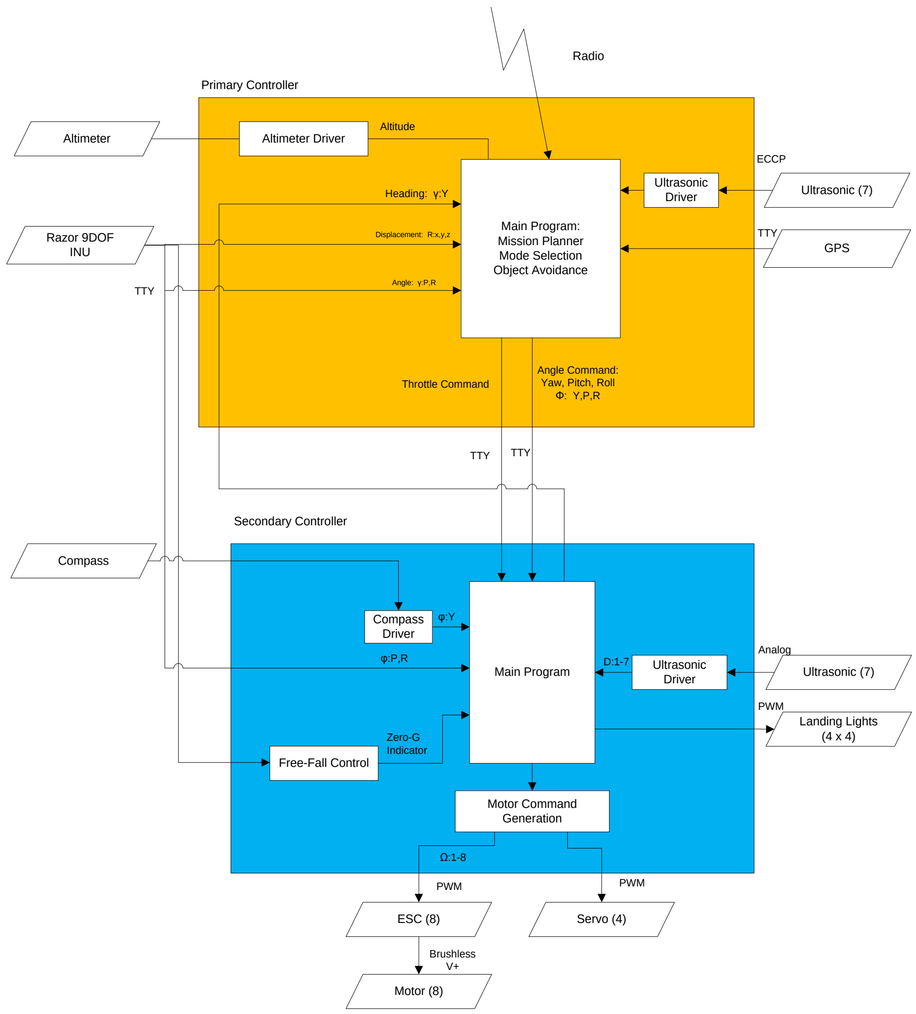




- Quad-Rotor design – Offers simpler control system with fewer moving parts than a single rotor helicopter and minor reduction in lift capacity

Vehicle

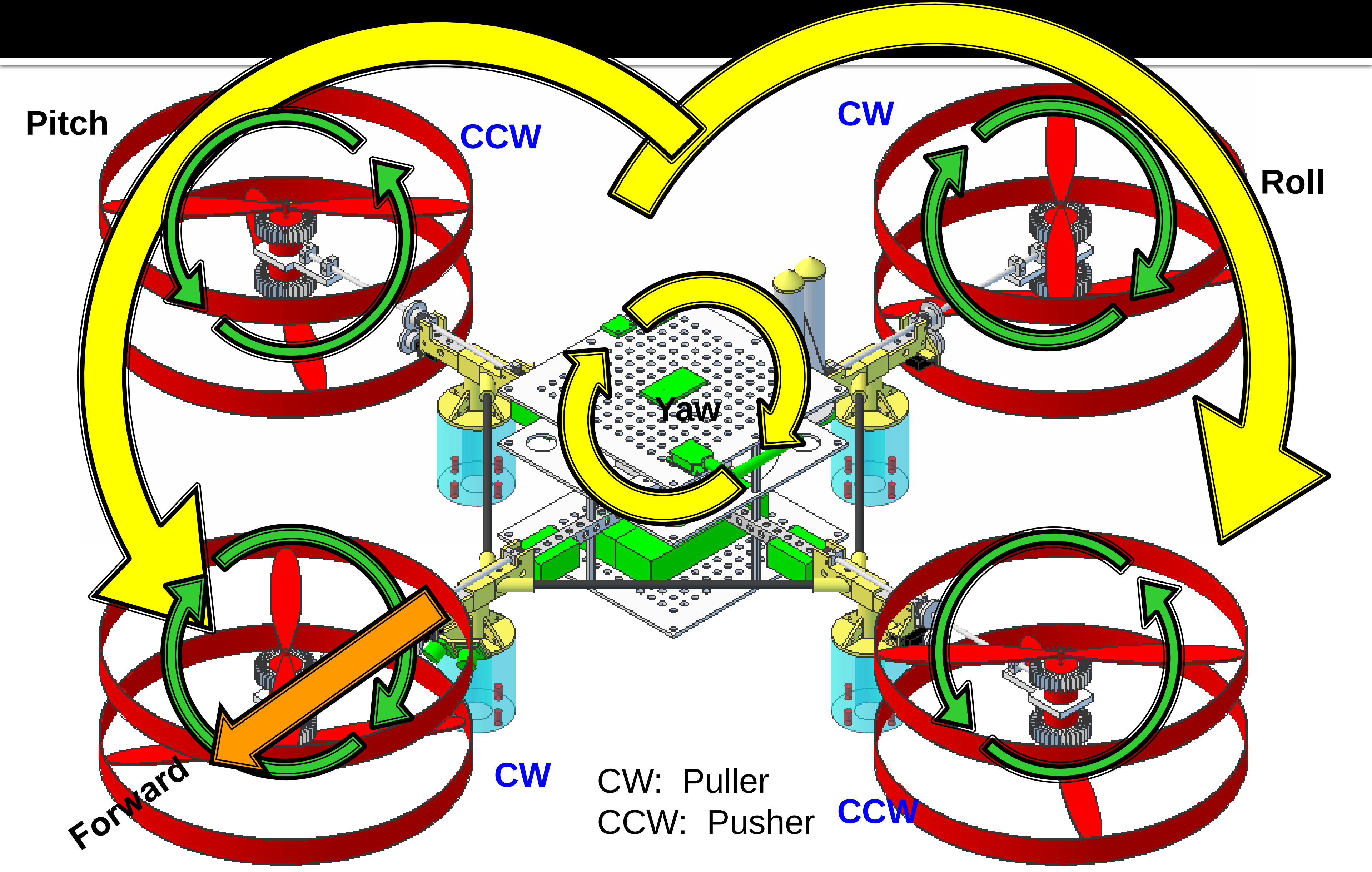
- 2 "Brains", 1 SoM Board and 1 Parallax Propeller™ uC
- SoM handles waypoint navigation, mission planning, vehicle health.
- Propeller™ uC handles PWM generation.
- In the event of an in-air mishap, Propeller™ uC can take over Vehicle and land safely.



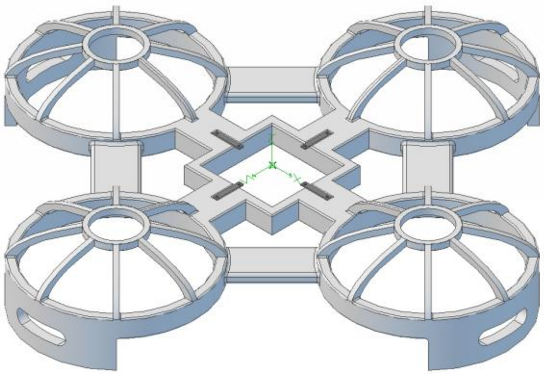
Vehicle Specifications

- Sensors: 3-Axis Accelerometer, 3-Axis Gyroscope, 3-Axis Magnetometer (INU), Digital Compass, Altimeter, GPS, 7 Ultrasonic Sensors
- Power: 8 Brushless DC 200 Watt Motors, 4 Micro Servo's, 2 Lithium-Ion 11.1V 5 Amp-Hours Batteries, 4 18A Electronic Speed Controllers, 5V and 3.3V Linear Voltage Regulators.
- Control: SoM Controller (Primary), Propeller Controller (Secondary), custom PCB.
- Communications: Xbee Radio for Command/Control, Video Transmitter, Wi-Fi (Field programming, tentative).
- Fabrication: ~50% COTS, ~50% produced by MakerBot/Ponoku.

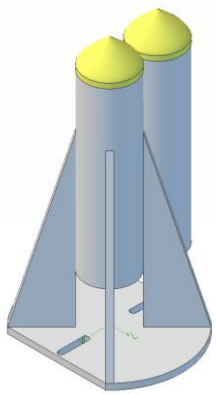
Movement



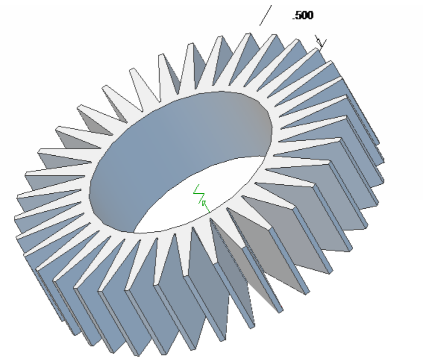
Prototype Systems



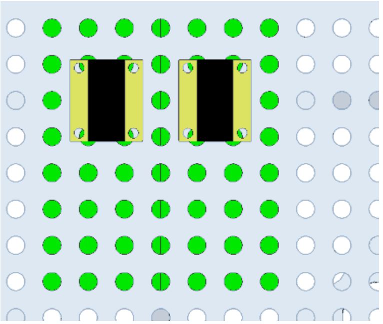
Safety System



Recovery System

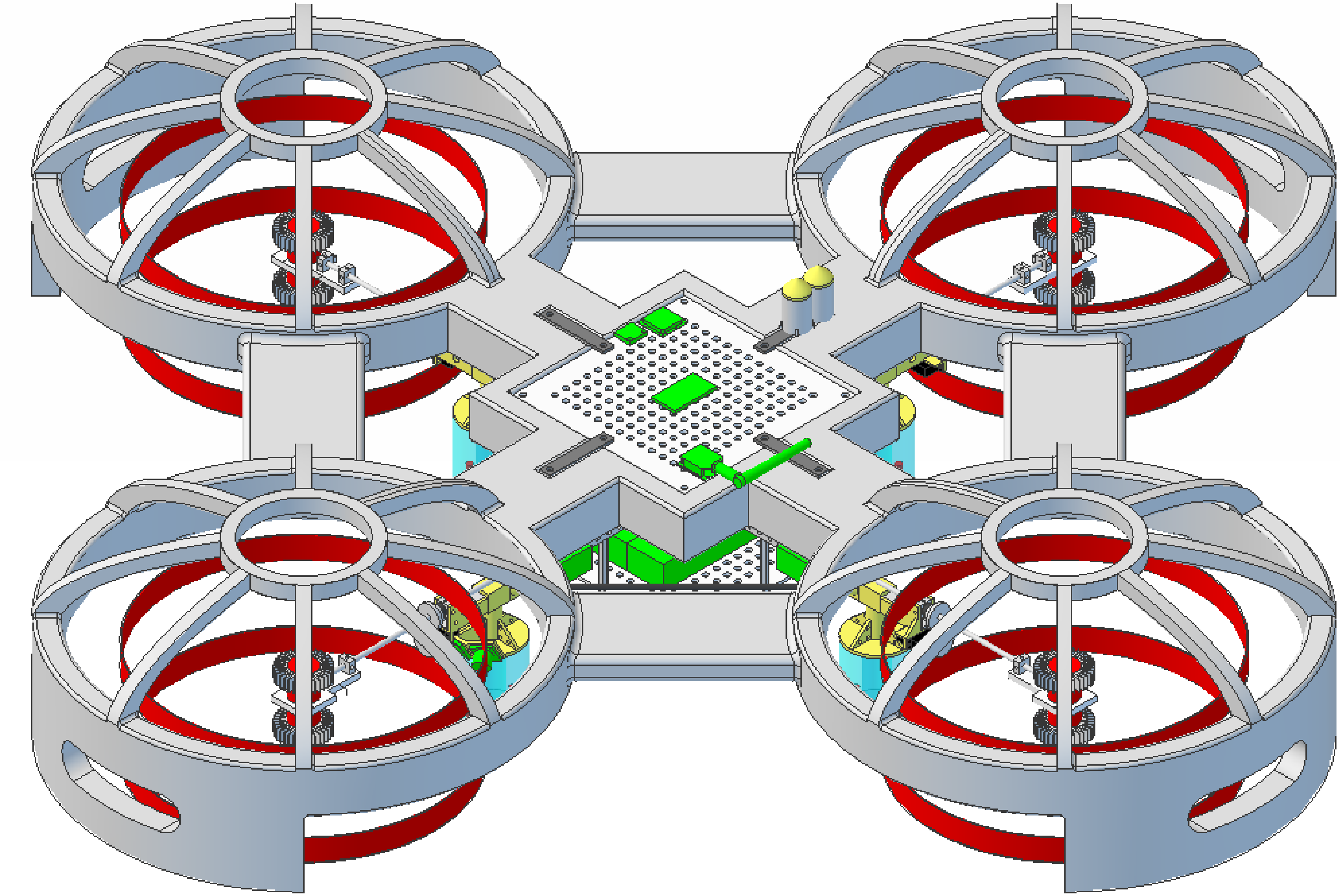


Heat Removal System

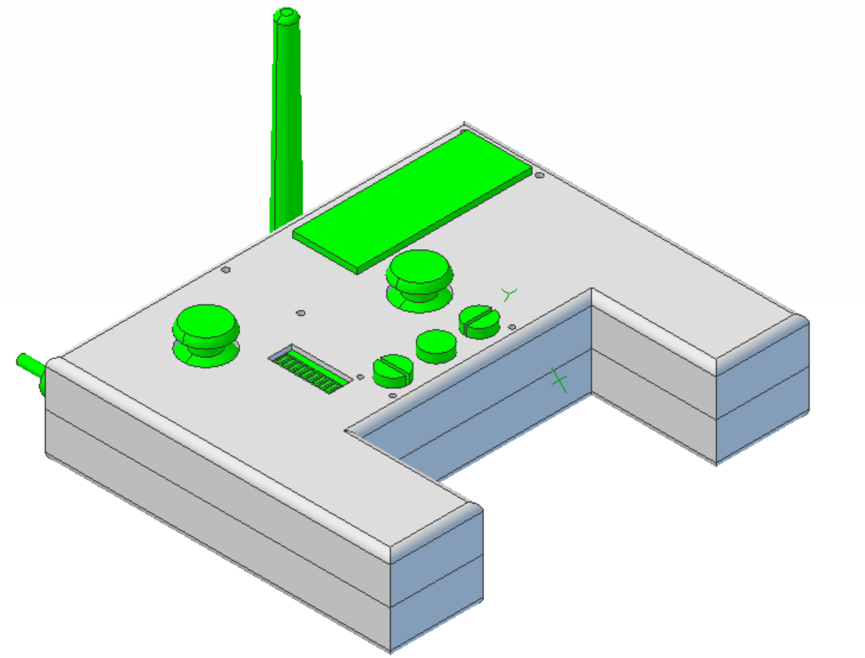


Test-Fixture Attachment System

Vehicle w/ Prototype Systems



RCU



- Custom PCB inside Xbox-360 Controller
- Features Mode and Error Display, Vehicle Battery Indicator, Force-Feedback and 5 hours of continuous operation.

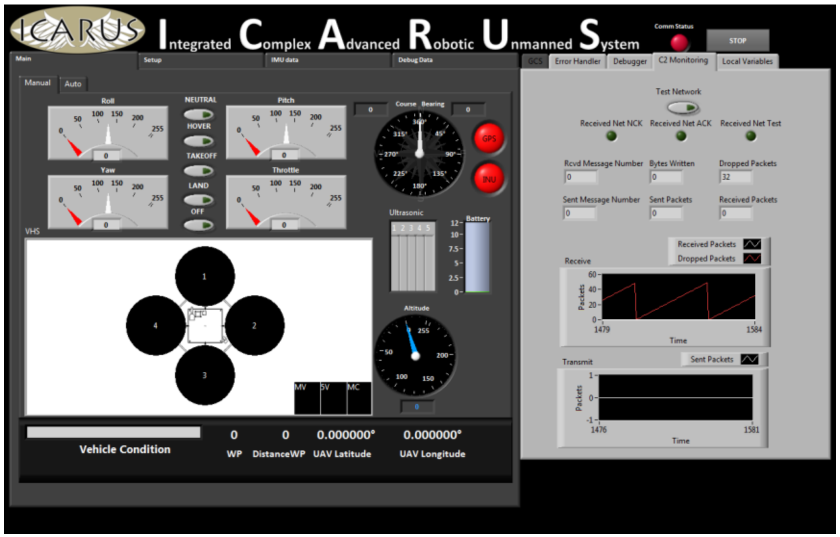
RCU Specifications

- Communications: XBee Radio for Command/Control
- Input/Output: 9 Switches/Buttons, 2 Dual-Axis Joysticks, GPS Sensor, 10-Segment LED, LCD Screen, Vibrating Motors.
- Power: 2 Ni-Mh AA Batteries, 3.3 and 5V Boost Converters.

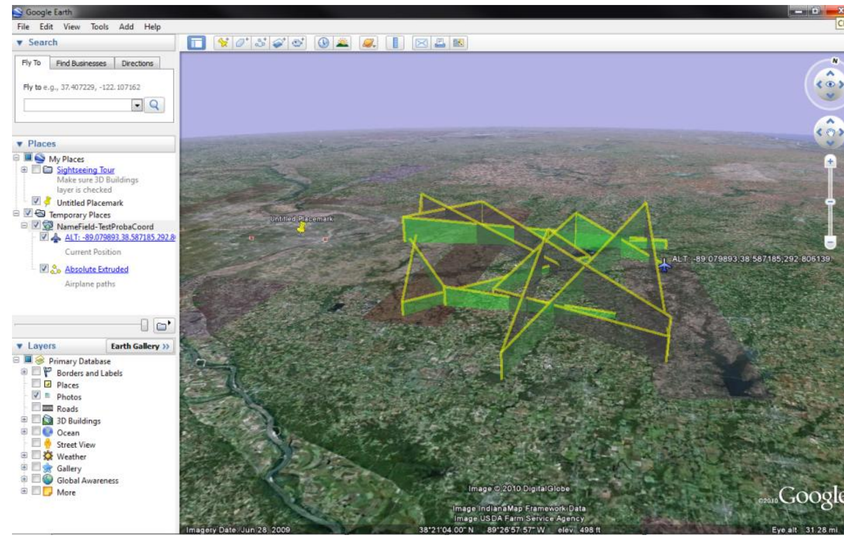
GCS

- Includes computer, touch-screen monitor and batteries for field operation.
- Communications Radio and Video Receiver
- Heavy-duty field transportable case

GCS Interface



- Manual Control
  - Vehicle Sensor Display
  - Vehicle Health/Feedback System
- Autonomous Control
  - Set, Transmit Waypoints
- Communications
  - View Network Status
- Configuration/Debugging



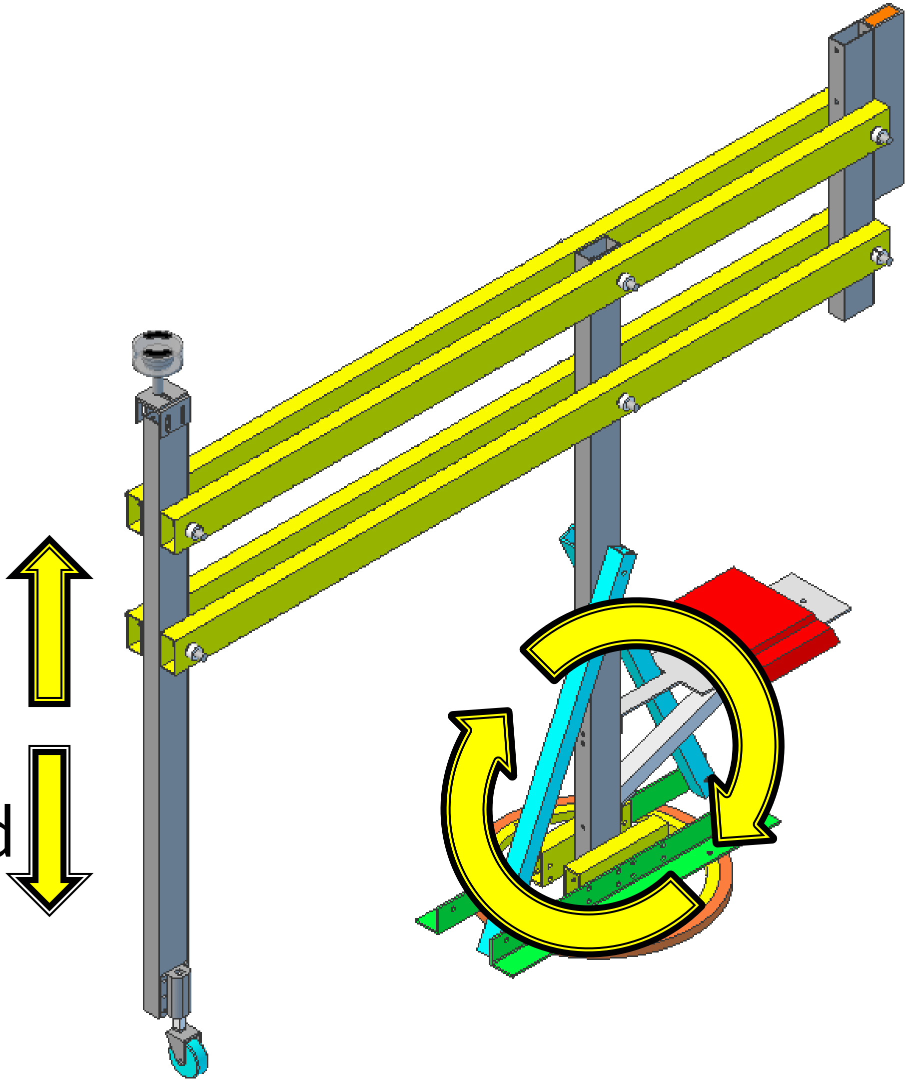
- Google Earth Integration
  - Fully controllable Google Earth (location search, zoom, pan, etc).
- View Waypoints and Vehicle Location/Path

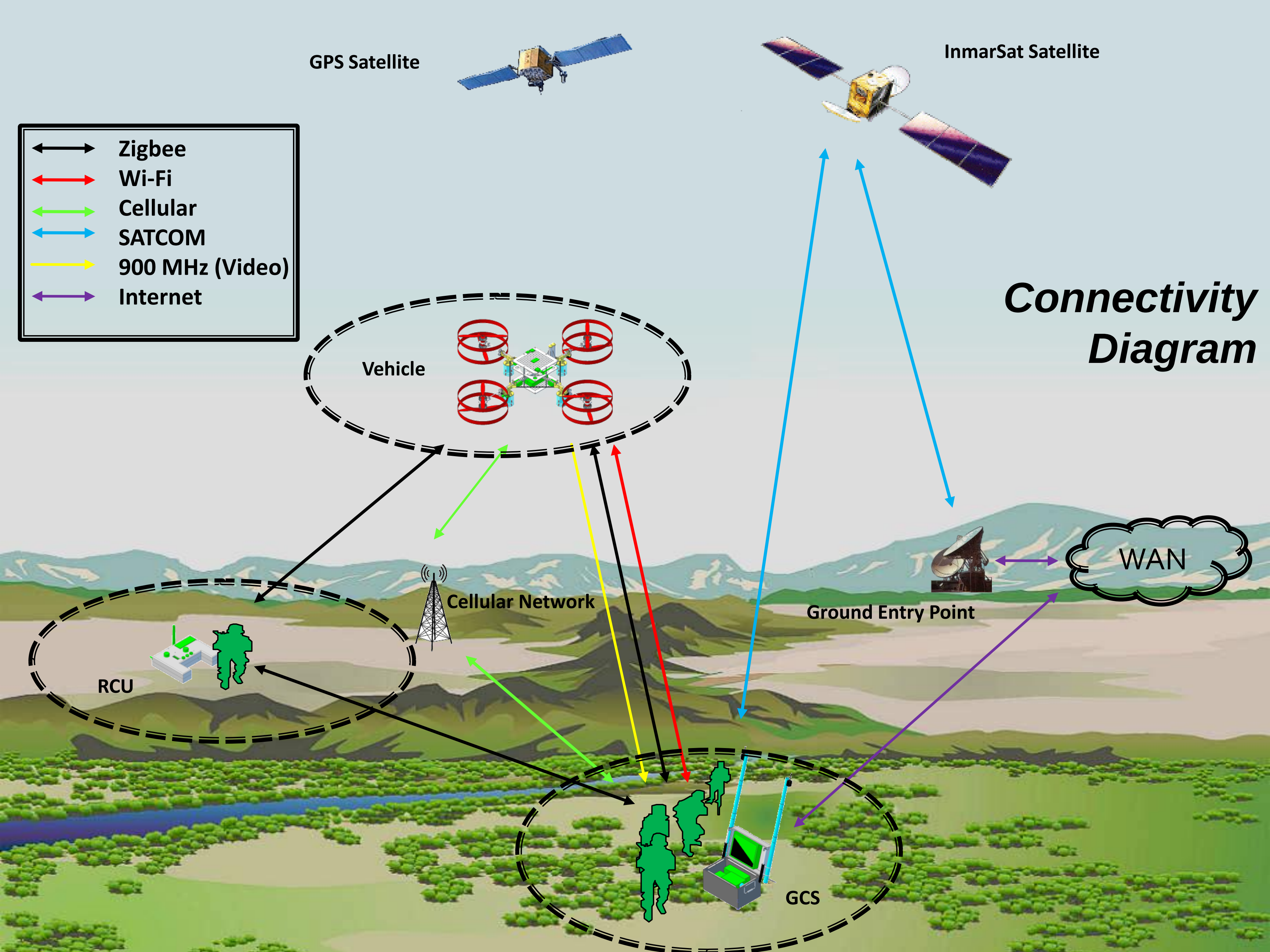
GCS Specifications

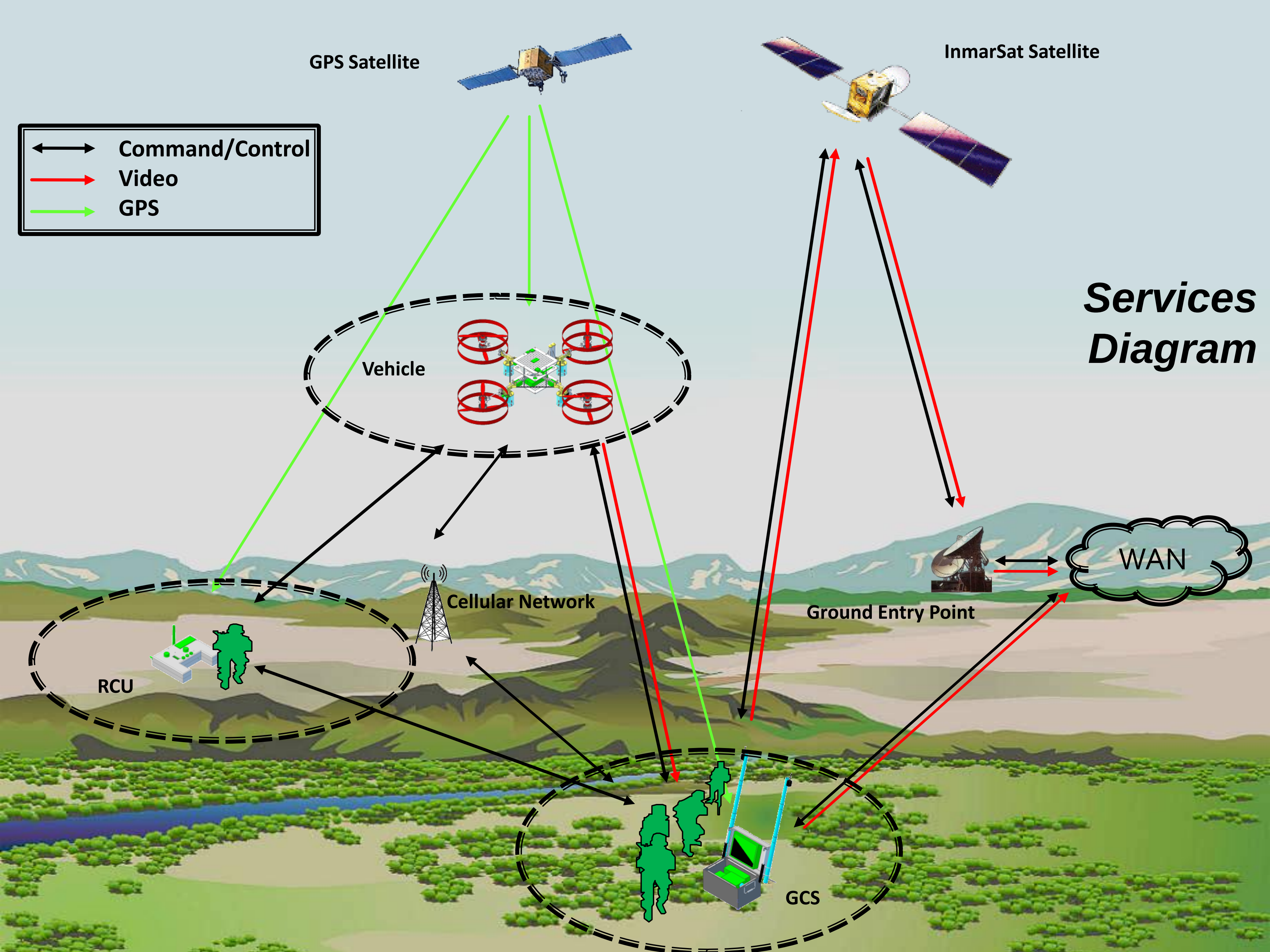
- Software: National Instruments LabView integrated with Google Earth mapping software.
- Power: 2 12V 26Amp-Hour Batteries, 120V AC Power Inverter, Vehicle battery fast charger.
- Communications: XBee Radio for Command/Control, Video Receiver

Test-Stand

- Used for Vehicle Calibration and Capacity measurements
- Able to Pivot vertically, rotate continuously and pitch/yaw/roll on Test-Fixture Assembly
- Power applied to Vehicle via Slip-Ring – No tangled wires




GPS Satellite
InmarSat Satellite
Zigbee
Wi-Fi
Cellular
SATCOM
900 MHz (Video)
Internet
Connectivity Diagram
Vehicle
Cellular Network
WAN
Ground Entry Point
RCU
GCS


GPS Satellite
InmarSat Satellite
Command/Control
Video
GPS
Services Diagram
Vehicle
Cellular Network
WAN
Ground Entry Point
RCU
GCS

Capabilities

Capabilities - Planned	
Manual Control via RCU or GCS	Simple Calibration and Testing via Test-Stand
Limited Autonomous Navigation via RCU	Error Display on RCU and GCS
Extended Autonomous Navigation via GCS	Force-Feedback on RCU
Automatic Takeoff, Hover and Landing	Vehicle Health Reporting

Capabilities - Future	
Real-Time Video Transmission to GCS	Image Capture
Wireless airborne programming	Advanced Hover modes
Vehicle Status Audio via RCU	Extended Range
Configurable Payloads	Terrain Following
Extended Flight Duration	Obstacle Avoidance
Swarm Autonomy	Vehicle Status - Audio

Technologies

Technologies - Planned	
Command/Control Network Monitoring	Inertial Navigation Unit (INU) w/ Altitude and Heading Reference System (AHRS)
Power Management	Primary/Secondary Controller Implementation
Waypoint Navigation	Communications Protocol
Co-Axial Rotors	Tilt Rotors

Technologies - Future	
3d Feedback	Audio Commands
Automatic Landing Pad	Cellular Network
Cel-Phone Control	Target Detection
Data Storage	GCS Interface (MATLAB)
JAUS Interoperability	Motor Heat Dissipation
R/C Control	RCU Testing Software
Recovery System	Wireless Charging
Satellite Communications	Simultaneous Localization and Mapping (SLAM)

System Specifications

- Range: ~1.5 km LOS (~3km with Xbee Mesh Network)
- Duration:
  - Vehicle: ~12 min (100% Throttle) , ~20 min (Hover)
  - RCU: ~4-6 hrs
  - GCS: ~4-6 hrs (including field charging Vehicle)
- Speed: ~2 - 4 kph
- Weight: ~5.5 lbs
- Size: 48" x 48" x 10.5"
- Propeller Rotation: Max: 3,000 RPM
- Vertical Thrust: ~7.8 lbs

Questions?

- Contact:
  - David Gitz: david.gitz@icarusuav.com
  - Ben Wasson: ben.wasson@icarusuav.com