Elevating Spray Precision with Advanced Nozzle Control using Pulse Width Modulation (PWM)

By: Adam Madison

CapstanAG™

APPLICATION SYSTEMS FOR PROFESSIONALS™

Imagine, if you will, a world where Precision is Everything!

1. Perfect Patterns Every Pass
2. Adaptive Flow for Each Nozzle
3. Uniform Droplet Size Control
4. Real-Time Adjustment and Flexibility
5. Increased Chemical Efficacy

HOW CAN YOU DO THIS??

This can all be achieved using Pulse Width Modulation (PWM).

3 Types of Spraying

Speed and Pressure

- Fixed Tip Size
- Fixed Speed (As good as Pilot)
- Fixed Pressure (As good as Pilot)
- Rate Can Move Around

Rate Controller / Conventional

- Fixed Tip Size
- Rate Held Constant
- Variable Pressure Based off Speed
- Variable Droplet Size

PWM

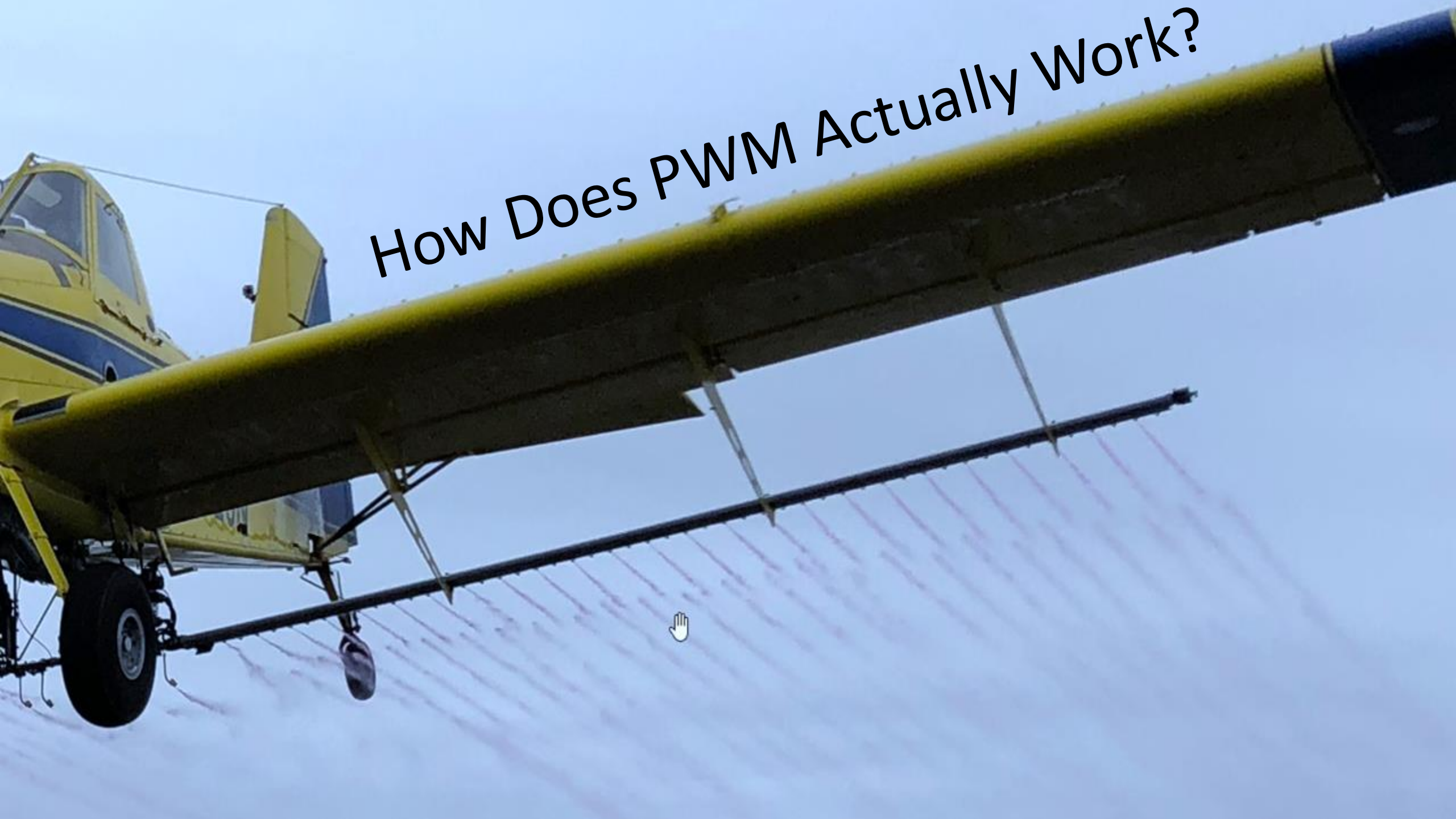
- Variable Tip Size
- Variable Speed
- Pressure Held Constant
- Droplet Size Held Constant
- Rate Held Constant

Conventional Spray System

- The rate controller changes flow by adjusting the flow control valve or the flow to a pwm driven pump
- Faster travel speed requires more flow.
- Increased flow requires increased pressure.
- Doubling the travel speed requires the flow to double. (2x speed = 2x flow)
- To double flow, pressure must increase 4 times. (2x flow = 4x pressure)

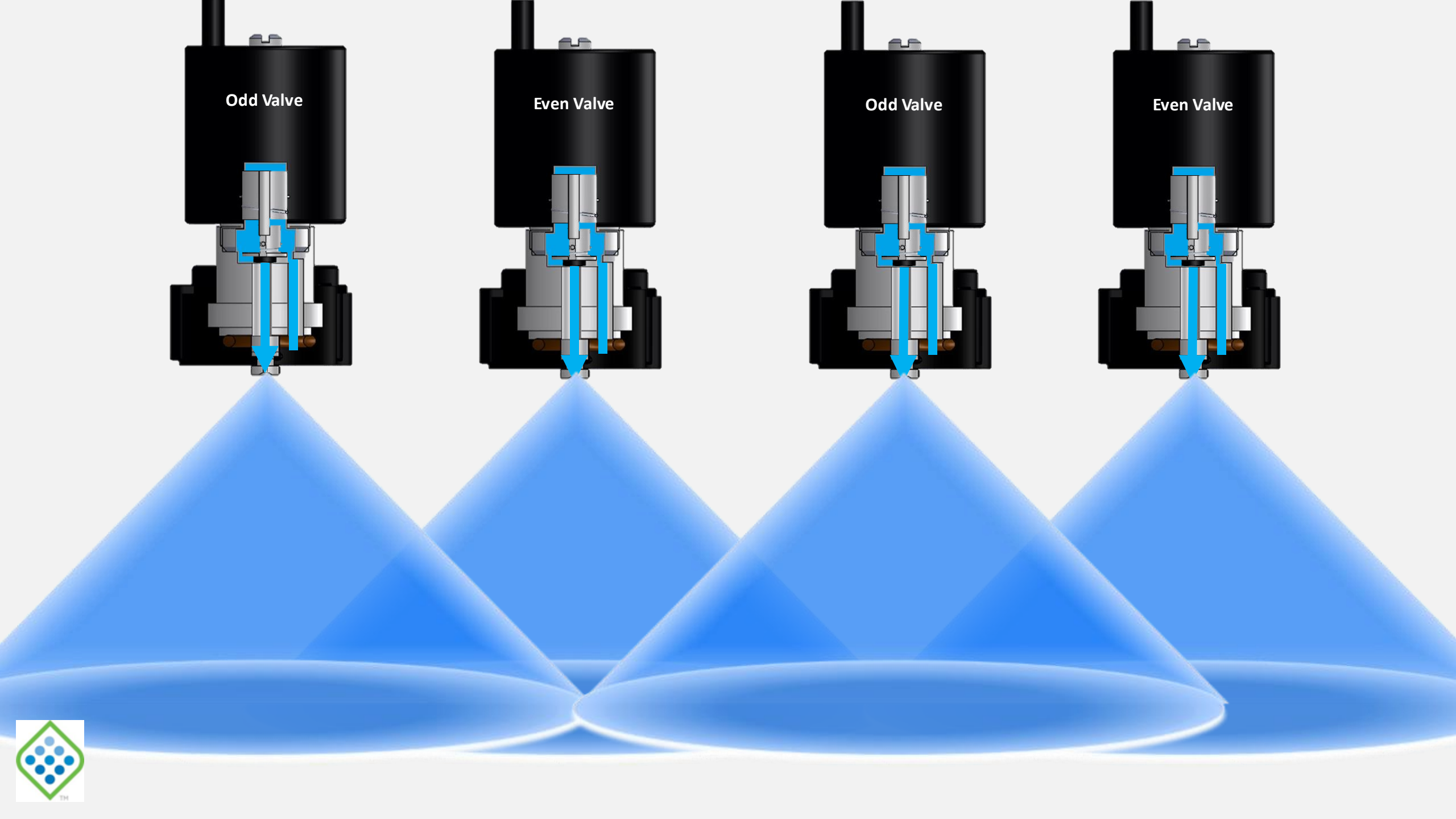
PWM Technology

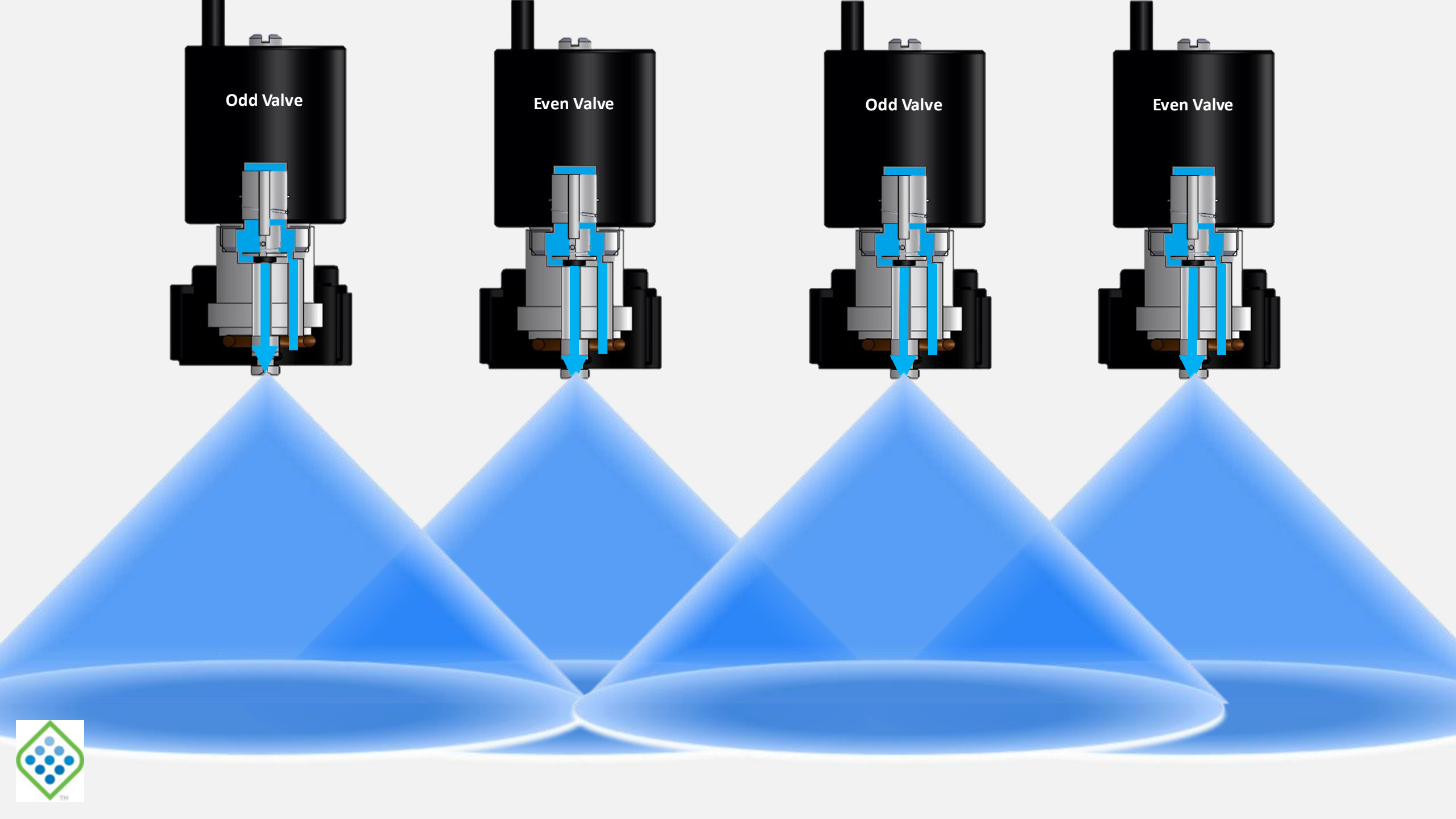
1. **Perfect Patterns Every Pass:**
   - Allows for ultra-precise control over spray patterns.
   - By adjusting the flow rate or duty cycle (**ON** time) at each nozzle, PWM can help create an even, consistent spray coverage across the entire field.
2. **Adaptive Flow for Each Nozzle:**
   - Unlike traditional spray systems, PWM systems allow for individual control of each nozzle. This means each nozzle can be tuned to deliver exactly the right amount of product, adapting instantly to changes in speed or field conditions, ensuring optimal application every time.
3. **Uniform Droplet Size Control:**
   - By precisely managing pressure and pulse width (duty cycle), PWM allows for greater control over droplet size, which is crucial in reducing drift and increasing target coverage. This helps in making applications more effective and reducing waste due to off-target drift.
4. **Real-Time Adjustment and Flexibility:**
   - Provides the capability to respond to changing field conditions in real time, such as adjusting flow rates to match the target area's exact needs, ensuring the best possible coverage and effectiveness.
5. **Increased Chemical Efficacy:**
   - With each droplet consistently sized and spaced, the chemical's impact on the target area is optimized, meaning you're getting the most out of every tank and helping to achieve better pest or weed control outcomes.


How Does PWM Actually Work?

PWM Valve assembly pulsing at 20Hz

- Instant on, on in 20 milliseconds (ms)
- Instant off, off in 7 milliseconds (ms)
  - Off in 1.5 feet.
- At 150 mph, that is 11 feet per pulse.


Odd Valve
Even Valve
Odd Valve
Even Valve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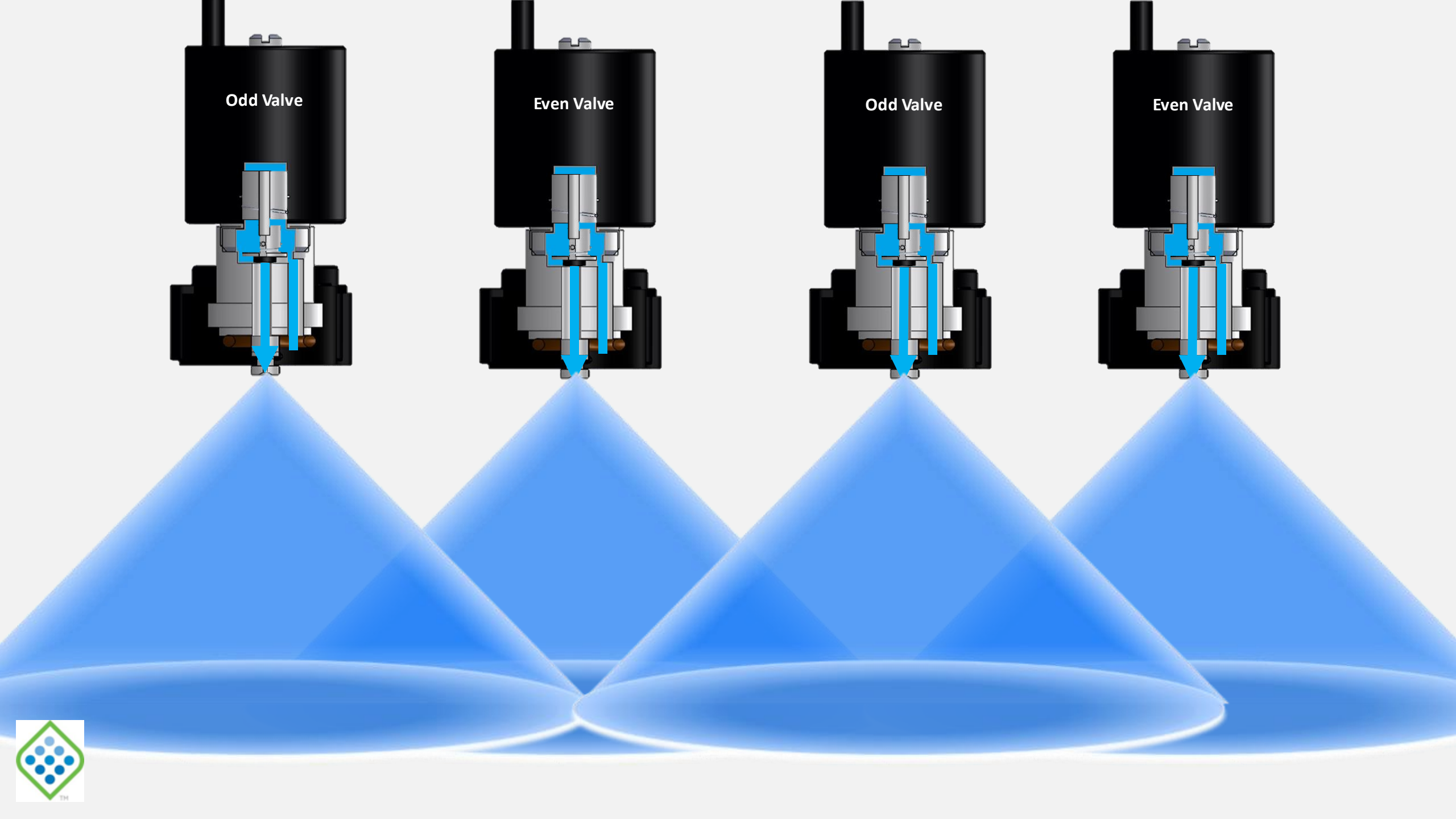
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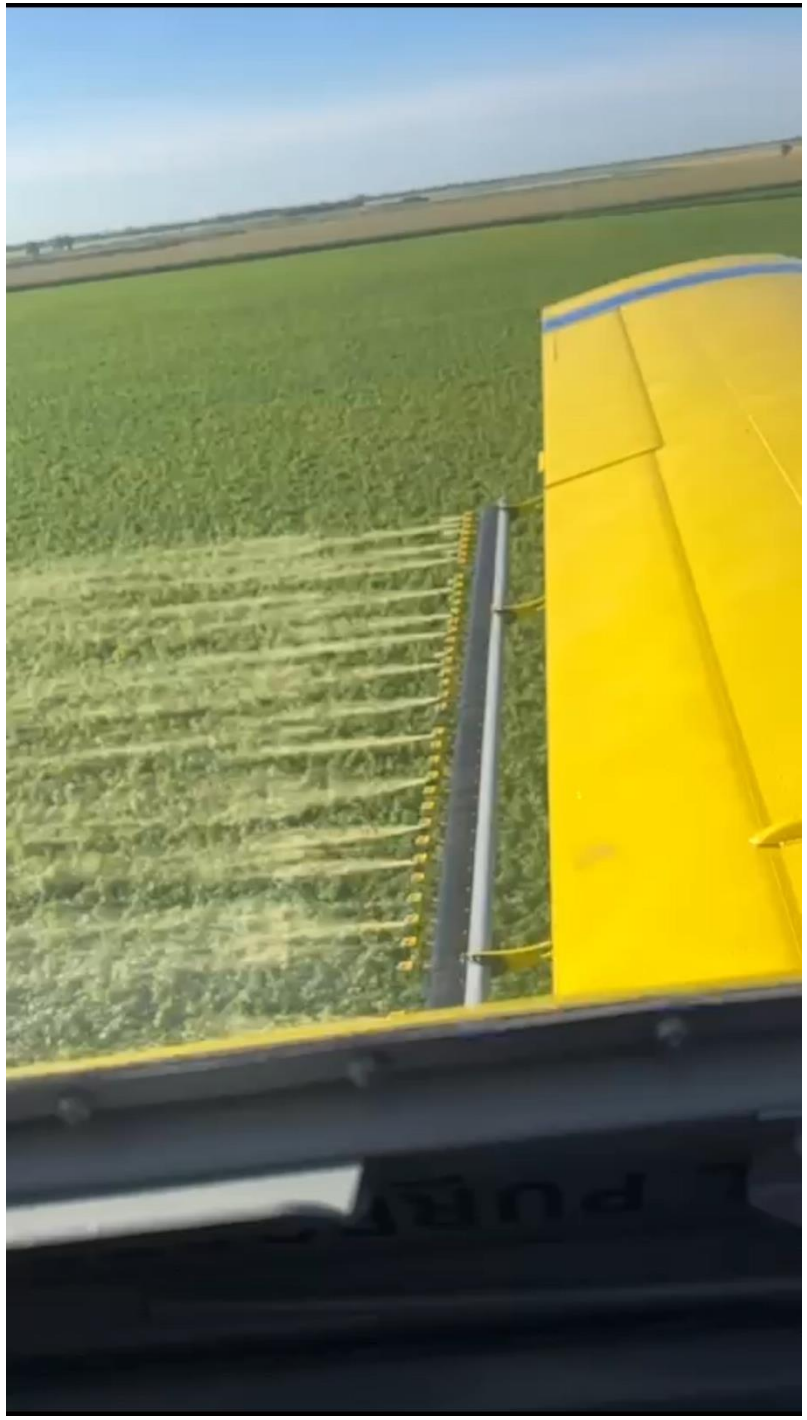


PWM can simulate a variable tip without changing tips…

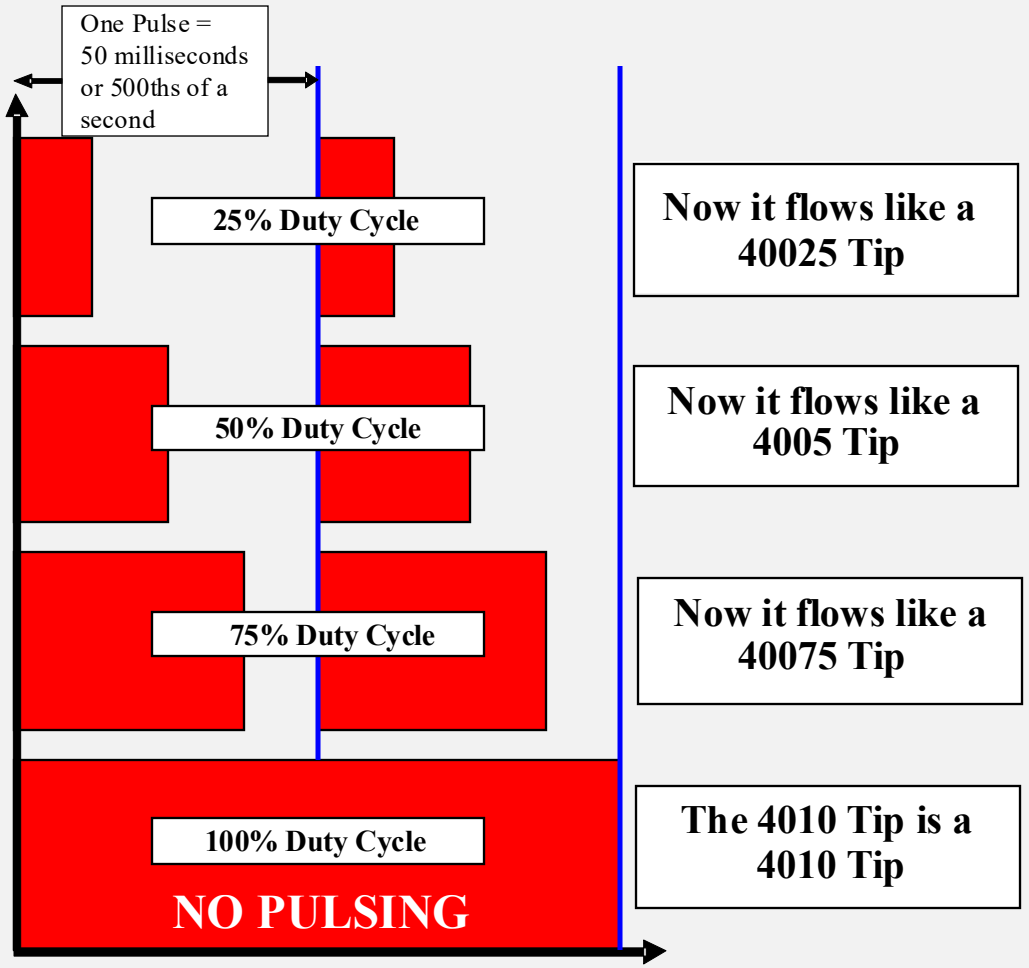
1. Uses a larger tip

   (Top Rate and Maximum Speed)

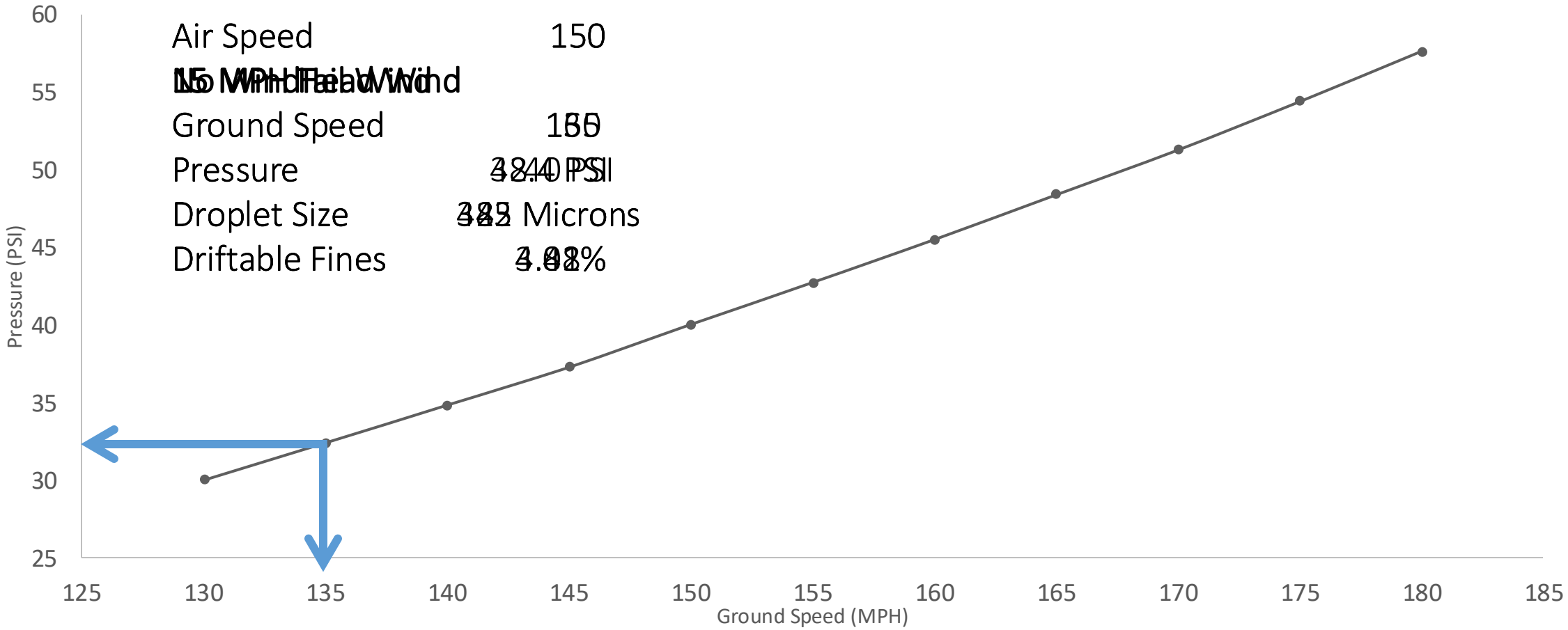
2. Use PWM to Simulate a Smaller Tip

   a. Manage Pressure

For example: Using a 4010 flat fan tip



Conventional Tip Curve



Tip: CP11TT-0010 Straight Stream
(Ref: USDA ARS Nozzle charts)

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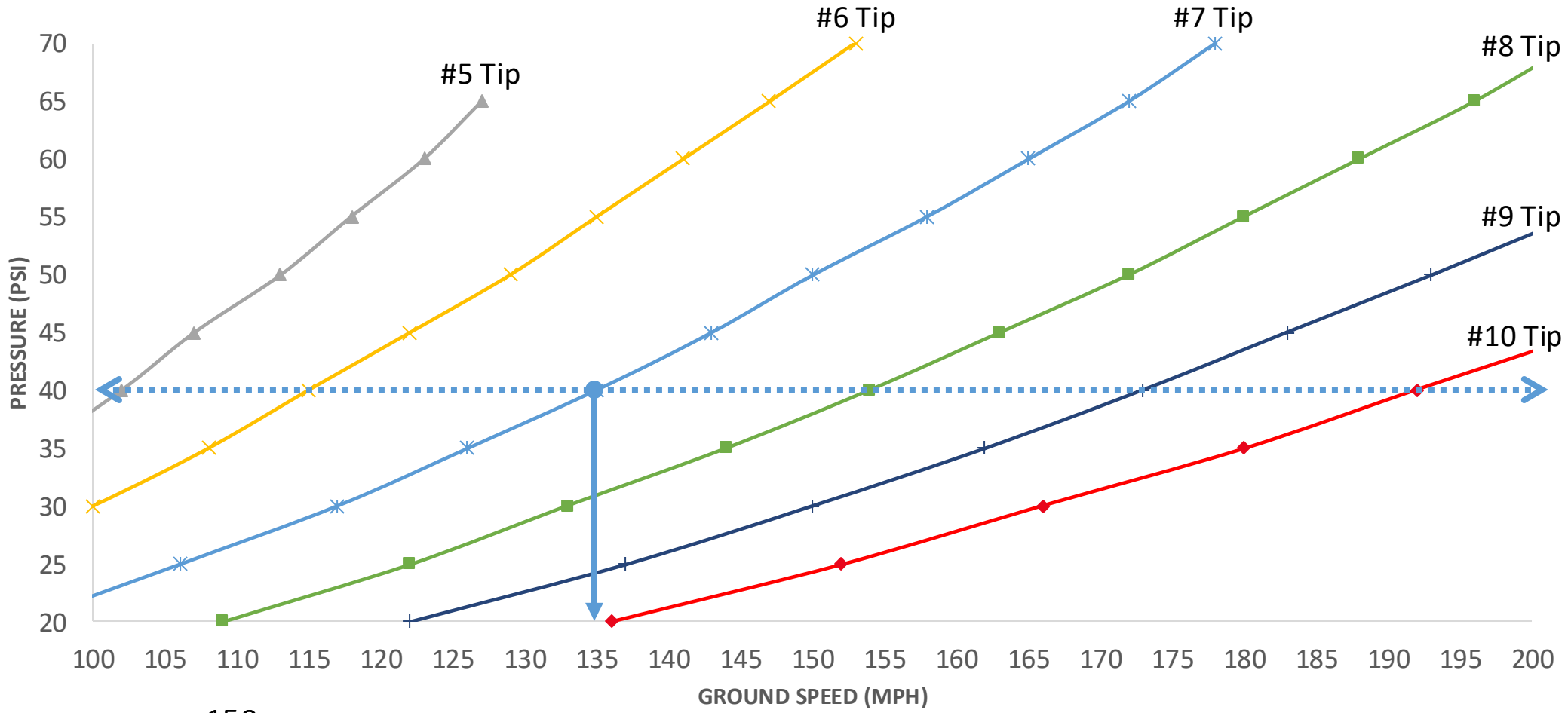
PWM TIP CURVE



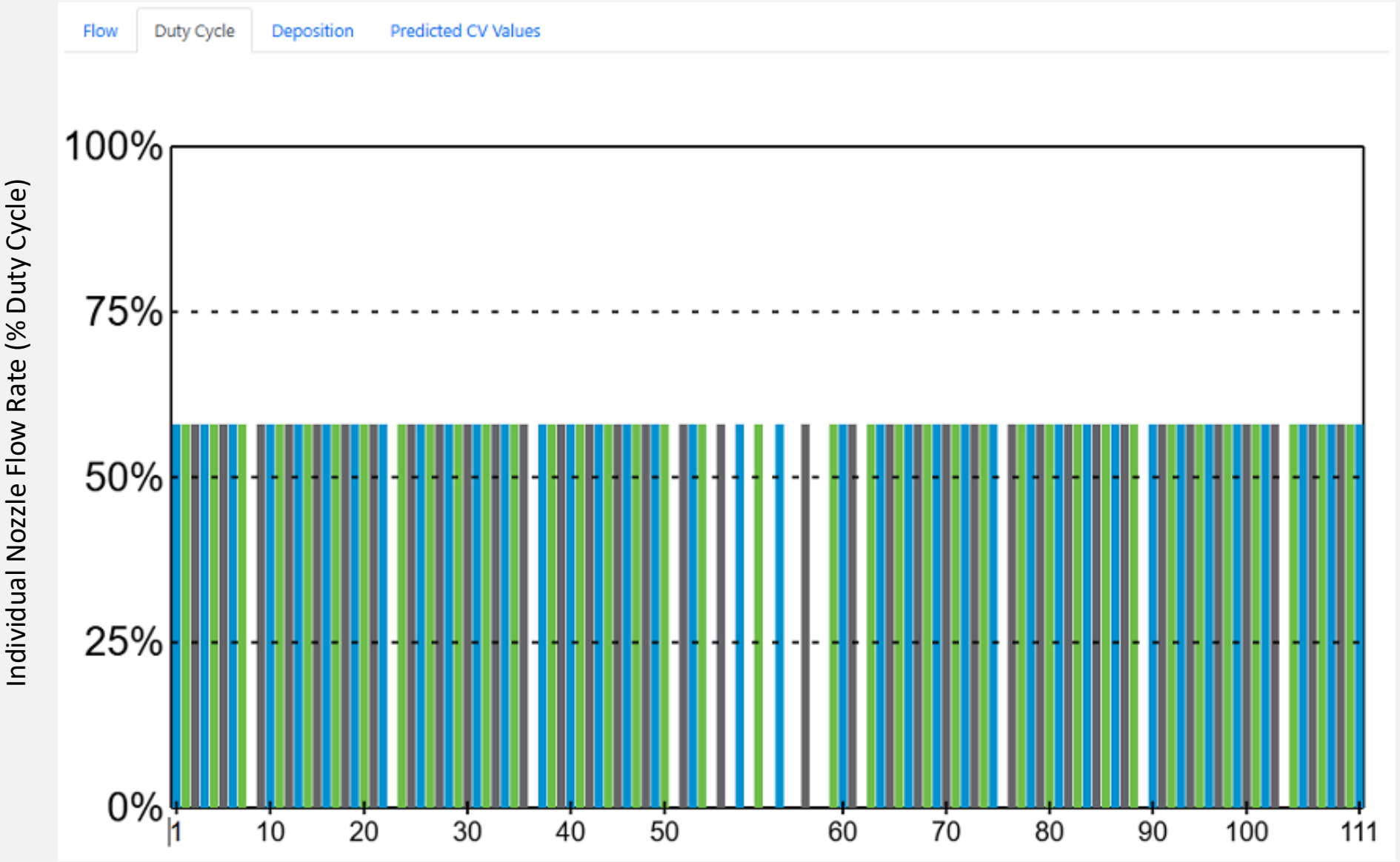
Air Speed	150
Wind	15 MPH Tail Wind
Ground Speed	180
Pressure	40 PSI
Droplet Size	383 Microns
Driftable Fines	4.08%


The Future with Pulse Width Modulation

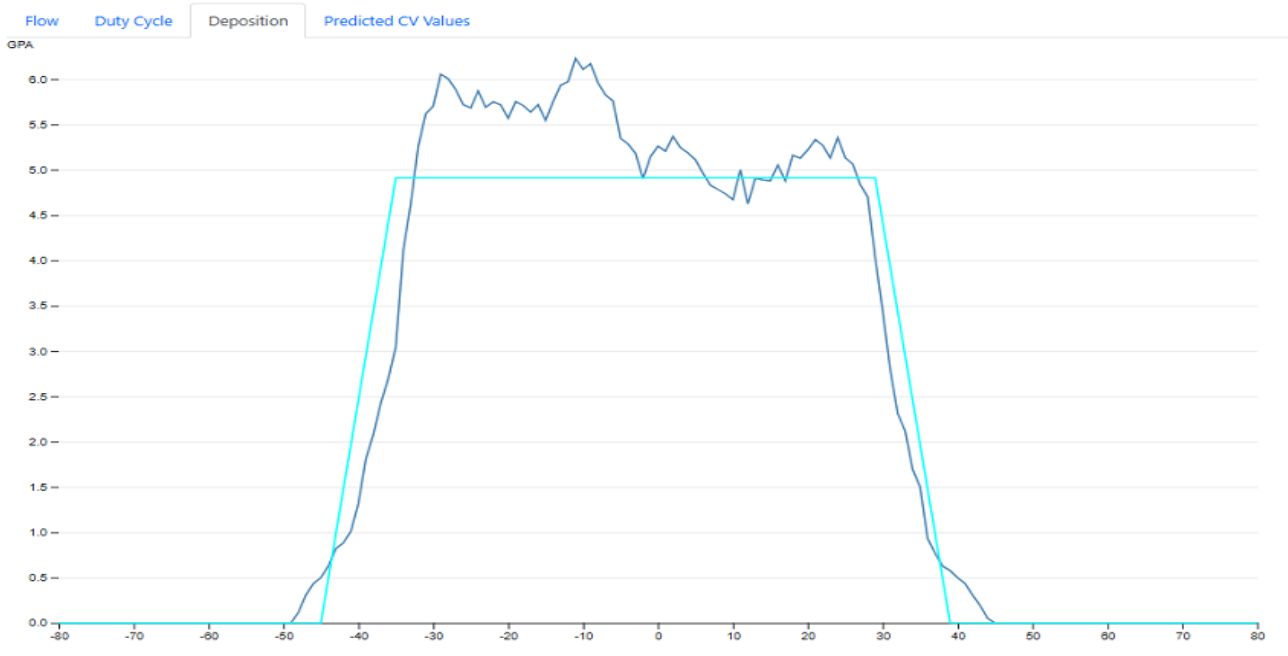
ReCurve™ Nozzle Configuration Software

Graphical Representations Identifying Pattern Shaping Recommendations

Normal Recommended Individual Nozzle Configuration

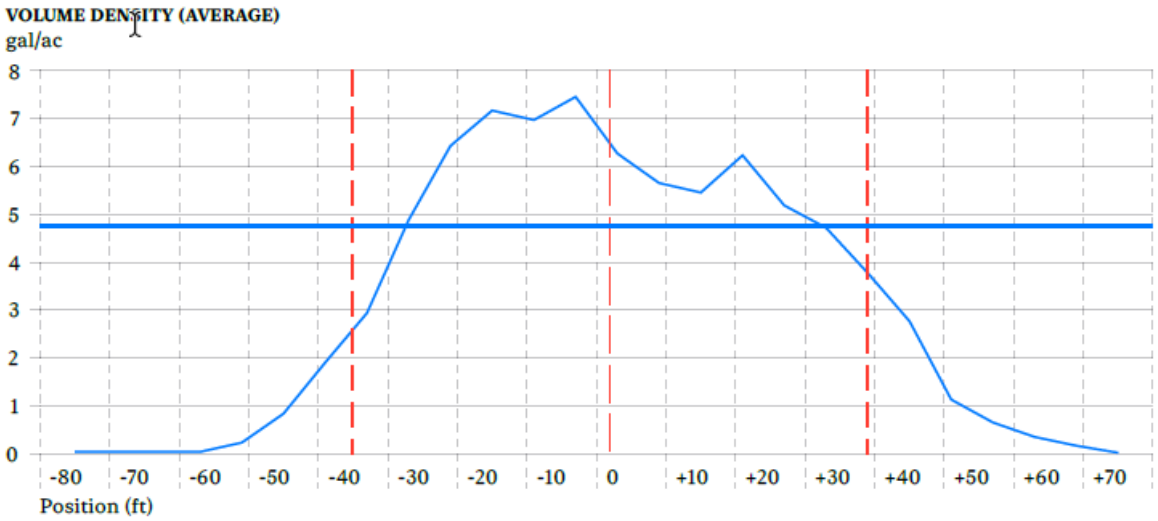


Prediction of Conventional Pattern



Swath (ft)	COV (RT)	COV (BF)
62	18%	24%
64	14%	21%
66	11%	19%
68	9%	18%
70	9%	18%
72	13%	19%
74	16%	21%
76	21%	24%
78	25%	27%
80	30%	31%
82	34%	35%

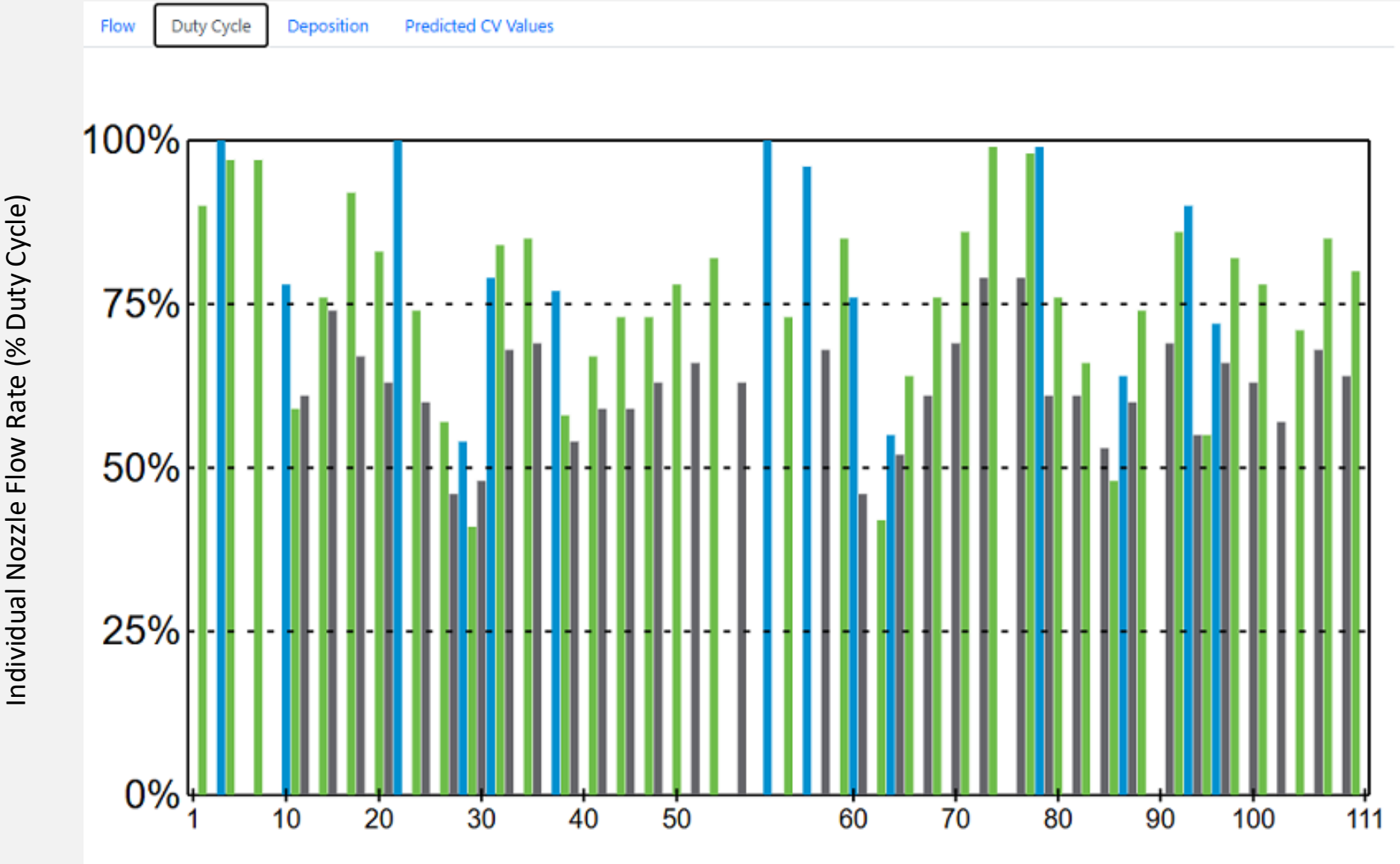
DropFlight Pattern Results of Conventional Pattern



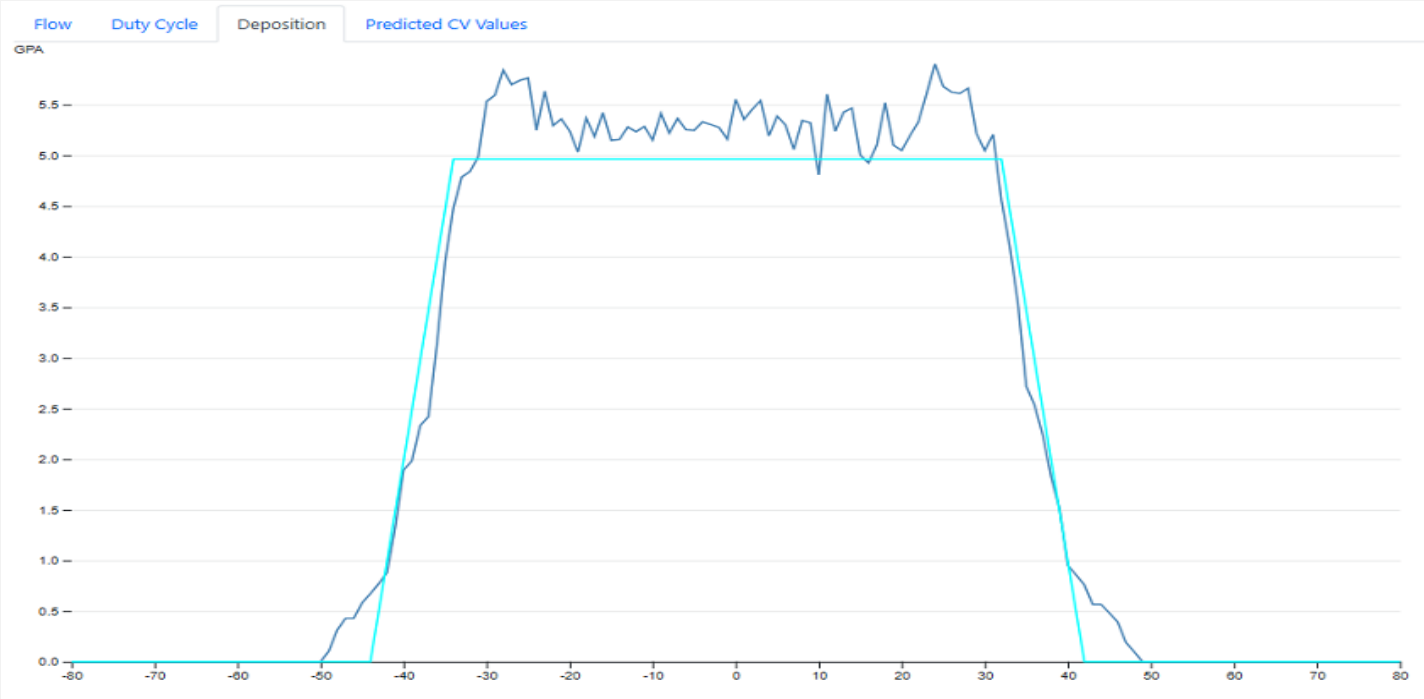
COEFFICIENT OF VARIATION

Swath	RT	B2B
48 ft	4.9%	2.8%
54 ft	7.8%	6.3%
60 ft	9.9%	7.6%
66 ft	8.8%	8.3%
72 ft	8.2%	9.1%
78 ft	8.3%	13.4%
84 ft	12.1%	16.4%
90 ft	18.7%	23.4%
96 ft	25.1%	28.0%

ReCurve™ Recommended Individual Nozzle Flow Configuration



ReCurve™ Prediction of Recommended Pattern



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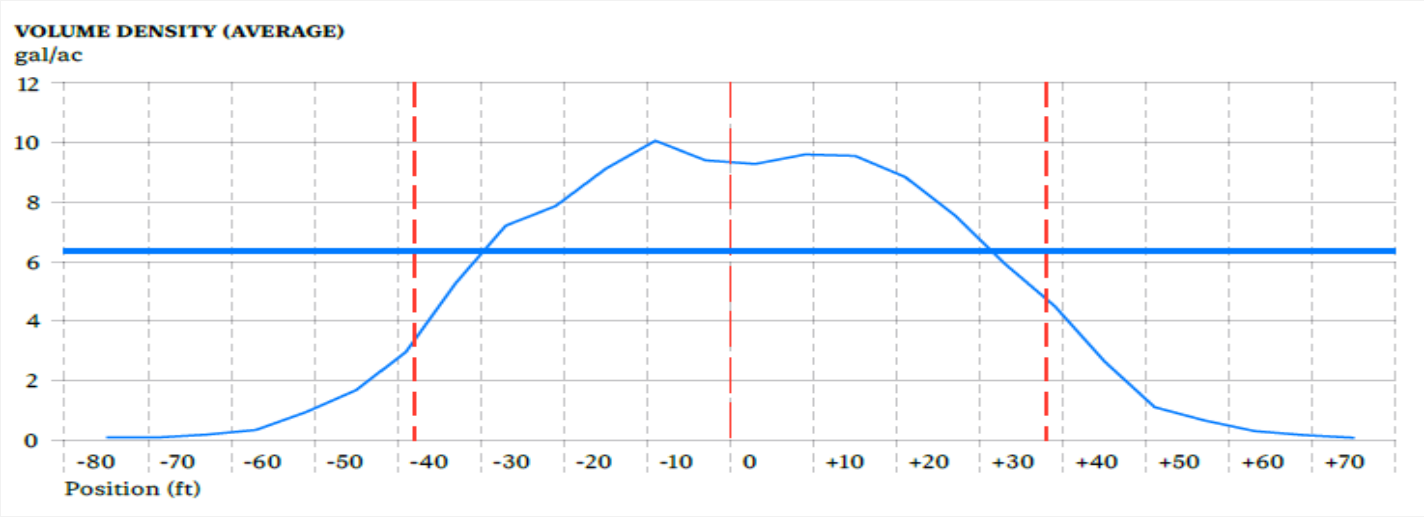
70	11%	12%
72	8%	9%
74	6%	8%
76	9%	10%
78	13%	13%
80	17%	18%
82	22%	22%

DropFlight Pattern Results of ReCurve™ Configuration



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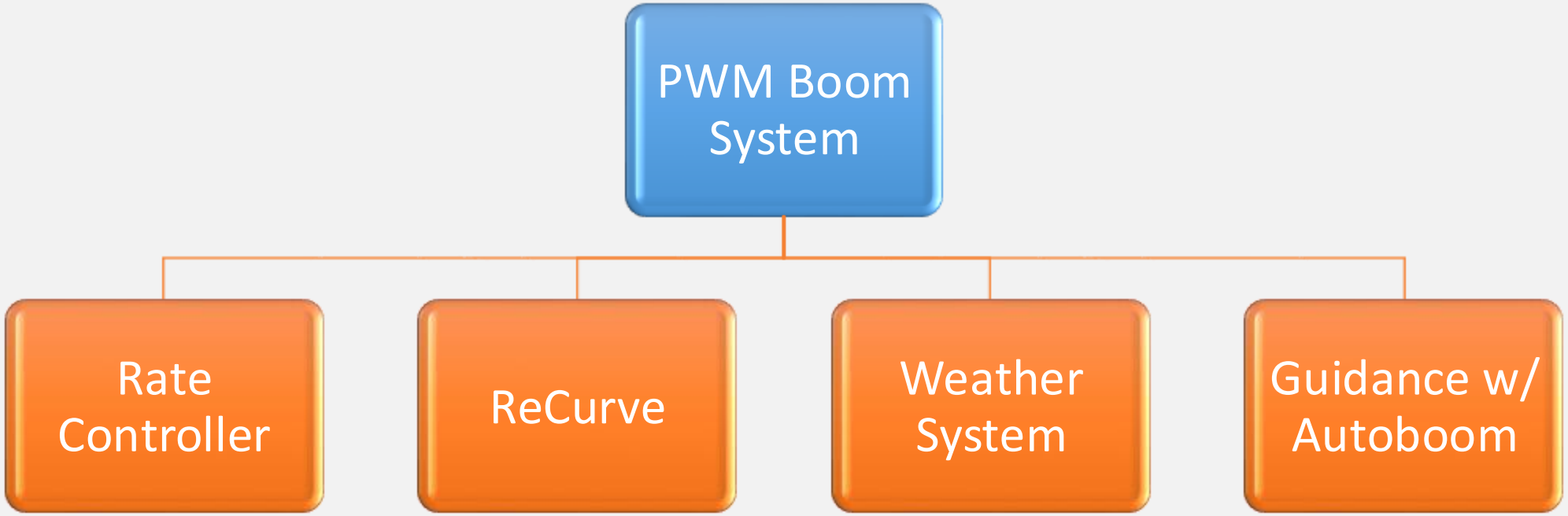
78 ft	7.5%	9.1%
84 ft	13.4%	14.4%
90 ft	20.9%	22.0%
96 ft	26.9%	27.3%

One Big Happy Family

- Now that we know what PWM can do for us, what if we were to combine some sensors/components.



Autonomous Boom:

- Having all these sensors/components working together in unison, the pilot can just fly, and the boom turns on and off based off polygons, wind direction, wind speed, etc.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