YAMAHA

Introduction to the Yamaha RMax Remotely Piloted Helicopter and Review of U.S. Activities

Steve Markofski – Unmanned Systems Division

RMAX Type II G

- Yamaha History & Milestones
- Yamaha Global Products
- Yamaha Motor Corporation, U.S.A.
- RMax General Product Background
- RMax Specifications
- RMax Basic Flight Operation
- RMax Safety Systems Overview
- RMax Performance Summary
- RMax Development History
- RMax Use in Japan
- Overseas Expansion
- UC Davis Project
- FMRA / Section 333

History & Milestones

1955

- Founding of Yamaha Motor Corporation
- Production of first motorcycle (YA-1,125cc)

1960

- Begins business operations in the United States (Los Angeles, CA)

1987

- Development completed for Yamaha's first commercial-use unmanned helicopter "R-50"

RMAX Type1G

Yamaha Global Products

- **Land** (Motorcycle, ATV, SxS, Snowmobiles, Electric & Electro-Hybrid Vehicles)

- **Water** (Boats, Marine Engines, Water Vehicles)

- **Power Products** (Golf Carts, Generators, Snow Throwers)

- **Commercial & Industrial Products** (Aeronautical Products, Engines, & Other)

Key Attributes: Innovation, High Quality Products, Customer Satisfaction

General Product Background

Load into Vehicles

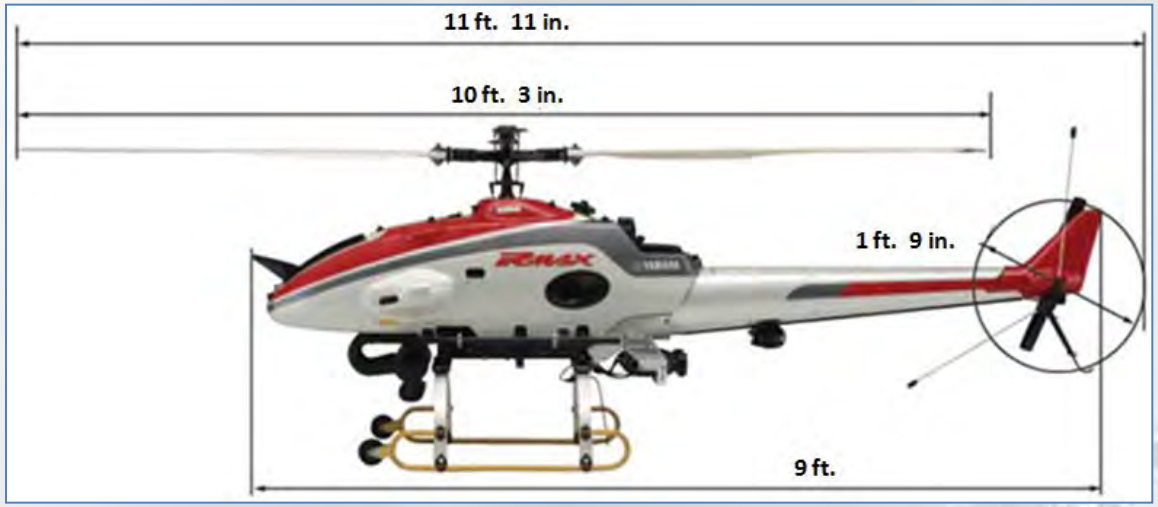
Sprayer Tanks

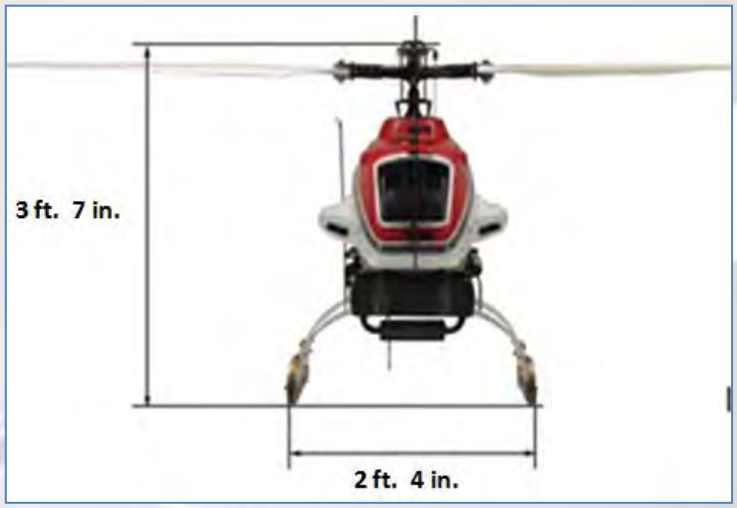
Sprayer System

Control System

RMAX Type II G

RMax Basic Specifications





DIMENSIONS

MAIN ROTOR DIAMETER	10 ft. 3 in.
TAIL ROTOR DIAMETER	1 ft. 9 in.
OVERALL LENGTH	9 ft. (Overall length with rotor 11 ft. 10.91 in.)
OVERALL WIDTH	2 ft. 4 in.
OVERALL HEIGHT	3 ft. 7 in.
DRY WEIGHT	141 lbs.

ENGINE

TYPE	2-stroke, horizontally opposed 2-cylinder
CYLINDER DISPLACEMENT	246 cc
MAXIMUM OUTPUT	21 hp
STARTING SYSTEM	Electric starter
FUEL	Regular unleaded mixed with 2-stroke engine oil
SOUND DATA	72dB (at 50 meters)

RMax Performance Specifications

PERFORMANCE

LOAD CAPACITY*	61 lbs. 12 oz.
CONTROL SYSTEM	Yamaha Attitude Control System (YACS) with GPS
TRANSMITTER	72 MHz / 6 Frequency

*The performance may vary depending on environmental conditions, such as the temperature, humidity, and altitude

RMax Sprayer Specifications

LIQUID SPRAYER

CASSETTE TANK CAPACITY	2 gal. 1 pt. x 2 tanks
DISCHARGE METHOD	Double-acting piston with flat nozzle
DISCHARGE RATE	.32 to .53 gal /minute (speed-linked method)
NOZZLE PITCH	4 ft. 4.75 in.
SPRAYER WEIGHT	16 lbs. 5 oz.

RMAX Type II G

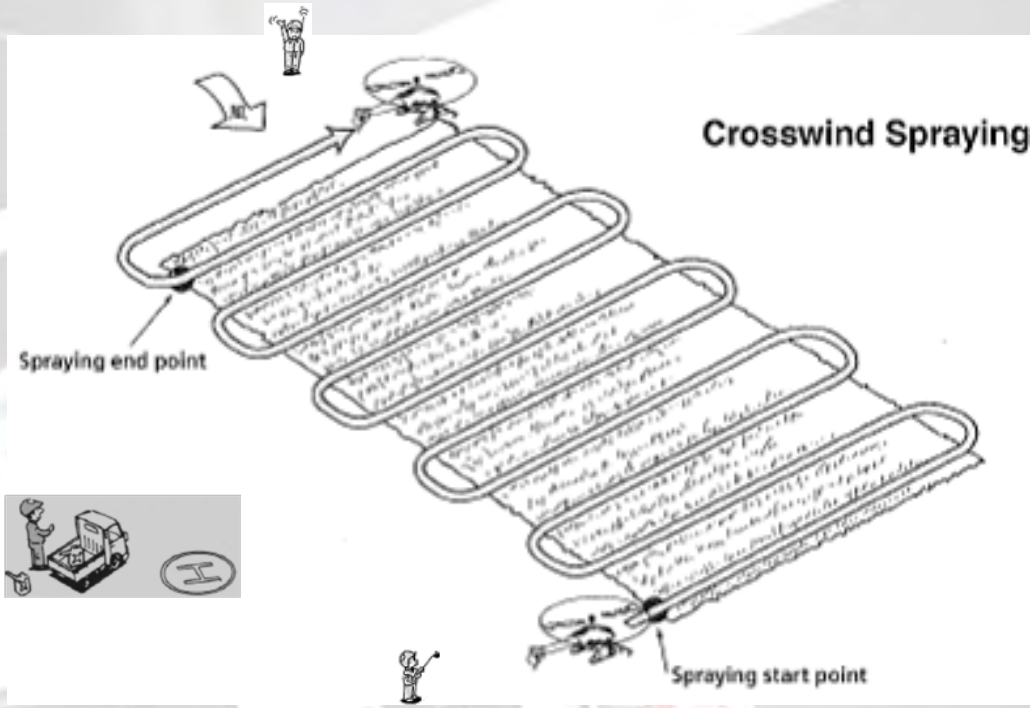
RMAX Basic Spray Operations & Flight Pattern

Spray Application Height

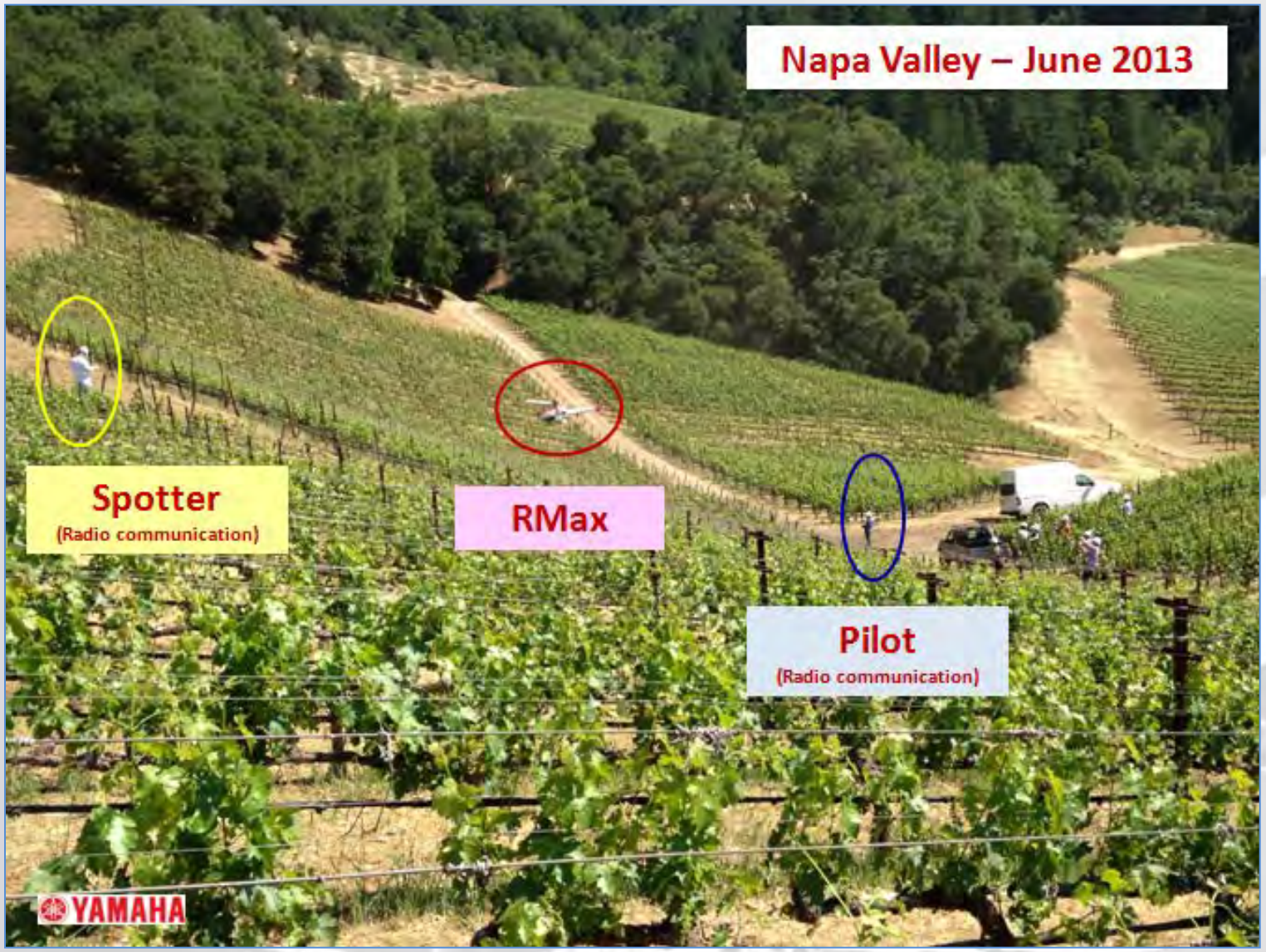
- 10 ft above the target

Basic Spray Operation, Pattern & Speed

- Nose Away Attitude from Pilot in Command
- 9 – 12 mph Maximum Speed
- 65 ft distance-off required for all participating crew

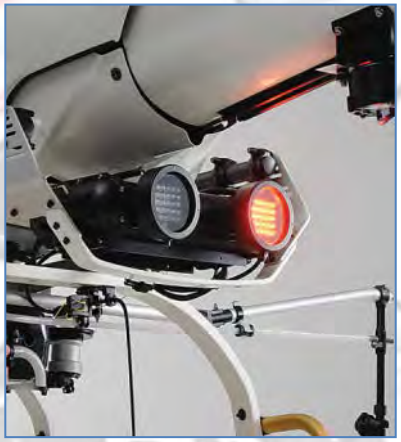


Standard RMAX Flight Pattern



Safety Systems Overview

- Self-Monitor Function (Diagnostic before takeoff)
- YACS - Yamaha Attitude Control System (Attitude control)
- GPS flight control system (Speed & altitude control)
- Radio interference / Loss of radio communication (Loss link hover)
- YACS warning Light / GPS indicator light (Visual indicators during flight)
- Speed indicator light (Visual indicator during flight)
- Rotor brake



Development History

20+ Years of Safe & Reliable Commercial Operations

<u>1980's</u>

1983: Development begins with request from Japanese Government

1987: Yamaha completes development of R-50

<u>1990's</u>

1991: Yamaha begins marketing R-50 Type II in Japan

1995: Yamaha Attitude Control System (YACS) introduced on R-50

1997: RMax released offering greater payload & greater ease of use

<u>2000's</u>

2002: 1 million acres per year sprayed by remotely piloted helicopters

2003: RMax Type II released, updates include GPS for greater control

2012: 2,400 RMax helicopters in service in Japan

Performance Summary

- Years in service: 20+ years
- Units in operation: 2,400 RMax today
- Acres sprayed: 2.4 million annually
- Total flight hours: 2.0+ million




Yamaha has Manufactured over 4,500 Helicopters

RMax Use in Japan

Agriculture Applications

Rice Paddies

Wheat

Soy Beans

Pine Trees

Vegetables

Fertilizer

Success Factors

Remotely Piloted Helicopters are Recognized Solutions to Several Key Problems Confronting Agriculture Today

- Aging farming population
- Restrictions on manned crop dusting due to spread of urbanization (less drift)
- The depressed cost of agricultural products

Success of Remotely Piloted Helicopters in Japan

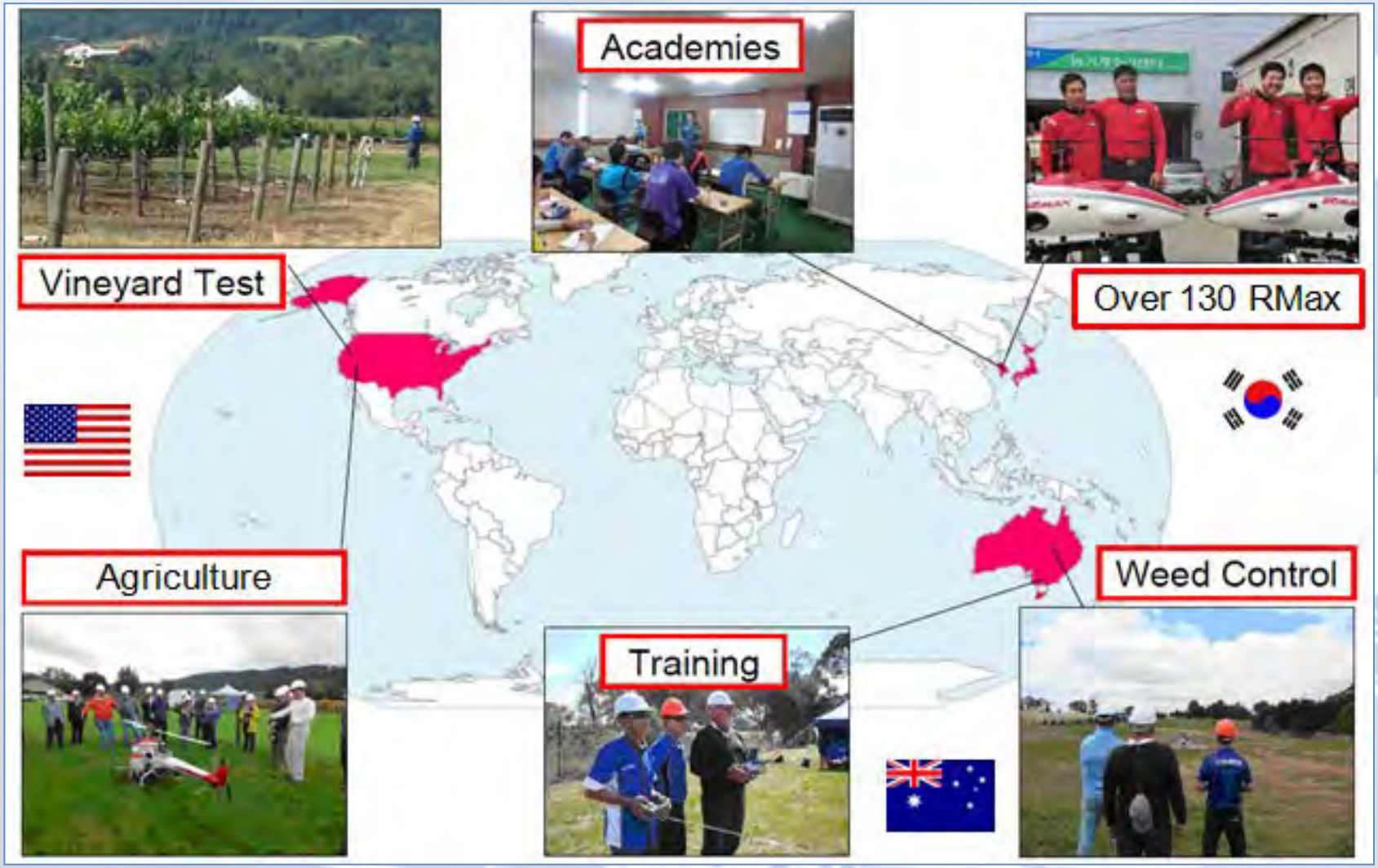
- Increased safety
- Coverage efficiency and accuracy
- Significantly lower costs

Success of RMax

- Yamaha's advance flight control system
- Reliability
- Training

Overseas Expansion

South Korea / Australia / USA



UC Davis Project

2015 UC Davis Project

Project Background and Goal:

In 2012, UC Davis and Yamaha Motor Company initialed a project investigating the use of the RMax, unmanned helicopter for agricultural spraying. 2015 project is a continuation and expansion of the cooperative work.

Project Objectives:

1. Conduct an analysis of typical pesticide label suitability for use with the RMax spray system and identify pesticide labels consistent with RMax application;

2. Apply registered pesticides with RMax to manage portion of Oakville test vineyard from bud break to harvest in order to determine efficacy and deposition;

3. Adapt the AgDisp model to the RMax characteristics and field verify the performance of the model as compared to observed spray swath; and,

4. Demonstrate the vehicle operation to agricultural industry, media and regulatory representatives and educate them on the technology and concepts of UAV use in agricultural spraying.

Identified Advantages

- Safer than manned ground application
- Improved operational efficiency
- No soil compaction
- No crop damage
- Quality spray deposition

Tractor driver suffers life-threatening injuries

The remains of a tractor that rolled down a hill Thursday morning. The driver was extricated from under the tractor by first-responders and taken to an area hospital.

UC Davis Project

2015 Residue Spray Test Results

Ground Spray Rig

RMax

Pre sample 0.18 ppm 150 leaves # grams in sample
100 leaves per sprayed sample

	Ground		UAV	
	ppm boscalid	g sample	ppm boscalid	g sample
Bottom Block 1	12.80	185.69	19.50	209.00
Bottom Block 2	15.70	204.69	13.90	219.75
Bottom Block 3	17.20	189.59	10.40	239.41
Bottom Ave	15.23	193.32	14.60	222.72
Bottom Std Dev	2.24	10.04	4.59	15.42
Middle Block 1	15.40	257.02	12.00	241.71
Middle Block 2	12.00	225.59	26.90	244.13
Middle Block 3	18.10	210.53	18.80	245.67
Middle Ave	15.17	231.05	19.23	243.84
Middle Std Dev	3.06	23.72	7.46	2.00
Top Block 1	9.51	199.55	43.40	182.49
Top Block 2	23.50	192.50	34.30	189.95
Top Block 3	22.20	201.95	14.20	197.17
Top Ave	18.40	198.00	30.63	189.87
Top Std Dev	7.73	4.91	14.94	7.34

Summary of means and standard deviations

Foliage location	Ground spray ppm	UAV spray ppm
Top	18.40 (7.73)	30.63 (14.94)
Middle	15.17 (3.06)	19.23 (7.46)
Bottom	15.23 (2.24)	14.60 (4.59)
Overall	16.27 (4.59)	21.49 (11.23)

FAA Modernization & Reform Act of 2012
Section 333 Grant of Exemption

Section 333 of The FAA Modernization and Reform Act of 2012

Section 333 gives the FAA the authority to grant case-by-case authorization for certain UAS to perform commercial operations in the NAS prior to the finalization of UAS rules.

→ Section 333 Exemption process provides a path for operators who wish to pursue safe and legal entry into the NAS.

Yamaha Received Grant of Exemption for the RMAX on May 1, 2015

Grant of Exemption allows Yamaha Motor Corp., USA to operate the RMAX for agriculture related operations in the US.

Summary of conditions & limitations:

- VLOS
- Pilot in Command (PIC) must hold a Sport Pilot Certificate
- PIC must hold a current US Driver's License
- PIC + Visual Observer (VO) must complete Yamaha RMAX Certification Training for roles
- Daylight Hours / Good Weather
- Operations over uninhabited areas (e.g. vineyards, fields, groves & orchards)
- Operations defined as "agricultural aircraft operation" will be in accordance with 14 CFR part 137

FAA Modernization & Reform Act of 2012
COA for Section 333

Certificate of Waiver or Authorization for Section 333

Certificate of Waiver (COA) is effective only with the approved FAA Section 333Grant of Exemption.

Yamaha's COA for the RMAX is effective from May 4, 2015 to May 31, 2017

COA allows Yamaha Motor Corp., USA to operate the RMAX in the US under the following provisions:

- Below 200 feet AGL
- Distant (D) NOTAM must be filed no more than 72 hours, but not less than 24 hours prior to ops
- PIC to remain clear & give way to all manned aviation ops & activities at all times
- PIC & VO maintain instantaneous communications at all times
- 5 nautical miles (NM) from airports with operational control tower
- 3 NM from airports with published instrument flight procedures, but no tower
- 2 NM from airports with no published instrument flight procedures or tower
- 2NM from heliport, gliderport or seaport

YAMAHA

Thank you!

UAV Regulatory Issues
Ken Everett

Areas that UAV's Could be Used

* Sloping Terrain
* Vector Control
* Future sites ?

DPR is looking at:

Licensing

Labeling

Worker Protection

Drift/Buffer Zones

Licensing Requirements

Commercial Pilots License

FAA Medical

Journeyman Certificate

Apprentice Certificate

Exam Questions regarding UAV's

Labeling

* Aerial Labels
* Required To Follow Aerial Instructions
* Could See Specialized UAV labeling
* Reduced Water Volumes

Exposure/Drift studies

Environmental Monitoring

* Working on a Drift Study
* Modeling

Worker Health and Safety

* Exposure Study Protocols being prepared
* Pilot exposure
* Observer/Mix Loader Exposure
* Equipment Movement Exposure
* PPE Requirements

Questions?