20 January 2015

U. S. Department of Transportation
Docket Management System
1200 New Jersey Ave, SE
Washington, DC 20590
Re: Exemption Request

Re: Petition for Exemption (14 CFR §11.81) by the Federal Aviation Administration ("FAA") for the usage of Small, Unmanned Aerial Systems ("sUAS") for scientific research, air quality monitoring, and geospatial applications.

Dear Sir or Madam,

I, Christopher Rice, President and Founder of Colorado Cartographics, LLC ("CCL"), a consulting firm located in Wheat Ridge, Colorado, am petitioning to be granted exemption from the Federal Aviation Regulations ("FAR") listed in **Section II** of this document. It is my intention to be compliant with the FAA Modernization and Reform Act of 2012, Public Law 112-95, Sections 331-334 ("The Act"), and operate sUAS solely for the purposes defined in **Section III** of this document.

CCL is a consulting firm that provides geospatial, surveying, and geosciences services to a wide range of industries in the United States. The company leverages the capacities of mapping software, GPS systems, and surveying equipment to provide these services to industries that rely on them for regulatory compliance, public safety, and asset management. Being positioned in this highly competitive industry requires a significant investment in the aforementioned software and hardware products, but to also be aware of forthcoming technological developments. The sUAS is among a group of several technological developments that CCL considers to be a tool that will have a positive impact on the way we perform data collection, photogrammetry, air quality monitoring, and visual documentation methodologies, all of which are services we provide for our customers.

Section I. Petitioner Contact Information

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Section II. The specific Sections of Title 14 CFR that CCL wishes to seek exemption:

1. Chapter 1, Subchapter C, Part 21, Subpart H
2. Chapter 1, Subchapter C, Part 45, §45.23 (a)
3. Chapter 1, Subchapter D, Part 61, §61.113(a)
4. Chapter 1, Subchapter D, Part 91, §91.7(a)
5. Chapter 1, Subchapter D, Part 91, §91.111(a)
6. Chapter 1, Subchapter D, Part 91, §91.119(d)
7. Chapter 1, Subchapter D, Part 91, §91.121

Section III. Extent of relief and reasons CCL is requesting relief from existing regulations.

CCL is requesting relief from the aforementioned Title 14 CFR regulations so it may engage in sUAS operations for the advancement of applied technologies that will benefit both the company, customers, and the scientific and geospatial community. The extent by which CCL seeks relief is exclusive for the applications listed below:

- **Photogrammetry Applications:** By using fixed, downward-facing cameras, photogrammetry enables creation of overlapped aerial images for use in geospatial software (GIS), ground-truthing, and visual documentation. CCL is presently able to process aerial imagery, and strives to provide rapid delivery of high-resolution ortho-rectified images for clients requesting these products. The advantages of using sUAS versus manned aircraft are: significant cost reduction, safety considerations, and imaging from lower altitudes below current regulations (Appendix A, Figure 1).

- **Light Detection and Ranging ("LiDAR"):** This technology is used for generating high-resolution surface models of land topography, civic features, and building interiors. Commonly, LiDAR systems are attached to a manned helicopter or a fixed-wing aircraft, however, some manufacturers are rapidly developing lightweight units designed for sUAS. Deploying sUAS with LiDAR capability reduces costs greatly, benefiting all stakeholders. CCL is planning to use LiDAR systems onboard sUAS to generate topographical surfaces of mining sites, reclamation areas, and land development locations. LiDAR also aids in calculating volumetric analysis for waste pile removal, Earth-moving cost evaluation, and slope severity studies (Appendix A, Figure 2.).

- **Infrared ("IR") and Thermal Imaging:** Both technologies detect surface features at frequencies beyond the visual spectrum, enabling advanced data visualization for a wide range of industries. Examples of IR imaging include: vegetative analysis and chemical spill identification. Thermal imaging examples include: surface heat signature, heat loss, pipeline conditional assessments, and efficiency studies of building structures and residences. IR and thermal imaging sensors fitted to sUAS benefit from low flight costs, flight precision, and rapid data acquisition. CCL has yet to acquire an IR/thermal imaging apparatus, but we are planning to prototype thermal imaging for our energy customers who have expressed an interest in checking midstream pipelines for potential leaks and/or

valve gasket failures. The costs associated with thermal and IR sensing equipment are prohibitive, yet funding by potential investors or corporate research grants would assist in fulfilling these valuable research methods for our sUAS fleet.

- **Air Quality Monitoring:** In an effort to assist energy companies with environmental compliance, it is our intention to utilize the sUAS for fixed-interval methane monitoring at fixed altitudes ranging from 25' - 200' Above Ground Level ("AGL") near natural gas separation, flaring, and compressor sites. Using sophisticated monitoring equipment designed for sUAS payloads, coupled with onboard telemetry, we will be able to gather this data while the sUAS is airborne. Together with onboard GPS, the monitoring system logs positions of air quality samples, providing a geospatial component for map creation, and interpretation. CCL is currently collaborating with a natural gas company, researching and designing a mobile monitoring system for sUAS that is portable, lightweight, and communicates with onboard telemetry systems for real-time data acquisition.

Section IV. How CCL's Exemption Request will benefit the Public as a whole.

The sUAS platform provides a significant benefit to industries that create advantages for deployment of technologies listed in **Section III**, and the consequent benefits to the Public are listed below:

- A direct result of a sUAS's ability to provide a much more affordable alternative to manned vehicle operations is ultimately a lower cost to end consumers, especially if the organization cannot absorb such costs. The economic benefits of operating sUAS versus the combined costs of operating a helicopter or fixed-wing aircraft are significant for these reasons:

    1. Aircraft/pilot/air traffic control costs can be prohibitively expensive, and the FAR altitude restrictions (14 CFR §91.119) may affect value of resulting product,
    2. Fuel surcharge fluctuations passed on to organizations hiring aircraft services,
    3. Fossil fuel emissions as a result of operating manned aircraft versus electric-powered sUAS,
    4. Decreased noise pollution,
    5. Fewer or nonexistent innate dangers due to catastrophic manned aircraft failures resulting in death, damage to property, and potential legal disputes,
    6. Job creation.

- A sUAS's ability to operate in conditions and airspace where manned aircraft are limited or forbidden provides growth in areas where human interests and public health concerns exist. One such example of this application is the natural gas industry, which CCL currently provides many services for. As exploration and production operations encroach on human population areas, issues concerning air quality arise. The implementation of sUAS fitted with air quality monitoring sensors (or ground sensing equipment) enables accurate samples to further the mitigation process. The low costs resulting from sUAS

operation greatly increase the interval time between flights, resulting in higher aggregation of relevant study data over time periods where short times between acquisition is fundamental.

- A secondary goal of CCL's exemption is to develop awareness of sUAS capabilities for the geospatial industry, but also for local communities in Colorado. The issues surrounding sUAS usage range from privacy and civil rights, to illegal usage in National Parks. In an effort to communicate awareness of the importance of sUAS introduction into our communities, CCL is working alongside community leaders and public institutions (local libraries, schools, and community centers) to educate the public, assist with clarifying sUAS guidelines and restrictions, and communicate potential future applications. Lastly, CCL is an advocate for campaigns such as "Know Before You Fly", to spread the message about sUAS restrictions and safety. Our number one goal is to foster a sense of safety but also provide an open dialogue regarding this rapidly developing technology.

Section V. Reasons why CCL's exemption will not adversely affect safety, or how the exemption would provide a level of safety at least equal to the existing rule.

It is CCL's intention to add sUAS capabilities to its portfolio of products and services for its existing and future customers. The four applications outlined in **Section III** are tailored for industries where risk of human intervention and damage to property are low to nonexistent. In our current areas of interest, we are fortunate to have low population densities, and a trace amount of civil infrastructure and public and private services (i.e. hospitals, hotels, residential subdivisions). Our flight areas encompass an area no larger than ½ of a square mile maximum, limiting any chances of posing additional risks other than ones beyond our control.

CCL has aggregated approximately 100 hours building, testing, and familiarizing ourselves with the flight characteristics of our prototype sUAS fleet, and we fully understand and recognize their capabilities and deficiencies. Furthermore, we have evaluated each units' flight envelope limits, mimicked mid-flight failures, and are in the process of testing parachute deployment to safely return a failed sUAS to the ground in the event of a system failure.

CCL's sUAS Fleet Specifications

CCL's fleet of two (2) prototype sUAS consist of the following characteristics that illustrate their minimal impact to human beings, manned aircraft, and infrastructure:

1. ***DJI F550 Flamewheel Multi-rotor (6-propeller hexagonal frame, plastic/metals):***

- Total weight with maximum allowable payload: 6.5lbs,
- Dimensions: Greatest width: 550mm (21.65in), Height (with landing gear): 10.5"
- Maximum speed: 30kts
- Battery system (4-cell, 14.8 volt, 4000maH lithium-polymer) provides eight (8) to twelve (12) minutes of flight time, and one (1) minute of reserve for RTH function if necessary,

- NAZA-M V2 Flight Controller (with GPS and compass) is installed on this sUAS, and is the most advanced system currently available, with latest firmware release,
- Use of First-Person View ("FPV") for advanced flight safety; provides real-time video-downlink from sUAS to video monitor on transmitter.

2. Tarot T810 Foldable Multi-rotor (6-propeller hexagonal frame, carbon fiber):

- Total weight with maximum allowable payload: 9.3lbs,
- Dimensions: Greatest width: 810mm (31.9in), Height (with landing gear): 14.25"
- Maximum speed: 30kts
- Battery system (2x 6-cell, 22.2 volt, 5000maH lithium-polymer) provides fifteen (15) minutes of flight time, and two (2) minutes of reserve flight time,
- NAZA-M V2 Flight Controller is also installed on this unit,
- Use of First-Person View ("FPV") for advanced flight safety; provides real-time video-downlink from sUAS to video monitor on transmitter.

Flight Controller and Fail-Safe systems

The existing flight control technology that CCL utilizes is the DJI NAZA-M V2 Flight Controller, which provides these safety features:

- **GPS Attitude Control:** Prior to flight operation, the GPS records latitude and longitude, and that position becomes the *origin of flight.* Once airborne, the GPS holds the sUAS in this position, and does not deviate from it, unless the mode is changed by the operator. This level of safety safeguards the sUAS, preventing it from drifting away, and posing a potential risk of injury or damage to property.

- **Attitude Control:** The flight controller disables the GPS, and allows operator to control the sUAS in a manner consistent with manual flight. The onboard stability systems keep sUAS horizontally stabilized, to prevent erratic flight performance.

- **Return-to-Home ("RTH"):** If the operator, under any circumstances, deems the operation of the sUAS to become a risk to persons, property, or the sUAS itself, the RTH command may be invoked, safely returning the sUAS to the *origin of flight*, subsequently landing and powering down autonomously. This feature is a design protocol that allows the operator to dismiss operation in the event of his or her inability to control the sUAS, as in with an emergency situation.

Inherent risks of operating a sUAS

CCL assumes there is risk involved with operating a sUAS. As with any aircraft, manned, or unmanned, unforeseen circumstances beyond the pilot's control do exist. However, proper safety protocols, regularly-scheduled maintenance, and continuous pilot training are essential to minimize these risks. Below are three identified risks that exist that apply to all multi-rotor sUASs, and may lead to failures beyond the Flight Controller's ability to assist in safe recovery and landing:

- **Physical Failures.** In the event of a physical failure, an example being a failed propeller or breach of the sUAS frame's capacity to support normal flight, the NAZA-M V2 flight controller may have limited ability to stabilize the sUAS, resulting in ground impact. This unfortunate occurrence is an innate risk, and must be addressed for safety considerations.

- **Electrical Faults.** This type of failure poses a risk to normal sUAS flight, and may result in sUAS instability and potential ground impacts. Electrical faults may originate in the battery system, receiver, flight controller, flight motors, GPS, or the speed controller units.

- **Wildlife.** In the unlikely event of wildlife strikes, or aggressive wildlife encounters, the sUAS flight characteristics may be severely compromised, resulting in ground impact, property damage, or injury to persons. The aforementioned sUAS parachute system is a fail-safe method for safely returning a sUAS to the ground, and is highly recommended to ensure safe recovery of sUAS and promotes safe operation.

Radio Control and Telemetry Equipment used on CCL sUAS Fleet

CCL's fleet of sUAS multi-rotors are controlled remotely by a Spektrum Dx8, an 8-channel, 2.4GHz transmitter. The FPV systems employ the BosCam 5.8GHz transmitter/receiver combination and a 7" TFT display monitor with a sun hood affixed to the Spektrum transmitter. The usage of a GoPro Hero 4+ enthusiast video camera will be used on the Tarot T810 for higher-resolution FPV video feed.

CCL's Commitment to Safety and Regulatory Compliance

It is CCL's intention to be in full compliance with the statutes set forth by The Act, if an exemption is granted. When the additional Certificate of Authorization ("COA") process is completed thereafter, CCL will be able to operate sUAS in a commercial manner. After all licensing is complete, CCL will enforce a strict set of procedures that will:

- Ensure that each pre-flight checklist is completed before flight operations begin,

- Equip sUAS with flightworthy components and ensure all required spare parts are immediately available, along with proper tools, batteries, chargers, and associated equipment is always on site at each flight location,

- Ensure sUAS manufacturer notifications regarding operational safety and any additional known issues that may affect flight performance are resolved prior to any flight operation, otherwise sUAS will remain grounded,

- Confirm communication between the sUAS and the Flight Transmitter / FPV system is fully functional before any flight operation begins,

- Ensure GPS systems are in full working order and an acceptable level of GPS satellite acquisition is achieved before any flight operation begins,

- If applicable, confirm DJI PC Ground Station flight routine is loaded, and test flights record successful launch, route, and completion,

- Calibrate altimeters using DJI PC Ground Station to the study site's maximum altitude, and limit sUAS altitude to 300' AGL to avoid flight outside of this envelope.

- Ensure a minimum of five (5) miles from any airport exists from closest edge of flight plan area. (Figure 3, Appendix A), and maintain a distance of 500' minimum from people, vehicles, and property.

- If utilizing the PC Ground Station Waypoint Manager, enable the No Waypoint Zones map, which disables positioning of waypoints within five (5) miles of a major airports (Figure 4, Appendix A)

- Never exceed visual line-of-sight distance (VLOS) during flight operations, and set a timer for five (5) minutes at beginning of flight operation, to remind pilot about remaining battery life, and always have a trained spotter not operating the sUAS accompany the pilot,

- Display (if necessary) signage/warning beacons/traffic cones if sUAS usage in close proximity to public right-of-way,

- Be aware of air traffic conditions in the immediate area, by observing existing aircraft flight patterns, changes in wind direction and intensity, and consultation of consumer-grade aviation tracking applications (e.g. FlightRadar24), if necessary,

- Be aware of changing weather conditions that may affect overall flight performance and line-of-sight visibility of sUAS, and always err on the side of caution by grounding sUAS if conditions are likely to worsen,

- Properly adhere to post-flight guidelines, which include: disconnection of circuitry that could result in user injury, storage of all components in proper containers, checking area for any components left behind, and securing any gates at exit from private property,

- Communicate completion of flight operations to constituents, stakeholders, or customers.

- Have in our possession all documentation pertaining to the FAR Exemption, including licenses, medical cards, if applicable.

- Comply with any additional and future regulations enforced by the FAA FAR.

Section VI. Federal Register Rulemaking, CCL reasoning for Exemption.

1. *Title 14, CFR 21: Certification Procedures for Products and Parts Subpart H, Airworthiness Certificates (§21.171 - §21.199).*

   Section 333 of The Act states:

   (1) which types of unmanned aircraft systems, if any, as a result of their size, weight, speed, operational capability, proximity to airports and populated areas, and operation within visual line of sight do 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 section 44704 of Title 49, United States Code, is required for the operation of unmanned aircraft systems identified under paragraph (1).

Reason for Exemption: The operational characteristics of CCL's sUAS fleet, which consist of small size and weight, low speed, a limited geographical extent, together with CCL's compliance with airport and populated area proximity rules, meet the level of safety compliance proposed by Section 333. Paragraph (2) states that if sUAS meet this requirement, exemption from *14 CFR 21, Subpart H* may be granted.

2. *Title 14, CFR §45.23(a),(b): Display of Marks, General*

   (a) Each operator of an aircraft must display on that aircraft marks consisting of the Roman capital letter "N" (denoting United States registration) followed by the registration number of the aircraft. Each suffix letter used in the marks displayed must also be a Roman capital letter.

   (b) When marks include only the Roman capital letter "N" and the registration number is displayed on limited, restricted or light-sport category aircraft or experimental or provisionally certificated aircraft, the operator must also display on that aircraft near each entrance to the cabin, cockpit, or pilot station, in letters not less than 2 inches nor more than 6 inches high, the words "limited," "restricted," "light-sport," "experimental," or "provisional," as applicable.

Reason for Exemption: (a): CCL's sUAS surface areas prevent attachment of a distinguishable registration number greater than 2" in height (applicable only to §45.23b) from a distance equal or greater than 40 feet, unless the usage of optical magnification is employed. The addition of a flag or equivalent surface by which registration number must be visible may inhibit usage of sUAS due to the additional payload weight and potential surface area, which may result in flight instability and/or failure. (b): The classification of sUAS under the current regulatory restriction period is unclear, therefore, this exemption shall remain active.

3. *Title 14 CFR §61.113(a): Private Pilot Privileges and Limitations*

   (a) Except as provided in paragraphs (b) through (h) of this section, no person who holds a private pilot certificate may act as pilot in command of an aircraft that is carrying passengers or property for compensation or hire; nor may that person, for compensation or hire, act as pilot in command of an aircraft.

Reason for Exemption: Due to the nature of sUAS being unmanned, it is not possible to carry passengers. However, property assets for the purposes of scientific research and photogrammetry will consist of the sUAS payload, and the company's pilot in command (sUAS operator) will be compensated for expertise, services, and deliverables as a result of operating the sUAS.

4. *Title 14 CFR §91.7(a): Civil Aircraft Airworthiness*

   (a) No person may operate a civil aircraft unless it is in an airworthy condition.

Reason for Exemption: The aforementioned *14 CFR 21 Subpart H* exemption from requiring airworthiness certificates for sUAS is the reason for this exemption.

5. *Title 14 CFR §91.111 (a): Operation near other aircraft*

   (a) No person may operate an aircraft so close to another aircraft as to create a collision hazard.

Reason for Exemption: Occasionally, sUAS engage in simultaneous flight routines that employ more than one (1) sUAS in a tightly controlled, patterned flight plan based on onboard GPS positioning navigation systems. This method of data collection employs interferometric capture sequences, requiring more than one measurement sensor during the flight routine.

6. *Title 14 CFR §91.119(d): Minimum Safe Altitudes*

   (d) Helicopters, powered parachutes, and weight-shift-control aircraft: If the operation is conducted without hazard to persons or property on the surface, a helicopter may be operated at less than the minimums prescribed in paragraph (b – 1000') or (c – 500') of this section, provided each person operating the helicopter complies with any routes or altitudes specifically prescribed for helicopters by the FAA.

Reason for Exemption: Given that sUAS operators must obey a maximum of 300' AGL, and below the 500' restriction for manned aircraft in non-congested areas, this exemption applies to the routes and altitudes for helicopters specifically, as research areas and areas of interest (AOIs) may exist within these corridors. Additional research on the location of these helicopter-specific flight corridors will be conducted before any flight operations commence.

7. *Title 14 CFR §91.121: Altimeter Settings*

   (a) Each person operating an aircraft shall maintain the cruising altitude or flight level of that aircraft, as the case may be, by reference to an altimeter that is set, when operating… [remainder of Regulation].

Reason for Exemption: sUAS altimeter settings are controlled by the onboard altimeter (GPS-based), or supplemental barometric altimeter for use as a backup and/or altitude validation unit. Additionally, "cruising altitude' does not apply to sUAS within CCL's operational capacities, unless this term is used to describe the altitude by which the actions stated in Section III are considered as such.

Section VII. Additional Information, Views, or Arguments.

Personal Statement

In conclusion, CLL agrees with the FAA's heightened awareness of the issues surrounding the widespread usage of sUAS in the United States. It is an obvious problem with potentially serious consequences if sUAS are operated irresponsibly. Our company is committed to not only fully understanding and abiding by the laws surrounding the usage of sUAS, but to also be an advocate for others to comply with the rules and regulations that exist for the safety of U.S. citizens.

In the scientific and geospatial community, there are numerous applied technologies that influence how research is conducted. These broad industries are consistently on the forefront of the latest and greatest advancements, and in most cases, is the basis of their origin. Remove this ability, and the result is a slowdown of economic growth, fundamental to sustainability. This is the reason why we at CCL believe that the sUAS and its associated benefits are so relevant to the advancement of human development, whether it is to assist farmers with increasing crop yields, or mitigating health risks to thousands of people, its one small step in a long, legislative process that will ultimately benefit us all.

CLL appreciates the opportunity to be able to petition for this exemption, and is fortunate to have the right to do so. The other members of the sUAS community who are passionate about the ability to operate sUAS in the National Airspace System are all advocates for safety and responsibility. CCL is honored to be a part of such a group that sees the long-term benefits of creating sUAS compliance and control, and we greatly appreciate the efforts of the FAA, its Director, and Administrators.

Section VIII. Exemption Outside the United States.

CCL has no intention to operate a sUAS outside the United States.

To the Director and Administration of the Federal Aviation Administration, I hereby submit this Petition for Exemption, dated January 20, 2015.

Respectfully,

Christopher Rice, President
Colorado Cartographics LLC

Appendix A

Figures 1-4

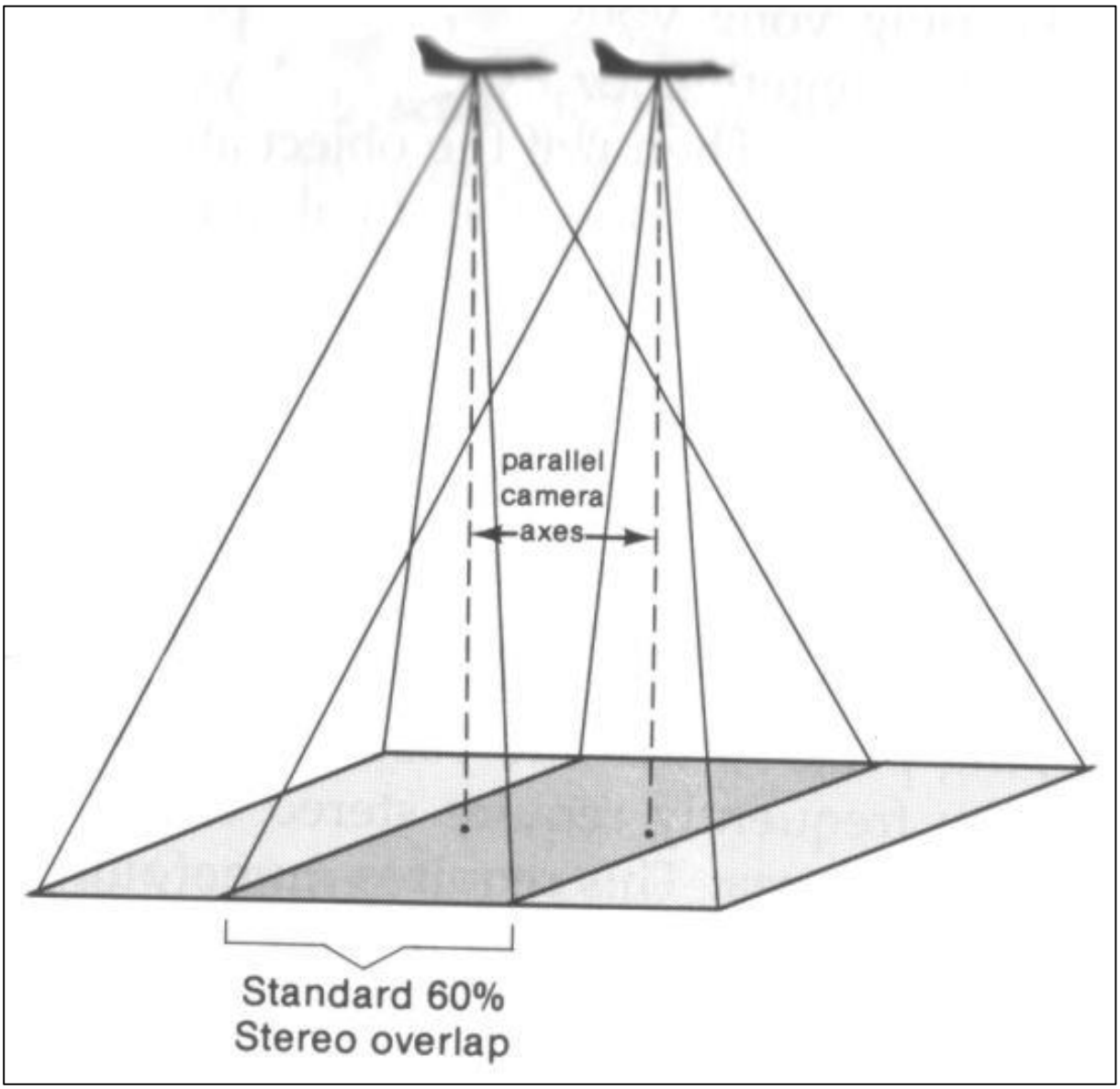

Figure 1. Principles of Photogrammetry. Downward-facing camera captures images, then overlaps by 60% to remove parallax for true nadir (straight down) perspective. (Graphic: courtesy of the University of California, Santa Barbara, Geography Department).

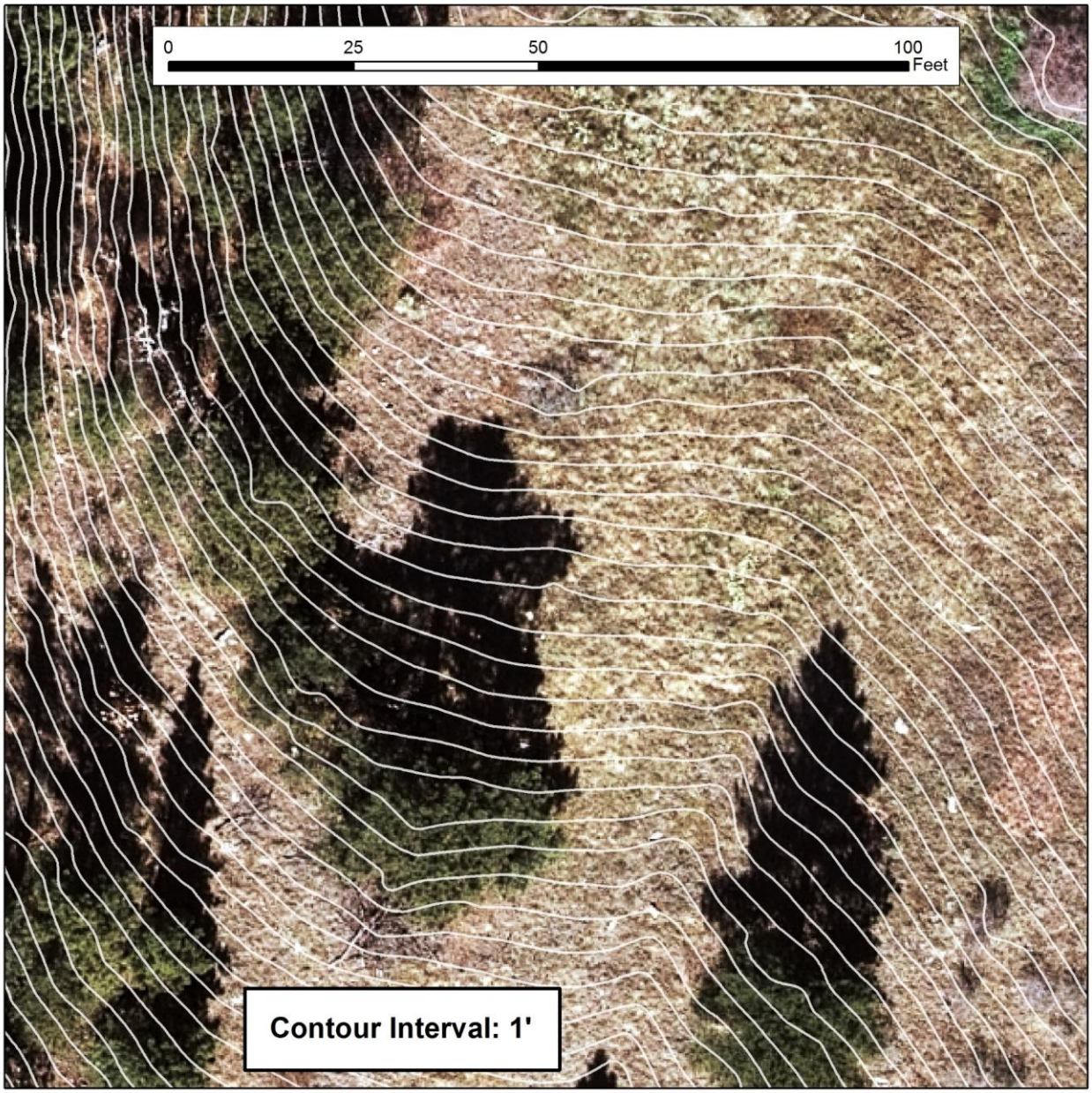

Figure 2. Example of a High-Resolution Contour Elevation Model (white lines) generated by LiDAR, and Background Full-Color Orthographic Imagery Captured with UAS.

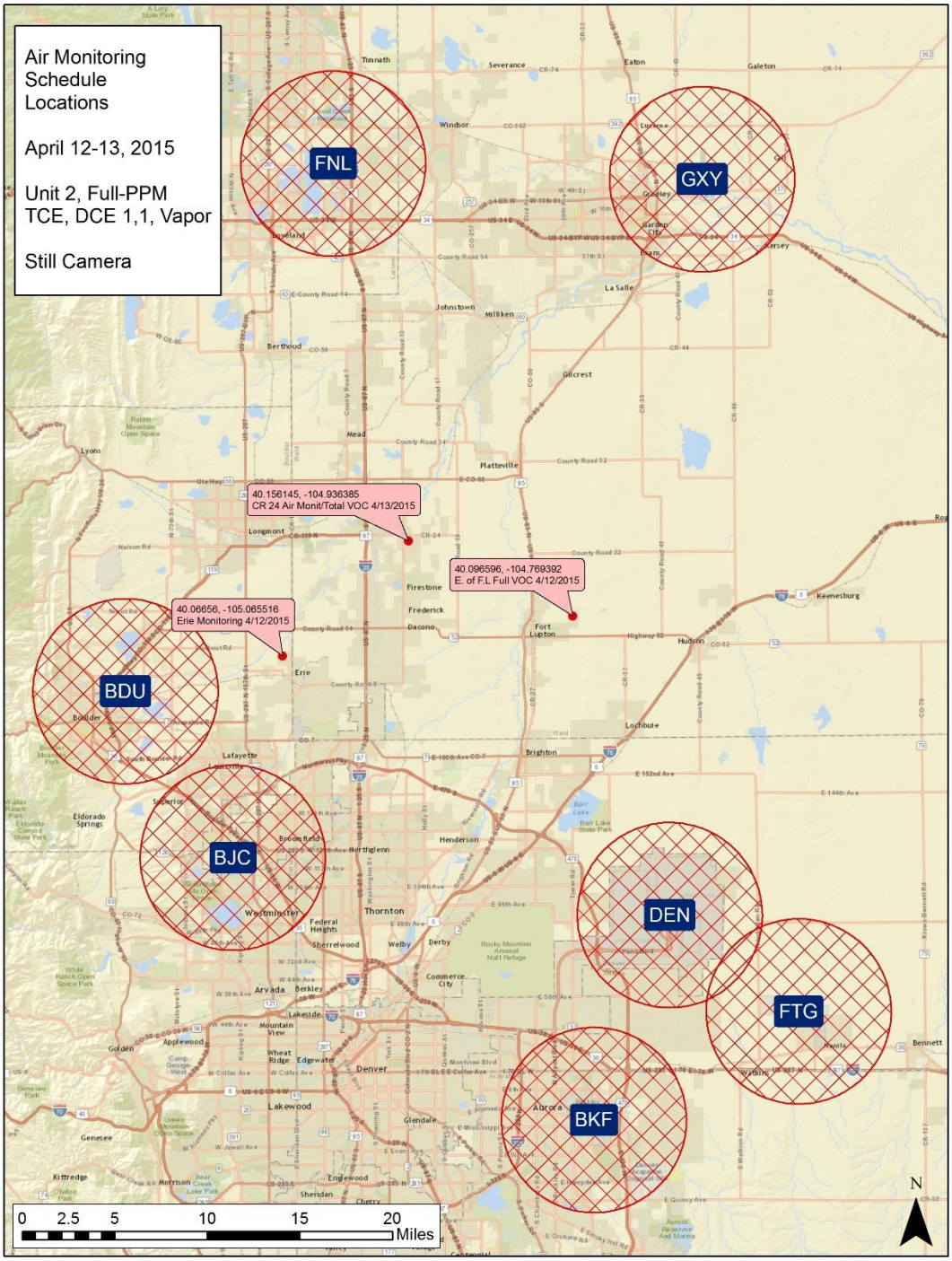

Figure 3. Sample *Air Monitoring Schedule Locations* index exhibit, including all airports with five (5)-mile radius buffers applied. This will be standard procedure prior to each CCL flight operation.

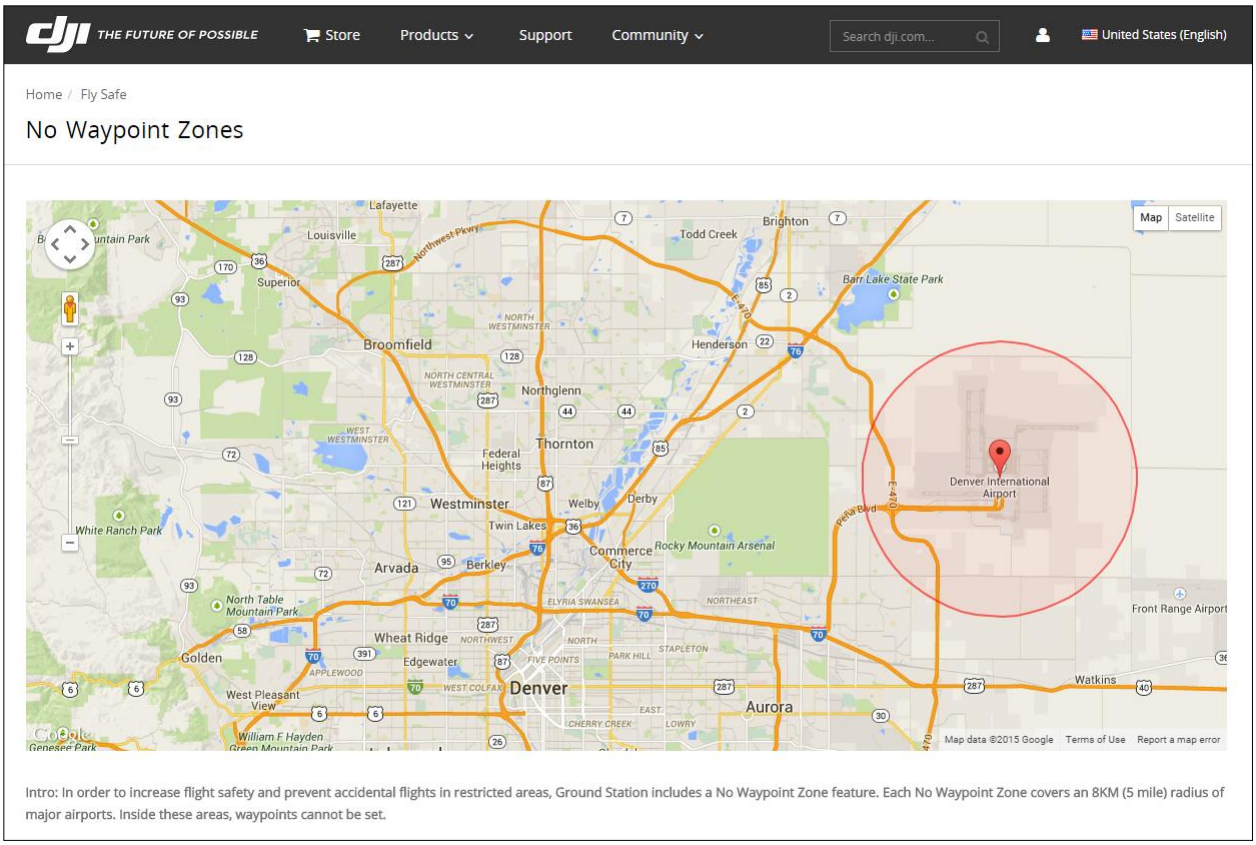

Figure 4. DJI's No Waypoint Zones example of 5-mile radius around Denver International Airport

- END OF PETITION -