Risk & Reward: Small Unmanned Aircraft Systems for Agricultural Producers (5/21/2018)

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FAA Regulations:

Unmanned Aircraft Systems (UAS) portal: https://www.faa.gov/uas/
Getting Started: https://www.faa.gov/uas/getting_started/
Remote Pilot Certification (RPC): https://www.faa.gov/uas/getting_started/fly_for_work_business/becoming_a_pilot/
FAA Small Unmanned Aircraft Regulations (Part 107) FACT SHEET (March 23,2018): https://www.faa.gov/news/fact_sheets/news_story.cfm?newsId=22615
Aircraft Registration: https://faadronezone.faa.gov/#/
Unmanned Aircraft System Traffic Management (UTM): https://www.faa.gov/uas/research/utm/
FAA's LAANC (Low Altitude Authorization & Notification Capability) System: https://jrupprechtlaw.com/low-altitude-authorization-notification-capability-laanc-system

Pilot Certification and Aircraft Registration for Non-hobby Users of Small Unmanned Aircraft Systems (sUAS) (Jan. 2017): https://www.uaex.edu/publications/pdf/FSA-6150.pdf
Ruppprect Law 'Free Part 107 Test Study Guide': http://jrupprechtlaw.com/part-107-test-study-guide

AUVSI (Association of Unmanned Vehicle Systems International) **2013 Economic Report:**
http://www.auvsi.org/our-impact/economic-report

Legal:

1. **FAA Fact Sheet on 'State and Local Regulations of UAS'** (12/17/2015): https://www.faa.gov/uas/resources/uas_regulations_policy/media/UAS_Fact_Sheet_Final.pdf
2. **Drone Legislation Directory** (2018): https://jrupprechtlaw.com/drone-legislation
3. **Drone Law Journal:** http://dronelawjournal.com/
4. **Drone Law Blog** (Rupprecht Law): http://jrupprechtlaw.com/drone-law-blog
5. **UAVs and the Law: The National Agricultural Law Center** (*not current*)**:** http://nationalaglawcenter.org/wp-content/uploads//assets/articles/UAVs-and-the-Law.pdf
6. **Seeking law abiding drones: what to tell clients that want to use drones in their businesses**, Business Law Today, 2/3/2015: http://tinyurl.com/zyz7zh4
7. **Centre for Spatial Law and Policy:** http://www.spatiallaw.com/

8. **Local and State Drone Laws** (March 2017): http://dronecenter.bard.edu/state-and-local-drone-laws/
9. **Center for they Study of the Drone at Bard College:** http://dronecenter.bard.edu/
10. **Drones and the Law** (Feb. 11, 2014): http://www.agweb.com/article/legal_ease_drones_and_the_law_naa_john_dillard-john-dillard/

Websites/blogs:

- sUAS News: http://www.suasnews.com/
- Drone Zone: http://www.agweb.com/drone-zone/
- **DroneLife.com**: http://dronelife.com/
- CropFlight Agricultural UAV blog (not current): https://cropflight.wordpress.com/
- **Academy of Model Aeronautics (AMA)**: http://www.modelaircraft.org/
- eXtension UAS in Agriculture Learning Network (not current): http://www.learnuasag.org/
- MAVLab (Delft Univ. of Technology): http://mavlab.tudelft.nl/
- The Drone Professor: https://www.thedroneprofessor.com/

Insurance/risk:

Background:

a. Drone Insurance: A step-by-step guide to liability & drone hull insurance (no date): https://uavcoach.com/drone-insurance-guide/
b. Who needs drone insurance – and how much does it cost? We talked to an industry leader to find out. (April 9, 2018): https://dronelife.com/2018/04/09/verifly-how-much-drone-insurance-do-you-really-need
c. What you need to know about drones and your insurance, Sept. 9, 2017: https://www.thebalance.com/what-you-need-to-know-about-drones-and-your-insurance-3961255
d. Rise of the Drones: Managing the Unique Risks Associated with Unmanned Aircraft Systems (Allianz; Sept. 2016): http://www.agcs.allianz.com/assets/PDFs/Reports/AGCS_Rise_of_the_drones_report.pdf
e. Dawning of the Drones: The Evolving Risk of Unmanned Aerial Systems (MARSH; June 2015): https://www.marsh.com/content/dam/marsh/Documents/PDF/US-en/Dawning%20of%20the%20Drones-06-2015.pdf
f. Can I Buy Drone Insurance (no date): http://www.agweb.com/article/can-i-buy-drone-insurance-ben-potter/
g. Can I Buy Drone Insurance (10/27/2014): http://www.proag.com/News/Can-I-Buy-Drone-Insurance-2014-10-27/2654
h. UAVs Need Insurance (Sept. 2014): http://magissues.farmprogress.com/WAL/WF09Sep14/wal014.pdf
i. Where will the drones take us? (Swiss Re; March 2017): http://www.casact.org/education/rpm/2017/presentations/CL-6_2.pdf
j. Be Safe and Responsible - or Don't Fly a Drone (no date): http://bestdroneforthejob.com/safety/
k. Drone Insurance and Liability Coverage: Do You Need It? (Jan. 17, 2018): https://blog.dronedeploy.com/drone-insurance-and-liability-coverage-do-you-need-it-b042485c46d5
l. Do you need a drone insurance and what is the cost? (Feb. 9, 2018): http://www.droneguru.net/do-you-need-a-drone-insurance-and-what-is-the-cost/

m. What your business forgot to do when deciding to buy a drone (no date; Nationwide Insurance): https://www.trustedchoice.com/professional-liability-insurance/pilot-coverage/commercial-drone-insurance/
n. Drone insurance: do you really need it? (April 25, 2017): https://fitsmallbusiness.com/drone-insurance/
o. Drone insurance: where to buy it & how much to get (Oct. 3, 2017): https://bestdroneforthejob.com/drone-buying-guides/drone-insurance-where-to-buy-it-how-much-to-get/
p. Drone insurance: on-demand vs. annual policy, which one is right for you? (Sept. 29, 2016): https://dronelife.com/2016/09/29/drone-insurance-demand-vs-policy-one-right/

Providers:

- AIG: http://www.aig.com/business/insurance/specialty/unmanned-aircraft-system
- Costello Insurance Assoc.: http://www.aviationi.com/droneuavhome.htm
- Surety One, Raleigh, NC: http://www.aerialvehicleinsurance.com/
- Transport Risk Management: http://www.transportrisk.com/uavrcfilm.html
- Travers & Associates: https://www.traversaviation.com/uav-drone-insurance.html
- Unmanned Risk (UR) Management: http://unmannedrisk.com/
- Academy of Model Aeronautics: https://quote.amadroneinsurance.com/quote/?source=google http://www.modelaircraft.org/files/InsuranceSummaryMembers.pdf (based on a recent e-mail, AMA may not cover the liability insurance for academia, as member of AMA, if you are a faculty/researcher of a university.)
- Verifly: https://verifly.com/
- SquareTrade (drone only): http://www.officedepot.com/a/content/services/ppp-drones/
- BWIFly: http://bwifly.com/aviation-insurance/drones/?_vsrefdom=adwords&gclid=EAIaIQobChMI-cyItdXG1wIVieNkCh3xAAc0EAAYASAAEgIXDPD_BwE
- American Heritage: https://www.americanheritageinsurance.com/drone-insurance.php?gclid=EAIaIQobChMI-cyItdXG1wIVieNkCh3xAAc0EAAYAyAAEgJmNPD_BwE
- The Hoxton Agency: https://hoxton.com/

UAS Aircraft:

- **Best Drones for Agriculture 2017: The Ultimate Buyer's Guide** (May 4, 2017): http://bestdroneforthejob.com/drone-buying-guides/agriculture-drone-buyers-guide/
- Drone-buyer checklist (March 21, 2014): http://www.agweb.com/article/drone-buyer_checklist_naa_ben_potter/
- Top 10 best drones for sale January 2018: http://myfirstdrone.com/tutorials/buying-guides/best-drones-for-sale/
- The Drone Chart-2017 Drone/Quadcopter Comparison: https://www.thedronechart.com/
- How to Buy a Drone, UAVCoach: http://uavcoach.com/buy-a-drone/

Drone rental:

7 Drone Rental Sites to Consider (Jan. 24, 2018): https://dronelife.com/2018/01/24/drone-rental-sites/

- Blue Skies Drone Rental (8 US locations): https://www.blueskiesdronerental.com/
- Lensrentals (Cordova, TN): https://www.lensrentals.com/rent/video/drones
- The Lens Depot (Oviedo, FL): https://www.thelensdepot.com/rent-drones.html

- Camera Lens (Chesterfield, IN): https://www.cameralensrentals.com/

Background on aircraft components:

- Features to Consider When Purchasing a Small Unmanned Aircraft System (sUAS), (June 2017): https://www.uaex.edu/publications/pdf/FSA-6151.pdf
- How Many Sensors Are In a Drone, and What Do They Do (July 22, 2016): http://www.sensorsmag.com/position-presence-proximity/how-many-sensors-are-drone-and-what-do-they-do-22743?page_id=1
- Which Sensors Drones Use to Fly? (June 15, 2016): https://quadmeup.com/what-sensors-drones-use-to-fly/
- Drone Gyro Stabilization, IMU and Flight Controllers Explained (June 12, 2016): https://www.dronezon.com/learn-about-drones-quadcopters/three-and-six-axis-gyro-stabilized-drones/
- Beginners Guide to Drone Autopilots (flight controllers) and how they work (Nov. 2015): http://www.dronetrest.com/t/beginners-guide-to-drone-autopilots-flight-controllers-and-how-they-work/1380
- Drones and UAV (LiDAR for collision): https://leddartech.com/drones-uas/

Practice aircraft:

Blade Nano QX RTF: https://www.amazon.com/BLADE-Nano-QX-RTF-Quadcopter/dp/B00SNEJA92
Holy Stone HS170: https://www.amazon.com/Holy-Stone-Predator-Helicopter-Quadcopter/dp/B0157IHJMQ/ref=sr_1_4?s=toys-and-games&ie=UTF8&qid=1510607069&sr=1-4&keywords=drone+holy+stone+HS170
Cheerson CX-10 Mini: https://www.amazon.com/Cheerson-CX-10-Mini-Quadcopter-Drone/dp/B00KXZC762/ref=sr_1_1_sspa?s=toys-and-games&ie=UTF8&qid=1510607427&sr=1-1-spons&keywords=cheerson+cx-10&psc=1
Eachine H8 Mini: https://www.amazon.com/EACHINE-Mini-Quadcopter-Drone-Mode/dp/B01LQ6NCUQ/ref=sr_1_1?s=toys-and-games&ie=UTF8&qid=1522185006&sr=1-1&keywords=Eachine%2BH8%2Bmini&th=1

Mission Planning software:

- Maps Made Easy: https://www.mapsmadeeasy.com/drone_mapping
- Ardu Pilot Mission Planning: http://ardupilot.org/planner/docs/common-mission-planning.html
- ConservationDrones.org: https://conservationdrones.org/mission-planner/
- FPV Camera: https://fpvbooster.com/index.php?option=com_content&view=article&id=3
- Topoflight: http://www.topoflight.com/
- UgCS (multi-drone support): https://www.ugcs.com/en/ugcs_features_applications#ugcs-applications
- DJI Go 4: https://itunes.apple.com/us/app/dji-go-4/id1170452592?mt=8
- DJI GS Pro: https://itunes.apple.com/us/app/dji-gs-pro/id1183717144?mt=8
- Litchi (for DJI aircraft): https://flylitchi.com/
- Airmap: https://www.airmap.com/
- Airdata UAV: https://app.airdata.com/main?a=register
- Skyward: https://skyward.io/

Data Processing/software:

- Ingesting, Managing, and Using UAV (Drone) Imagery in the ArcGIS Platform (Nov. 17, 2015): ESRI UAV workflow: http://tinyurl.com/hclnebh
- QGIS (open source GIS): http://www.qgis.org/en/site/forusers/download.html
- Microsoft Image Composite Editor (ICE): https://www.microsoft.com/en-us/research/product/computational-photography-applications/image-composite-editor/ (stitching)
- MeshLab (open source); http://www.meshlab.net/ (3D modeling)
- Autopano Pro & Giga (by Kolor): http://www.kolor.com/autopano/ (stitching)

- Fiji (**i**s **J**ust **I**mageJ, with extras. It is a distribution of ImageJ with many plugins useful for scientific image analysis in fields such as life sciences. Open source image processing): https://fiji.sc/
- ImageJ (open source Java image processing) tutorial: http://imagej.net/Stitch_and_Align_a_sequence_of_grid_images_Tutorial
- Mapknitter: https://publiclab.org/wiki/mapknitter (open source orthorectification)
- LISA Geo: http://www.lisa-geosoftware.de/
- Dronemapper: https://dronemapper.com/
- Pix4D (mapping & photogrammetry): https://pix4d.com/
- AgiSoft Photoscan: http://www.agisoft.com/
- PixelWrench2 (Tetracam): http://www.tetracam.com/Products_PixelWrench2.htm (multispectral image editing software)
- Simactive (image processing): https://www.simactive.com/
- Inpho (Trimble; image processing): http://www.trimble.com/imaging/inpho
- OrthoVISTA XTREME (by Stellacore Soln's LLC): http://www.orthovista.com/
- EnsoMOSAIC Agri-QGIS extension (by MosaicMill): http://www.mosaicmill.com/products_other/em_agri.html
- ENVI (by Harris Geospatial): http://www.harrisgeospatial.com/ProductsandTechnology/Software/ENVI.aspx
- ERDAS IMAGINE (by Hexagon Geospatial): http://www.hexagongeospatial.com/products/producer-suite/erdas-imagine
- Propeller (by Propeller Aerobotics Pty Ltd, Australia): http://www.propelleraero.com/ (Cloud software for drone data)
- Infragram (by Public Lab): https://infragram.org/
- Maps Made Easy (image processing): https://www.mapsmadeeasy.com/
- TurfAnalyzer (software to quantify plant health): https://www.turfanalyzer.com/

Data Processing SERVICES:

- DroneDeploy: https://www.dronedeploy.com/ (cloud-based image processing and analysis)
- Airinov: https://www.airinov.fr/en/ (cloud based image processing and analysis cereals & rape seed)
- Agremo (f. AgriSens): https://www.agremo.com/
- ANRA Technologies (mission planning & image processing): http://www.anratechnologies.com/home/

Sensors:

- What is CIR imagery and what is it used for? August 2016: https://www.altavian.com/knowledge-base/cir-imagery/
- (A simple primer on the vegetation index, NDVI) Misconceptions about UAV-collected NDVI imagery and the Agribotix experience in ground trothing these images for agriculture (Agribotix) (no date): http://agribotix.com/blog/2014/6/10/misconceptions-about-uav-collected-ndvi-imagery-and-the-agribotix-experience-in-ground-truthing-these-images-for-agriculture/
- Multispectral Imaging Camera Drones in Farming Yield Big Results (Oct. 10, 2017): https://www.dronezon.com/learn-about-drones-quadcopters/multispectral-sensor-drones-in-farming-yield-big-benefits/
- 12 Top Lidar Sensors for UAVs and So Many Great Uses (Jan. 17, 2018): https://www.dronezon.com/learn-about-drones-quadcopters/best-lidar-sensors-for-drones-great-uses-for-lidar-sensors/
- CMOS Sensors Enable Phone Cameras, HD Video, NASA Spinoff: https://spinoff.nasa.gov/Spinoff2017/cg_1.html
- Drone Aerial Photography and Videography. Data Collection and Image Interpretation. John Jensen. 2017. $14.99. https://itunes.apple.com/us/book/drone-aerial-photography-and-videography/id1283582147?mt=11

RGB:

- PhaseOne IXU: http://industrial.phaseone.com/iXU_camera_system.aspx
- Trillium HD25: http://w3.trilliumeng.com/orion-hd25.html

IR/NIR:

- Agrocam: http://www.agrocam.eu/
- Leonardo DRS: http://www.drsinfrared.com/
- Sentera Double (NIR + HR color): https://sentera.com/product/sentera-double-4k-inspection-sensor/
- Sentera Single (NIR): https://sentera.com/wp-content/uploads/2017/02/NDVI_Single_Sensor_New_Lit4056-WEB.pdf
- Sentera EO/IR (HD + IR video): https://sentera.com/sensors/
- FLIR A6750sc: http://www.flir.eu/science/display/?id=67022
- Infrared Cameras Inc (several IR models): http://www.infraredcamerasinc.com/blog/aerial-uav-applications-in-the-agricultural-field/
- DJI Zenmuse XT: http://www.dji.com/zenmuse-xt
- Aerialtronics PENSAR: https://www.aerialtronics.com/en/products/pensar
- Orion HD50 MWIR: http://w3.trilliumeng.com/orion-hd50.html

Background on converting cameras:
Digital cameras are equipped with an infra-red blocking filter that may be replaced by an external band-pass filter.

The use of modified cameras allows for image acquisition in spectral bands that are not currently used in traditional visible wavelength photography.

- Infragram Convertible Cameras (no date) (lists of cameras and a rating of converting): https://publiclab.org/wiki/infragram-convertible-cameras
- Infrared Camera conversion NIR NDVI (Jan. 25, 2017): https://www.rcgroups.com/forums/showthread.php?2821297-Infrared-Camera-conversion-NIR-NDVI
- Color-infrared (CIR) Imagery: http://www.mngeo.state.mn.us/chouse/airphoto/cir.html
- Do It Yourself Digital Infrared Camera Modification Tutorials (Life Pixel) (no date): https://www.lifepixel.com/tutorials/infrared-diy-tutorials

Companies that modify cameras:

- MaxMax: https://www.maxmax.com/
- IRpro: http://www.irprostore.com/
- Kolari Vision: https://kolarivision.com/ndvi-drone-camera-conversions/
- Drones Imaging: http://www.dronesimaging.com/en/solutions/ndvi-cameras/

Thermal

- Parrot Bebop-Pro Thermal: https://corporate.parrot.com/en/pressrelease/parrotbebop-prothermaltheall-in-onedronesolutionforthermalimaging
- FLIR Duo: https://www.flir.com/products/duo/
- FLIR Duo R: https://www.flir.com/products/duo-pro-r/
- FLIR One: http://www.flir.com/flirone/ios-android/
- Vayu HD (Sierra-Olympic): http://www.specim.fi/fx/
- Jenoptik IR-TCM HD: https://www.jenoptik.com/products/cameras-and-imaging-modules/thermography-camera/stationary-infrared-cameras/ir-tcm-hd-high-level-measuring-accuracy

Multispectral

- RedEdge-M (5 bands) (MicaSense): https://www.micasense.com/rededge/
- Parrot Sequoia (4 band): https://www.micasense.com/parrotsequoia
- Sentera Quad (3 bands + RGB): https://sentera.com/sensors/
- ADC (Tetracam)(no longer in production): http://www.tetracam.com/Products-ADC.htm
- ADC Lite (Tetracam): http://www.tetracam.com/Products-ADC_Lite.htm
- ADC Micro (Tetracam): http://www.tetracam.com/Products-ADC_Micro.htm
- GEMS (Sentek Systems): http://precisionaguavs.com/sensors/
- SlantRange 3p: http://www.slantrange.com/3p/
- Kernel (MAPIR; 6 bands): https://www.mapir.camera/pages/kernel-cameras

- Survey2 (MAPIR; 2 bands): https://www.mapir.camera/collections/survey2

Hyperspectral

- OCI™-OEM (BaySpec): http://www.bayspec.com/spectroscopy/oci-oem-hyperspectral-camera/
- Headwall Photonics: http://www.headwallphotonics.com/spectral-imaging/hyperspectral/micro-hyperspec
- FX series (SPECIM): http://www.specim.fi/fx/

LiDAR

- HDL-32E (Velodyne): http://velodynelidar.com/vlp-16-lite.html
- Puck LITE (Velodyne): http://velodynelidar.com/vlp-16-lite.html
- LIDAR-Lite v2 (PulsedLight): http://tinyurl.com/jzevogp
- SF02/F (Lightware): http://lightware.co.za/shop2017/proximity-sensors/1-sf02f.html (review: http://diydrones.com/profiles/blogs/sf02-laser-altimeter-review)
- Phoenix LIDAR: https://www.phoenixlidar.com/lidar-products/
- RIEGL VUX-1UAV: http://www.riegl.com/products/unmanned-scanning/riegl-vux-1uav/
- SICK 3D LiDAR sensors: https://www.sick.com/us/en/detection-and-ranging-solutions/3d-lidar-sensors/c/g282752
- LeddarTech: http://leddartech.com/drones-uas/ (altimeter)
- YellowScan: http://www.yellowscan.fr/
- Robin Mini + UAV package (3D Mapping): https://www.3dlasermapping.com/wp-content/uploads/2018/01/ROBIN-MINI-Datasheet17-18-WEB.pdf

Webinars:

How Can Ultra-High Resolution Drone Imagery be Acquired and Used for High Throughput Plant Phenotyping, Kevin Price, AgPixel, March 1, 2017: https://learn.extension.org/events/3011

"I have a drone, now what?", James Robbins, Wed, March 15, 2017: https://www.youtube.com/watch?v=f9x8Sf9S4pA&feature=youtu.be

UAV's in Nurseries: Count on It, James Robbins, Wed, Feb 12, 2014: https://www.youtube.com/watch?v=-M7QkVXD9Ok

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