



Airrobot Unmanned Aerial System

Technical Overview

Operation

Safety

Status Monday, December 10, 2012

Description of Technology

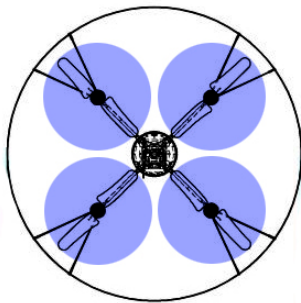
Micro Unmanned Aerial System with virtually silent electrical propulsion for close range stealth ISR out of line of sight during day and night operations and additional use as a tactical-UGS and fire support.

Key Features

- Vertical take off and landing
- Electrical propulsion for virtually silent operation
- Hover and stare with hands off functionality
- Perch and stare capabilities with out of line of sight remote landing and take off
- Assisted tele op and autonomous flight (waypoint programming)
- Precise maneuvering for operation in extreme proximity to the area of interest (< 1 ft to target)
- Stable close to ground operation at altitudes < 2 ft
- Out of line of sight flight through video (video game like control for easy learning)
- Endurance < 30 min
- Range < 2400 ft limited through video transmitter range
- One man mobile operation
- Deployment time < 3 min
- Gross weight < 2 lbs (Unit) apprx. 18 lbs packed
- Modular Payloads to meet different mission needs (day/night/IR/radiation sensors/high res)
- Max. payload 0.5 lbs
- Man portable and backpack able

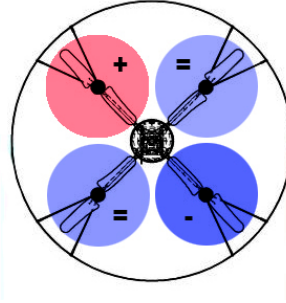
Airframe and Propulsion

Quad Rotor with independent rotation speeds resulting in “active maneuverability”. Counteraction to external forces is performed by adding power, shortening the response time. (in comparison to ducted fan with subtractive method)



Rotor speeds and torque hovering without external influence. (ideal case)

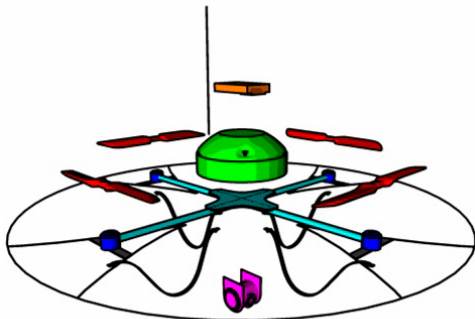
All rotors rotate at same speed



Rotor speeds and torque when sudden external force is applied to one side of the unit

Rotors actively balance unit by generating additional thrust in the correct area, reducing thrust where necessary

Mechanical structure



- Modular system – parts can be removed without tools
- Primary material carbon fiber results in low radar profile
- Small de-centered engines result in small thermal footprint

Technical Data Overview

Electrical Propulsion System

- Lithium polymer batteries 14.8 V 3.7 Ah interchangeable
- Recharging time 2 h min for full cap.
- 4 Brushless and gearless electrical motors
- Maintenance free
- Max. 2300 rpm

Performance

- Endurance < 30 min
- Max. speed 25 mph
- Max altitude 450 ft
- Max climb speed 2 m/s (electronically limited)

Environmental limitations

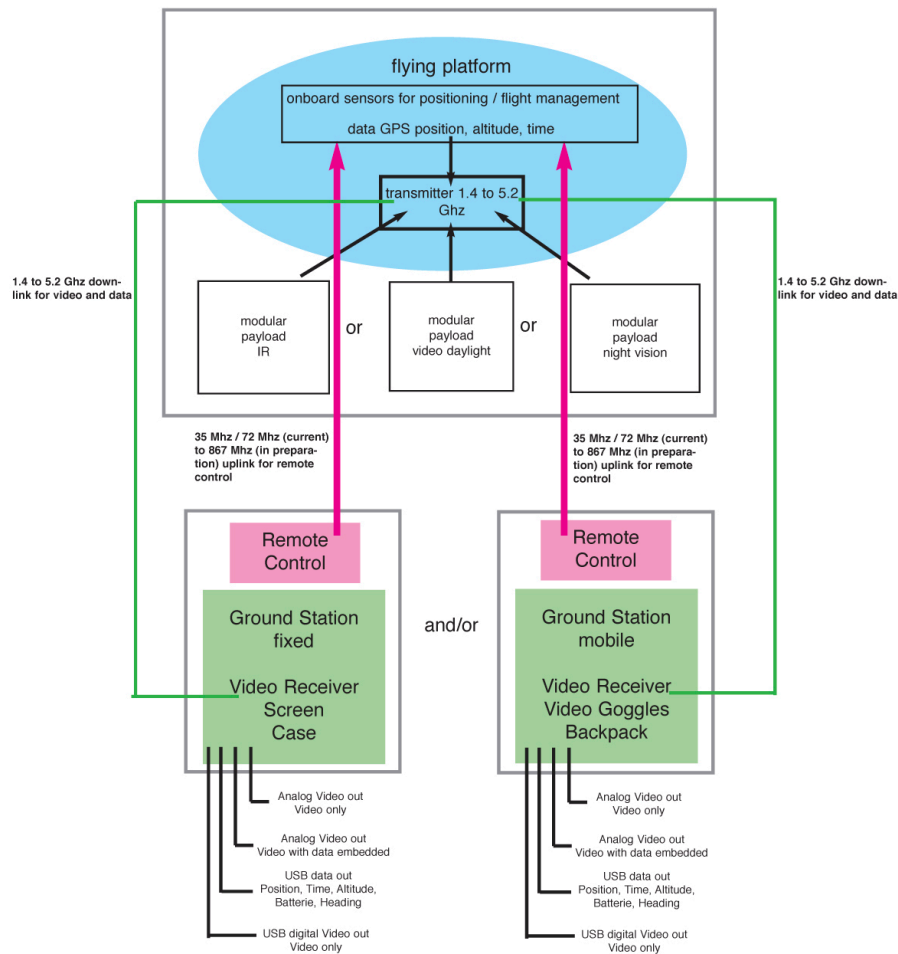
- Wind Speed max. 8.5 m/s (regular operator)
- Temperature 30oF –115oF, 100% humidity
- Ice rain
- Presence of strong magnetic fields

General Technical Data

- Gross weight 2 lbs
- Max payload 0.5 lbs
- Diameter 40 inches

Communication

- Video/ data transmission downlink 2.4 Ghz
- Data downlink transmission rate 38,400 bps
- Encryption possible with digital transmitter
- Range of video/data transmission 2400 ft extendable with relays
- Telemetry digital uplink 925 Mhz



Stabilization/Positioning Sensors

Autonomous attitude control

1. Rotational Speeds

- 3 Axis: Roll, Pitch, Yaw
- Range: $\pm 150^\circ/\text{s}$
- Resolution: $0.4^\circ/\text{s}$
- Update rate: 10 Hz

2. Accelerations

- 3 Axis: Drone Body Frame, X, Y, Z
- Range: $\pm 4g$
- Resolution: 0.15 m/s^2
- Update rate: 10 Hz

3. Estimated Roll, Pitch angles

- 2 Axis: Roll, Pitch
- Range: $\pm 30^\circ$
- Resolution: 0.1°
- Accuracy: $\pm 2^\circ$ over full Temperature Rating ($-10^\circ\text{C} \dots +40^\circ\text{C}$)
- Update rate: 10 Hz

Autonomous altitude control

1. Baro-Altimeter

- Relative Altitude: m
- Resolution: 0.05 m
- Drift: $\pm 15 \text{ m/h}$ (meter per hour)
- Drift depends on Weather Changing
- Update rate: 10 Hz

Autonomous direction control/heading

1. Magnetometer

- Tilt Compensated Heading
- Range: 360°
- Resolution: 0.5°
- Accuracy: $\pm 5^\circ$ over full Tilt ($\pm 25^\circ$ Roll or Pitch)
- Update rate: 10 Hz

Auto positioning

1. GPS (normal GPS, NO DGPS)

- Latitude, longitude
- Horizontal and vertical speed
- Course
- Update rate: 4 Hz

2. Proprietary optical based low altitude/alternative positioning system

Available Payloads

- **Daylight color video camera**

- Resolution 480 x 640 px
- Frame Rate: 25 fps PAL, 30 fps NTSC
- Angle of view 70 degrees
- Real time data transmission to ground station

- **Dawn/ low light**

- Black and white imaging
- Resolution 570 lines
- Frame Rate 25 fps
- Sensitivity 0.0003 lux
- Angle of view 70 degrees
- Real time data transmission to ground station

- **10 MP still camera with live video feed**
 - Color still images with 10 MP image size
 - Real time video feed parallel
 - Sensitivity up to 400 ASA
 - Remote controlled 3x optical Zoom
 - Images stored on SD card onboard unit
 - Camera trigger and zoom from RC

- **IR thermal image camera**
 - 384 x 288 pixel array 35 μ micro-bolometer
 - Response 7-14 μ m (filter band with)
 - Thermal sensitivity < 50 mK
 - Refresh rate real-time 50/60 Hz
 - Start-up time ~ 4 sec.
 - Contrast/brightness advanced image processing
 - Saturation temperature 1100° F (600° C) +/- 10 % w,
 - Automatic electronic iris
 - Optic focal length 15 mm, field of view ~ 48° x 37°
 - Focus method manual, temperature stabilized
 - For detection of human activity up to 330 feet

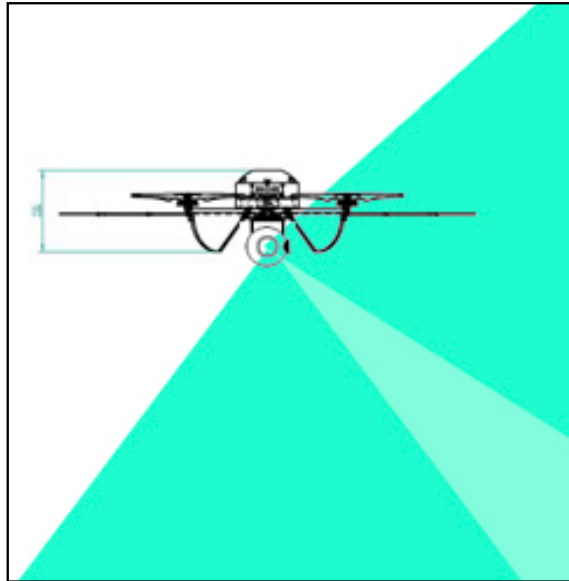
Payloads in preparation

- HD video camera
- Radiation Sensor
- Gas sensors
- Listening devices
- Bomb Sniffer (sensaic)

Payload suspension and control

- Tilt mechanism allows for 110 degree up and down with

max 20 degrees upward
max 90 degrees downward



- Camera pan 360 degrees through rotation of the unit

Max angle of view with 70-degree field of view camera is 170 degrees up and down and 360 degrees around controlled from remote control.

- Modular payload carrier allows for swap of payloads within less than 30 seconds

Safety Features

Lost RC

In case of lost radio communication unit will hover and stay in one position and altitude automatically, either till radio communication is reestablished or battery is exhausted. Alternative procedures programmable – Auto home, climb and wait. Without GPS availability unit will initiate auto landing.

Battery Failure

In case of battery failure, unit will initiate a slow auto landing. Unit always preserves enough battery power to ensure safe landing with all sensors and stabilization systems working

Processing and Stabilization

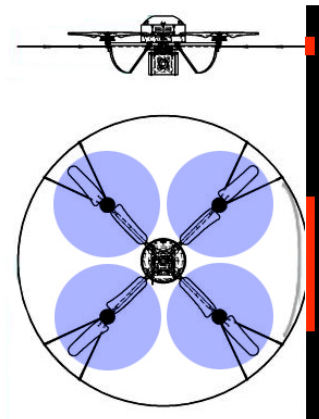
All processing for auto positioning and auto stabilization is built into the unit. The unit does not need radio communication to maintain this functionality. No processing is performed on the ground station

Operator Error

Unit has envelope protection and does not allow maneuvers, which could lead to crash like over steering or exceeding maximum angle of 25 degrees

Safety ring

Flexible protection ring allows for operation extremely close to subjects of interest without risk of damage to the rotors



Handling

Small rotors with low torque and momentum provide safe handling and minimize risk of injury

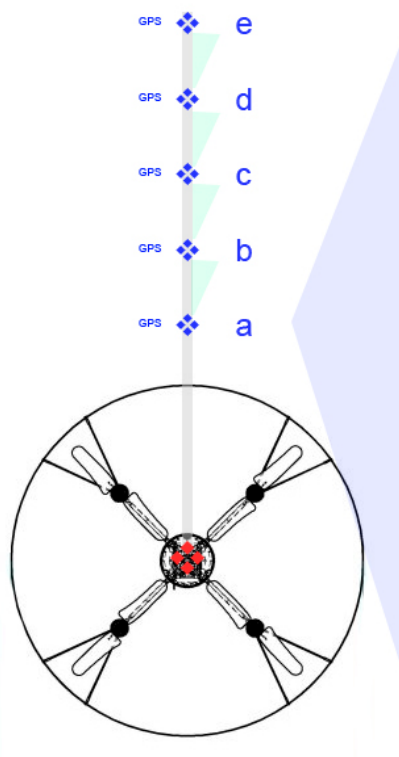
Flight Control

Currently “stabilized tele-op” with autonomous hover in locked position, altitude and heading. Fully autonomous waypoint navigation is in preparation.

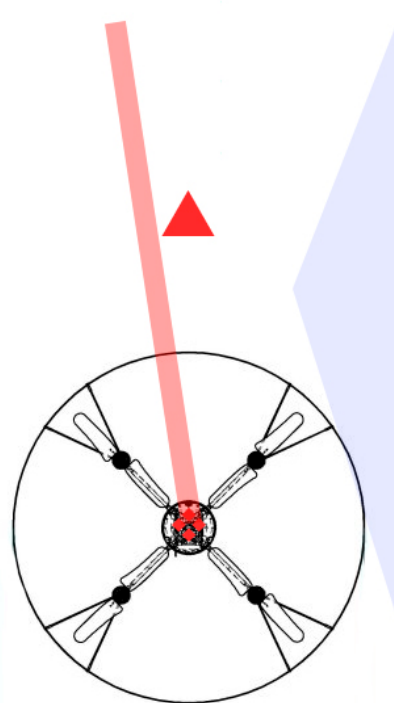
Controls 2 omni-directional joysticks (Game consol set up)

Fly by wire with forward command setting target waypoints depending on command strength.

Low Command Strength



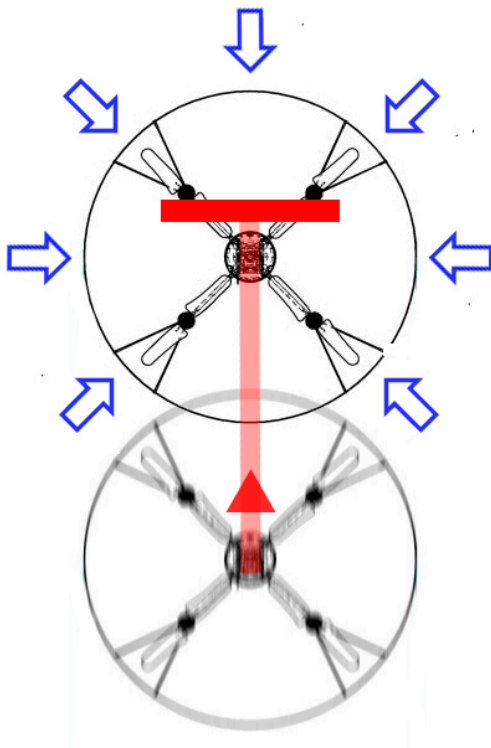
High Command Strength



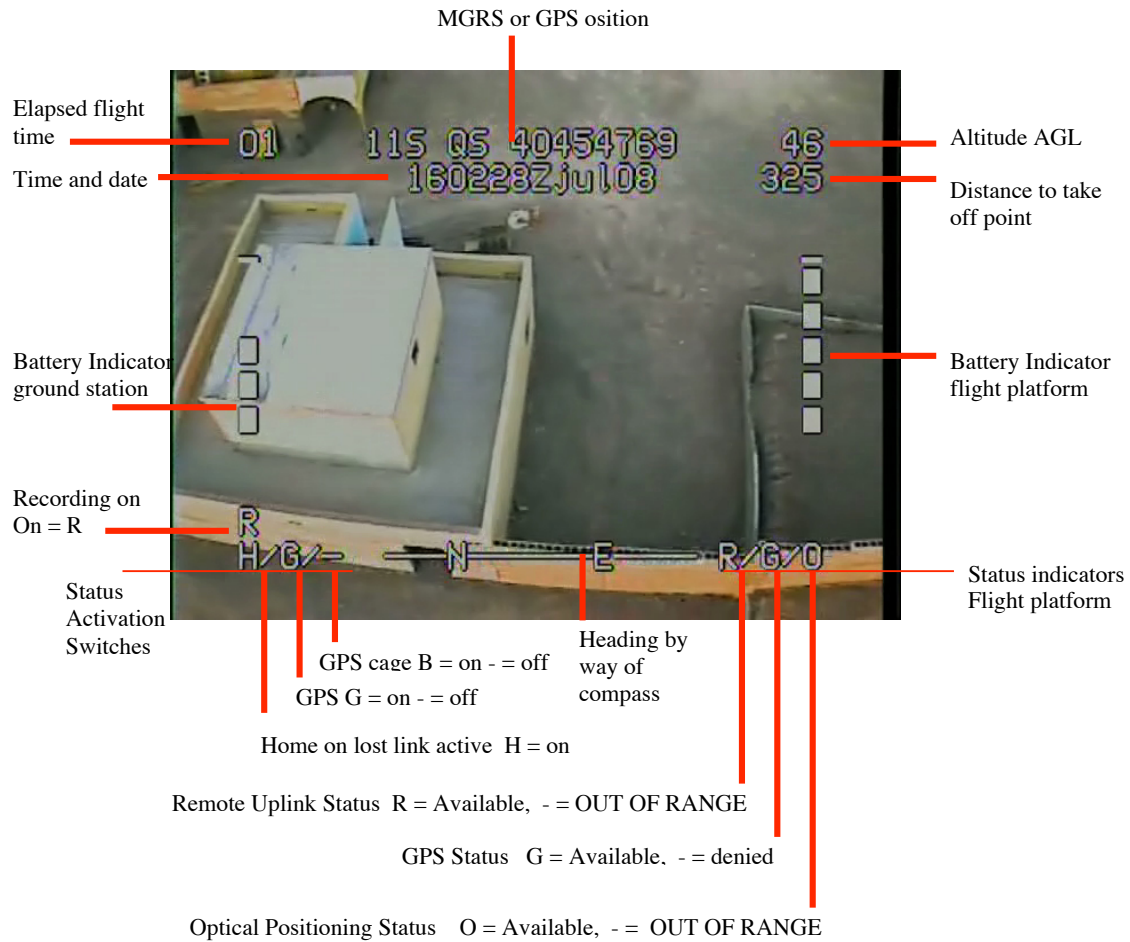
With no commands (neutral joysticks) the unit assumes that it has to stay in the exact last position, heading and altitude

It will abort the execution of the last command (e.g. forward) and initiate appropriate action to hold and maintain the position which leads to an active breaking out of any movement

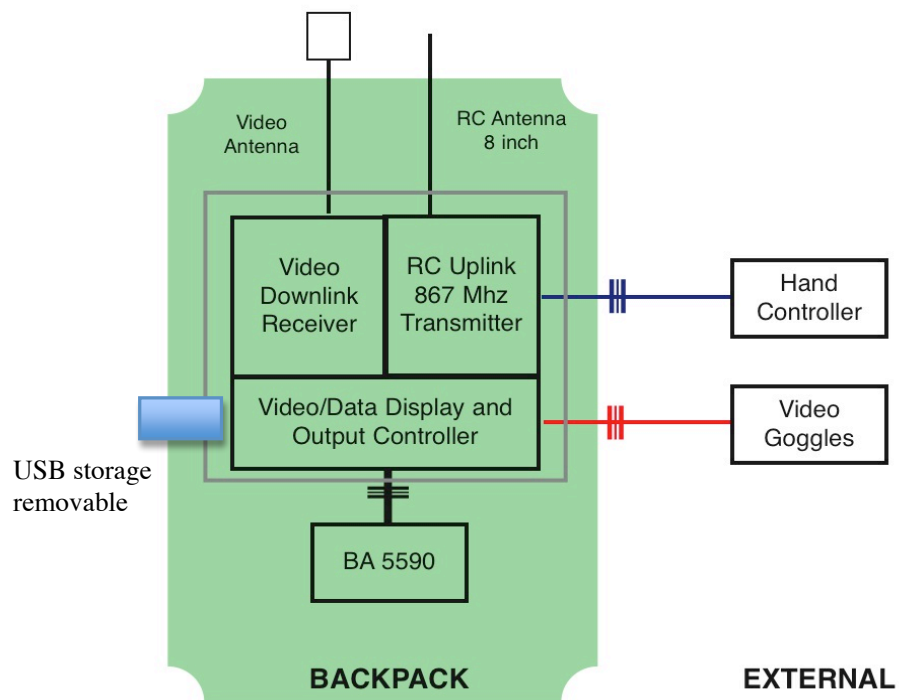
The unit will then use its auto positioning systems to stay at the last position and in the last altitude

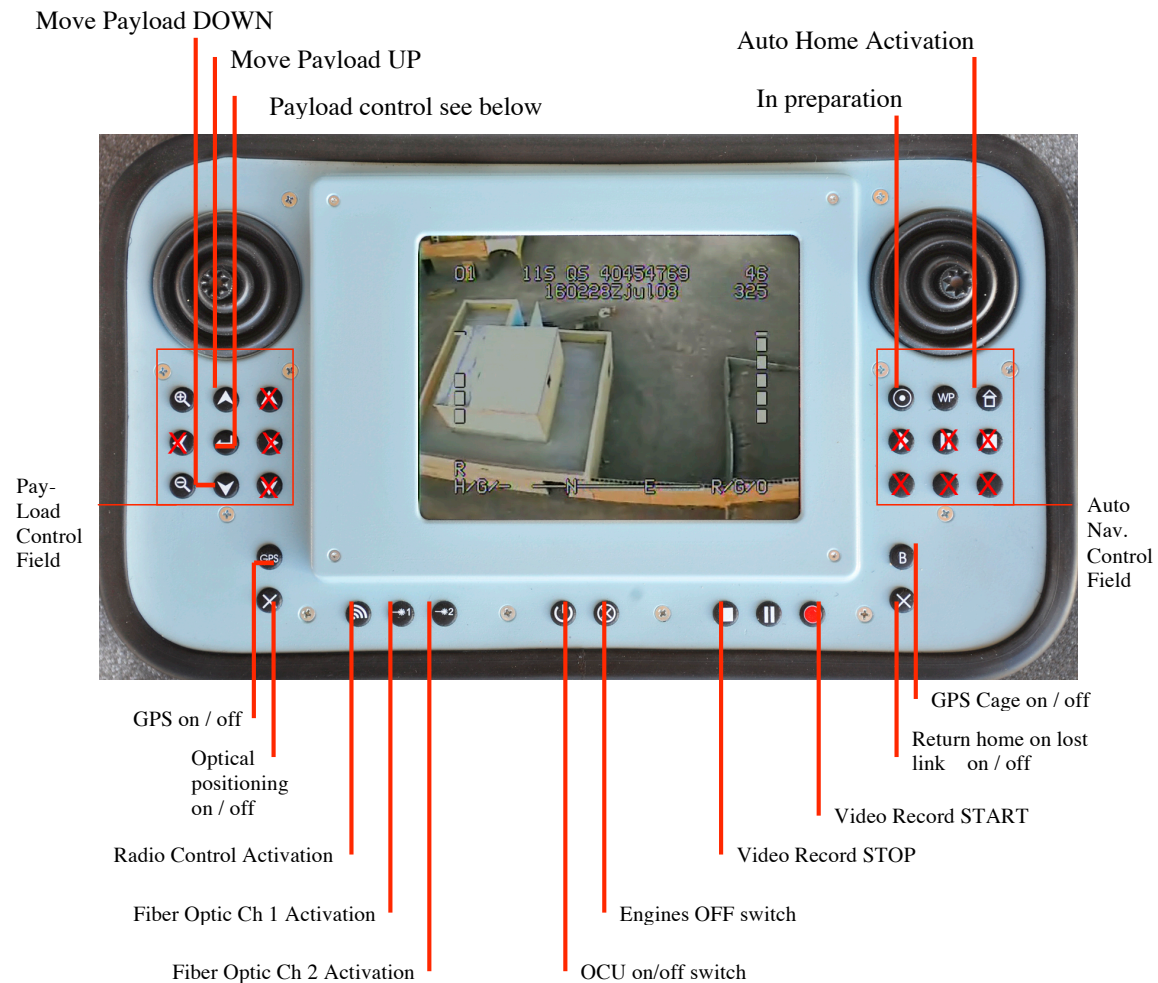


Flight “out of line of sight” using video signal in heads up display



Schematics Mobile Ground Station in Backpack





Payload control

- With IR sensor toggles between daylight video and IR
- With 10 MP still camera triggers still image

Buttons crossed out with **X** are not active at this time.

Maintenance / Field Repair

The Flying Platform is maintenance free and does not require scheduled or regular maintenance. Engines are brushless and gearless. Besides the engines there are no moving parts like servos.

Batteries maintain their charge and do not self-discharge. Self-discharge is $< 3\%$ per year. Average life cycle is 150 charges.

Most wear and tear parts (protection ring, landing gear, rotors), which may break, are replaceable in the field without tools.

Sensor Payloads are user replaceable within less than 30 seconds and can be swapped in the field in case of damage or malfunction.

Training

Operators can be trained to operate the unit within 1 to 3 hours of practical training, depending on their previous experience with model airplane flying and/or video gaming. Video gaming experience will shorten learning time due to the similarities in controls and visual interface. The unit can be operated through the video feed much like a video game (no reversal of perspectives as when flying in line of sight). No aviation experience is needed and all squad members can be trained. Training can take place one operator at a time. Risks during training are low because of envelope protection of the unit (system refuses to execute commands leading to crash except collision), low mass and safety features (protected blades).

Availability/Maturity

The AirRobot is in regular production and is an off the shelf unit. It is deployed with the German Armed Forces since approx. 1.5 years, as well as by various Search and Rescue Teams and Law Enforcement Agencies in Europe. It is currently fielded with the US army through the Rapid Equipping Force.

Manufacturers' scheduled product roadmap and developments

Operational

Nov 2008

Ground station based waypoint control system

- Allows for pre programming of waypoint path and autonomous flight within radio communication range as well as radio silent flight and override for remote control of the unit.

Scheduled

Autonomous collision avoidance and distance control

- Enables unit to fly autonomously in confined spaces
- Ensures easier and safer operation by untrained personnel
- Increase capabilities for indoor flying
- Further improves GPS independent auto positioning