Section 333 Exemption Package

GeoStar sUAS

Aerial Survey & Terrain Modeling System

Prepared by:

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President

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List of Abbreviations

AC	Alternating Current
AGL	Above Ground Level
ATC	Air Traffic Control
CFR	Code of Federal Regulations
COA	Certificate of Waiver or Authorization
CTAF	Common Traffic Advisory Frequency
ELT	Emergency Locator Transmitter
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulation
GIS	Geospatial Information System
GCS	Ground Control Station
GMRS	General Mobile Radio Servicem
GPS	Global Positioning System
INS	Inertial Navigation System
mAh	Milli-Amp Hours
NAS	National Airspace System
PIC	Pilot in Command
RC	Radio Control
RTL	Return to Launchpoint
sUAS	Small Unmanned Aerial System
TCI	Telemetry Control Interface
UAV	Unmanned Aerial Vehicle
UAS	Unmanned Aerial System
VDC	Volts Direct Current
VFR	Visual Flight Rules
VHF	Very High Frequency

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UAV Pilot Information

Timothy Joseph Briggs
Private Pilot Certificate
Certificate Number: 3518562
ASEL, Tail Dragger, Complex, High Performance endorsements.
Medical: Class II, October 2014
ASEL Time: 880 hours

US Navy Sensor Operator Flight Time (1983-2005)
P-3 Orion, S-3 Viking
Total Time 4000+ hours

US Army Contract Sensor Operator Flight Time (2007-2015)
Shorts 360
Beech King Air 350
Total Time 3500+ Hours

Fixed Wing Radio Control Experience
30+ Years

GeoStar UAV Flight Time
14 flights, 3.3 hours total time in type

SECTION I – INTRODUCTION AND BACKGROUND INFORMATION

Introduction

AeroLogix Consulting Inc. ("AeroLogix") is the designer, builder and the operator of the GeoStar sUAS aerial imaging system. The system is capable of creating high resolution geospatial ("GIS") imagery and engineering grade survey products. The heart of the system is the GeoStar UAV, a semi-autonomous fixed wing aircraft with electric power and a payload capacity exceeding 10 pounds. AeroLogix currently operates the GeoStar sUAS as a public aircraft in partnership with Le Sueur County, Minnesota under FAA Certificate of Waiver or Authorization (COA), 2014-CSA-35. AeroLogix prepared and submitted all COA application requirements and documentation on behalf of Le Sueur County. COA 2014-CSA-35 is included for your reference to this application. AeroLogix is seeking exemptions under the provisions of Section 333 of the FAA Modernization and Reform Act of 2012 ("The Reform Act") to commercially operate additional GeoStar UAV airframes to multiple public and private customers. AeroLogix seeks to operate the identical sUAS system in similar operational and airspace conditions as previously vetted and approved in COA 2014-CSA-35.

FAA FORM 7711-1 UAS COA Attachment 2014-CSA-35 Page 1 of 21

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

CERTIFICATE OF WAIVER OR AUTHORIZATION

ISSUED TO
Le Sueur County, MN

Attn: Justin Letterman
88 South Park Ave.
Le Center, MN 56057

This certificate is issued for the operations specifically described hereinafter. No person shall conduct any operation pursuant to the authority of this certificate except in accordance with the standard and special provisions contained in this certificate, and such other requirements of the Federal Aviation Regulations not specifically waived by this certificate.

OPERATIONS AUTHORIZED
Operation of the GeoStar Unmanned Aircraft System (UAS) in Class E and G airspace, at or below 600 feet Above Ground Level (AGL) within La Sueur County, MN as depicted in Attachment 1, under the jurisdiction of the Minneapolis Air Route Traffic Control Center (ARTCC) and Minneapolis Terminal Radar Approach Control (TRACON). See Special Provisions.

LIST OF WAIVED REGULATIONS BY SECTION AND TITLE
N/A

STANDARD PROVISIONS

1. A copy of the application made for this certificate shall be attached and become a part hereof.
2. This certificate shall be presented for inspection upon the request of any authorized representative of the Federal Aviation Administration, or of any State or municipal official charged with the duty of enforcing local laws or regulations.
3. The holder of this certificate shall be responsible for the strict observance of the terms and provisions contained herein.
4. This certificate is nontransferable.

Note-This certificate constitutes a waiver of those Federal rules or regulations specifically referred to above. It does not constitute a waiver of any State law or local ordinance.

SPECIAL PROVISIONS

Special Provisions are set forth and attached.

This certificate 2014-CSA-35 effective from August 25, 2014 through August 24, 2016 and is subject to cancellation at any time upon notice by the Administrator or his/her authorized representative.

BY DIRECTION OF THE ADMINISTRATOR

FAA Headquarters, AJV-115 (Region)

Jacqueline R. Jackson (Signature)

August 25, 2014 (Date)

Acting Air Traffic Manager, UAS Tactical Operations (Title)

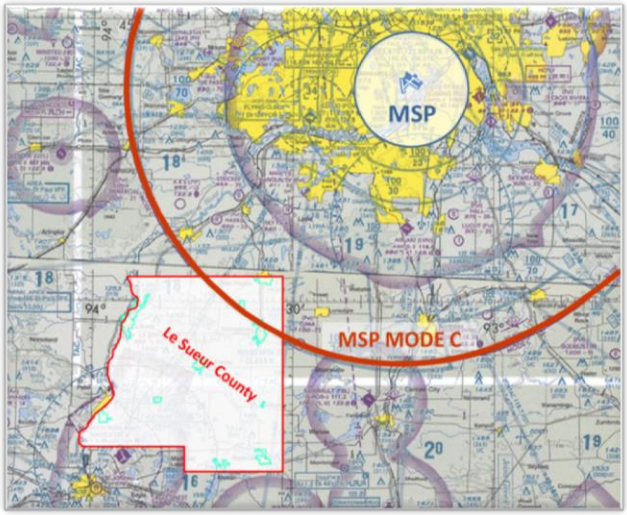
FAA Form 7711-1 (7-74)

Version 2.1: June 2012

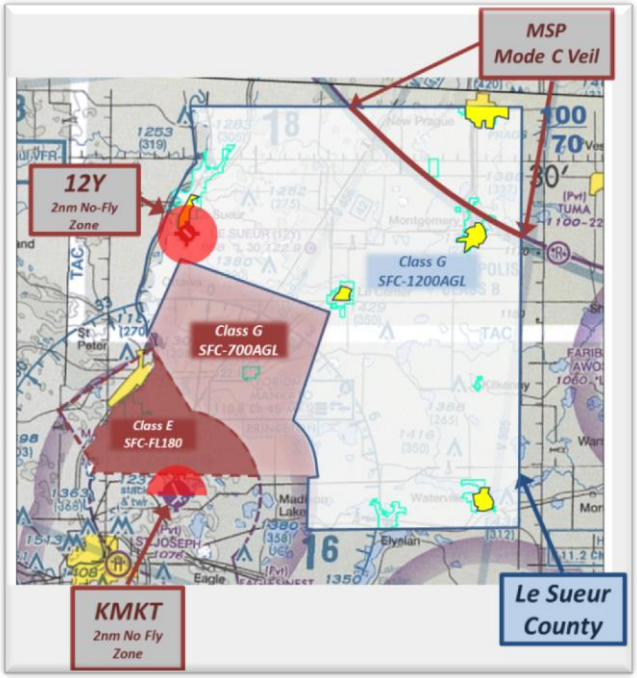
COA 2014-CSA-35 Cover Page

GeoStar sUAS Public Operations in 2014

The AeroLogix/Le Sueur County partnership was awarded one of Minnesota's first and largest public-use COAs, 2014-CSA-35. FAA authorization was granted on 25 August, 2014 to begin operations of the GeoStar sUAS throughout most of Le Sueur County in Class E and G airspace. Except for five densely populated towns and two airport areas, all of rural Le Sueur County was granted authorization for GeoStar sUAS operations.



Le Sueur County Depicted on Twin Cities Sectional Chart



AeroLogix/Le Sueur County Authorized GeoStar sUAS Operating Areas

(all white and magenta areas are authorized)

Flight operations began in early September 2014 and continued without incident through late November 2014 when snow cover prevented further aerial surveys. During that time, 14 GeoStar missions were safely conducted from multiple locations in Le Sueur County. The GeoStar UAV met or exceeded all design and performance goals and the program was well received by the general public and local press.[1,2,3] AeroLogix and Le Sueur County intend to resume regular operations under COA 2014-CSA-35 in the spring of 2015 in various locations within Le Sueur County to survey agricultural ditches and to provide imagery and engineering products for other county civil engineering projects.

GeoStar UAV

The GeoStar UAV saw immediate success as a safe and stable aerial photography platform. It was quickly demonstrated how AeroLogix and the GeoStar sUAS were capable of creating high resolution geospatial ("GIS") imagery and engineering grade survey products, *at a fraction of the cost of conventional providers.* The Le Sueur County program and the products that were created generated immediate interest among local GIS users and civil engineering professionals. The following institutions have expressed interest and/or directly requested AeroLogix and GeoStar sUAS services:

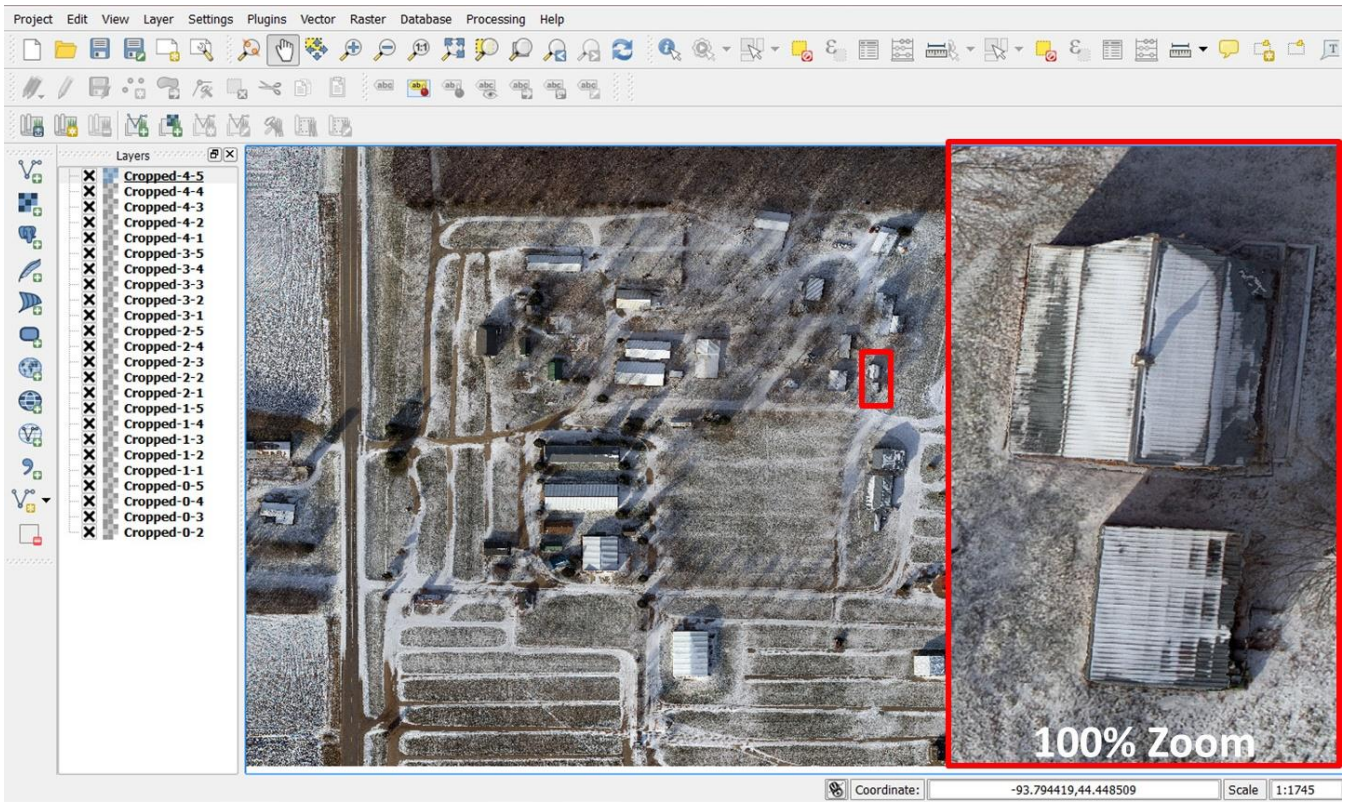
-US Department of Agriculture/University of Minnesota clover crop research project.
-US Fish and Wildlife Service
-Minnesota Department of Transportation (3 projects)
-Minnesota Department of Soil and Water
-Scott County, Ravine Survey
-Dakota County, Vermillion River Survey
-Minnesota State University Mankato, GIS Department
-University of Minnesota, Aerospace Engineering Dept., Graduate Student Program.

1: Mankato Free Press 03 December, 2014, "Drone Mapping Shows Promise"; http://www.mankatofreepress.com/news/local_news/drone-photography-shows-promise/article_74b585a0-1b2a-5d25-9125-fc1e6fe3a662.html
2: Minneapolis Star Tribune 26 October, 2014, "Look Up In The Sky"; http://www.startribune.com/local/280418882.html
3: Mankato Free Press, 28 September 2014, "Le Sueur County To Pioneer Drone Mapping" http://www.mankatofreepress.com/news/local_news/le-sueur-county-to-pioneer-drone-mapping/article_f14b1b3a-292b-50c2-a8ce-8649e86d8777.html

Intended Section 333 Operational Areas

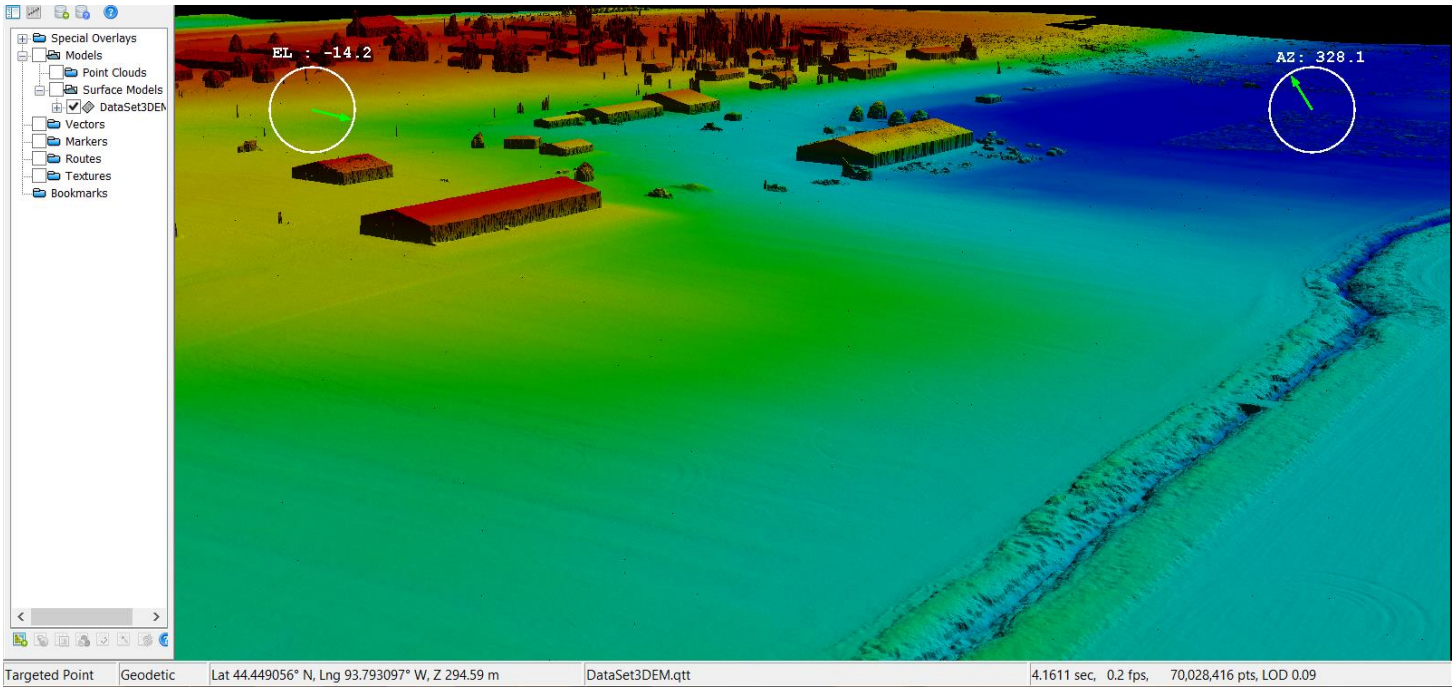
AeroLogix seeks to commercially operate the GeoStar sUAS under a Section 333 exemption in rural areas, generally in Class G and Class E airspace. Initial commercial operations are anticipated in the rural sections of various counties in southern Minnesota. Further operations in other parts of Minnesota and into other states are expected to follow. AeroLogix expects to file specific COA requests for operating airspace as new projects are contracted. Detailed descriptions of proposed operational parameters are in Section II of this document under: "GeoStar sUAS General Operating Parameters"

GeoStar sUAS Imagery Product Samples



Sample AeroLogix/GeoStar GIS Imagery – Le Sueur County, MN

AeroLogix/GeoStar 3-D Terrain Model Example – Ditch 34 in Le Sueur County



Sample Digital Elevation Model – Le Sueur County, MN

Specific Sections From 14 CFR Sought For Exemption

14 CFR Part 21, Subpart H:	Airworthiness Certificates
14 CFR § 91.203(a)(1)	Certifications Required
14 CFR § 45.23	Display of marks; general.
14 CFR § 45.25	Location of marks on fixed-wing aircraft.
14 CFR § 45.29	Size of marks.
14 CFR § 61.113	Private Pilot Privileges and Limitations: Pilot In Command
14 CFR § 61.133	Commercial Pilot Privileges and Limitations.
14 CFR § 91.7 (a)	Civil Aircraft Airworthiness
14 CFR § 91.9 (b)(2)	Civil Aircraft Flight Manual in the Aircraft
14 CFR § 91.121	Altimeter Settings
14 CFR § 91.151 (a)(1)	Fuel Requirements for Flight in VFR Conditions.
14 CFR § 91.207 (a)(1)	Emergency Locator Transmitters (ELTs).
14 CFR § 91.307 (a)	Parachutes and Parachuting
14 CFR § 91.405 (a)	Maintenance Required
14 CFR § 91.407 (a)(1)	Operation After Maintenance, Preventative, Rebuilding or Alteration
14 CFR § 91.409 (a) (1)(2)	Inspections
14 CFR § 91.417 (a)(b)	Maintenance Records

These specific sections will be discussed following a description of the GeoStar sUAS system and proposed operations under a Section 333 exemption.

Review of Section 333 Conditions.

The Congressional mandate in Section 333 of the Reform Act allows a limited introduction of commercial Unmanned Aerial Systems (UASs) into the national airspace system in advance of permanent rulemaking, if it can be accomplished safely. The Secretary is given the discretion to determine which types of UASs do not create a hazard to users of the NAS or the public or pose a threat to national security when considering the following:

-The UAS's size, weight, speed, and operational capability;
-Operation of the UAS in close proximity to airports and populated areas; and
-Operation of the UAS within visual line of sight of the operator.

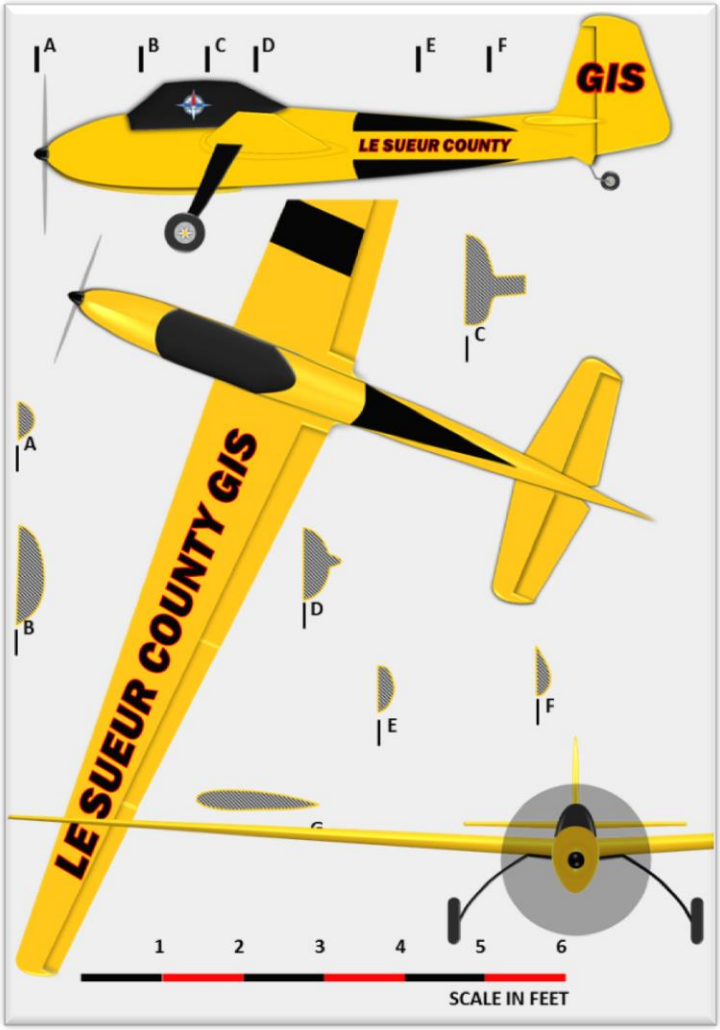
We shall address these conditions as they apply to GeoStar sUAS and the proposed operations.

SECTION II – THE GEOSTAR sUAS DESCRIPTION AND PROPOSED OPERATIONS

GeoStar UAV Dimensions and Weights:

The FAA defines "Small Unmanned Aerial Systems" (sUAS) as those that weigh less than 55 pounds. The GeoStar UAV normally flies at an operational weight of 21-25 pounds, depending on desired battery load. The GeoStar is entirely electric powered with independent circuits for main propulsion, avionics and telemetry. The GeoStar UAV is constructed with a hollow fiberglass fuselage. Wings are made from a foam core with carbon fiber reinforcements and then sheeted with a fiberglass strengthened wood veneer. The following physical specifications are provided:

a. Wingspan: 157.4" (13'1")
b. Fuselage length: 72.5"(6')
c. Wing area: 1934 sq. in/13.43 sq. ft.
d. Wing cubic loading: 8.1oz per cubic foot (at 25lbs)
e. Empty Weight (No propulsion batteries, camera payload or parachute) 14.8 lbs.
f. Maximum gross takeoff weight: 25.0 lbs.
g. Payload Capacity: Up to 10.2 lbs. of camera, battery and parachute payload can be carried.



GeoStar UAV 3-View

GeoStar UAV Operating Speeds

The GeoStar UAV was designed as a stable fixed wing aerial photography platform with electric power and good payload capacity. Slower operational speeds were desired to maximize photographic performance and were achieved through substantial wing area and relatively light wing loadings. Internal mounting of all components minimizes aerodynamic drag and an efficient sailplane-derived airfoil displays excellent handling characteristics across the speed range. All of these characteristics combine to facilitate safe launch, recovery and efficient cruise performance. The following speeds are provided based on actual GeoStar flight testing and data logged by telemetry and onboard airspeed instrumentation. Speeds were measured at the maximum weight of 25lbs:

a. Maximum speed, level flight:	65mph
b. Stall Speed Clean:	24mph
c. Stall Speed Max Flaps:	21mph
d. Cruise/Photo collect speed:	40-45mph
e. Power-off glide speed:	40mph
f. Best rate of climb speed:	40mph
g. Rate of Climb:	600 fpm (750fpm demonstrated at 21 lbs. mission weights)

GeoStar UAV Takeoff

GeoStar sUAS Description and Operational Capabilities

General: The GeoStar sUAS is designed as a semi-autonomous precision aerial photography system. The entire system is transported to the collection area in a modified trailer. The GeoStar UAV launches and recovers at or near each desired collection area. A two or three person crew of UAV Pilot, Telemetry Operator and (optionally) one Observer operate the GeoStar sUAS. The GeoStar UAV is launched like a conventional aircraft by manual pilot control, similar to a standard radio controlled airplane. It requires a takeoff run of about 20-50 feet, depending on weight, wind conditions and runway surface. Once safely airborne, an autopilot is enabled and the UAV flies autonomously along a pre-programmed route of parallel tracks, holding a steady speed and altitude. When flying autonomously via autopilot control, it remains continuously connected to a Ground Control Station via two independent command and control links. The system is designed around collections of up to 1 square statute mile. Flying at a cruise speed of 40mph, one square mile of terrain can be collected in about 20 minutes. A high-resolution digital camera is installed to capture a series of still photographs. The camera is aimed straight down and is commanded to shoot at timed intervals. To comply with FAR 91.119 as prescribed in COA 2014-CSA-35, most missions are flown at an altitude of 500-600 feet above the ground. Upon completion of the photo mission, the UAV descends while returning to the launch point and enters an orbit at the initial recovery altitude of 350 feet AGL. The UAV can then be recovered manually by the pilot on the wheels or with a parachute recovery system. The parachute also serves as an important emergency backup system to safely recover the UAV in the event of a system malfunction.

GeoStar UAV Parachute Recoveries

Command and Control: The GeoStar UAV is designed to function as a semi-autonomous aircraft with redundant systems for connectivity and a continuous telemetry interface with a Ground Control Station.

a. Primary Radio Control (RC). Primary, manual pilot control of the UAV is through a conventional Radio Control (RC) system. From the RC controller, the UAV Pilot can activate all UAV systems and command the autopilot into different operational modes. The RC system maintains continuous connectivity with the UAV and immediately overrides any autopilot function. An external power amplifier and larger antenna extend Primary RC range to approximately 3sm when operating at 300-600 feet AGL

b. Autopilot Function. The GeoStar UAV autopilot system uses 3 axis gyros, GPS/INS navigation, barometric altimeter, magnetic compass and pitot/static derived airspeed to perform a variety of automated flight tasks from simple stabilization to fully autonomous flight and precision navigation. Autopilot navigation and control enables the GeoStar UAV to fly the precise ground tracks and stable altitudes required for precision aerial survey. Successful autopilot function has been demonstrated in winds aloft conditions exceeding 20 knots. Altitude holding precision is generally +/- 5 feet and airspeed stability is typically +/- 3mph in level or turning flight. The autopilot incorporates 5 distinct modes of operation:

-Manual Mode. No autopilot input to flight controls. All control remains with the UAV Pilot via the handheld RC controller and the UAV is flown like a standard RC airplane. The UAV is normally launched in this mode.

-Stabilize Mode. In this mode, the autopilot maintains "wings level" and seeks to remain in level flight. The UAV Pilot's control inputs will maneuver the UAV but upon release of the controls, the UAV returns to level, stabilized flight. Power level is manually set by the Pilot.

-Loiter Mode. When commanded to Loiter Mode, the UAV will establish a left-hand orbit of preset radius and maintain the altitude established at the moment Loiter was initialized. A designated airspeed is preset for Loiter mode and maintained throughout the Loiter. The GeoStar Loiter radius is preset to 40 meters and airspeed is preset to 40mph.

-Auto Mode. In this mode, the autopilot steers the aircraft along a route of preset waypoints using 3-axis gyros, GPS/INS navigation, barometric altimeter, magnetic compass and pitot/static derived airspeed. It also will seek and/or maintain a preset altitude and airspeed. While in Auto mode, the UAV Pilot can intervene and maneuver the aircraft manually at any time and/or increase the power setting for a faster airspeed. However, the UAV Pilot cannot command a power setting below a preset Auto Mode minimum airspeed setting.

-Return to Launch-point (RTL) Mode. In this mode, the autopilot steers the aircraft back to the launch point and then loiters at a preset altitude, diameter and airspeed. RTL can be preset as the final leg of a mission or commanded manually any time the aircraft is within RC range by handheld controller function. RTL can also be commanded via Telemetry Control Interface (discussed below). The Autopilot also incorporates a number of safety features that will automatically command the aircraft to RTL under certain Lost Link and low-voltage conditions.

c. Telemetry Module. A separate telemetry module, independently powered and operating on a discrete frequency spectrum, interfaces with the autopilot. Flight data from the autopilot is broadcast via this module at a rate of 10hz, reporting the aircraft's current position, flight parameters and systems status in real-time. The data is viewed and flight performance can then be monitored at the Ground Control Station computer by a dedicated Telemetry Operator. The Telemetry system also provides audible cues and alerts of autopilot mode changes, waypoint progress, lost link alarms, low voltage alarms and other malfunctions. The UAV Pilot is also able to monitor the Telemetry display and audio cues on a secondary monitor mounted on the RC Controller. Telemetry range exceeds 3sm when operating at 500 feet AGL.

Ground Control Station Telemetry Display – 25 November 2014 Mission In Le Sueur County, MN

The telemetry interface can also command the autopilot independently from the Primary RC controller. Commands such as Return to Launch-point, Loiter, speed and altitude changes and new waypoints can all be sent via this link. The parachute recovery system can be activated from this link as well. This "Telemetry Control Interface" (TCI) functionality is an important safety feature, affording a reliable secondary method of controlling and recovering the UAV in the event of lost or interrupted primary RC control.

d. Ground Control Station (GCS). AeroLogix sUAS GCS is based in a specially modified trailer. The "Operations Trailer" is equipped with light and AC power. The trailer provides:

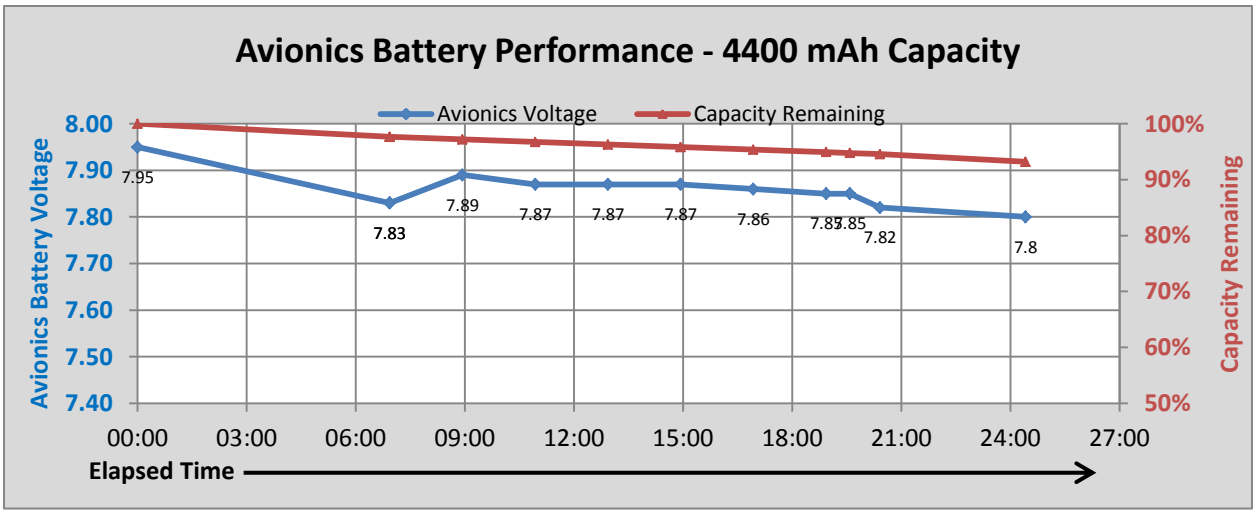
-A 110volt/3500-watt gasoline powered generator for AC power.
-Telemetry Operator GCS Computer.
-UAV Pilot Auxiliary Telemetry Display
-GCS Telemetry antenna mountings
-VHF Radios for air traffic communications.
-GMRS Radios for Communications between UAV Pilot, Observer and Telemetry Operator.
-Weather station.
-Battery chargers.
-Workbench, tools and spare parts for assembly and field repairs.
-Transport for all GeoStar sUAS components.

Ground Control Station - Operations Trailer

GeoStar UAV Power Scheme. The GeoStar UAV is an all-electric design, utilizing rechargeable Lithium-Polymer batteries for all systems. Unlike many all-electric sUAS that utilize a single battery power source, the GeoStar UAV power scheme isolates the critical systems into independently powered and regulated circuits.

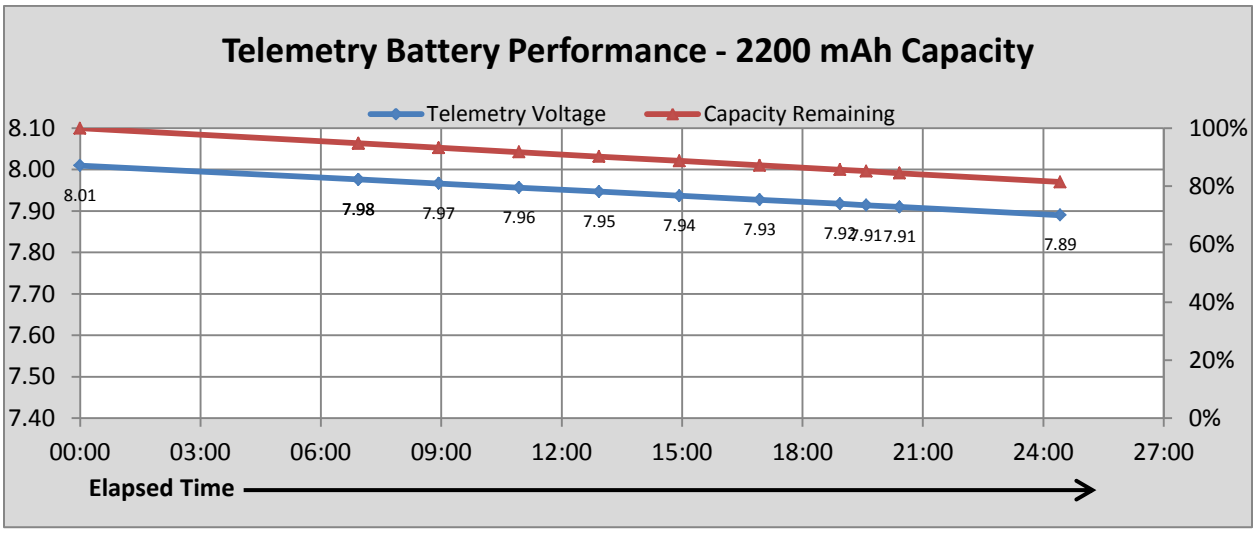
a. Main Propulsion Power. The GeoStar UAV can utilize up to four separate "6S" (22.2 VDC) 6000 mAh Lithium-Polymer battery cells for main propulsion. Cells are connected in parallel to achieve 12,000, 18,000 or 24,000 mAh of capacity. The multiple battery scheme allows tailoring of capacity to fit the mission profile. The main battery voltage level and current draw is relayed back to the GCS via telemetry, allowing continuous monitoring of main propulsion motor performance and battery state. GeoStar flight testing revealed remarkable efficiency and endurance. With a full battery load of 24,000mAh, endurance at normal cruise speeds can exceed 60 minutes while affording a 15 minute reserve capacity. Specific battery consumption and mission profiles will be discussed later in this document.

b. Avionics Power. The Avionics system in the GeoStar UAV is comprised of the Primary RC Receiver, autopilot system, voltage regulators and system servos. Avionics power is provided by two Lithium-Polymer "2S", 7.4 VDC rechargeable batteries connected in parallel. The avionics battery voltage level and current draw is relayed back to the GCS via telemetry, allowing continuous monitoring of battery state. The useful duration of these batteries exceeds 3 hours, insuring positive control and autopilot function well beyond the endurance of the Main Propulsion Batteries. An autopilot Power Module regulates and conditions power for the Autopilot and RC Receiver. The servos are powered from a separate power converter and isolated servo power circuit within the Autopilot. A total of 11 servos are utilized by the GeoStar UAV. Servos are the only likely source of electrical noise or voltage fluctuations within the avionics power circuits. By isolating the servos to their own regulated power circuit, any anomalies within the servo circuit will not affect the sensitive autopilot and RC Receiver functions. The avionics battery performance is depicted below based on telemetry data from a 25-minute mission:



Avionics Battery Performance

c. Telemetry Power. The aircraft's telemetry module is powered independently by its own 7.4 VDC Lithium-Polymer battery and power regulator that provide a steady 5.5 VDC. The telemetry module battery duration exceeds 2 hours at max power output. The telemetry battery performance is depicted below based on measurements before and after a 25-minute mission:

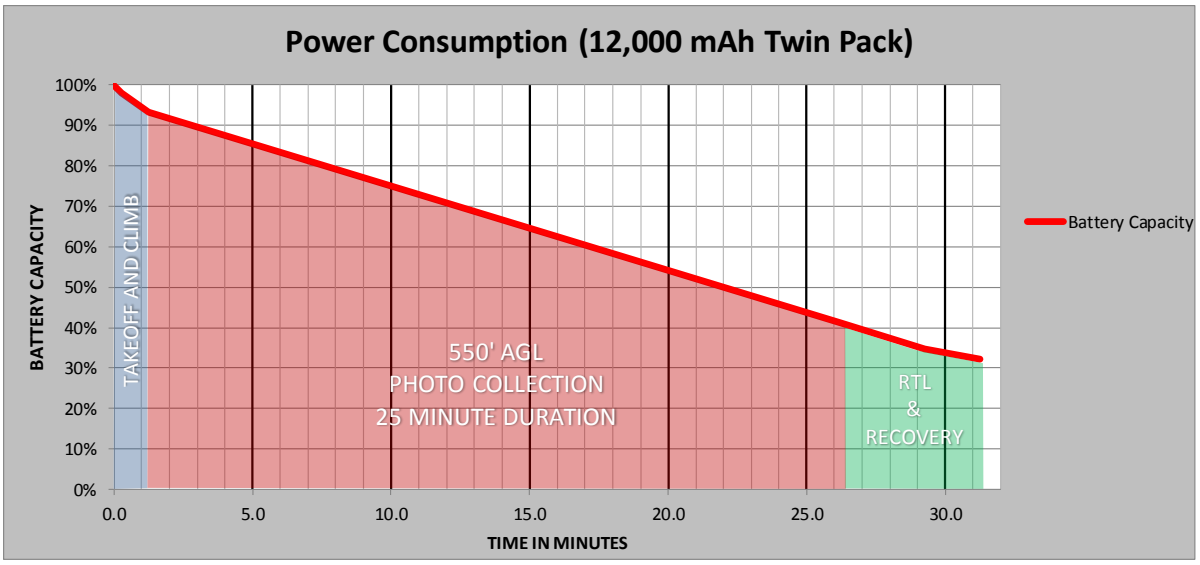


Telemetry Battery Endurance

Flight Profile and Endurance. Operating within the constraints of COA 2014-CSA-35 – namely operations within visual range - GeoStar operations in the Fall of 2014 were generally within 1sm of the launch point. The complete load of 4 main propulsion batteries was not always required to comply with our COA mandated 30 minute reserve requirement of 14 CFR 91.151, (Minimum Fuel Requirements). Sufficient endurance for shorter test and photo missions was afforded with two or three main propulsion batteries. Power consumption rates were recorded on all flights and those figures allow accurate estimation of battery consumption.

For reasons to be discussed later in this application, AeroLogix will be requesting an exemption from the requirements of 14 CFR 91.151. The maximum anticipated flight profile for most missions will be approximately 30 minutes from start to finish. Envisioned operations will keep the UAV within 1-2sm of the GCS. The following table and graph depict a typical photo mission collecting 1sq mile and reveal a generous 32% reserve capacity when operating with just two main propulsion batteries. This represents an available 15 minutes of reserve capacity at cruise power settings. Consumption rates were compiled from actual GeoStar telemetry feeds when operating at temperatures of 25°-50°F. The "Amp Draw" value during the "Collect" phase is an average value as the rate varied from 10-20amps at different times during the collections.

Flight Phase	Amp Draw	Duration	Capacity Used (mAh)	Capacity Remaining (mAh)	Capacity Percentage Remaining	Minutes Elapsed	**Minutes Remaining In Cruising Flight**
Start	0	0	0	12000	100%	0.0	**48**
Takeoff	56	0.25	233	11767	98%	0.3	**47**
Climb	35	1	583	11183	93%	1.3	**45**
Collect	15	25	6250	4933	41%	26.3	**20**
RTL	15	3	750	4183	35%	29.3	**17**
Approach/Landing	10	2	333	3850	32%	31.3	**15**
12,000mAh Battery Capacity - 21 Lbs.							



GeoStar Mission Profile –Battery Consumption

GeoStar sUAS Systems Redundancy. In order to achieve maximum safety of operations, another specific design goal of the GeoStar sUAS was systems redundancy to avoid "single point of failure" scenarios. The following design features of the GeoStar sUAS were incorporated to maximize reliability and safety of operations:

a. Aileron Control Servo Redundancy. The GeoStar UAV employs dual ailerons on each wing panel, each actuated by its own independent servo. In the unlikely event of an aileron servo or linkage malfunction, partial yet positive aileron control remains on the affected wing panel.

b. Elevator Control Servo Redundancy. In a similar fashion to the ailerons, each elevator surface is actuated by its own independent servo. If a single elevator servo or linkage malfunction occurs, sufficient elevator authority is maintained on the other to safely maneuver and recover the UAV.

c. Main Propulsion Battery Redundancy. The GeoStar UAV employs from 2 to 4 main propulsion battery cells connected in parallel. While unlikely, an internal battery or connection failure of one cell will not result in a complete loss of main propulsion power. In the most likely flight profile scenarios, the remaining cell(s) will provide sufficient power for a return to the launch point and safe recovery of the UAV. A battery failure will be indicated at the GCS by telemetry data indicating a more rapidly decreasing battery voltage.

d. Avionics Battery Redundancy. In a similar fashion to the main propulsion batteries, two avionics batteries are connected in parallel to power the critical Autopilot and servo circuits. While unlikely, an internal battery or connection failure of one cell will not result in an immediate loss of avionics power. In the most likely flight profile scenarios, the remaining cell will provide sufficient avionics power for a return to the launch point and safe recovery of the UAV.

e. GCS Systems Redundancy. The GeoStar sUAS Ground Control Station (GCS) has a portable electric generator with an endurance exceeding 12 hours. The critical flight control and communication systems are battery powered with rechargeable batteries. The generator insures these systems remain on AC power and in a fully charged state as the GeoStar sUAS is operated. In the event of a generator shutdown, all components revert to their battery power, allowing successful return and recovery of the GeoStar.

GeoStar sUAS Lost Link/Failsafe Descriptions - General. As described earlier in this application, the GeoStar UAV employs two, separate Command and Control Links operating on discrete frequencies. Either link system can command the UAV to Return To Launch-point (RTL) and/or command Parachute Deployment. The complete loss of either link system will command an immediate and automatic Return To Launch-Point (RTL) mode change within the autopilot. The UAV will autonomously return and then orbit over the launch point at a safe, predetermined altitude and airspeed. All lost-link conditions are tested and confirmed during GeoStar UAV preflight actions.

GeoStar sUAS Lost Link/Failsafe Descriptions – Primary RC Control Link. The UAV Pilot manually controls the GeoStar UAV and commands Autopilot modes via the Primary RC Link. The RC Controller remains powered, connected and in the possession of the UAV Pilot throughout the GeoStar mission profile. If the Primary RC control link is lost at any time, a sequence of events is automatically triggered:

a. Short Term Interruption Failsafe – Primary RC. When an interruption of the Primary RC link ***exceeds 1.5 seconds***, the Autopilot commands a "Circle" mode, whereby the UAV begins a circular flight path and holds a steady altitude. Circle radius is preset to 40 meters. The Telemetry Computer will report visually "FAILSAFE" and audibly announce, "MODE CHANGE TO CIRCLE" followed by, "NO DATA FOR 10 SECONDS", "NO DATA FOR 15 SECONDS" etc.. If the Primary RC link is reestablished within 20 seconds, the Autopilot remains in "Circle" mode until the UAV Pilot commands a new Autopilot mode.

b. Long Term Interruption Failsafe - Primary RC. When an interruption of the Primary RC link ***exceeds 20 seconds***, the Autopilot will automatically command a Return to Launch-Point" (RTL) mode change. The Telemetry Computer will report visually "FAILSAFE" and audibly, "NO DATA FOR 20 SECONDS", "MODE CHANGE TO RTL," whereby the UAV immediately begins a return to the launch point and a descent to the recovery altitude. If the Primary RC link is reestablished after the automatic RTL is initiated, the Autopilot remains in RTL mode until a new Autopilot mode is commanded by the UAV Pilot.

Telemetry Computer Display - Primary RC Link Fail-Safe Indication

GeoStar sUAS Lost Link/Failsafe Descriptions – Telemetry Link. The Telemetry link is continuously monitored during a GeoStar sUAS mission by a dedicated Telemetry Operator. Link status and signal strength is reported in the main Telemetry Display. The "%" value represents the percentage of good data packets received via the Telemetry link. The signal strength is indicated by 1-3 vertical bars.

Telemetry Connection Status

a. Lost Telemetry Link Indications. Momentary losses of Telemetry Link are seen on the Telemetry display as loss of signal strength and/or a decrease in the percentage value of data packets. When a continuous loss ***exceeds 5 seconds***, the program announces "NO DATA FOR 5 SECONDS," "NO DATA FOR 10 SECONDS" etc... A complete loss of telemetry data is indicated by a "Failsafe" indication and a red " X " in the telemetry status area of the Telemetry Display.

Lost Telemetry Display

b. Lost Telemetry Link Failsafe. The GeoStar UAV Autopilot is programmed to trigger an automatic Failsafe RTL if Telemetry loss ***exceeds 20 continuous seconds.*** The Autopilot will command RTL, whereby the UAV immediately begins a return to the launch point and a descent to the recovery altitude. The Telemetry Computer will announce, ""NO DATA FOR 20 SECONDS." It will continue to make "NO DATA" announcements at 10 second intervals until the Data Link is restored or until silenced by the Telemetry Operator. The Telemetry Computer will continue to visually report "FAILSAFE." With a complete loss of Telemetry data, the mode change to RTL can only be evidenced visually by the UAV Pilot and/or the Observer. If the Telemetry Link is reestablished after the automatic RTL is initiated, the Autopilot remains in RTL mode until a new Autopilot mode is commanded by the UAV Pilot.

GeoStar sUAS Lost Link/Failsafe Descriptions – Simultaneous Primary RC and Telemetry Links Lost. To mitigate the risk of this scenario, Command and Control links to the GeoStar UAV are independently powered, both in the UAV itself and at the GCS. The independent batteries powering the UAV Telemetry and Avionics have a useful duration that greatly exceeds the battery life of the Main Propulsion System. While unlikely, the possibility exists for both Command and Control links to malfunction. Two possible scenarios exist in this case. Outcomes and actions depend on the functionality of the UAV autopilot. If the GeoStar retains a functioning autopilot, RTL will be commanded upon loss of either link and the aircraft will return and orbit over the launch point at a predetermined altitude.

a. Simultaneous Primary RC and Telemetry Links Lost – Autopilot Functional. A functional Autopilot affords options in dealing with a complete Command and Control Link loss. As discussed earlier, a loss of either link will trigger an automatic RTL and loiter over the launch point at a safe, pre-determined altitude. This affords time to troubleshoot each system and ideally perform an immediate Parachute Recovery. If contact cannot be regained, the UAV will orbit at the launch site until Main Propulsion batteries are exhausted. As the main propulsion battery voltage diminishes, a slow circling descent at approximately 40mph will occur at the launch point until ground impact. Since the autopilot/avionics circuit is independently powered, the autopilot will continue to command a 40 meter orbit radius throughout this descent.

b. Simultaneous Primary RC and Telemetry Links Lost – No Autopilot Functional. While extremely unlikely, this scenario represents the "worst case" scenario to an airborne GeoStar UAV. All Failsafe parameters are stored in the Autopilot and a malfunction of this system could disable Failsafe logic and control performance. A complete loss of Primary RC and Telemetry links as well as autopilot functions and failsafe modes will likely result in uncontrolled/uncommanded flight. UAV actions depend on the nature of the autopilot malfunctions and the resulting inputs to the flight control servos. If the UAV fails to RTL, fails to respond to control inputs or mode changes from either Command and Control link, the UAV Pilot and crew have few options. If the UAV remains in stable flight despite complete loss of both links and Autopilot, troubleshooting at the GCS shall be attempted to regain Command and Control. The long connectivity ranges afforded by both the Primary RC and Telemetry Link help in this regard. If the UAV continues to fly away in stable flight, it could potentially do so until the Main Propulsion batteries are exhausted. In a clean configuration and neutral flight control surfaces, an unpowered gliding descent at approximately 40mph and 100-500fpm will occur until ground impact.

GeoStar sUAS Lost Link/Failsafe Descriptions – Low Voltage Failsafes. The GeoStar UAV autopilot system is capable of monitoring the voltage and current levels of the avionics circuit. With the avionics circuit batteries having over a much longer duration than main propulsion batteries, the likelihood of an avionics low-voltage scenario is remote. The failsafe remains a useful tool in the event of a battery malfunction. Low voltage conditions in this circuit will trigger one of two automated failsafe responses to maintain UAV functionality and effect a safe recovery.

a) 1st Low Voltage Threshold. When avionics voltage drops below 7.0 volts, an audible alarm announces

"WARNING - LOW VOLTAGE"

b) 2nd Low Voltage Threshold. When avionics voltage drops below 6.8 volts, automatic RTL is initiated.

GeoStar sUAS General Operating Parameters

Proximity to Airports: Operating under the provisions of COA 2014-CSA-35, AeroLogix is not allowed to operate the GeoStar sUAS within 2nm of the public airports in or near Le Sueur County. We are allowed to operate within the Class E surface area near the uncontrolled Mankato airport (KMKT) provided we remain outside of 2nm and monitor the CTAF frequency. We are required to terminate the flight/exit the KMKT Class E Surface Area when aircraft broadcast intentions to depart or land on certain runways. These limitations have not significantly impacted operations. AeroLogix requests the same authorizations for uncontrolled airport proximity as previously granted in COA 2014-CSA-35.

With potential commercial operations in many different areas, AeroLogix recognizes the need for greater planning and coordination when operations are desired near or within controlled airports and airspace. AeroLogix anticipates additional requirements/limitations in this regard with a 333 exemption. We request consideration and authorization of GeoStar sUAS operations in Class D and C airspace provided prior coordination and approval with appropriate ATC is conducted and postive communications can be assured.

Operations within Mode C Veils: Operating under the provisions of COA 2014-CSA-35, AeroLogix is authorized to operate the GeoStar sUAS in a portion of the MSP Mode C veil without a transponder, provided operations remain in Class G airspace and prior coordination with Minneapolis Approach ATC is performed. The dual command and control systems were deemed appropriate mitigation for the requirements of 14 CFR 91.215. As COA 2014-CSA-35 states:

"The GeoStar separate Command and Control links and ATC approval are acceptable mitigations for 14 CFR 91.215 requirements in the absence of a Mode C transponder."

AeroLogix requests the same authorizations for operations within Mode C veils as previously granted in COA 2014-CSA-35.

Proximity to Densely Populated Areas: Operating under the provisions of COA 2014-CSA-35, AeroLogix is not allowed to operate the GeoStar sUAS over densely populated areas. These are generally depicted on FAA Sectional and Terminal Area Charts in yellow. AeroLogix <u>is not</u> seeking authorization to operate over densely populated areas and only requests the same authorizations previously granted in COA 2014-CSA-35.

Weather Minimums: Operating under the provisions of COA 2014-CSA-35, AeroLogix operates the GeoStar UAV in day VMC conditions with at least 3sm of visibility and a ceiling no lower than 1000'AGL. The following conditions were prescribed.

Unless otherwise authorized as a special provision, all operations must be conducted in visual meteorological conditions (VMC) during daylight hours in compliance with Title 14 of the Code of Federal Regulations (CFR) Part 91 §91.155 and the following:

…Special Visual Flight Rules (VFR) operations are not authorized.

…VFR cloud clearances specified in 14 CFR Part 91 §91.155, must be maintained, except in Class G airspace where Class E airspace visibility requirements must be applied, but not less than 3 statute miles (SM) flight visibility and 1000' ceiling.

…Night operations are prohibited unless otherwise authorized as a special provision.

AeroLogix requests the same authorizations for operational weather minimums as previously granted in COA 2014-CSA-35.

Operations within Visual Line Of Sight: Operating under the provisions of COA 2014-CSA-35, GeoStar sUAS operations must remain in visual contact with the UAV Pilot or up to one qualified observer. The Observer must remain in constant radio contact with the UAV Pilot and Telemetry Operator whenever the GeoStar flies beyond the visual range of the UAV Pilot. No "daisy-chains" of observers are allowed. AeroLogix does not seek operations with multiple observer "daisy chains" or any operations beyond visual range. AeroLogix only requests the same authorizations as previously granted in COA 2014-CSA-35.

Compared to many sUASs, the GeoStar is a much larger aircraft (13' wingspan) and has a distinctive shape and coloring to facilitate visual contact. Flight testing the GeoStar UAV at altitudes of 300-550 feet AGL revealed visual contact can be maintained to approximately 1sm with the unaided eye.

GeoStar UAV in Flight

GeoStar sUAS – Operational Scenarios

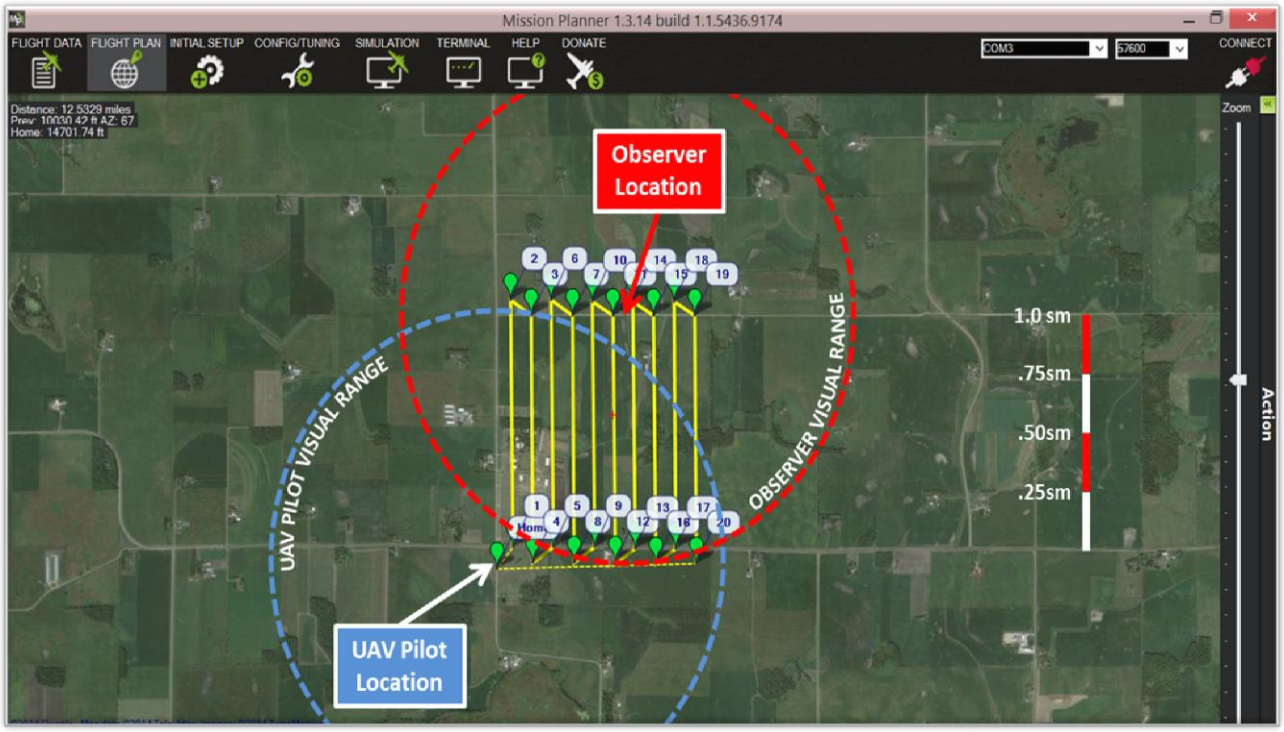
Operational Scenarios – General: Operating under the provisions of COA 2014-CSA-35, GeoStar sUAS operations are limited to a maximum altitude of 600 feet AGL while also being required to comply with 14 CFR 91.119 (Minimum Safe Altitudes) – requiring a 500 foot clearance from objects or persons on the ground. As a result, the current GeoStar imaging system is optimized for collections in the 500-600 foot AGL range. Flight operations in 2014 revealed this to be a practical altitude block for the GeoStar sUAS. AeroLogix does not seek exemption from 14 CFR 91.119 or operational altitudes higher than 600 feet. We only request the same altitude authorizations previously granted in COA 2014-CSA-35. AeroLogix anticipates three types of collection scenarios with the GeoStar sUAS.

-Area Survey

-Road/Utility Survey

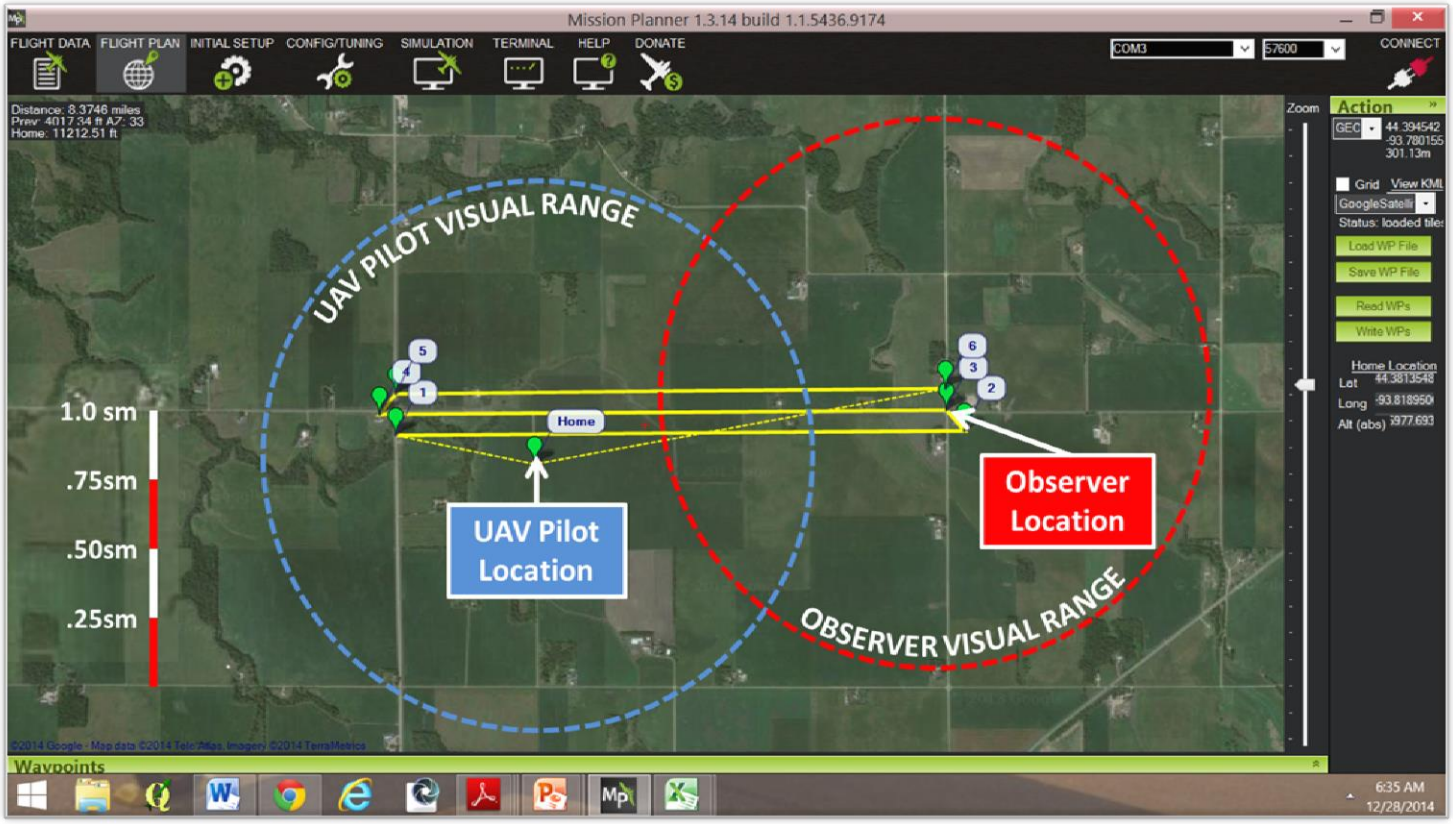
-Irregular Route Survey

Operational Scenario – Area Survey: Area surveys are usually flown with a series of parallel tracks. Track spacing is determined by desired imagery parameters. Operating between 500 and 600 feet AGL with the standard imaging configuration, the GeoStar sUAS can map an area of one square mile in approximately 20-25 minutes. While the GeoStar UAV is capable of flying and collecting much larger areas, additional operational and technical factors come into play that make larger areas less practical. AeroLogix intends to scale each area collection flight to one square mile or less. When conditions dictate a flight path beyond visual range of the UAV Pilot, AeroLogix will post a qualified observer. A standard 1sq mile area collection is depicted below:



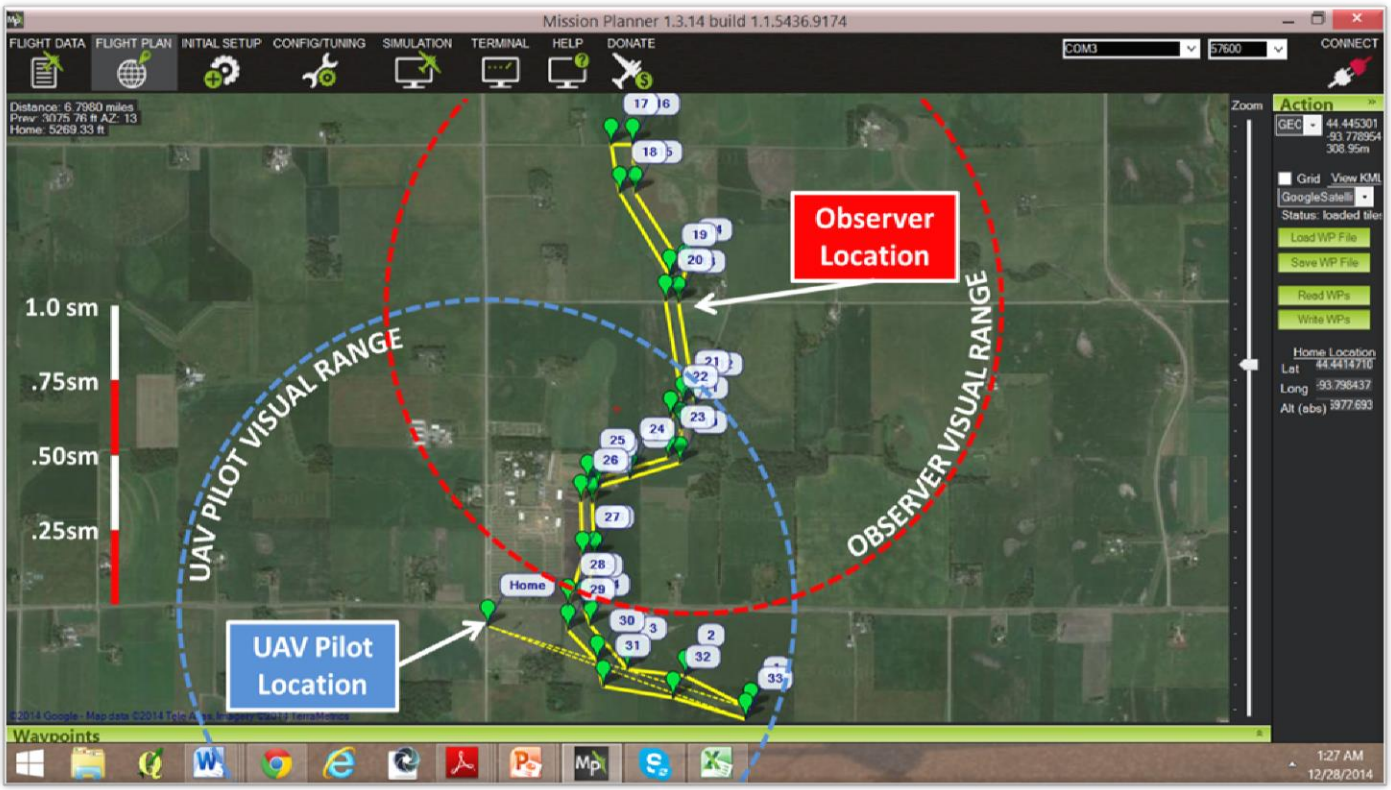
1sq Mile Area Survey Plan Depiction

Operational Scenario – Road/Utility Survey: Road and utility surveys are another highly anticipated mission for the GeoStar sUAS. The GeoStar sUAS can create survey grade imagery and engineering products on short notice and at a significant cost savings to public and private organizations. AeroLogix intends to collect these surveys in segments of up to 2sm, generally flying 3 parallel tracks. Limiting the segments to 2sm or less insures the UAV remains within visual range of the UAV Pilot and up to one observer. It also affords a generous excess of connectivity ranges. Flying 3 parallel tracks, a linear 2-mile segment can be collected in approximately 12-15 minutes. A typical 2sm road survey is depicted below:



2 Statute Mile Road Survey Depiction

Operational Scenario – Irregular Route Survey: Many anticipated collections will involve irregular flight paths in order to accurately survey non-linear agricultural ditches, rivers, streams and roads. Most collections will involve closely spaced parallel tracks along the path, collecting overlapping photos on both tracks. AeroLogix intends for the GeoStar to remain within 2sm of the launch point, to insure the UAV remains within visual range of the UAV Pilot and up to one observer. It also affords a generous excess of connectivity ranges. Depending on route geometry, most collections will be completed in 15-20 minutes. The route depicted below can be collected in approximately 15 minutes, including time for launch, climb and recovery.



Irregular Route Survey – Agricultural Ditch

SECTION III - SPECIFIC CFR EXEMPTION REQUESTS & SUPPORTING EXPLANATIONS

14 CFR Part 21, Subpart H: Airworthiness Certificates
14 CFR § 91.203(a)(1) Certifications Required

14 CFR Part 21, Subpart H, establishes the requirements for the issuance of airworthiness certificates;

14 CFR 91.203(a)(1) establishes the requirement for all civil aircraft to have a Certificate of Airworthiness

Explanation Supporting Exemption

The FAA publication, "Public Guidance for Petitions for Exemption Filed under Section 333" Rev. 9/25/2014, states:

Section 333 of the Reform Act grants the Secretary of Transportation authority to determine:

1. If an unmanned aircraft system, as a result of its size, weight, speed, operational capability, proximity to airports and populated areas, and operation within visual line of sight does not create a hazard to users of the national airspace system or the public or pose a threat to national security; and

2. Whether a certificate of waiver, certificate of authorization, or airworthiness certification under 49 USC § 44704, is required for the operation of unmanned aircraft systems identified under paragraph (1).

AeroLogix respectfully submits that airworthiness certification under Part 21 is not required for safe operation of the GeoStar sUAS in the NAS. Operating under the provisions of COA 2014-CSA-35, GeoStar sUAS flight operations were authorized by the FAA without an Airworthiness Certificate. Le Sueur County was allowed to certify GeoStar UAV airworthiness as a public aircraft and to dispatch AeroLogix and the GeoStar sUAS on aerial survey missions throughout most of the county. AeroLogix and Le Sueur County worked jointly to develop and document the procedures for safe operation and continued airworthiness of the GeoStar sUAS. This documentation is provided with our application. With successful flight operations and smooth integration into the NAS in 2014, AeroLogix has successfully demonstrated its competence in designing, constructing, maintaining and operating the GeoStar sUAS in the NAS.

The GeoStar UAV has proven to be an airworthy, safe and reliable sUAS aircraft. The size, weight and speed parameters were described earlier in detail along with a full description of innovative design features that enhance safety. While meeting the FAA criteria for sUAS systems, the GeoStar sUAS design surpasses many current sUAS systems in safety and redundancy features.

From an operational perspective, AeroLogix intends to operate the identical GeoStar sUAS system under similar operational and airspace conditions as previously vetted and approved by the FAA in COA 2014-CSA-35. AeroLogix intends short duration flights in rural, sparsely populated areas, within visual range and in compliance with 14 CFR 91.119. All GeoStar operations will be conducted by a certificated Private Pilot or FAA prescribed alternative qualification.

Collectively, we believe these factors combine to fulfill the conditions expressed in Section 333 and merit worthy consideration for exemption as expressed in the Reform Act. We assert that by design, operational intent and by successful NAS integration already demonstrated in 2014, that the GeoStar sUAS will achieve equivalent or greater levels of safety as those demonstrated by conventional providers of Aerial Survey.

14 CFR § 45.23 Display of marks; general.
14 CFR § 45.25 Location of marks on fixed-wing aircraft.
14 CFR § 45.29 Size of marks.

14 CFR 45.23 (a,b)	*Establishes required markings for aircraft and additional markings requirements for Limited, Restricted, Light Sport, Experimental or provisionally certificated aircraft*
14 CFR 45.25 (a,b)	*Establishes locations for prescribed markings*
14 CFR 45.29(a,b (1))	*Establishes marking size criteria for fixed wing aircraft*

Explanation Supporting Exemption

The first GeoStar sUAS airframe was required to be registered with the FAA and an application was submitted in December 2014. Approval and assignment of a registration "N" number is pending approval as of this writing. AeroLogix will be registering all subsequent GeoStar airframes as they are completed.

Due to the aircraft size, it is not possible to comply with the size and location requirements expressed above. A request for an alternate form of compliance was filed with AFS-86, UAS Airworthiness Section and has been approved. The approved alternative involves 4-inch letters affixed to upper and lower wing surfaces and 1-inch letters on either side of the vertical stabilizer/rudder. AeroLogix respectfully requests that subsequent GeoStar UAV airframes be authorized marking in accordance with the approved alternative marking scheme for the first GeoStar airframe.

Proposed "N" Number Marking Locations – (Pending Approval with FAA)

14 CFR § 61.113 Private Pilot Privileges and Limitations: Pilot In Command
14 CFR § 61.133 Commercial Pilot Privileges and Limitations.

14 CFR 61.113 (a,b)	*Limits Private Pilots to non-commercial operations*
14 CFR 61.133 (a)	*Establishes Pilot in Command certification requirements of an aircraft used for compensation or hire.*

Explanation Supporting Exemption

AeroLogix respectfully seeks exemption to allow the Pilot in Command of the GeoStar sUAS to conduct commercial sUAS operations with a Private Pilot Certificate or FAA authorized alternative. GeoStar sUAS flight operations under COA 2014-CSA-35 prescribed a minimum acceptable Pilot in Command (PIC) as:

...The PIC must hold, at a minimum, a current FAA private pilot certificate or the FAA accepted agency equivalent, based on the application or 14 CFR Part 61.under all operations:

(1) Approved for flight in Class A, B, C, D, E, and G (more than 400 feet above ground level (AGL)) airspace

...Operations without a pilot certificate may be allowed when all of the following conditions are met:

(1) The PIC has successfully completed, at a minimum, FAA private pilot ground instruction and passed the written examination, or the FAA accepted agency equivalent, based on the application.

AeroLogix intends to operate the identical GeoStar sUAS system under similar operational and airspace conditions as previously vetted and approved by the FAA in COA 2014-CSA-35. We respectfully request the same authorizations with regards to Pilot qualifications. AeroLogix recognizes that UAS operational safety is greatly enhanced by the knowledge and experience that come with a Pilot certificate and recent flying experience of conventional aircraft in the NAS.

14 CFR § 91.7 (a) Civil Aircraft Airworthiness

14 CFR 91.7 (a)	*States that no person may operate a Civil Aircraft unless it is in an airworthy condition.*

Explanations Supporting Exemption

AeroLogix respectfully seeks exemption from 14 CFR 91.7 (a) due to civil aircraft "airworthiness" generally being defined by the conditions that support the granting of an Airworthiness Certificate in compliance with 14 CFR Part 21. AeroLogix is seeking exemption from the requirements of 14 CFR Part 21 and thus cannot comply with the definition of airworthiness as defined by that Part.

AeroLogix intends full compliance with 14 CFR 91.7 (b) that prescribes a more general definition with the Pilot in Command as being responsible for determining:

...whether that aircraft is in condition for safe flight. The pilot in command shall discontinue the flight when unairworthy mechanical, electrical, or structural conditions occur.

The Pilot in Command assembles the GeoStar UAV at the launch site and performs all preflight assembly and inspection in accordance with the procedures set forth in GeoStar sUAS Operations Manual. This manual is submitted for FAA reference with this application.

14 CFR § 91.9 (b)(2) Civil Aircraft Flight Manual in the Aircraft

14 CFR 91.9 (b)(2)	*(regarding flight manuals)…"is available in the aircraft a current approved Airplane or Rotorcraft Flight Manual, approved manual material, markings, and placards, or any combination thereof."*

Explanation Supporting Exemption

AeroLogix respectfully seeks exemption from 14 CFR 91.9 (b)(2) due to the size and nature of the sUAS and Pilot access to such manuals. AeroLogix submits an equivalent level of safety will be achieved by keeping the GeoStar UAV Operations Manual at the Ground Control Station.

14 CFR § 91.109(a) Flight Instruction

14 CFR 91.109(a)	*Requires flight instruction be conducted in aircraft with fully functioning dual controls.*

Explanation Supporting Exemption

AeroLogix respectfully submits that the GeoStar sUAS is not capable of compliance with this regulation due to the unmanned, remotely piloted nature of its design. Any flight instruction performed with a prospective UAV Pilot shall be conducted with a secondary RC Controller ("buddy box") wired to the Primary RC Controller. The "buddy box" allows the Instructor Pilot to transfer control to the Trainee Pilot's RC controller via a positive push-button switch. If the Instructor Pilot is required to resume control, he simply releases the switch and control is instantly transferred back to the Primary RC Controller and the Instructor Pilot. AeroLogix submits that an equivalent level of safety is achieved with this arrangement as are dual controls in a conventional aircraft.

14 CFR § 91.121 Altimeter Settings

14 CFR 91.121(a)	*Establishes requirements for barometric altimeter settings when operating below 18,000 feet MSL*

Explanation Supporting Exemption

AeroLogix respectfully seeks exemption from 14 CFR 91.121 (a). The GeoStar UAV autopilot system has an internal barometric sensing altimeter that does not incorporate a means to manually adjust for pressure variation. Each time the autopilot initializes, the altimeter automatically calibrates and establishes the initialization altitude as zero (0) feet AGL. All altitudes referenced and used by the autopilot are in AGL values. GPS altitudes are available as a secondary altitude reference in the event of a barometric altimeter failure. Failsafe logic automatically reverts to GPS altitudes in the event of a barometric altimeter failure. AeroLogix submits that an equivalent level of safety will be achieved by the automated altimeter calibration and GPS failsafe logic.

14 CFR § 91.151 (a)(1) Fuel Requirements for Flight in VFR Conditions.

14 CFR 91.151(a)(1,2) (a) No person may begin a flight in an airplane under VFR conditions unless (considering wind and forecast weather conditions) there is enough fuel to fly to the first point of intended landing and, assuming normal cruising speed—

(1) During the day, to fly after that for at least 30 minutes;

Explanations Supporting Exemption

While the GeoStar UAV is capable of complying with this regulation for many projected mission profiles, AeroLogix respectfully requests exemption from the requirements of 91.151 for GeoStar sUAS. Compliance with this regulation requires loading of additional batteries and increases the weight of the GeoStar UAV. While performance is satisfactory at the maximum weight of 25 lbs., a shorter reserve requirement would allow fewer batteries and lighter weights for shorter mission profiles. This would allow greater efficiency, shorter takeoff and landing runs, less stressful parachute recoveries and better management of battery packs in the field. Operating with the 12,000 mAh "twin pack," most projected mission profiles can be launched, flown and recovered while maintaining a 15 minute reserve capacity. GeoStar flight operations in 2014 demonstrated that 15 minutes would be an adequate reserve capacity based on the following criteria:

1) Proximity to launch and recovery location. The GeoStar UAV launches and recovers from the same location. Maximum ranges shall not exceed approximately 2sm for most projected operations. At cruising speed, the GeoStar requires only 2-3 minutes of flight time to return to the launch/recovery location.

2) Short Duration Flights. 91.151 contemplates a pilot/passenger-carrying flight to a destination airfield in VFR conditions. The prescribed reserve affords a limited measure of dealing with slower-than-projected groundspeeds en route or delays getting into the arrival airport. These issues are generally not a consideration for the GeoStar sUAS as it operates for relatively short periods of time and within a very short distance of the launch/recovery point.

3) Excess Reserve Capacity Aggravates "Lost Link/Flyaway" Scenarios. While extremely unlikely to occur, the possibility exists for a malfunction to cause uncommanded flight for the duration of the main propulsion batteries. 30+ minutes of reserve capacity could compound the issues faced in this scenario by potentially causing the UAV to fly away farther and higher. 15 minutes of reserve capacity is sufficient to perform all GeoStar sUAS lost-link troubleshooting procedures and would limit the maximum range attainable in a flyaway scenario.

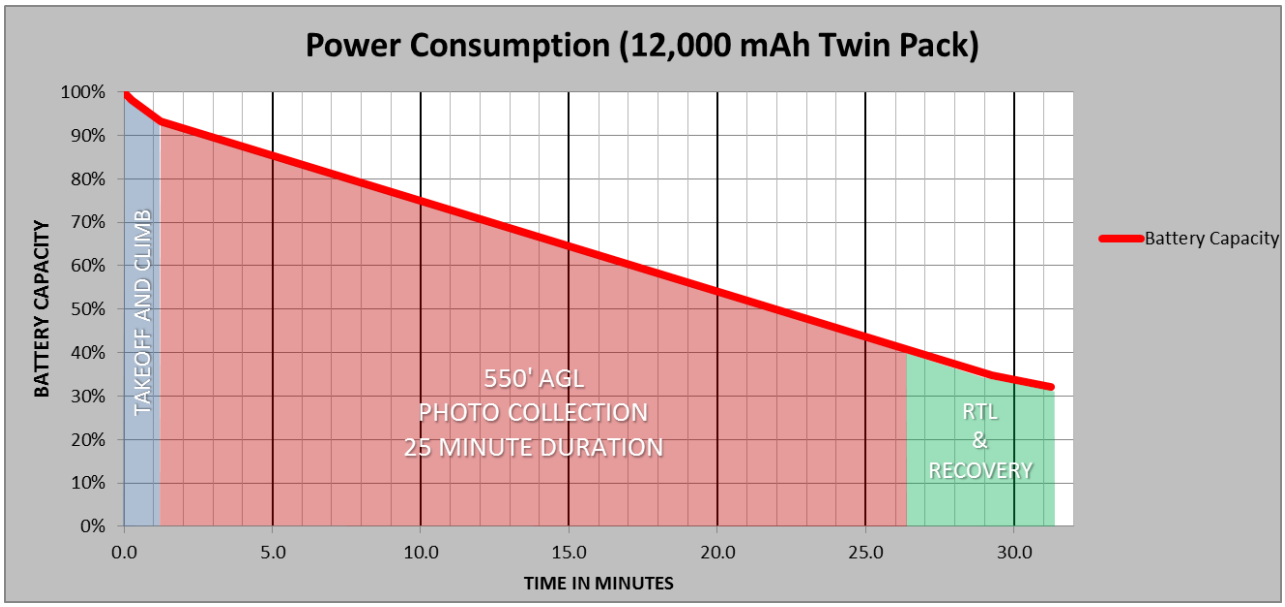
4) Independent Power Circuits for Avionics, Telemetry and Main Propulsion. The GeoStar sUAS telemetry and avionics circuits are not dependent on the main propulsion batteries for their endurance and reserve capacity. These batteries will continue to control gliding flight and/or command parachute deployment for 2-2.5 hours beyond the main propulsion batteries' maximum endurance.

5) Telemetry data for real-time status of the main propulsion batteries. The main propulsion battery voltage level and current flow is fed to the GCS via telemetry link. The UAV Pilot is able to monitor this data in real time and assess battery condition and motor performance as a mission progresses.

6) Projected Flight Profiles and Battery Loads. A 15 minute reserve allows much better loading flexibility for the GeoStar sUAS. While most anticipated missions will be flown in less than 30 minutes, the GeoStar imaging system can be fitted with a variety of lenses that deliver imaging "footprints" of different sizes. Capturing very high-resolution images with smaller footprints can require longer flight times to capture an equivalent area. Flight profiles for the different battery configurations are depicted in the tables and graphs below. The "Amp Draw" value during the "Collect" phase is an average value. The actual rate varies as the battery voltage diminishes over time and as the autopilot manages the power level during the collections. Rates are based on actual GeoStar telemetry feeds when operating at temperatures of 25^0-50^0 F.

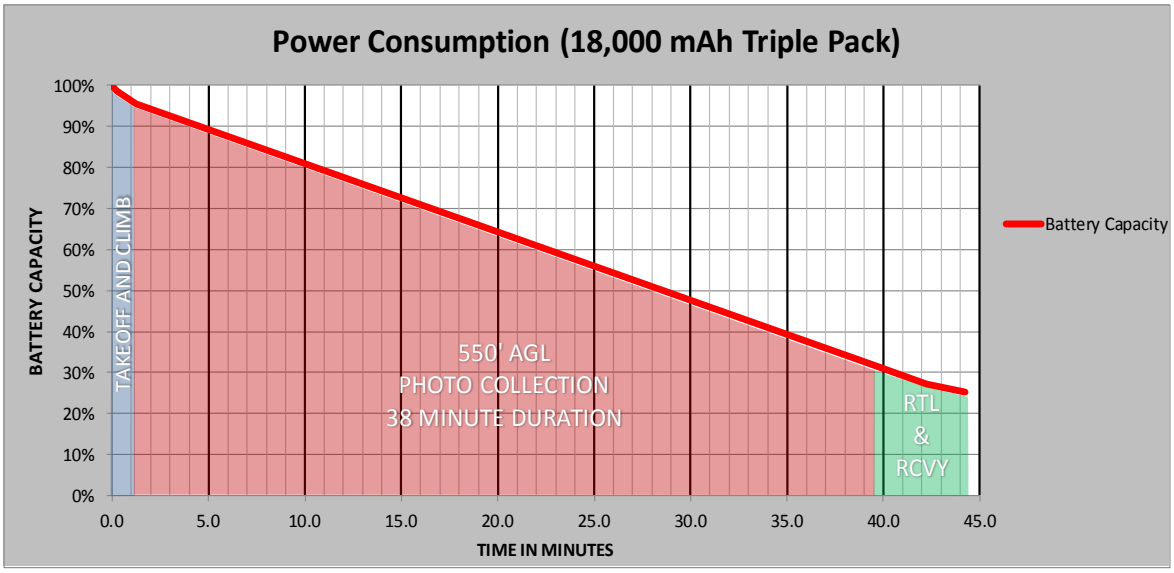
a) 12,000mAh Twin Pack Battery Endurance Profile. Allowing for a 15 minute reserve, this battery load allows a collection of up to 25 minutes and overall flight profile of just over 31 minutes. The majority of likely operations will fall within this flight profile.

Flight Phase	Amp Draw	Duration	Capacity Used (mAh)	Capacity Remaining (mAh)	Capacity Percentage Remaining	Minutes Elapsed	**Minutes Remaining In Cruising Flight**
Start	0	0	0	12000	100%	0.0	**48**
Takeoff	56	0.25	233	11767	98%	0.3	**47**
Climb	35	1	583	11183	93%	1.3	**45**
Collect	15	25	6250	4933	41%	26.3	**20**
RTL	15	3	750	4183	35%	29.3	**17**
Approach/Landing	10	2	333	3850	32%	31.3	**15**
12,000mAh Battery Capacity - 21 Lbs.							



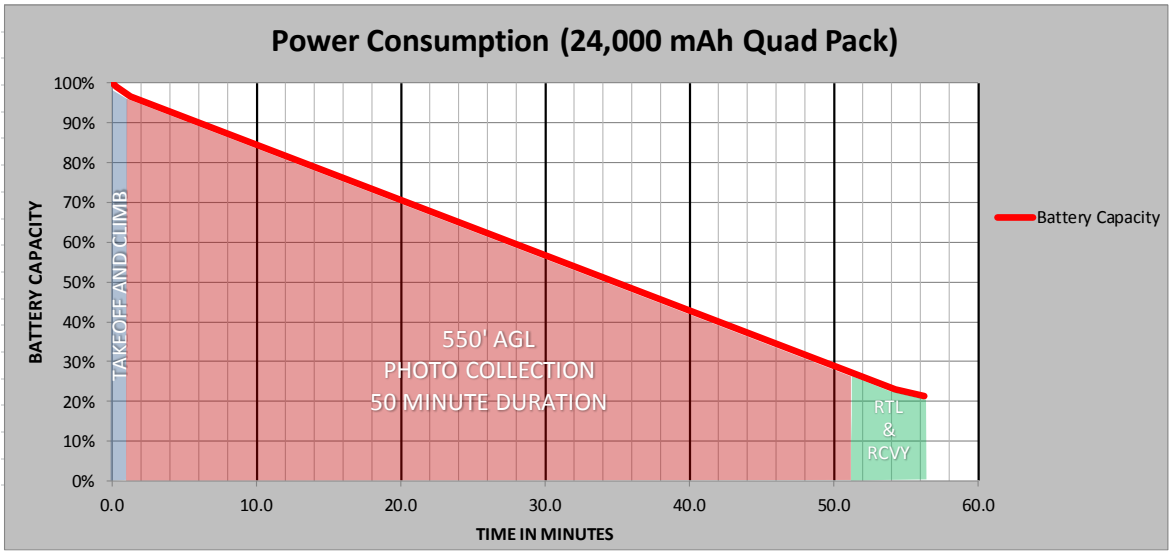
b) 18,000mAh Triple Pack Battery Endurance Profile. Allowing for a 15 minute reserve, this battery load allows collections of up to 38 minutes and an overall flight profile of approximately 45 minutes.

Flight Phase	Amp Draw	Duration	Capacity Used (mAh)	Capacity Remaining (mAh)	Capacity Percentage Remaining	Minutes Elapsed	**Minutes Remaining In Cruising Flight**
Start	0	0	0	18000	100%	0.0	**60**
Takeoff	56	0.25	233	17767	99%	0.3	**59**
Climb	35	1	583	17183	95%	1.3	**57**
Collect	18	38	11400	5783	32%	39.3	**19**
RTL	18	3	900	4883	27%	42.3	**16**
Approach/Landing	11	2	367	4517	25%	44.3	**15**
18,000mAh Battery Capacity - 23 Lbs.							



c) 24,000mAh Quad Pack Battery Endurance Profile. Allowing for a 15 minute reserve, this battery load allows collections of up to 50 minutes and overall flight profile of approximately 56 minutes.

Flight Phase	Amp Draw	Duration	Capacity Used (mAh)	Capacity Remaining (mAh)	Capacity Percentage Remaining	Minutes Elapsed	**Minutes Remaining In Cruising Flight**
Start	0	0	0	24000	100%	0.0	**72**
Takeoff	56	0.25	233	23767	99%	0.3	**71**
Climb	35	1	583	23183	97%	1.3	**70**
Collect	20	50	16667	6517	27%	51.3	**20**
RTL	20	3	1000	5517	23%	54.3	**17**
Approach/Landing	12	2	400	5117	21%	56.3	**15**
24,000mAh Battery Capacity - 25 Lbs.							



6) Summary. Since the first GeoStar test flight, the compiling of battery consumption and performance data has been a primary objective. AeroLogix can now accurately predict the endurance for the various battery configurations and monitor performance in real time against this data. AeroLogix respectfully submits that when consideration is given to the GeoStar sUAS operational parameters, systems redundancy, telemetry data feeds and the improved flight performance gained by flexible loading options, an equivalent level of safety can be achieved with 15 minutes of reserve capacity for main propulsion batteries.

14 CFR § 91.207 (a)(1) Emergency Locator Transmitters (ELTs).

14 CFR 91.207 (a)(1)	*Establishes the requirement that all US-Registered Civil Aircraft must attach an approved, automatic ELT.*

Explanations Supporting Exemption

AeroLogix respectfully seeks exemption from 14 CFR 91.207 (a)(1). The size and weights of available ELT systems preclude their installation into the GeoStar UAV. AeroLogix submits that an equivalent level of safety to an ELT system is achieved with the real-time telemetry feed of the UAV's position and operations within visual range.

14 CFR § 91.307 (a) Parachutes and Parachuting

14 CFR 91.307 (a)	*Establishes: No pilot of a civil aircraft may allow a parachute that is available for emergency use to be carried in that aircraft unless it is an approved type and has been packed by a certificated and appropriately rated parachute rigger—.*

Explanations Supporting Exemption

The AeroLogix GeoStar UAV utilizes a 12' or 14' parachute for use in both normal and emergency recoveries. The parachute is of a very lightweight design and synthetic material originally used in amateur rocketry. "Approved Type" parachutes for use by human parachutists are not of a practical size or weight to be compatible with the GeoStar UAV. AeroLogix submits that this regulation is not applicable to the GeoStar sUAS and respectfully seeks exemption.

14 CFR Subpart E Maintenance, Preventative Maintenance and Alterations

14 CFR § 91.405 (a) **Maintenance Required**
14 CFR § 91.407 (a)(1) **Operation After Maintenance, Preventative, Rebuilding or Alteration**
14 CFR § 91.409 (a) (1)(2) **Inspections**
14 CFR § 91.417 (a)(b) **Maintenance Records**

14 CFR Subpart E	*Establishes maintenance requirements for US-Registered Civil Aircraft.*

Explanations Supporting Exemption

The regulations cited above prescribe maintenance requirements and recordkeeping for aircraft maintained in accordance with Part 43. Aircraft of this type are those that have an Airworthiness Certificate and have met the requirements for certification under 14 CFR 21 Part H. The AeroLogix GeoStar sUAS is seeking exemption from the requirements of an Airworthiness Certificate. If granted, the exemption will nullify the requirements cited above.

GeoStar sUAS flight operations under COA 2014-CSA-35 prescribe maintenance and maintenance record keeping in the following manner:

"…Software and hardware changes should be documented as part of the normal maintenance procedures. Software changes to the aircraft and control station as well as hardware system changes are classified as major changes unless the agency has a formal process, accepted by the FAA. These changes should be provided to the UAS Integration office in summary form at the time of incorporation."

"…All previously flight proven systems to include payloads, may be installed or removed as required, and that activity recorded in the unmanned aircraft and ground control stations logbooks by persons authorized to conduct UAS maintenance Describe any payload equipment configurations in the UAS logbook that will result in a weight and balance change, electrical loads, and or flight dynamics, unless the agency has a formal process, accepted by the FAA."

"…For unmanned aircraft system discrepancies, a record entry should be made by an appropriately rated person to document the finding in the logbook. No flights may be conducted following major changes, modifications or new installations unless the party responsible for certifying airworthiness has determined the system is safe to operate in the NAS and a new AWR is generated, unless the agency has a formal process, accepted by the FAA. The successful completion of these tests must be recorded in the appropriate logbook, unless the agency has a formal process, accepted by the FAA."

AeroLogix intends to operate the identical GeoStar sUAS system under similar operational and airspace conditions as previously vetted and approved by the FAA in COA 2014-CSA-35. We respectfully request the same authorizations with regards to UAV Maintenance. AeroLogix is the original designer and builder of the GeoStar UAV and intimately familiar with its construction and maintenance. All GeoStar maintenance will be performed by AeroLogix personnel.

Equivalent Safety

The Congressional mandate in Section 333 of the Reform Act allows a limited introduction of commercial Unmanned Aerial Systems (UASs) into the national airspace system in advance of permanent rulemaking, if it can be accomplished safely. As summarized in this document, AeroLogix has designed the GeoStar sUAS with a set of innovative safety features and a focus on systems redundancy that few sUASs can match. AeroLogix seeks to maximize the overall safety potential of a fixed-wing sUAS by both technical achievement and operational professionalism. We respectfully petition the FAA to consider AeroLogix and the GeoStar sUAS as a professional sUAS operation, previously vetted via the public-use COA process and having already demonstrated safe integration of GeoStar sUAS operations into the National Airspace System in 2014. The FAA and general public can have confidence that the operations will achieve an equivalent or greater level of safety as that demonstrated by conventional aerial survey providers.

Public Benefit

The AeroLogix GeoStar sUAS concept began as means to economically serve the aerial survey needs of a rural, southern Minnesota county. On-demand aerial survey by conventional means is a costly undertaking and beyond the economic reach of many public and private entities. The success of the GeoStar sUAS quickly demonstrated that high-resolution GIS imagery and survey grade modeling products were now affordable thanks to the innovations and cost savings derived from using a UAS. The GeoStar sUAS can deliver small scale collections, specifically tailored to each project or need and at an affordable cost. In many cases, these benefits were simply not attainable until now. As highlighted earlier, many publicly funded users of conventional aerial survey services were immediately interested in the cost benefit and operational flexibility demonstrated by the AeroLogix GeoStar sUAS. The following public entities have expressed interest and/or directly requested GeoStar sUAS services:

-US Department of Agriculture/University of Minnesota clover crop research project.
-US Fish and Wildlife Service
-Minnesota Department of Transportation (3 projects)
-Minnesota Department of Soil and Water
-Scott County, Ravine Survey
-Dakota County, Vermillion River Survey
-Minnesota State University Mankato, GIS Department
-University of Minnesota, Aerospace Engineering Dept., Graduate Student Mentorship Program.

A Section 333 exemption would allow much greater flexibility to service these and other publicly funded users of aerial survey services. The economic benefit potential to the public is significant.

From an environmental standpoint, the GeoStar sUAS provides numerous benefits over conventional providers of aerial survey. Being electric powered, the GeoStar UAV is nearly silent when flying at normal collection altitudes. It also operates at a higher altitude than many other sUAS systems that seek similar approval for aerial imaging. Once airborne, it is difficult to distinguish the GeoStar UAV from a conventional aircraft. It does not have the menacing presence of many sUASs but rather displays a graceful, soaring character in flight. These features combine to make it unobtrusive to residents, livestock and wildlife in the rural areas contemplated for operations. The GeoStar sUAS utilizes only a small gasoline-powered generator in the field for power. Burning small amounts of unleaded gasoline, the volume of pollutants is significantly less than that of a conventional aircraft burning leaded gasoline or jet fuel. With electric power, the GeoStar will never deposit pollutants on lakes, farmland or natural areas.

Natural disaster response is another useful public application of the GeoStar sUAS. In the spring and early summer, many areas of southern Minnesota and the Minnesota River valley face flooding due to extreme winter snowfalls. Tornados and other severe weather conditions strike without warning, causing wide-spread devastation. In situations like these, the GeoStar sUAS can be rapidly dispatched to rapidly produce imagery and terrain modeling products to support critical public agency response to such disasters.

AeroLogix submits that many aspects of the GeoStar sUAS are of significant public benefit. A Section 333 exemption will create the opportunity for many more public entities to enjoy the benefits of affordable and efficient aerial survey.

Summary for The Federal Register

Specific Rules Sought For Exemption

AeroLogix Consulting Inc., a Minnesota based builder and operator of advanced Small Unmanned Aerial Systems (sUAS), is seeking an exemption pursuant to Section 333 of the FAA Modernization and Reform Act of 2012. AeroLogix is requesting exemption from the following regulations under 14 CFR:

14 CFR Part 21, Subpart H:	Airworthiness Certificates
14 CFR § 91.203(a)(1)	Certifications Required
14 CFR § 45.23	Display of marks; general.
14 CFR § 45.25	Location of marks on fixed-wing aircraft.
14 CFR § 45.29	Size of marks.
14 CFR § 61.113	Private Pilot Privileges and Limitations: Pilot In Command
14 CFR § 61.133	Commercial Pilot Privileges and Limitations.
14 CFR § 91.7 (a)	Civil Aircraft Airworthiness
14 CFR § 91.9 (b)(2)	Civil Aircraft Flight Manual in the Aircraft
14 CFR § 91.121	Altimeter Settings
14 CFR § 91.151 (a)(1)	Fuel Requirements for Flight in VFR Conditions.
14 CFR § 91.207 (a)(1)	Emergency Locator Transmitters (ELTs).
14 CFR § 91.307 (a)	Parachutes and Parachuting
14 CFR § 91.405 (a)	Maintenance Required
14 CFR § 91.407 (a)(1)	Operation After Maintenance, Preventative, Rebuilding or Alteration
14 CFR § 91.409 (a) (1)(2)	Inspections
14 CFR § 91.417 (a)(b)	Maintenance Records

AeroLogix intends to commercially operate the GeoStar sUAS in rural areas for public and private customers. The GeoStar sUAS performs aerial survey to produce imagery and terrain modeling products useful in applications ranging from civil engineering, land and water resource management, environmental research, disaster response, agriculture and many others useful applications. The FAA has previously approved AeroLogix and the GeoStar sUAS for public operations under FAA Certificate of Waiver or Authorization (COA) 2014-CSA-35. This new exemption under Section 333 of the FAA Modernization and Reform Act of 2012 will permit AeroLogix to serve both public and private entities with safe and affordable aerial survey services. The FAA and general public can have confidence that the operations will achieve an equivalent or greater level of safety as that demonstrated by conventional aerial survey providers.