Who we are….

Seiler Instrument Company is a family owned firm established in 1945. We have offices throughout the Midwest with our corporate headquarters located in St. Louis, Missouri.

Our experienced industry leaders provide customers innovative solutions and knowledgeable support. Working with a variety of manufacturers, we provide value added solutions for Engineering, Architecture, Surveying, Construction, Rail, Fleet Management, Government, Utilities, and GIS markets.

We are committed to supporting our clients and are passionate about understanding your needs, challenges, and current technology goals.

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Unmanned Aerial Systems Salina Seminar Series

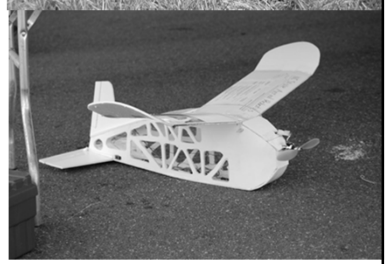
•Seiler Instrument
•Travis LeMoine
•January 7 & 8, 2016

Historic Evolutions

Why now?

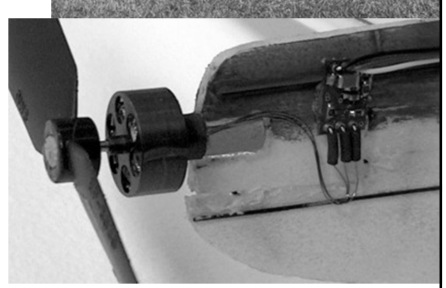
Airframes and Innovations

- Early fixed-wing airframes were typically all balsa wood with wings covered by film/ fabric
- EPP foam and other types of foam are now used as an extremely lightweight and durable alternative
- Development of Multi-rotors (accompanied by miniaturization of gyros & accelerometers)

Power Systems

- Early systems were petroleum based
- Initial electric motors were brushed to be recently replaced by brushless
- Nickel batteries replaced by Lithium

Autonomy & Flight Control

- Thermopiles, Gyro stabilization
- Open Source: ArduPilot, OpenPilot, KK, MultiWii, etc.
- Open Source Add-On: 3D Robotics Pixhawk
- Proprietary (DJI Naza, Mikrokopter, Micropilot, etc.)

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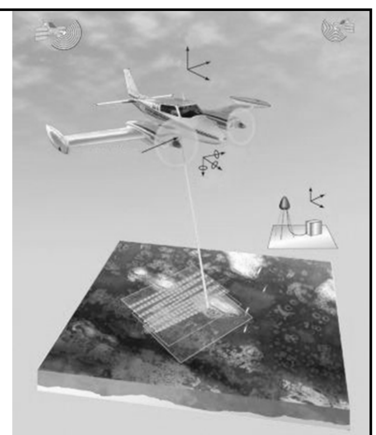
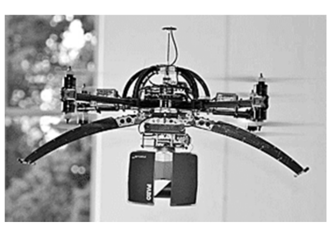
Lidar



- First airborne in ‘80s with introduction of GPS
- Accuracy improved in ‘90s with use of IMUs
- Current sensors are quite a bit smaller, but still not perfect for UAS



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Digital Image Sensors

- Mass consumer adoption of digital cameras in late 90s/ early 00s
- Full-size, high quality image sensors in small packages

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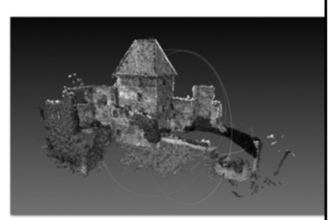
Software (free & not so)

- Relatively “new” breed of software called SFM (Structure From Motion)
- CMPMVS (Multi-view Reconstruction Software)
- MS Photosynth
- Autodesk 123d (formerly Photofly)



Paid Software

- Trimble Business Center/ Inpho UAS Master
- Pix4D
- Agisoft Photoscan

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Applications & Markets

UAS Aerial Imaging Solutions

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Benefits of Aerial Imaging Solutions

- Economic solution – enables aerial mapping technology, once reserved for the largest surveying & engineering firms, to be used by the masses
- Safety – enables surveying of rugged, hazardous, hard-to-reach or unhealthy areas without risking injury (or worse) to them or individuals in the area
- Efficient process – ability to collect and process data faster than often achievable with terrestrial-based survey technology
- Rapid workflow – system is designed to quickly plan a flight and collect data, allowing rapid response to your customer’s needs (traditional photogrammetry processes
- Versatile – a technology that can be used to serve numerous professional markets and applications

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Target Markets

- Engineering & Surveying
- Mining
- Civil & Heavy Earthworks Construction
- Oil & Gas
- Environmental & Landfill
- Public Agencies
- Agriculture & Forestry

Target Applications

	Boundary Surveys	Topographic Surveys	Site Planning	Route Planning	Progress Monitoring	As-Builts	Resource Mapping	Volume Calculation	Disaster Analysis	Vegetation Health
Engineering & Surveying	✓	✓			✓			✓		
Mining	✓	✓	✓	✓	✓	✓		✓		
Civil & Heavy Earthworks Construction	✓	✓	✓		✓					
Oil & Gas	✓	✓	✓	✓	✓	✓	✓	✓		
Environmental & Landfill	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Public Agencies	✓	✓	✓	✓	✓		✓		✓	✓
Agriculture & Forestry	✓		✓		✓		✓		✓	✓

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UAS Aerial Imaging Benefits

	Problem	UAS Feature	Benefit
Boundary Surveys	• Large area to be surveyed	• Up to 7.5 km^2 coverage per flight	• Reduced time & cost to collect data
	• Numerous interests to be mapped (roads, structures, fences, etc.)	• Scaled, geo-referenced orthophotos created	• Accurate and current representation of the land use and features
Topographic Surveys	• Slow data collection	• Up to 7.5 km^2 coverage per flight	• Reduced time & cost to collect data
	• Typically low or inconsistent density of measurements	• Fixed ground sampling of measurements down to 2.4 cm	• More accurate representation of topography
	• Numerous interests to be mapped (roads, structures, fences, etc.)	• Scaled, geo-referenced orthophotos and surface models created	• Accurate and current representation of the terrain, land use and features

Topographic Survey Example

Switzerland
510 Images
400 m Flight Height
11 cm GSD
3.12 km^2

UAS Aerial Imaging Benefits

	Problem	UAS Feature	Benefit
Site Planning	• Numerous interests to be mapped (access roads, drill rig pads, structures, drainage areas, etc.)	• Scaled, geo-referenced orthophotos and surface models created	• Reduced time & cost to collect data and generate feature maps
	• Availability of accurately geo-referenced imagery	• Scaled, geo-referenced orthophotos created	• Accurate and current representation of the land use and features
Route Planning	• Large area to be surveyed	• Up to 7.5 km^2 coverage per flight	• Reduced time & cost to collect data
	• Numerous interests to be mapped (roads, structures, fences, etc.)	• Scaled, geo-referenced orthophotos created	• Accurate and current representation of the land use and features
	• Availability of accurately geo-referenced imagery	• Scaled, geo-referenced orthophotos created	• Accurate and current representation of the land use and features

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Route Planning Example

Belgium
462 Images
150 m Flight Height
5 cm GSD
0.8 km^2

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UAS Aerial Imaging Benefits

	Problem	UAS Feature	Benefit
Progress Monitoring	• Lack of current overview view of site	• Scaled, geo-referenced orthophotos created	• Easy to visualized and understand progress by all stakeholders
	• Possibility of leaving the site with incomplete measurements	• “Over-flight” ensures the entire site is measured	• Eliminate the time & costs associated wit having to send a crew out to fill-in missing measurement
	• Traditional methods often interrupt site operations	• Remote sensing measurements keep operators away from job activity	• Delays in site productivity can lead to unplanned costs and schedule delays

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Progress Monitoring Example

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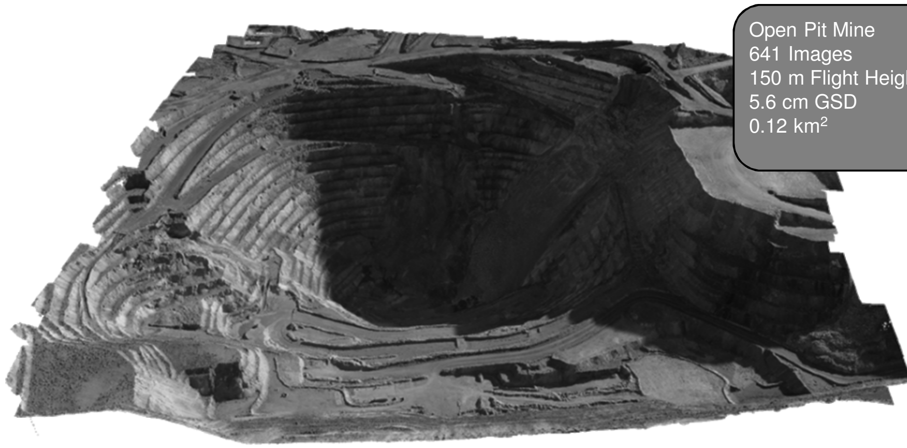
UAS Aerial Imaging Benefits

	Problem	UAS Feature	Benefit
Volume Calculation	• Large area to be surveyed	• Up to 7.5 km^2 coverage per flight	• Reduced time & cost to collect data
	• Typically low or inconsistent density of measurements	• Fixed ground sampling of measurements down to 2.4 cm	• More accurate representation of topography
	• Slow data collection	• Up to 7.5 km^2 coverage per flight	• Reduced time & cost to collect data
	• Individuals often work in hazardous conditions (terrain, vehicles, equipment, etc.)	• Remote sensing measurements keep operators in safe locations	• Reduce the potential for unforeseen costs and delays
	• Traditional methods often interrupt site operations	• Remote sensing measurements keep operators away from job activity	• Delays in site productivity can lead to unplanned costs and schedule delays

Volume Calculation Example



Open Pit Mine
641 Images
150 m Flight Height
5.6 cm GSD
0.12 km^2

UAS Aerial Imaging Benefits

	Problem	UAS Feature	Benefit
Resource Mapping	• Large area to be surveyed	• Up to 7.5 km^2 coverage per flight	• Reduced time & cost to collect data
	• Numerous interests to be mapped (roads, structures, fences, etc.)	• Scaled, geo-referenced orthophotos created	• Accurate and current representation of the land use and features
	• Lack of overview view of area of interest	• Scaled, geo-referenced orthophotos created	• Easy to visualized and understand land utilization
As-Builts	• Numerous interests to be mapped (roads, structures, fences, etc.)	• Scaled, geo-referenced orthophotos created	• Accurate and current representation of the land use and features
	• Typically low or inconsistent density of measurements	• Fixed ground sampling of measurements down to 2.4 cm	• More accurate representation of topography
	• Slow data collection	• Up to 7.5 km^2 coverage per flight	• Reduced time & cost to collect data

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Resource Mapping Example

Namibia
288 Images
100 m Flight Height
5 cm GSD
1.5 km^2

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UAS Aerial Imaging Benefits

	Problem	UAS Feature	Benefit
Disaster Analysis	• Large area to be surveyed	• Up to 7.5 km^2 coverage per flight	• Reduced time & cost to collect data
	• Numerous interests to be mapped (roads, structures, fences, etc.)	• Scaled, geo-referenced orthophotos created	• Accurate and current representation of the land use and features
	• Lack of current overview view of site	• Scaled, geo-referenced orthophotos created	• Easy to visualized and understand progress by all stakeholders
	• Individuals often work in hazardous conditions (terrain, downed powerlines, standing water, etc.)	• Remote sensing measurements keep operators in safe locations	• Reduce the potential for unforeseen costs and delays

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UAS Aerial Imaging Benefits

	Problem	UAS Feature	Benefit
Vegetation Health	• Large area to be surveyed	• Up to 7.5 km^2 coverage per flight	• Reduced time & cost to collect data
	• Traditional survey technologies to not offer the ability to determine health of vegetation	• NIR camera provides visual indication of different types and health of vegetation	• Clear understanding of health of vegetation to make the appropriate decisions for operations

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Vegetation Health Example

Assenede (Belgium), 28 May 2014
265 images in RGNIR
100 m flight height
80% overlap
3 cm GSD
0.75 km2

False color orthomosaic of cropland (left; showing vegetation as blue) and vegetation vigor index (right; warmer colors represent more vigorous plant growth). For the dots on the orthomosaic, the relation between image-based vegetation vigor index and Trimble GreenSeeker NDVI values was calculated (r^2 = 0.83)

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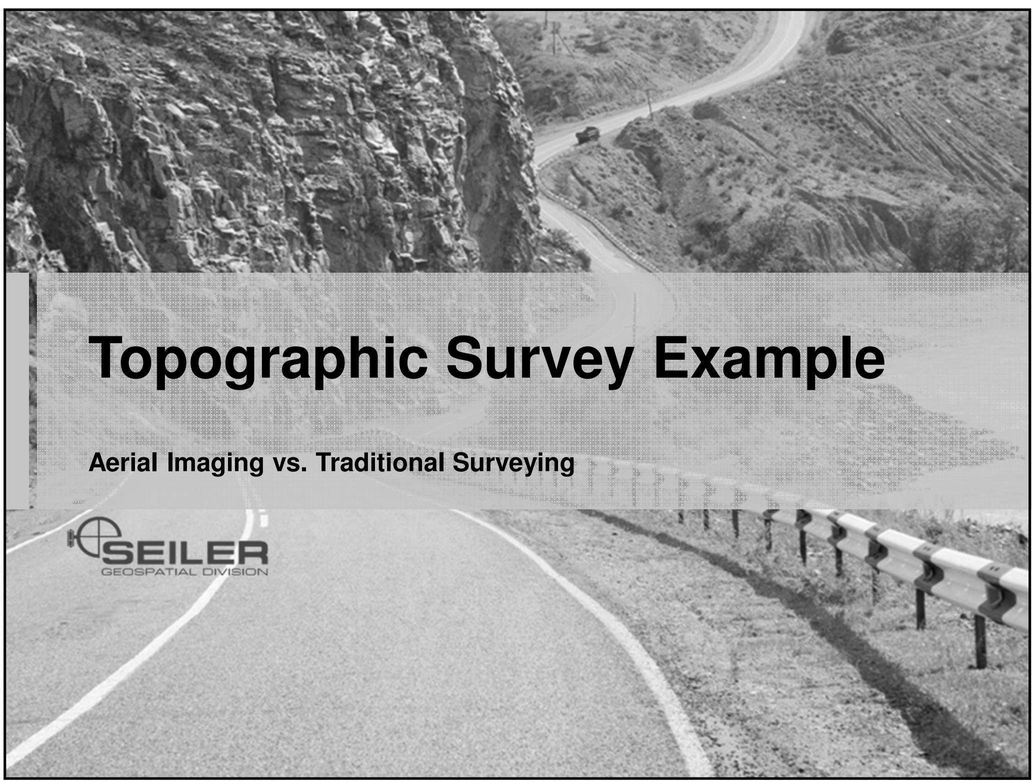

Topographic Survey Example

Aerial Imaging vs. Traditional Surveying

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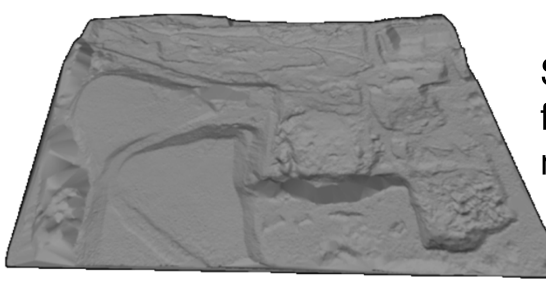
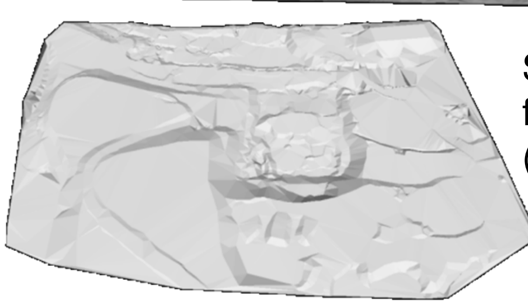
Topographic Survey Example

	UAS	GNSS	Comments
Area	1.5 km^2	1.5 km^2	
Ground control setup & measurement	1 ¼ hr	---	Ground control not required for all applications
Setup time	15 min	15 min (per day)	
Survey time	45 min	30 ½ hr (4 days)	
Tear-down time	15 min	15 min (per day)	
Data processing time	4 hrs (2.80 GHz Intel Core i7, 16 GB RAM)	---	Data can be processed overnight
Total time	6 hr 30 min	32 hr 30 min	5x faster than GNSS
Measurement sampling	3.8 cm (at 120 m flight altitude)	15 m	Minimum sampling size is 2.4 cm
Horizontal accuracy	2 cm	1 cm	
Vertical accuracy	4 cm	2 cm	

Topographic Survey Example



Surface model generated from UAS survey (300,000 measurements)



Surface model generated from GNSS survey (100,000 measurements)

Sensors, Platforms, & Systems

UAS Aerial Imaging Solutions

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Two styles of UAV

VS

Rotor

Fixed Wing

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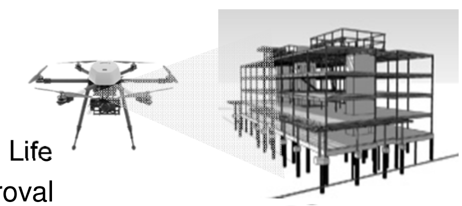
Different Solutions for Different Applications

- Fixed Wing Solutions
  - Larger open areas
  - Horizontal mapping
  - Efficient data capture
  - High Speed, Long Battery Life
  - Typically require site specific FAA approval (COA)
- VTOL (vertical take-off) Multirotor Solutions
  - Smaller obstructed areas
  - Horizontal or Vertical
  - Visual Inspections
  - Slower Speed, Shorter Battery Life
  - More likely to use blanket approval (COA)



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Hybrid Airframes

- VTOL with fixed wing
  - No “common” commercial system available (yet)
  - BIG companies are working on this for delivery (Amazon, Google)
  - Efficiency gains haven’t been realized

Source: Amazon/ Youtube

Source: Google/ Youtube

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Sensors

Source: Flir Systems

- Collection sensors
  - RGB Cameras
  - NIR Cameras
  - ‘Metric Cameras
  - Multispectral
  - Hyperspectral
  - Thermal
  - Air Sensors (methane, CO, CO_2, etc.)
  - LiDAR
- Navigation/ supplemental sensors
  - GNSS
  - IMU
  - Airspeed

Source: Phoenix Aerial Systems

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RGB Cameras

- Many, many options (practically any camera can serve as an RGB sensor)
- Best results come from a couple places
  - Large image sensor!!
  - More pixels, but not without a larger sensor
  - Fixed lens (for photogrammetry)
  - No autofocus (usually)

Source: canon.com

Source: DJI.com

Source: gopro.com

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Image Sensors & Megapixels

- Both are important!
- More megapixels means each pixel represents a smaller space of the image (resolution)
- Larger image sensors result in more space for each pixel to receive light (pixel density)
  - Lower pixel density results in less noise in the image, deeper colors & faster shutter speeds which means the UAV can fly in poorer conditions (higher wind speeds, lower light)

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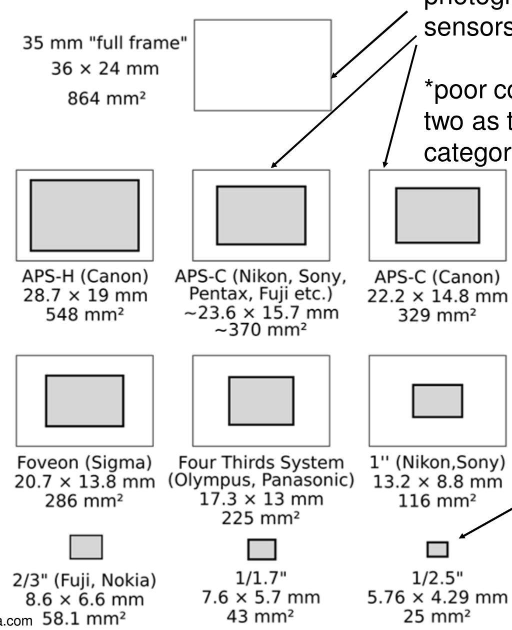
Image Sensors & Megapixels

Fortunately, most professional-grade UAS designed for photogrammetry use these sensors

*poor comparison between the two as the cameras in this category cost as much (or more) than the most common UAS



Unfortunately, this is the most common UAS sensor size (actually 1/2.3")

Source: wikimedia.com

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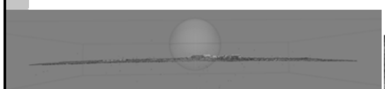
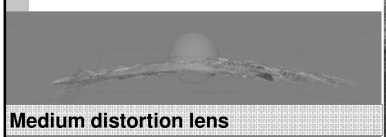
Fixed, immobile lens & autofocus

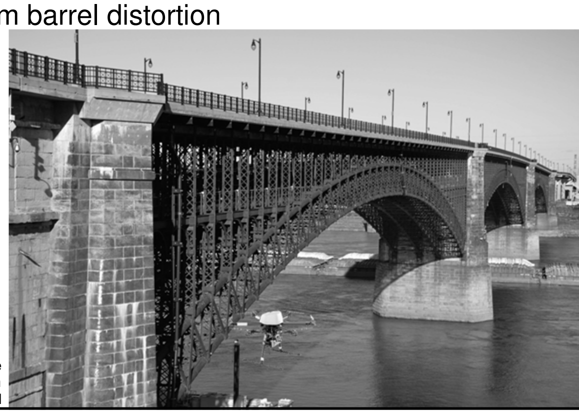
- Important in photogrammetry
  - Power-on lens movement is almost always inconsistent resulting in very small, yet significant changes in focal length
  - UAS reaction to wind can apply small forces in gravity to the camera resulting in small changes to the focal length in non-fixed lenses
  - Autofocus can delay the capture of imagery resulting in lower than intended overlap which reduces overall model accuracy
  - Lens distortion creates warping of data without GCPs





Fixed, immobile lens & autofocus

- Almost opposite in inspection UAS
  - Zoom lenses are helpful to get “closer” to POIs
  - UAS reaction to wind is mitigated by gimbal reaction
  - Autofocus is essential to adapt to closer proximity to POIs
  - Wide angle lenses help to see more at once, which inherently suffer from barrel distortion



Eads Bridge
Source: wikipedia.com
modified

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Infrared Cameras

- Used mostly for vegetation mapping and health
- RGB Cameras can be modified in some cases to collect NIR

Source: maxmax.com

Metric Cameras

- Typically RGB camera with superiority in geometric stabilization
  - Significant mitigation of stability loss can be found in lenses with lower distortion and through software models of each lens
  - Metric cameras are very expensive

LiDAR

- Ability to fire through vegetation is very beneficial
- LiDAR sensors have become small enough for UAS
  - Though still not “lightweight”
- Cost & accuracy are improving
- Biggest drawback (for now) is accuracy
  - Most inaccuracy comes in heading accuracy as there is no GNSS Azimuth Measurement System (GAMS)

Source: Riegl/ Youtube

Source: AutonomouStuff

Other sensors

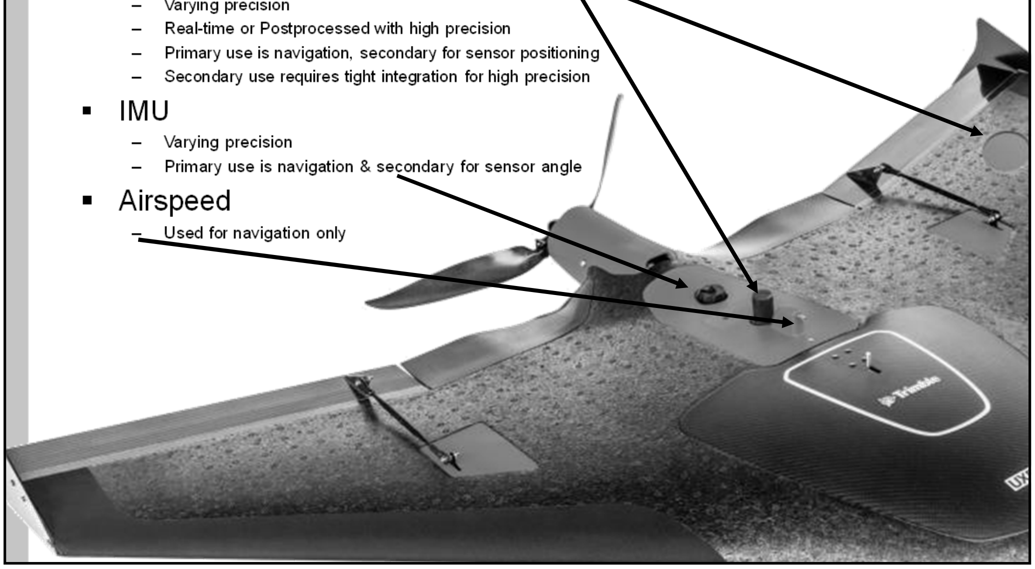
- Multispectral applications include agriculture & water quality
- Hyperspectral applications include agriculture, water quality & mining
- Thermal applications include heating/ cooling efficiency studies, firefighting, search & rescue, surveillance, livestock management
- Air sensors
  - Many different types (methane, CO, CO_2, ozone, particulates, and more)
  - Many applications

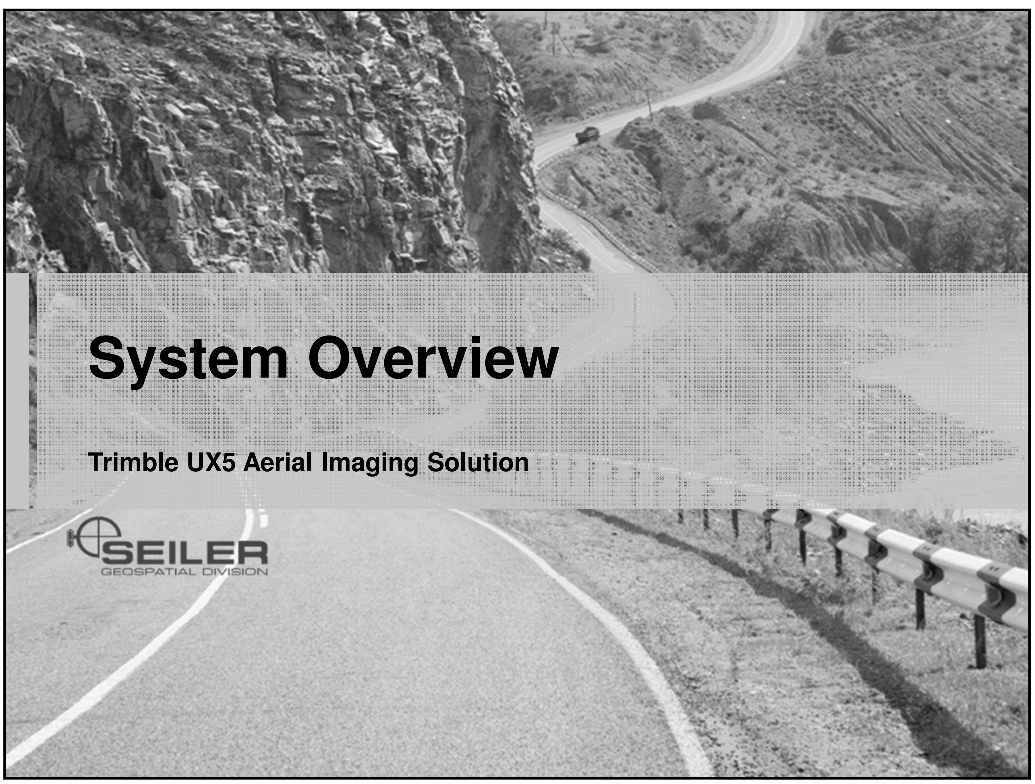
Source: Flir Systems

Source: micasense.com

Navigational/ Positioning sensors

- GNSS (variable precision)
  - Varying precision
  - Real-time or Postprocessed with high precision
  - Primary use is navigation, secondary for sensor positioning
  - Secondary use requires tight integration for high precision
- IMU
  - Varying precision
  - Primary use is navigation & secondary for sensor angle
- Airspeed
  - Used for navigation only

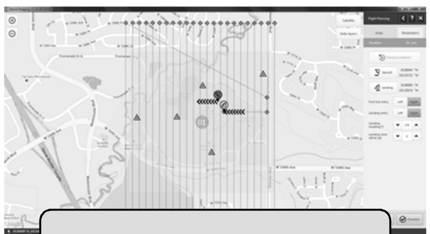




System Overview

Trimble UX5 Aerial Imaging Solution

Trimble UX5 Aerial Imaging Solution



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Trimble Access Aerial Imaging Application

- Mission planning
  - Create background map and add optional layers
  - Define mission area and avoidance zones
  - Define GSD, height and overlap
  - In the office or in the field
- Flight planning
  - Calculate and plan multiple flights for a mission
  - Define wind direction, takeoff location, and landing location
  - In the field
- Flight monitoring
  - Monitor the flight
  - Trigger emergency actions when needed
  - In the field
- Analysis
  - Check completeness of data
  - In the office or in the field

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Defining the Project Area

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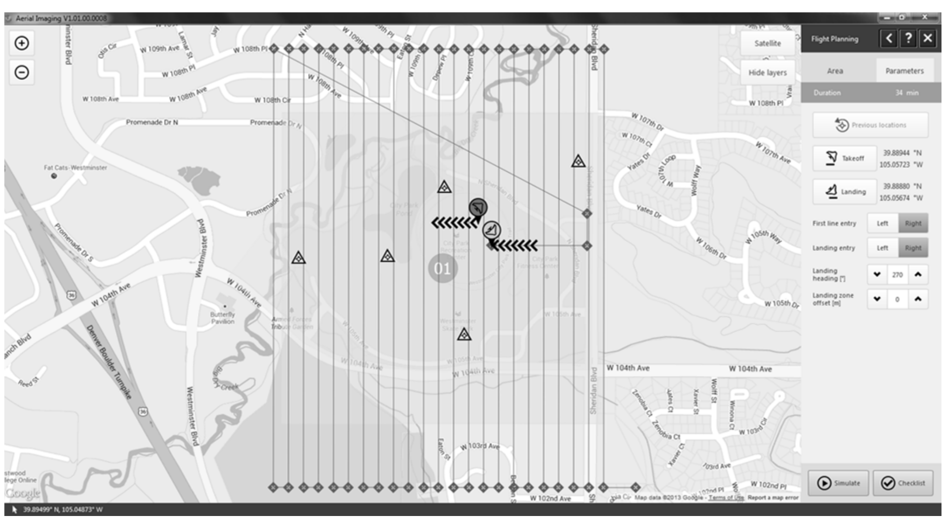
Defining the Flight



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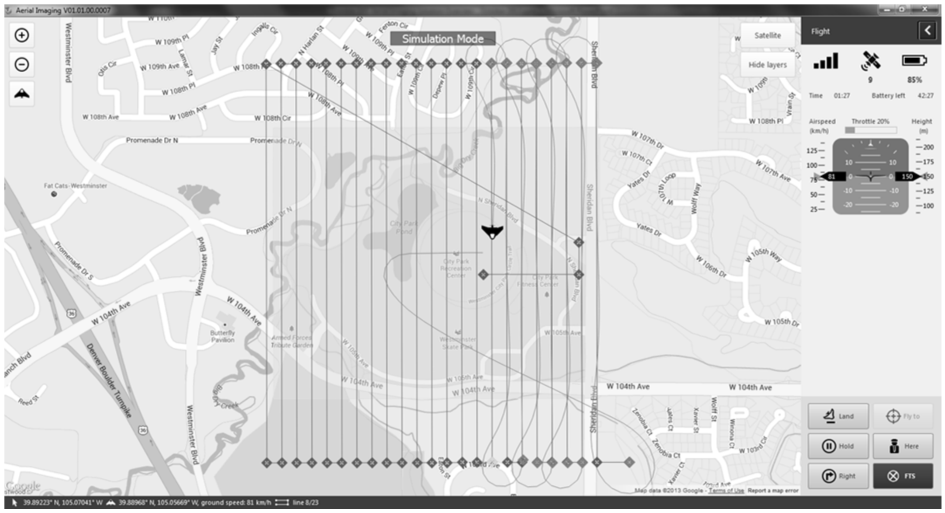
Flight Simulation



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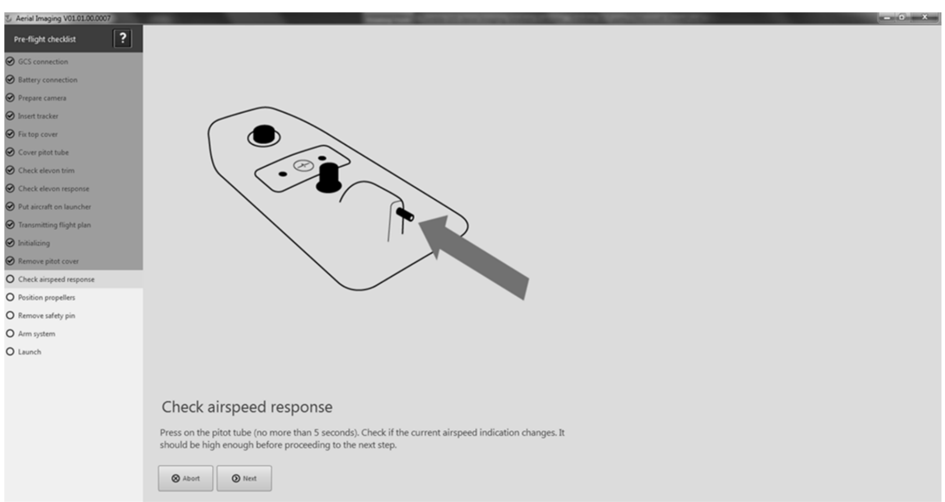
Flight Checklist



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Flight Monitoring

- Flight is controlled by the autopilot system
  - Based on the mission & flight plan from Trimble Access Aerial Imaging application
- Flight parameters & performance displayed
  - Virtual horizon
  - GPS lock
  - Communication link strength
  - Battery level
  - Aircraft height & speed (actual & planned)
  - Aircraft location & flight lines (on map)
- Manual evasive maneuvers available (if necessary)
- Landing confirmation

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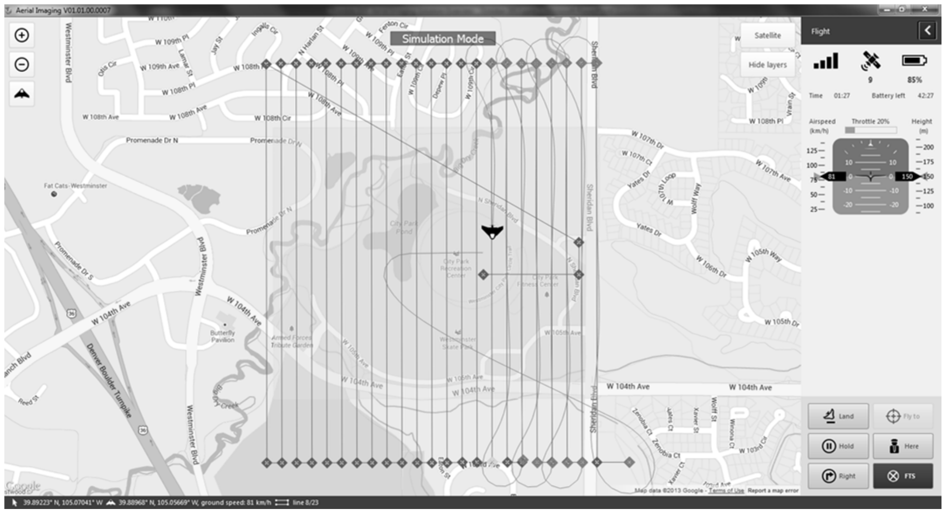
Flight Monitoring



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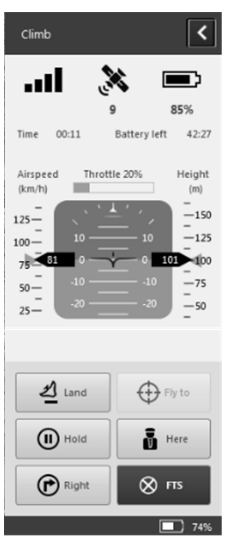
Safety Maneuvers



- Land
  - Instruct aircraft to follow land circuit before flight path is finished
- Fly To
  - Fly to a user-specified location on map and circle
- Hold
  - Circle at current position
- Here
  - Fly to location of pilot/GCS and circle
- Right
  - Fly 300 m to the right of current heading and circle
- FTS (Flight Termination System)
  - Abort flight immediately and spiral downward
- Up (not shown)
  - Instruct UA to increase altitude by 10 m
  - Available once a flight maneuver is enacted
- Down (not shown)
  - Instruct UA to decrease altitude by 10 m
  - Available once a flight maneuver is enacted

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Trimble UX5 Aerial Imaging Rover

- Airframe
  - Internal carbon frame
  - Expanded polypropylene foam body
  - Engine & propeller
  - Servo-controlled elevons
- Payload Bay
  - Battery
  - Camera
  - Tracking beacon
- eBox
  - GPS & orientation sensors
  - 2.4 GHz radio
  - Autopilot

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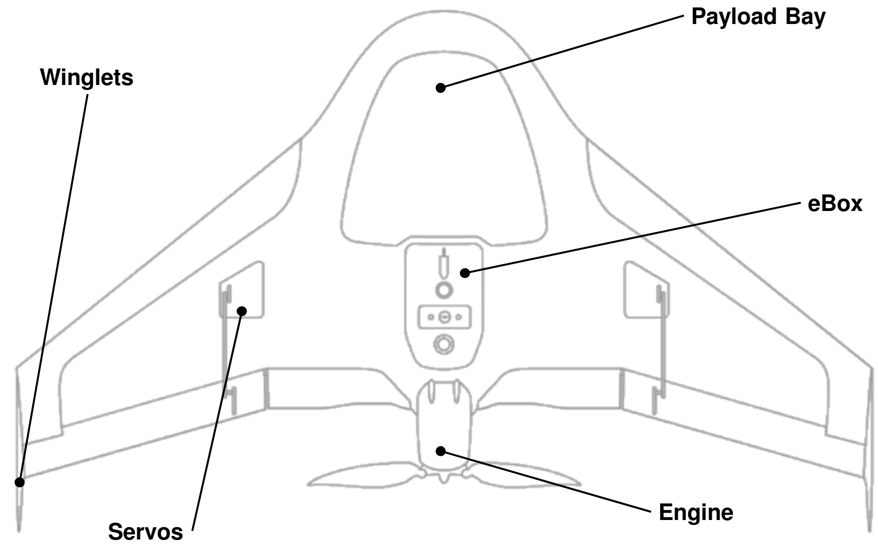
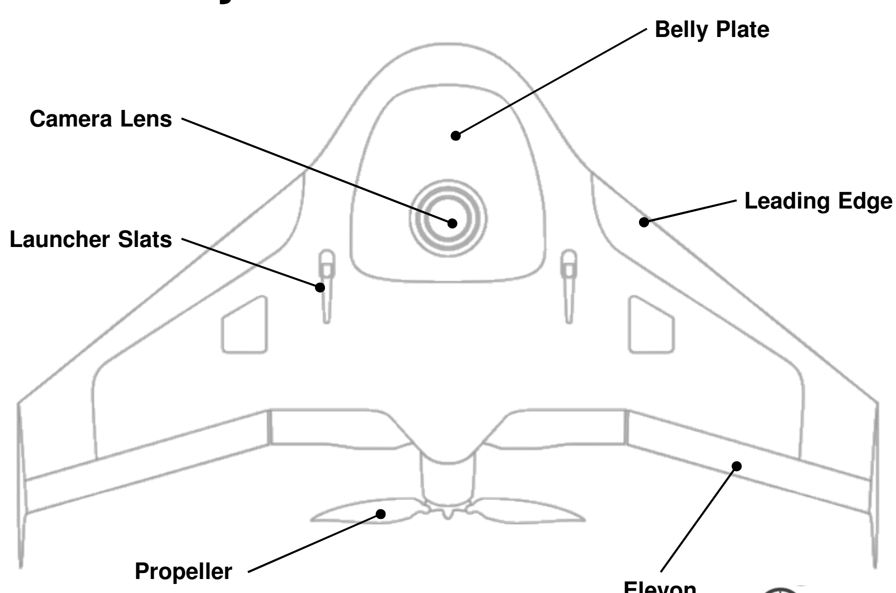
UX5 Top

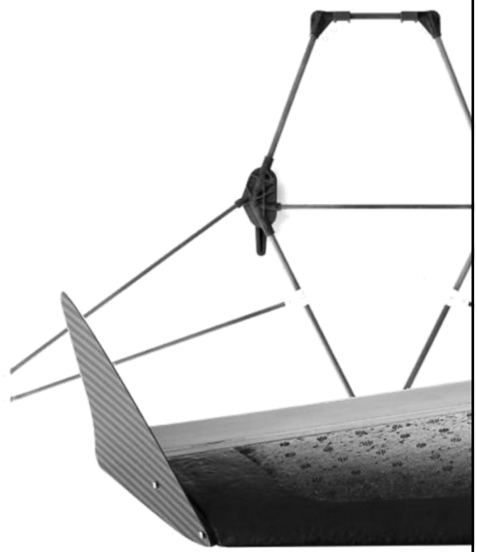


UX5 Belly

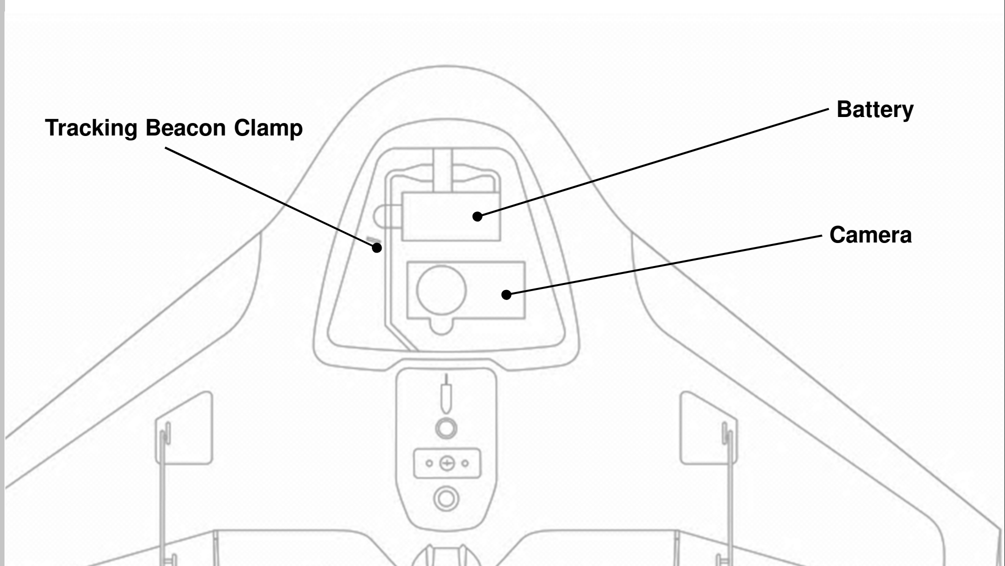


UX5 Airframe

- Internal carbon frame
- Expanded polypropylene foam
- Impact resistant plastics
  - Motor assembly
  - eBox
  - Servos
- Composite fiber parts
  - Elevons
  - Vertical winglets
  - Belly plate



UX5 Payload Bay



UX5 Camera

- Sony a5100 digital SLR
- 24 MP (APS-C) sensor
- Custom mounted Voigtlander fixed-optics lens
  - Increases the stability of the camera internal geometry
- Image size 6000 x 4000 px
  - (514 x 343.4 ft @ 328 ft flight height)
- RGB & NIR (Near Infra-Red) versions

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UX5 Camera Sensor Size

Common Sensor Sizes

Sensor Type	1/2.5"	1/1.8"	2/3"	4/3"	APS-C	35mm
Aspect Ratio	4:3	4:3	4:3	4:3	2:3	2:3
Diagonal (mm)	7.2	8.9	11	22.5	27.3	43.3
Width (mm)	5.8	7.2	8.8	18	22.7	36
Height (mm)	4.3	5.3	6.6	13.5	15.1	24

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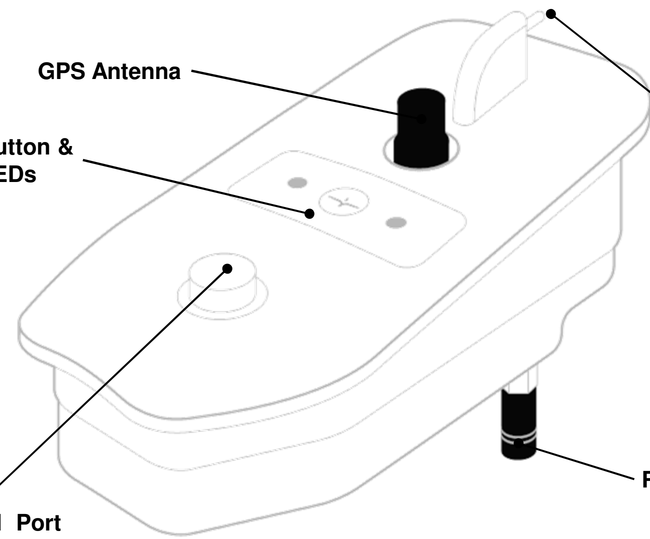
UX5 eBox



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Trimble UX5 Specifications

- Weight: 5.5 lbs
- Wingspan: 3.3 feet
- Launch Type: Catapult
- Cruise Speed: 50 mph
- Endurance (flight time): 50 min
- Flight Height (AGL): 250-2500 ft
- Flight Ceiling: 16,000 feet
- Wind Speed: 40 mph
- GSD: .79-7.9 inches
- Coverage (@ .07’ GSD): 187 acres
- Coverage (@ .13’ GSD): 544 acres
- Coverage (@ .33’ GSD): 1216 acres
- Landing Type: Belly
- Camera: Sony a5100 (24 MP)
- Near InfraRed Available

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Launcher Components

- Ramp
  - Bungee
  - Winching tool
  - Release handle
  - Safety pin
- Launcher Dock
- Support

Launcher Benefits

- Consistent launch
  - Speed
  - Launch angle
  - No risk of stall
  - Short learning curve for operator
  - Less stressful (user has to control speed & angle with a hand launch)
- Safety
  - Consistent & controlled launch sequence
  - User not exposed to running motor
  - Complies with Machinery Directive 2006/42/EC

Ground Control Station

- Rugged Tablet
- Flight Planning & Control Software
- Communications Link
- Download Connector

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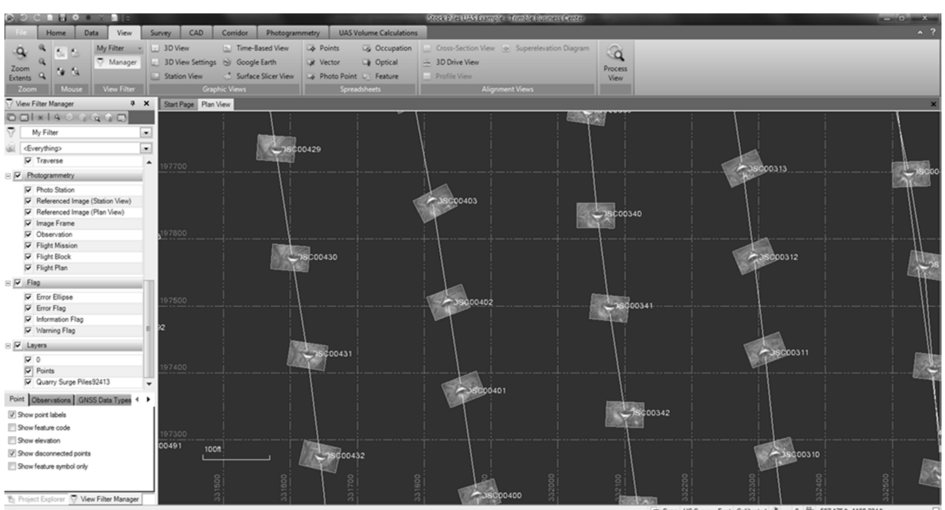
Visualize the Flight



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Measure Ground Control Points

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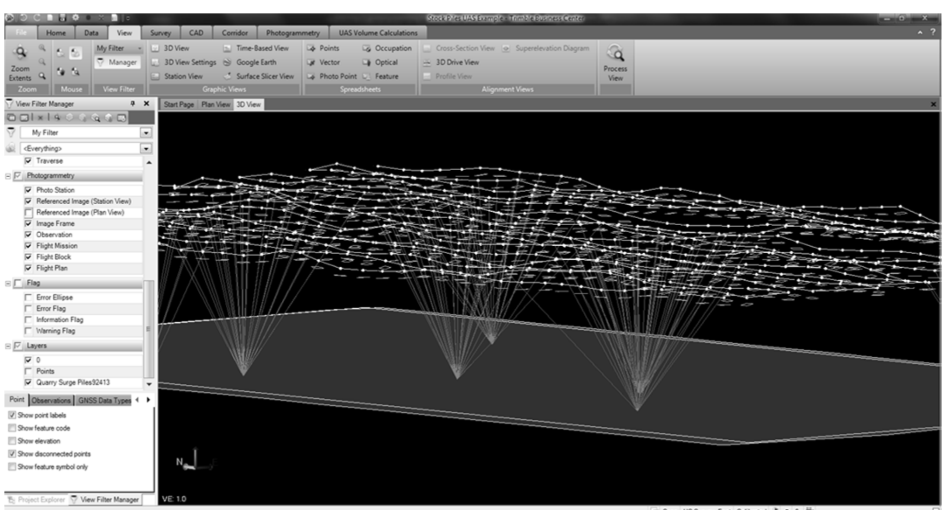
View Ground Control Point Relationships



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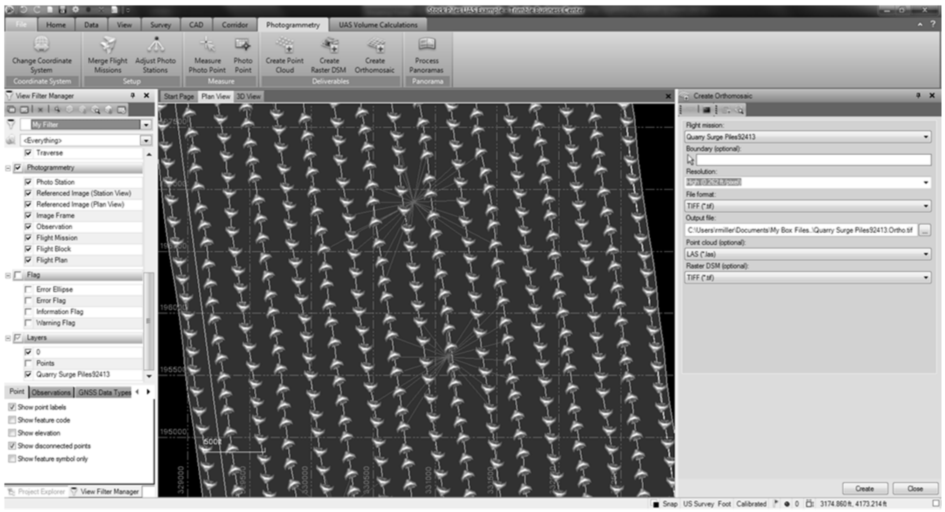
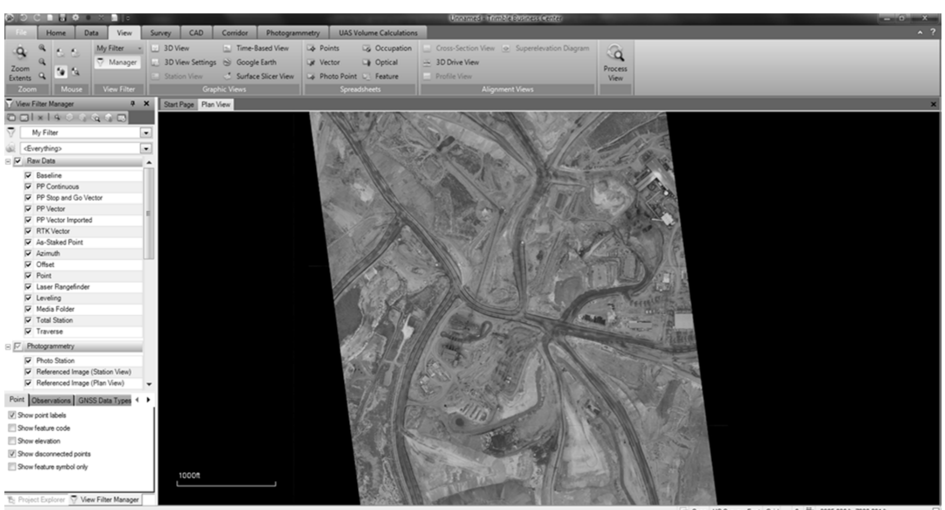
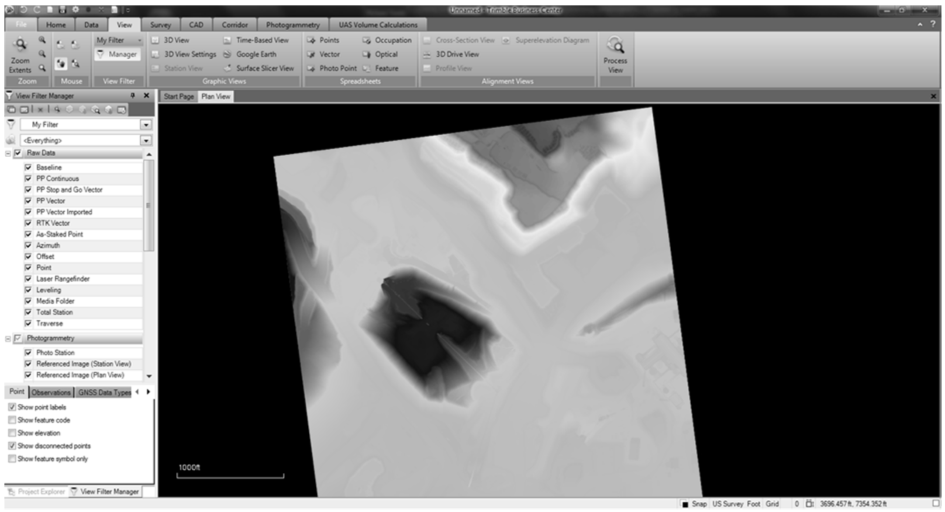
Create Deliverables



Create Orthomosaics



Create Digital Surface Models



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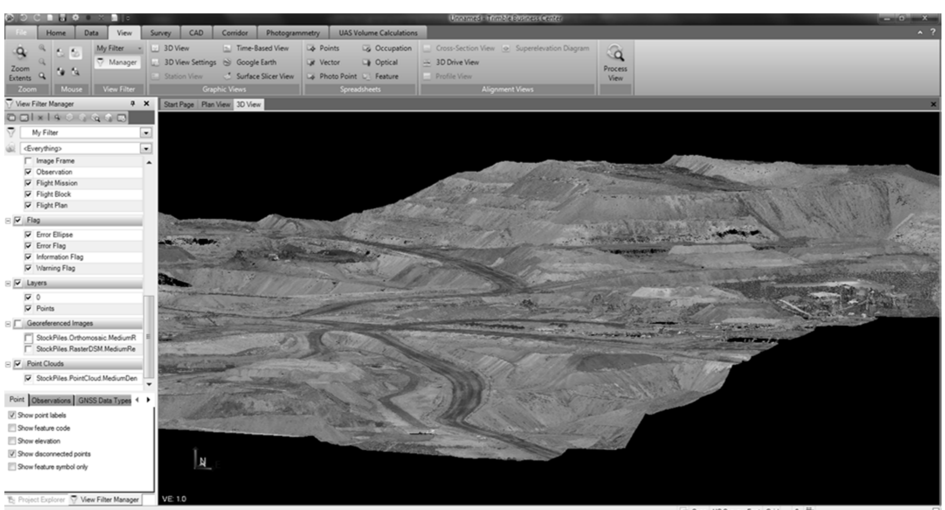
Create Point Clouds



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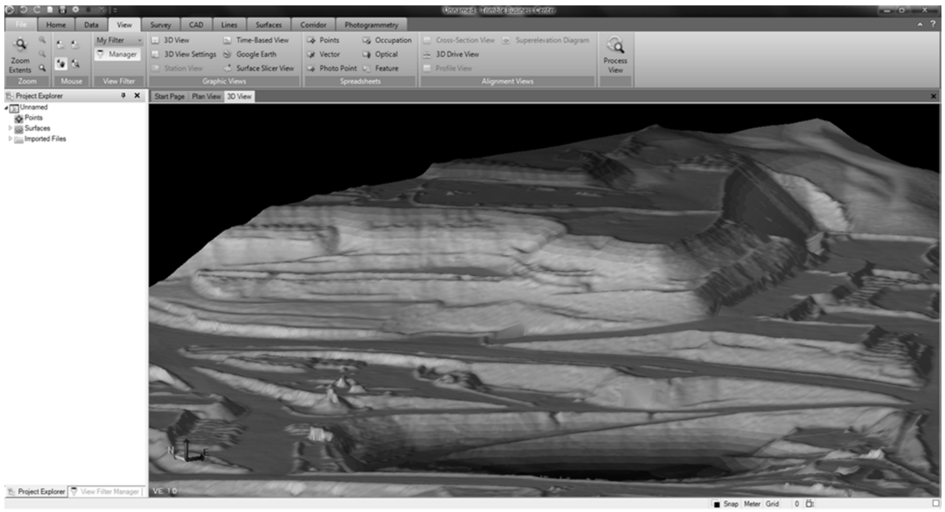
Create Surface



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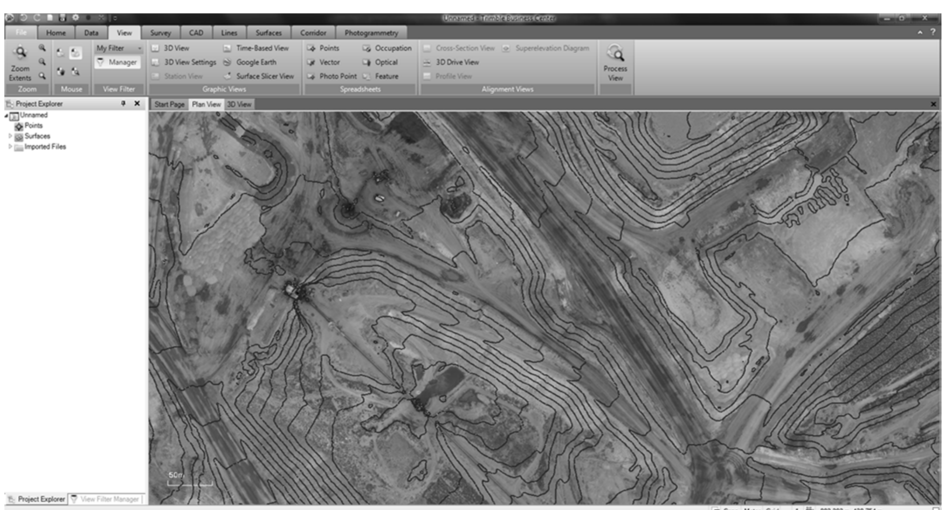
Create Contours



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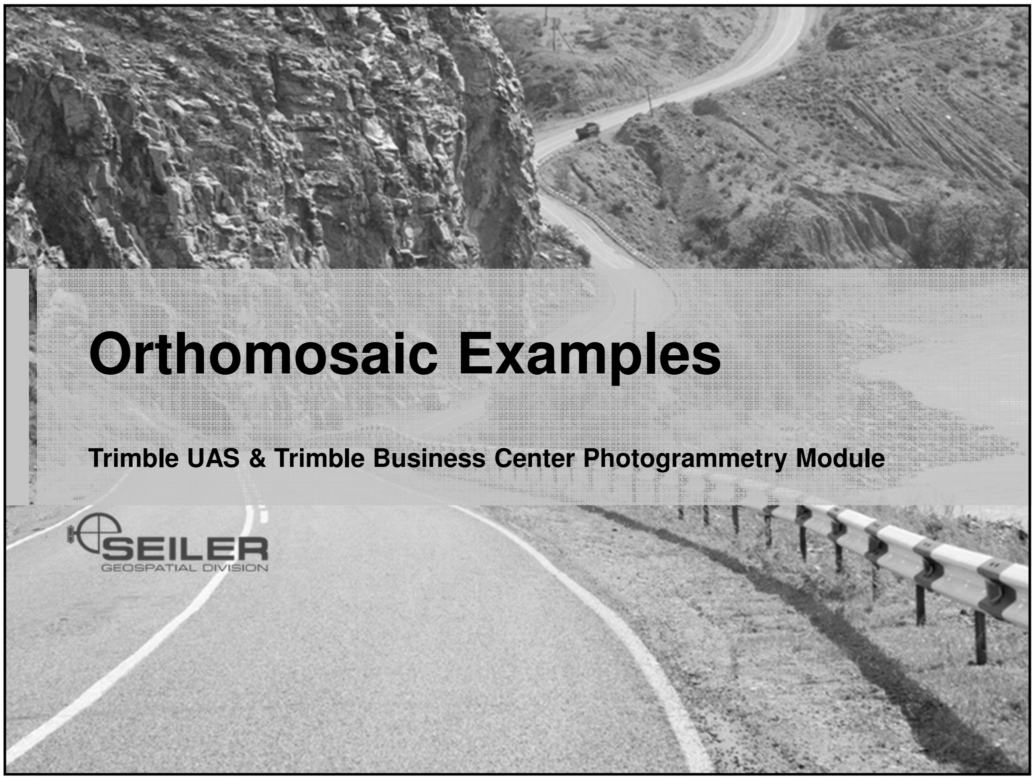
Orthomosaic Examples
Trimble UAS & Trimble Business Center Photogrammetry Module
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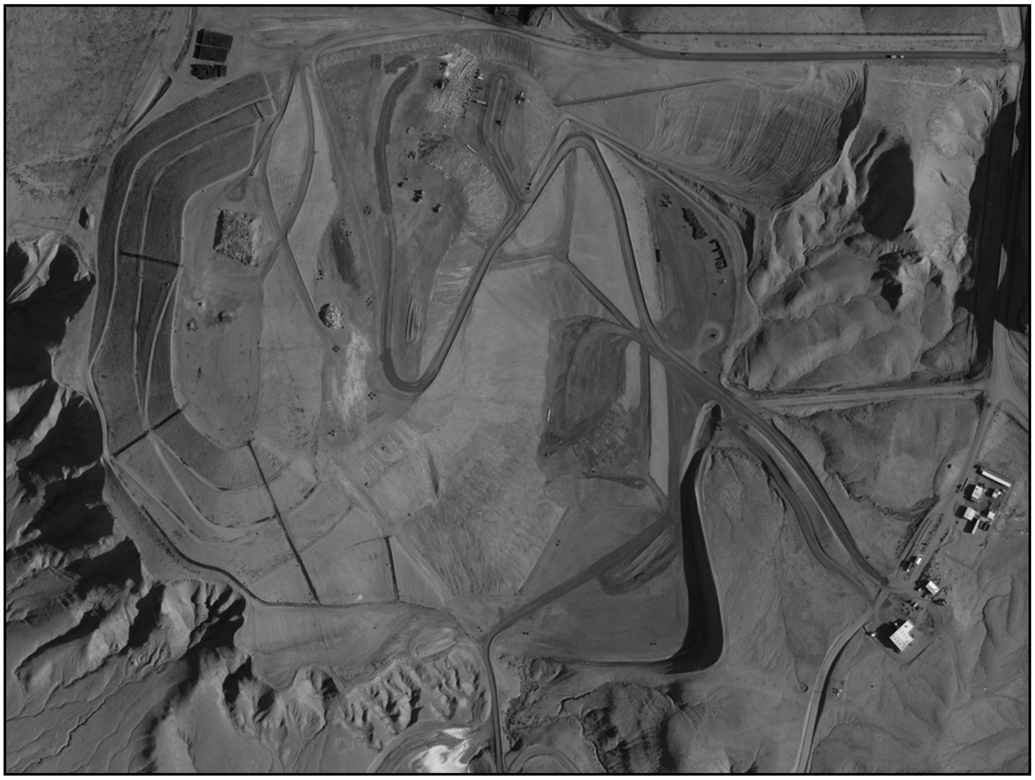
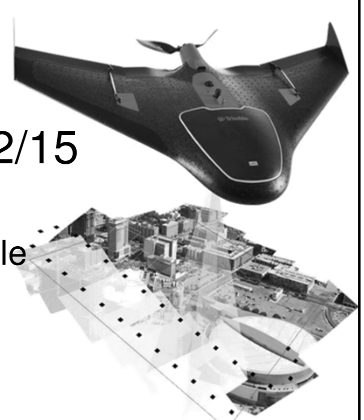
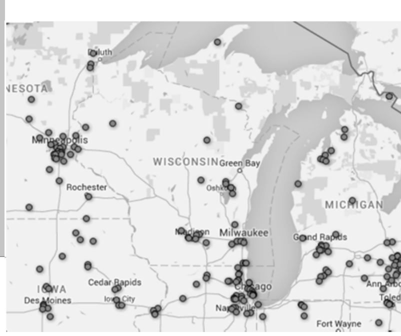


Regulatory

- Proposed Rules announced 2/15
  - Likely not in effect until 2017
  - Section 333 exemptions are available now! (2,451 approvals- 11/27/15)





Source: suasnews.com

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What are the proposed rules? (highlights)

- Operational
  - Aircraft less than 55lbs.
  - Under 500' AGL (above ground level)
  - Max. speed 100 mph
  - Must maintain visual contact
  - May not operate within 500' of non-participants (structures, people)
- Operator
  - Operator certification (no pilot needed)
- Not Finalized, under agency review

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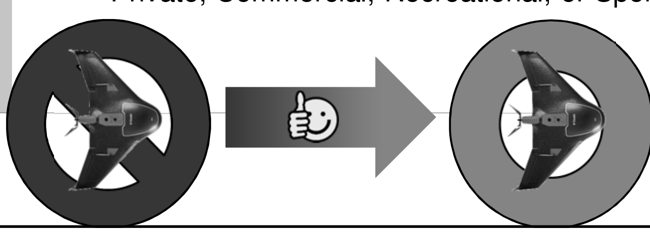
What are the typical 333 restrictions? (highlights)

- Operational
  - Under 400' AGL (above ground level)
  - Aircraft <55 lbs, speeds <100 mph
  - Must maintain visual contact
  - May not operate near people (500')
  - May not fly over "built-up areas"***
    - this isn't showing up any longer
  - Must have COA (either blanket or site specific)
- Operator
  - Private, Commercial, Recreational, or Sport Pilot's License Required



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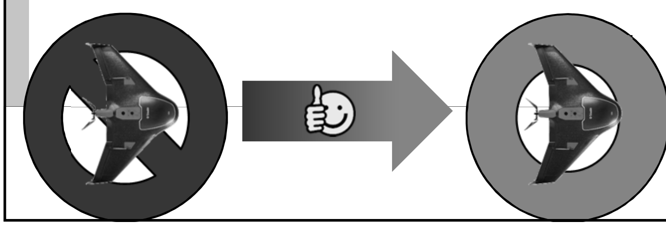
Civil COAs (highlights)

- Blanket COA
  - Flights under 200'
  - Not within 5 NM of towered airport, 2-3NM of non-towered
  - Not over major cities
  - Must file Notice to Airmen (NoTAM) 24-72 hrs before flight
- Specific COA
  - Takes 15-60 days to process
  - Typically will limit to <400' AGL, closer to airports with airport approval
  - Must file NoTAM 24-72 hrs before flight



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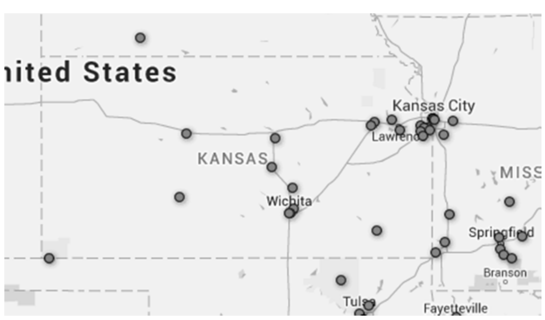
Who's flying (legally)?

- Section 333 Exempted: 2,799 approvals- 12/30/15
  - 20 in KS
- First 1000 exemption analysis (AUVSI)



Source: suasnews.com

INDUSTRY/OPERATION	# OF EXEMPTIONS
Aerial Photography	512
Real Estate	350
Aerial Survey	301
Aerial Inspection	242
Agriculture	164
Construction	134
Infrastructure Inspection	102
Film and TV	91
Utility Inspection	78
Environmental	61
Mining	25
Oil and Gas	24

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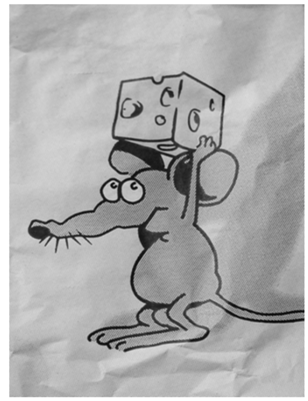
Why would someone want to go through the hassle of a 333?

- Offer a service very few can legally provide
- Many companies require this for UAV data
- Efficiency gains are tremendous on site development
- Develop internal knowledge prior to the implementation of official rules
- It is likely to only take a couple months for the initial exemption, then each site should be a quick approval



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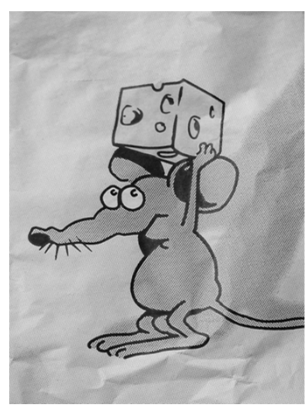
Section 333 Compliance

- Write and submit an exemption request (60-120 days)
- Purchase & Register Aircraft (15-30 days)
- Fly under blanket COA



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Why would someone want to go through the hassle of a 333?

- Consequences of Not
  - Liability
  - Fines ($10k/day)
  - Potential disbarment from government funded projects (unconfirmed)
  - FAA proposes $1.8M fine to SkyCap

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Seiler Preparations

- ✓ Develop in-house knowledge
- ✓ Acquire Trimble Certification
- ✓ Receive own exemption
- ✓ Acquire Aircraft (UX5, ZX5, Phantom)
- ✓ Aircraft Registration
- o Obtain pilot's license (or hire)
- o Assist customers in acquiring their own exemptions

Site preparations (Bong State Rec Area-Kansasville, WI)

- Determine aircraft type & identify site specific issues
  - Fixed wing for coverage area
  - Access control could be an issue as it's a public area with roads & people
  - No nearby airports
- Is COA needed?
  - Yes, fixed wings have a higher operational altitude
  - File civil COA via web portal
- File NOTAM via portal or 800 number
  - 48-72 hours prior to flight
  - Necessary under blanket COA as well
- Fly!
- Review Results
- Monthly Report

Adobe Acrobat Document

https://www.1800wxbrief.com/Website/createNewAccountAndProfile#!/

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Flight 1- acceptable weather

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Flight 3- unacceptable weather

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Section 333 Compliance- Monthly Reporting

UAS Civil COA - Monthly Operational Report Form

Due within 5 business days after end of reporting month

Monthly Operational Report Form

Field	Value
Month/Year:* *(mm/yyyy)*	12/2015
COA #:* *(2015-ESA-11064-1-333E)*	2015-CSA-12663-541-333E [Pre-Populate]
Proponent:*	Seiler Instrument
Type Aircraft:* *(Make / Model / Series)*	Trimble Navigation UX5 / Trimble Navigation UX5
Aircraft Registration #:*	N531LR
Total Number of Flights Conducted:* *(A flight during which any portion is conducted in the NAS must be counted only once, regardless of how many times it may enter and leave special use airspace between takeoff and landing.)*	3
Total Aircraft Operational Hours:* *(Expressed in hours and tenths of hours.)*	1.1
Total Ground Control Station Operational Hours:* *(Include LRE operations. Expressed in hours and tenths of hours.)*	1.6
For Each Flight: Date, Flight Number (for that day), Aircraft Operational Hours, GCS Operational Hours and Pilot Duty Time per PIC:* *09/13/2011: Flt. 1; 2.0hrs; 3.0hrs; 0.8hrs PIC1, 1.5hrs PIC2 Flt. 2; 4.0hrs; 5.0hrs; 1.8hrs PIC1, 2.7hrs PIC2 Flt. 3; 6.0hrs; 7.0hrs; 2.8hrs PIC1, 3.7hrs PIC2*	12/02/15: Flt. 1; .3hrs; .3hrs PIC Flt. 2; .3hrs; .3hrs PIC 12/10/15: Flt. 1; .5 hrs; .5hrs PIC
Total # of Deviations from ATC instructions and/or Letters of Agreement / Procedures:*	0
Number and duration of Loss of Communication (with either observer or ATC) and Lost Link Events:* *List the date, event type and duration for each event; for example: 09/13/2011; Lost Link; 1min 45sec 09/13/2011; Lost Link; 2min 11sec 09/27/2011; Loss of ATC Comm; 44sec*	0
Total # of Equipment Malfunctions:* *(Hardware/software affecting either the aircraft or the ground control station.)*	0
Describe any other Operational / Coordination issues:*	None

[Email Monthly Operational] [Cancel] [Reset]

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Software demo- time allowing

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Questions?

St. Louis • Kansas City • Milwaukee • Indianapolis • Omaha • Chicago