Aerial Application's Important Service to Agriculture

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Aerial Application Defined

Aerial application: is the use of airplanes and helicopters to seed, fertilize and treat crops with protective products to control weeds, insects and fungi. It is used on both organic and conventional cropland. Aerial application is also used to treat forestland, rangeland and pastureland for livestock and to control disease-carrying insects like mosquitoes and other health-threatening pests. It is an important part of food, fiber and bio-fuel production.

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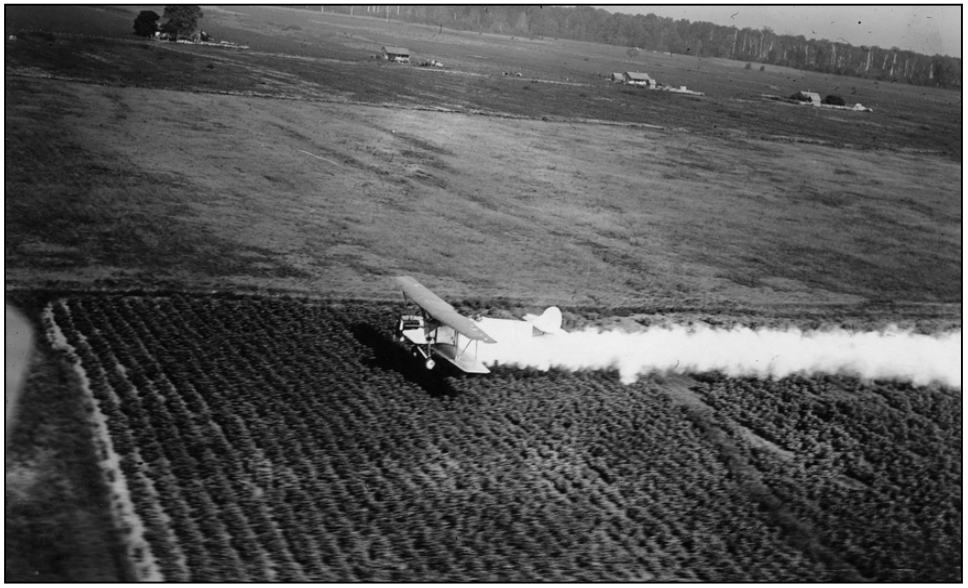
The History U.S. Ag Aviation

- **1921 – Lt. John Macready made the U.S.'s first aerial application by airplane spreading lead arsenate dust over catalpa trees in Ohio to kill sphinx moth larvae using a Modified Curtiss JN-6 "Super Jenny"**

- **Delta Airlines in the 1920s, started as Huff Daland Duster Company, the first company to apply pesticides through the air. Based in Monroe, LA they serviced cotton farmers in the Mississippi Delta.**



Agricultural Aviation Industry Overview

No. of aerial application operations in U.S. (94% of the owner/operators are also pilots)	1,350*
No. of additional non-owner ag pilots	1,430*
No. of aircraft per business:	2.1*
Percent of industry airplanes:	87%*
Percent of industry helicopter:	13%*
Percent powered by turbine engines	67%
Percent of all crop protection products applied aerially on commercial cropland:	18.75
No. of cropland acres treated by air annually: (doesn't include pasture, rangeland or urban uses)	71 million
Price range of agricultural aircraft	$100K-$1.4M

* From 2012 NAAA Survey

Reach of the Aerial Application Industry

- According to a 2012 NAAA survey, the five most common aerially treated crops are: corn, wheat/barley, soybeans, pastures/rangelands and alfalfa, but aerial application is used on many, many more crops grown in the U.S.
- The industry also provides protection to waterways (irrigation ditches, eradication of invasive species); accounts for nearly 100% of forest applications; is used for fire-fighting; and public health applications to control mosquitoes and other health-threatening pests.

Importance of Ag Aviation

Allows rapid treatment of large areas:

- **Fastest way to treat a crop (3-4 times faster than other forms of application; turbine 160 mph)**
- **Important when application is needed within a narrow timeframe**
- **Pest Resistance can be addressed by aerial's ability to treat in multiple conditions; allowing for the application to be made at the most precise, efficacious window.**

Importance of Ag Aviation

- Aerial application can reach remote, hard to reach areas without causing damage
  - i.e. surface water, wet soil, rolling terrain or dense plant foliage inaccessible to other forms of application.

Importance of Ag Aviation

- Aerial application can reach orchards and late stage crops or dense plant foliage without causing damage compared with other forms of application
  - Based on a study by Purdue University, crop loss due to ground trample from ground applicators could range from 1.5% to 5.0%

Managing Fungicide Applications in Soybean

PURDUE EXTENSION

Table 1. *Estimated impact of boom width on grain yield loss per acre from wheel-track damage in soybean at Farmland, Columbia City, and Butlerville, Indiana.*

	Boom Width (feet)			
	30	60	90	120
	Yield Loss Per Acre (%)			
Farmland 2005	5.5	2.8	2.1	1.4
Farmland 2006	6.7	3.4	2.6	1.7
Columbia City 2006	4.3	2.1	1.6	1.1
Butlerville 2005	3.2	1.6	1.2	0.8
Average	**4.9**	**2.5**	**1.9**	**1.3**

Yield losses were the same at all three row widths (7.5, 15, and 30 inches).

Importance of Ag Aviation

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Aerial Fertilizer Use

Application of fertilizer is also commonly done by air, particularly in 2015 with the wet spring planting season

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Late fertilizer runs show yield promise

Tom Doran, Field Editor

Tuesday, June 30, 2015 3:00 PM

LEXINGTON, Ill. — Aerial application of crop protection products has been common practice for decades and now is being looked at as an additional tool for hiking yields even further.

Schertz Aerial Service has been conducting on-farm research into high-yield soybeans since 2012 with a focus on applying by air granular potassium nitrate, ammonium nitrate or ammonium sulfate at the R2 growth stage or later.

Initial experimentation, including applications of potassium nitrate, resulted in moderate soybean yield increases, with an average yield increase of two to seven bushels. The potassium nitrate applications also resulted in observations of improved plant health with modest yield and quality benefits.

With the hypothesis that nitrogen could be a limiting factor in high soybean yields, this past year one of the aerial service's cooperators requested a soybean yield trial where 40 pounds of nitrogen was applied, as ammonium nitrate, in a side-by-side configuration in two applications.

The first ammonium nitrate application was made Aug. 4, at approximately the R2 full bloom stage. The second application was made 10 days later when the soybeans had progressed to the R3 or R4 growth stage. A large section of the field was left as

Schertz Aerial Service has been involved in on-farm research to look at the viability of a late-season fertilizer application to boost soybean yields. Results of those studies were part of a seminar hosted by the company at its Lexington, Ill., facility. Scott Schertz (left) and Bob Beck, WinField agronomist who has assisted with the research, were among the presenters at the seminar.

- Schertz Aerial Service has conducted tests showing ammonium nitrate fertilizer applications near the R2 full bloom stage increased soybean yields by 10 to 15 bushels over the 70-bushel base yield.
- Ag aircraft are well suited for late-timed fertilizer applications because they can deliver the product to the crop when it needs it the most without disrupting the crop or the field, he added.

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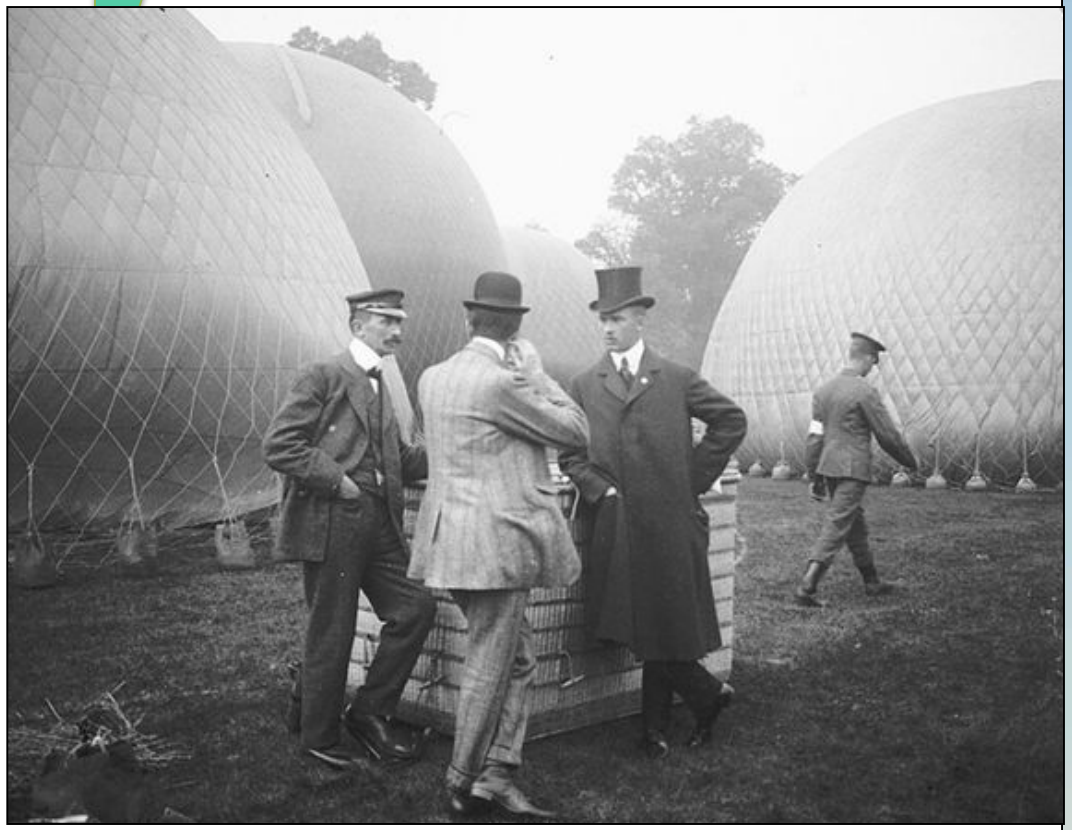
Aerial Seeding

In 1906 the first known aerial application of agricultural materials was made by John Chaytor who seeded a swamped valley floor in Wairoa, New Zealand, using a hot air balloon with mobile tethers.



Today's Aerial Seeding

- Today aircraft are used to seed many crops such as rice and forests for regrowth after a fire.
- Aircraft are also used to seed cover crops
- Cover crops is a rapidly growing service to help farmers:
  - control erosion
  - retain/recycle soil nutrients
  - build organic matter to improve soil health
  - improve water quality
  - improve moisture availability
  - break up disease and insect cycles

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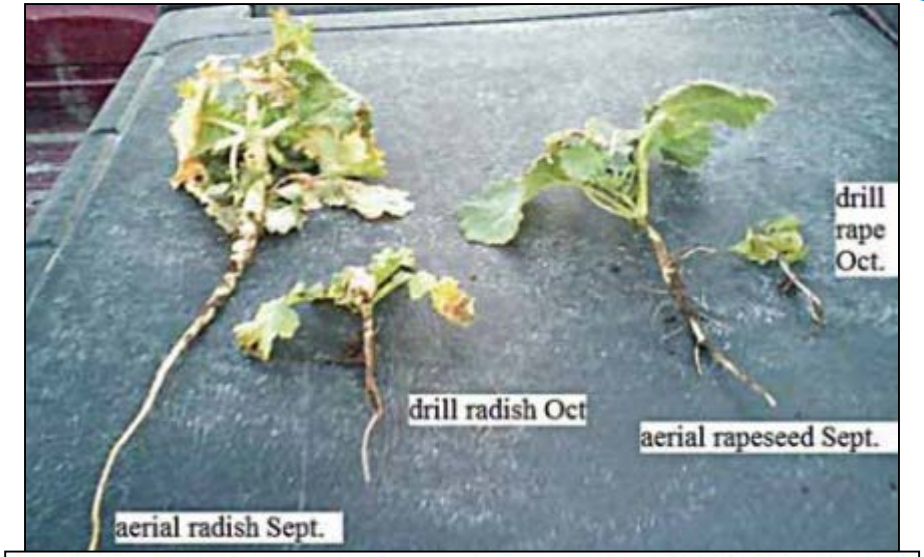
Today's Aerial Seeding

- NWF goal to increase cover crop acreage to 20 million acres by 2020
- Aerial expands the growing window of cover crops by an extra 1½ months allowing the seeds to establish themselves earlier and grow more before the first frost.



Winter rye shown in mid-September after aerial seeding.

Modern Aerial Application: Precision Ag

- Using Global Positioning Systems (GPS) and Geographic Information Systems (GIS) and flow control valves to make variable rate applications, and more precise applications of crop protection products, fertilizers and seeds
- Also allows, along with single boom shutoff valves and AIMMS, GPS, etc. for better control of the dispersion of these crop inputs.
- Precision Ag may result in lower expenses, even higher yield and better environmental stewardship.

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Modern Aerial Application: Precision Ag

- GIS provides the ability to measure complex data about the geography allowing for analysis and modeling. Normalized Difference Vegetative Index (NDVI) is another type of measurement system that uses sensors to measure chlorophyll levels in plants aiding in fertilizing and other inputs for crops using precision agriculture.
- Sensing can be conducted using, manned ag aircraft, satellites and, UAVs in limited circumstances, where FAA permission has been granted.

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Precision Ag Services Provided by Ag Aircraft, Satellites and UAVs (limited)

- Crop Sensing
  - Crop condition assessment imaging systems can be used for pest detection.
  - Airborne imaging systems offer advantages over satellite due to relatively low cost, high spatial resolution, easy deployment and real time availability of imagery for visual use.
  - At 500 ft. a pixel covers 1.4 in. and 500 ft. x 330 ft. of ground; at 10,000 ft. a pixel covers 28 in. and 1.9 mi. x 1.2 mi. of ground.

Nikon camera mounted on the step of an ag aircraft. A GPS receiver and video monitor integrated with the camera are mounted in the cockpit.

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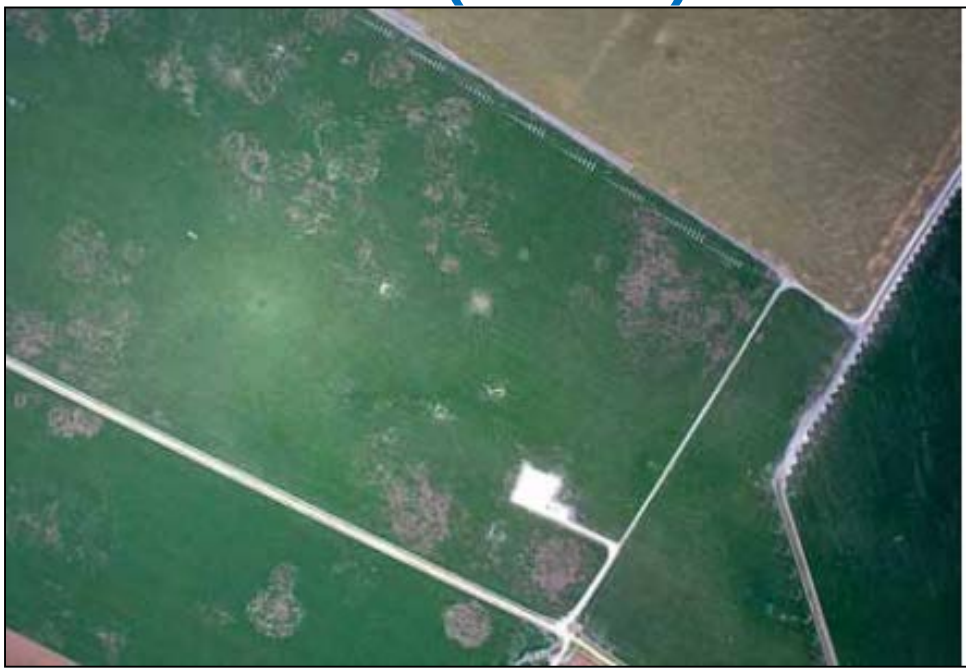
Precision Ag Services Provided by Ag Aircraft, Satellites and UAVs (limited)

- Aerial Imaging
  - Software can be used to perform basic image processing and create prescription maps for precision application.
  - 2012 NAAA Survey found that 21% of ag aviators use flow control devices for variable rate application (precision agriculture).



A color image acquired at 4,000 ft. AGL over a cotton field infected with cotton root rot using an ag aircraft. On the color image, healthy cotton plants have a dark green color, whereas infected plants have a grayish tone similar to bare soil.

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Agricultural Aviation Industry Precision Ag Overview

Percent of industry using variable rate application	21%*
Percent of industry using AIMMs	4%*¬
Percent of industry that use GPS	99%*°

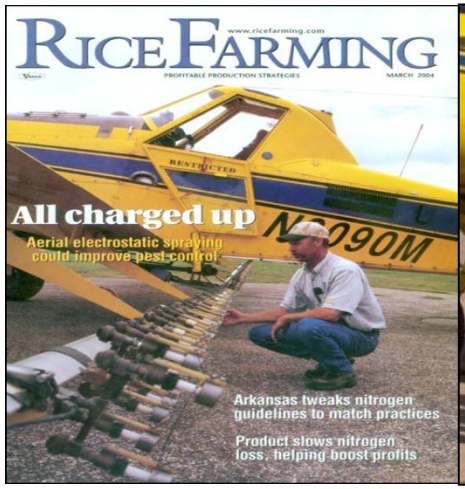
* From 2012 NAAA Survey

° An NAAA 1998 survey indicated that 60% of agricultural airplanes were equipped with GPS as compared to 25% in 1994.

¬ Aircraft Integrated Meteorological Measurement System

Aerial Application Technology Research

- Since 2002 NAAA has been successful in lobbying the government for an additional $7,112,500 to be invested in aerial application research.
- USDA economists have found that every dollar invested in ag research has a $20 return to the economy
- NAAA broadcasts in its publications and education programs the USDA-ARS AAT Group's cutting edge drift mitigation and efficacy technologies and techniques



USDA ARS Aerial Application Technology Research Unit High Speed Spray Nozzle Models

STEP 1: SELECT NOZZLE MODEL USING PULL DOWN MENU

CP11TT Straight Stream

VALID FOR AIRSPEEDS FROM 120 to 180 MPH

Aerial Application Technology Research Unit, Agricultural Research Service, U. S. Department of Agriculture, 3103 F&B Road, College Station, TX 77845, USA.

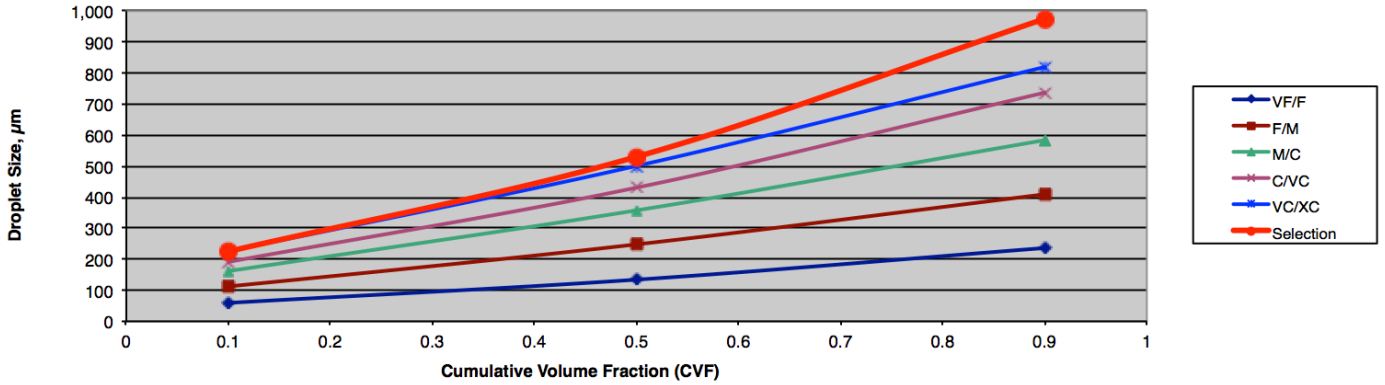
STEP 2: SELECT NOZZLE OPERATING PARAMETERS FROM PULLDOWN MENUS BELOW.

Acceptable Ranges:	Orifice Size	Nozzle Body Angle	Pressure	Airspeed
	6 to 25	0 to 45	30 to 90 psi	120 to 180 MPH
	10	0	60	140

CAUTION: Do not enter or clear data in the cells in this box!

$D_{V0.1}$ =	225	µm	= Droplet size such that 10% of the spray volume is in droplets smaller than $D_{V0.1}$.
$D_{V0.5}$ =	530	µm	= Volume median diameter. Droplet size such that 50% of the spray volume is in droplets smaller than DV0.5.
$D_{V0.9}$ =	975	µm	= Droplet size such that 90% of the spray volume is in droplets smaller than $D_{V0.9}$.
RS =	1.41		= Relative Span
%V<100µm =	1.80	%	= Percentage of spray volume in droplets smaller than 100 µm diameter.
%V<200µm =	9.55	%	= Percentage of spray volume in droplets smaller than 200 µm diameter.
$DSC_{V0.1}$ =	VERY COARSE		= Droplet Spectra Classification based on $D_{V0.1}$.
$DSC_{V0.5}$ =	EXT. COARSE		= Droplet Spectra Classification based on $D_{V0.5}$.
$DSC_{V0.9}$ =	EXT. COARSE		THE $D_{V0.9}$ CLASSIFICATION SHOWN IS FOR REFERENCE ONLY, DOES NOT IMPACT DSC RATING.
DSC =	VERY COARSE		= ASABE S572.1 Droplet Spectra Classification

The Red Curve Shows Data for the Selected Nozzle Operation.
The Other Curves are for the ANSI/ASAE S572.1 MAR 2009 Reference Nozzles.



Values and classifications reported here are least-squares best-estimate predictions from experimental data collected in a wind tunnel.
Values reported from other laboratories may not yield the exact same values, but similar trends would be expected.
The ASAE droplet spectra classification category boundaries were generated by reference nozzle data measured in a 15 mph concurrent airstream using a Sympatec HELOS.

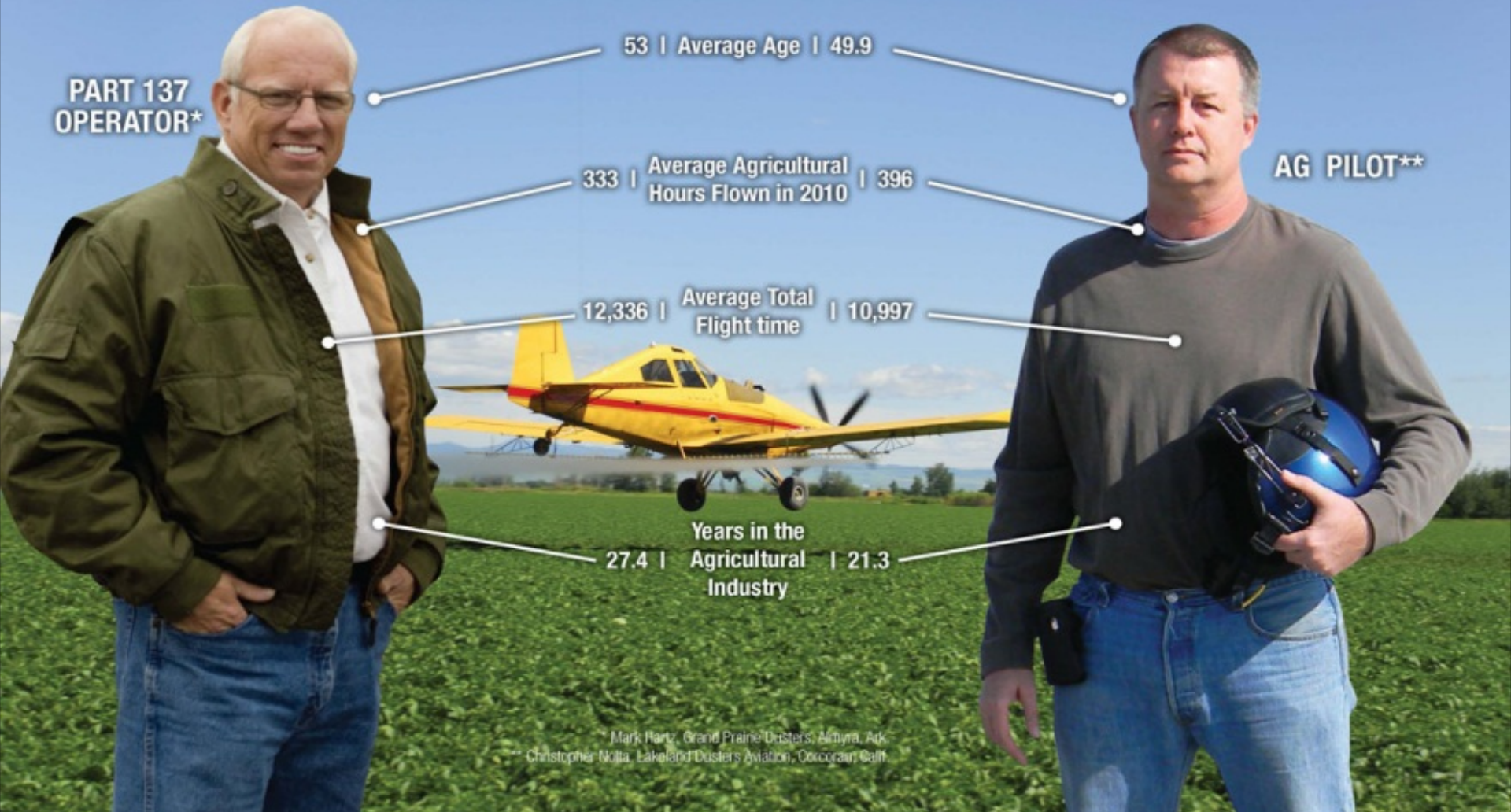
Aerial Application Professionalism

- Ag pilots have their commercial pilots' licenses and must also be registered as commercial pesticide applicators in the states which they make applications
- Aerial applicators must hold the Federal Aviation Administration Part 137 Certificate that allows for low-level aviation operations

Portrait of the 21st Century Aerial Applicator

A landmark NAAA survey of operators and pilots offers the most comprehensive glimpse of the aerial application industry ever

By Jay Calleja, Manager of Communications



Aerial Application Safety and Stewardship Programs

National Agricultural Aviation Research and Education Foundation (NAAREF) - developed the Professional Aerial Applicators' Support System (PAASS) Program - in 1998. PAASS is a comprehensive educational program for aerial applicators focusing on safety, security and drift mitigation.

- PAASS reached 2,027 during the 2013-14 Season
- PAASS is offered at approximately 22 of the state and regional ag aviation association conventions each year.
- State Regulatory Agencies offer CEU's for PAASS attendance.
- PAASS has received funding from EPA, FAA and various allied companies.
- Insurance companies offer discounts/additional coverage to ag pilots for attending PAASS. Has received funding and kudos from FAA & EPA
- Since 1998, aerial drift incidents have decreased 26%; ag aviation accidents have decreased 20.63% per 100,000 hours flown.
- PAASS drift mitigation topics include: nozzle selection and setup (ARS models); spray system maintenance; airspeed and drift potential; Inversions and drift potential; precision ag equipment

Aerial Application Safety & Stewardship Programs

- NAAA's Operation S.A.F.E. (Self-regulating Application & Flight Efficiency) program enables aerial applicators to attend spray equipment calibration clinics and have their aircraft professionally analyzed for spray pattern uniformity and droplet size. This minimizes drift and maximizes efficacy.

Obstacles Compromising Aerial Application Safety

Unmarked Towers

- Since 2005 7% of aerial application accidents were the result of collisions with towers
- 12 accidents; 5 fatal
- Since 2005 15.5% were the result of collisions w/ wires
- A 2014 legal settlement granted $6.7 million to ag pilot widow. Wind energy, tower, landowner and farming entities held liable for not marking and not informing pilot of tower
- NAAA is urging Congress and the FAA to require marking towers between 50-200 feet; and to develop a searchable database for the location of such towers

Fatal Air Tractor collision with a meteorological evaluation tower (MET). August 2013.

Obstacles Compromising Aerial Application Safety

Unmanned Aerial Systems (UAS)?

- 400 accidents/incidents involving military UAVs (June 2014 *Washington Post* Article)
- Dozens of near-misses between commercial aircraft and illegally operating UAVs (including two near misses between ag aircraft and UAVs in 2014)
- Security Concerns: UAV "spoofing" or hacking
- "Lost Link" concerns: Some aircraft have no lost link procedure and continue flying until they hit a obstacle or run out of fuel

UAV's Economic Potential

Market and Use Studies

- AUVSI Study
  - $13.6 billion economic impact within the first three years of integration, $82.1 billion between 2015 and 2025
- Lux Research Study
  - Ag drones could generate $350 million in revenues by 2025 from an estimated 330,000 U.S. units.
- Clemson University's Edisto Research & Education Center
  - A UAV can analyze a 10-acre field in less than 5 minutes, work that take a person days or weeks to complete
  - UAS potential for crop-sensing and aerial imaging; some aerial application operations are diversifying operations with UAVs.

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UAVs Used for Aerial Application Purposes

- UAVs in Japan
  - 90 percent of crop protection in Japan is performed by UAVs (4 gallon RMAX helicopter)
  - Average farm size in Japan is 1.5 hectares (3.7 acres), compared to 441 acres in the US.
  - RMAX hopper 4 gallons vs. 300+ average tank size for a modern ag aircraft
  - RMAX spraying speed 15 mph vs. 160 mph for a manned ag aircraft

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UAV Efficacy and Cost Concerns

- Application efficacy issues with today's UAVs compared to larger manned ag aircraft due to downward thrust-to-weight ratio—the amount of air pushed down to the crop canopy—from a rotor or fixed wing—is proportional to the weight of the aircraft that the air is holding up.
- Larger ag aircraft aide in thorough and efficient application of crop protection product
- A four gallon, 15 mph Yamaha R-MAX costs $86,000. Large UAVs cost in multi-millions of dollars and are not available for application. Manned ag aircraft range from $100,000- $1.5 million (800 gallon 160 mpg) and by far have the cost, speed and efficacy advantage.

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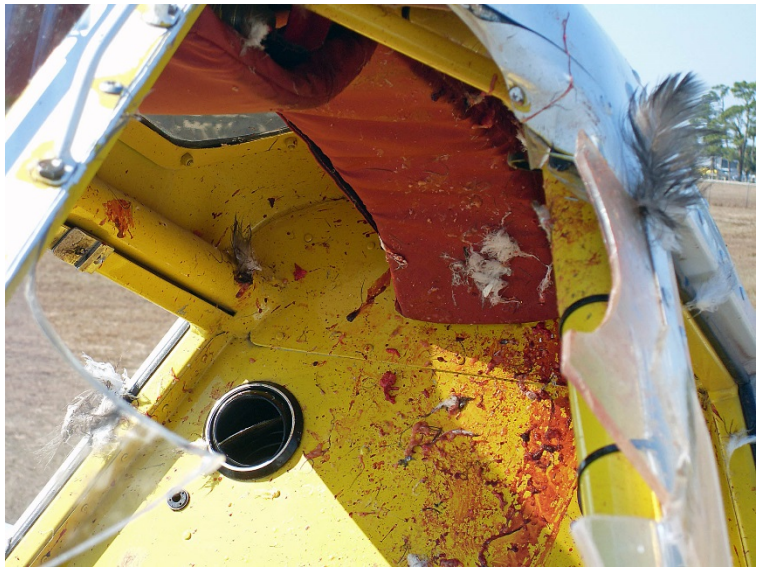
UAV-like Obstacles Compromising Aerial Application Safety

Ag Aviation's Additional Concerns with UAS Operating at Low-Level:

Bird Incidents

- Birds are the second leading cause of aviation fatalities
- 142,000 wildlife strikes with civil aircraft between 1990 and 2013, with 25 fatalities



Above: Luckily, operator Steve Fletcher only sustained minor injuries when a turkey vulture blew out the cockpit window of his Air Tractor 802 while he was flying. Turkey vultures only weigh between 2-4 pounds.

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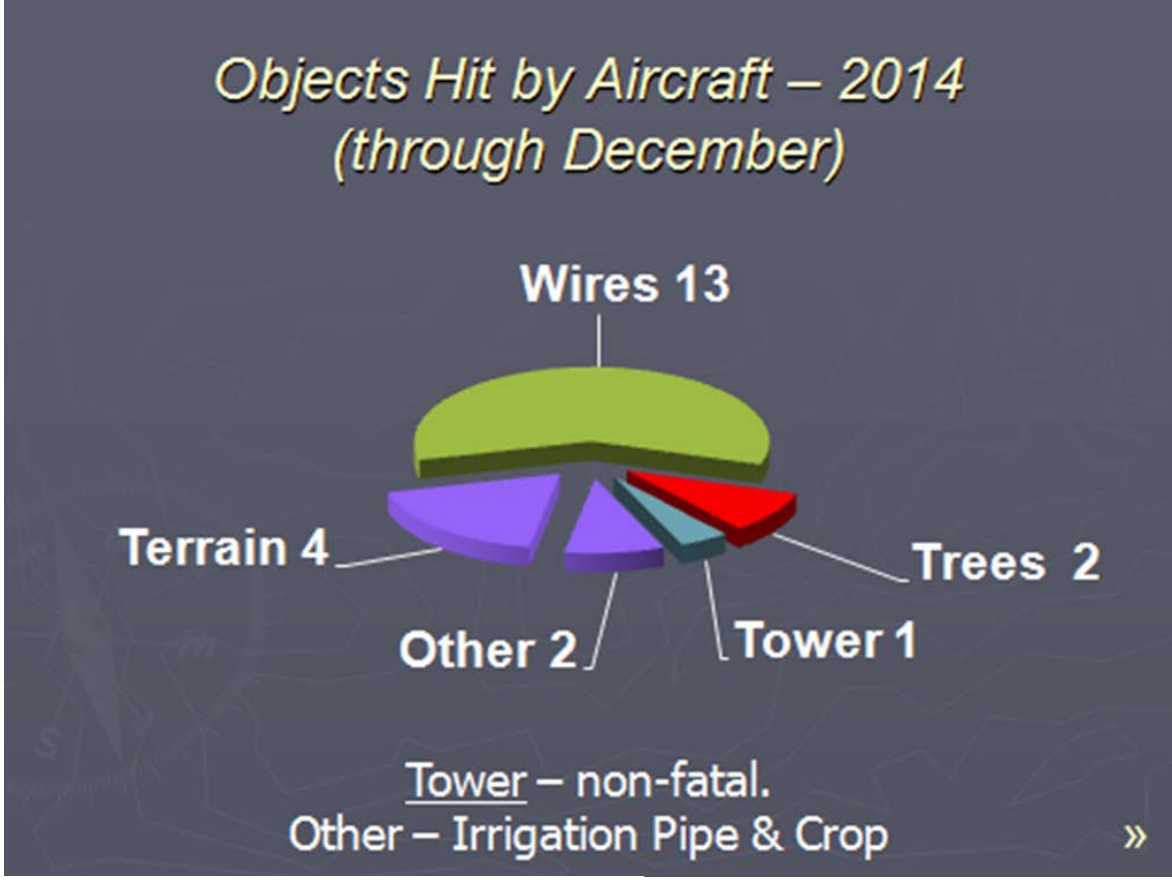
Ag Aviation's Additional Concerns with UAS Operating at Low-Level:



Fatal **Accidents (Ag Aviation)--2014**

Present UAV Use—Sec. 333 Petitions

- FAA has granted permission of UAV use and exemption from a number of FARs to a variety of industrial sectors varying from agriculture, to real estate to filming to search-and-rescue. The end of July 2015, the FAA announced granting its 1,000th 333 Petition for UAVs.
- Remain only legal method of commercial use until final small UAS rule is adopted (estimated 2017)
- Exemptions granted require private pilot's license, 48 hour NOTAMs, operation within line of sight, preflight inspection, and registering the UAV with an N-number.

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Future UAV Use: FAA sUAS Rule

- Applicable to UAS 55 pounds or less being operated for compensation or hire
- Operator may only operate the UAS within range of “natural vision”
- UAS must give way to manned aircraft
- Operator must self-certify that they have no condition that would medically prevent them from seeing and avoiding aircraft (no medical exam required)
- Written operator exam only (no operations requirements); every 2 years
- Requires UAS to be registered with the FAA with N number displayed
- Operator must assure prior to flight that the aircraft is airworthy
  - Unlike manned aircraft, there is no requirement for a FAA certification for airworthiness
- Requires coordination with ATC when operating in controlled airspace and airport operators when operating near airports

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UAVS CAN BE HAZARDOUS TO LOW-FLYING PILOTS

Don't Bet the Farm by Putting UAV Operations Above Pilot Safety.

Small UAVs can be virtually invisible—and potentially lethal—to agricultural pilots, emergency medical helicopters, law enforcement and other low-flying aircraft operating in the same airspace. Birds smaller than many UAVs have collided with aircraft, blowing through cockpit windows, disabling engines and killing pilots in the process.

Here's what you can do as a safe and responsible UAV operator:

- Get certified and well-trained in operating a UAV
- Equip UAVs with strobe lights and tracking technology, like an ADS-B Out system
- Follow the law—always give the right-of-way to the manned aircraft
- Coordinate with local aircraft operators about your UAV operations
- Carry sufficient UAV liability insurance

A UAV collision could have far-reaching consequences. An ag pilot's fatal collision with an unmarked meteorological tower resulted in millions of dollars in liability for the farmer, landowner and tower manufacturer. UAV operators could be similarly culpable for a midair collision.

Fly with care. Don't put your livelihood and pilots' lives at risk.

A message brought to you by your local aerial applicator and

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Learn more at AgAviation.org/uavsafety | Knowbeforeyoufly.org | Thinkbeforeyoulaunch.com

SEE AND AVOID

Manned Aircraft Must See a UAV to Avoid It.

The ability to see and avoid obstructions and other aircraft is the backbone of safety for aerial applicators and all air traffic operating under visual flight rules. All aircraft, including UAVs, have a responsibility to abide by this aviation safety principle. Small UAVs can be virtually invisible—and potentially lethal—to agricultural pilots, emergency medical helicopters, law enforcement and other low-flying aircraft operating in the same airspace.

Be smart about deploying a UAV over your fields.

- Equip UAVs with strobe lights and tracking technology,like an ADS-B Out system
- Get certified and well-trained in operating a UAV
- Follow the law—always give the right-of-way to the manned aircraft
- Coordinate with local aircraft operators about your UAV operations
- Carry sufficient UAV liability insurance

Fly with care. Make sure you can be seen and tracked by low-flying, manned aircraft. Keep a safe distance from them or land until aircraft have left the area.

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Learn more at AgAviation.org/uavsafety | Knowbeforeyoufly.org | Thinkbeforeyoulaunch.com

UAV Operations Responsibility & Liability

- UAV Insurance currently offered by certain insurance providers
- § 107.37 of FAA Proposed Rule for UAV's states: "(2) Yielding the right-of-way means that the small unmanned aircraft must give way to the aircraft or vehicle and…No person may operate a small unmanned aircraft so close to another aircraft as to create a collision hazard."
- Farmer insurance policies typically only cover between $100,000 and $300,000 in damages, and only in limited circumstances if at all when it comes to aviation
- $6.7 million wind energy settlement demonstrates liability

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Conclusion

- Aerial application is the fastest and in many cases only application method that can be used to see, fertilize and protect/enhance a crop.
- Technologies are continuously being developed evolving aerial application (droplet size calculators, precision ag, etc.)
- Aerial Applicators are experienced, and continually augmenting their professionalism (PAASS, Operation S.A.F.E., CEU's to retain licenses).
- Properly mark/track low-level obstacles and think about their placement to protect aerial applicators

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Questions?

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