Research Update: Updating the USDA ARS Spray Nozzle Models for Higher Airspeeds

B K Fritz[1], W C Hoffmann[1]

[1] USDA ARS Aerial Application Technology, College Station, TX

Aerial Application Technology

USDA ARS

http://apmru.usda.gov/

- Most are familiar with the present aerial spray nozzle models:

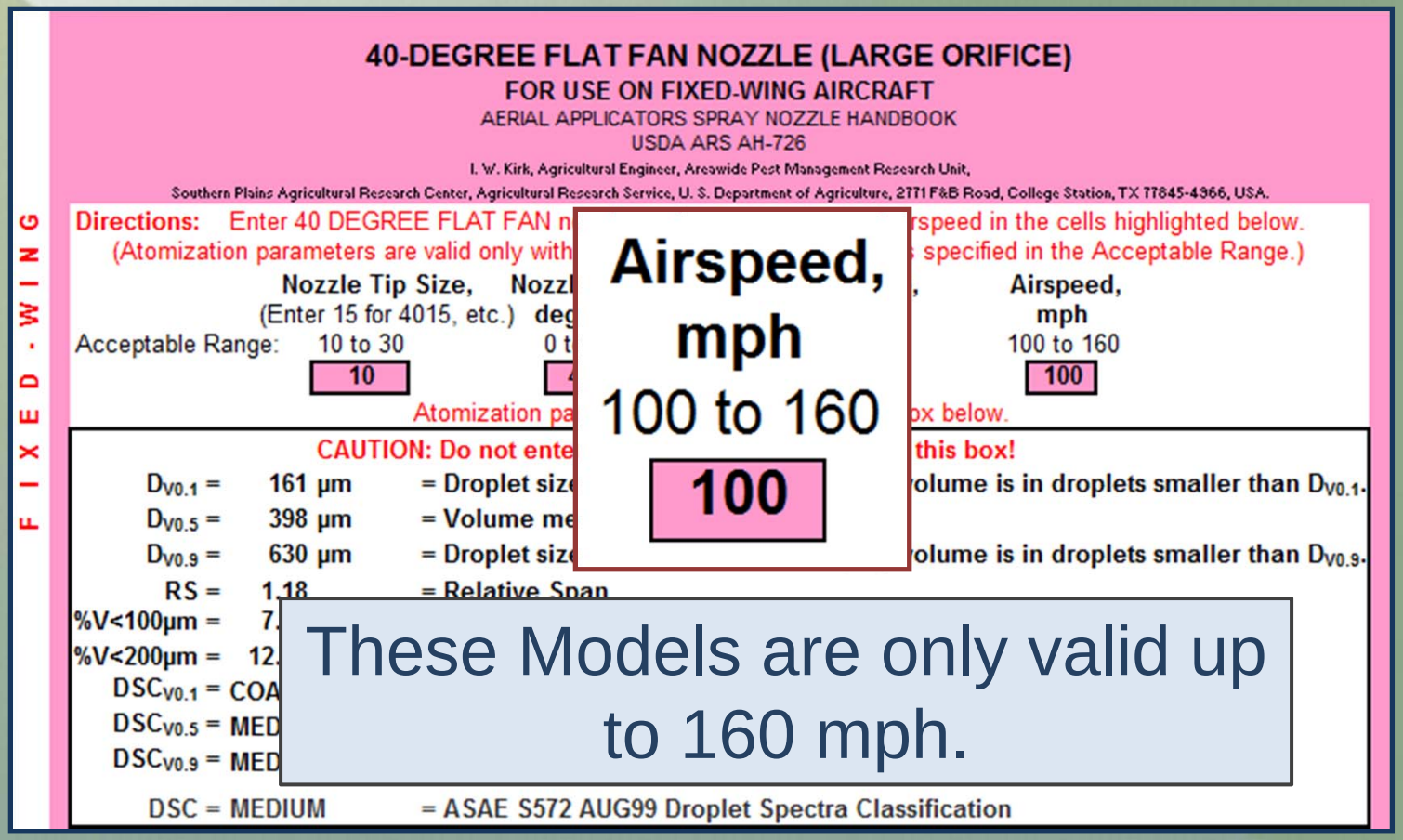
FIXED-WING SPRAY NOZZLE MODELS

- 40 DEGREE FLAT FAN (Large Orifice)
- 40 DEGREE FLAT FAN (Small Orifice)
- 80 DEGREE FLAT FAN
- CP-03
- CP-09 STRAIGHT STREAM
- CP-11TT STRAIGHT STREAM
- DAVIDON TRI-SET NOZZLE
- DISC ORIFICE 46 CORE
- DISC ORIFICE 46 CORE CERAMIC
- DISC ORIFICE 56 CORE
- DISC ORIFICE STRAIGHT STREAM
- LUND STRAIGHT STREAM

Rotary-Wing SPRAY NOZZLE MODELS

- CP-11TT NOZZLE WITH 110° FLAT FANS
- 40 DEGREE FLAT FAN NOZZLE (large orifice)
- 40 DEGREE FLAT FAN NOZZLE (small orifice)
- 80 DEGREE FLAT FAN
- ACCU-FLO DOUBLE ROW
- ACCU-FLO SINGLE ROW
- CP DR HIGH VOLUME FLAT FAN
- CP HIGH VOLUME FLAT FAN
- CP-03
- DISC ORIFICE-46 CORE
- DISC ORIFICE-STRAIGHT STREAM
- RAINDROP RD

Present Spray Nozzle Models



These Models are only valid up to 160 mph.

Why update the models?

AT-802A
Typical Working Speed up to 160 mph, but capable of 191 mph

660 Turbo Thrush
Cruising Speed 185 mph @ 55% Power

Updated Resources

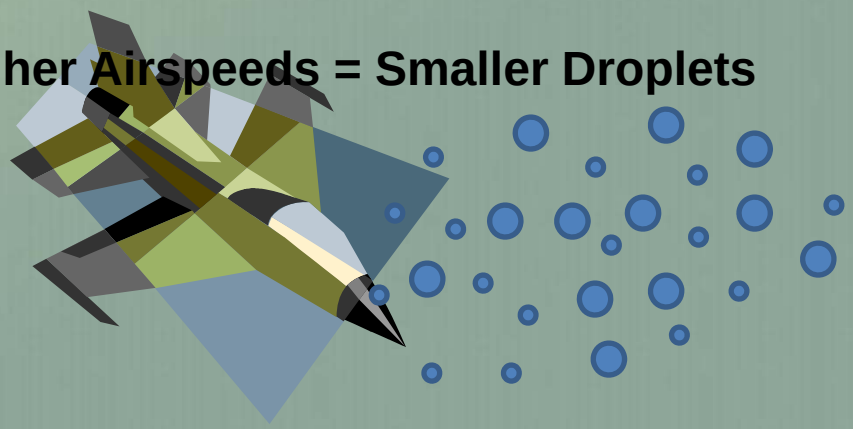
New High Speed Wind Tunnel (HSWT) Nozzle Testing System

- **Capable of airspeeds from 0 to 215 mph.**
- **Extend area outlet to allow testing of straight stream nozzles at 90˚**
- **New droplet sizing system makes model development quicker and easier.**

What happens is no surprise…

Slower Airspeeds = Larger Droplets

Higher Airspeeds = Smaller Droplets



There is a Need…

- To understand and be able to predict what will happen to spray applied at airspeeds beyond 160 mph.
  - WHY?
    - Droplet size
      - Can we setup nozzles to deliver that spray quality needed to meet labels and provide effective applications at higher speeds?
    - Spray pattern
      - Do higher airspeeds impact swath pattern and require different boom configurations?
    - Spray and nozzle interactions
      - Do nozzles or parts of a nozzle interact with the spray plume?

What we found…

Generating a MEDIUM spray at airspeeds >160 mph with present nozzles and spray methods will be difficult.

Where we are now…

- First round of updates is underway…
  - 40 degree flat fan nozzles for #4 to #30 orifice sizes.
  - FF tips held in CP11TT nozzle body coupled with CP06 swivel.

Thanks to Carolyn Baecker and CP Products for providing the nozzles for the initial testing.

Model Development

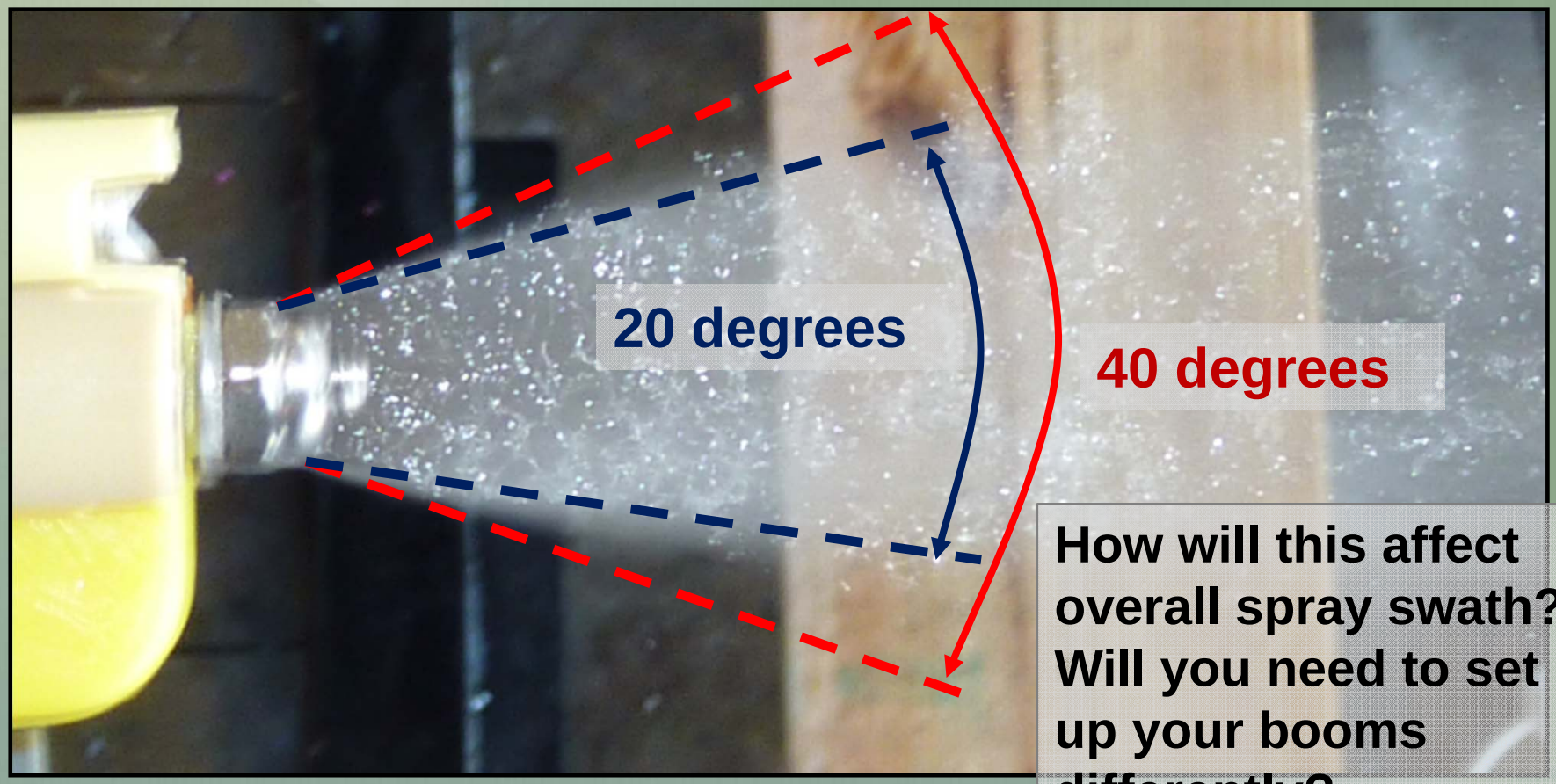
- Follows methods developed by Dr. Buddy Kirk.
  - Kirk, I.W. 2007. Measurement and prediction of atomization parameters from fixed-wing aircraft spray nozzles. Trans. ASABE 50(3): 693-703.
- 4 parameters, each across minimum, medium, and maximum values.
  - Orifice
  - Spray Pressure
  - Orientation
  - Airspeed

Measurements Needed to Make a Model

- 27 unique combinations of the Min, Mid, and Max values of the 4 parameters are established.
  - Example: #12 orifice, 45 deg, 40 psi, 170 mph
- The nozzle and tunnel are setup for these conditions and the spray droplet size is measured.
- After all measurements are completed…

What we saw…

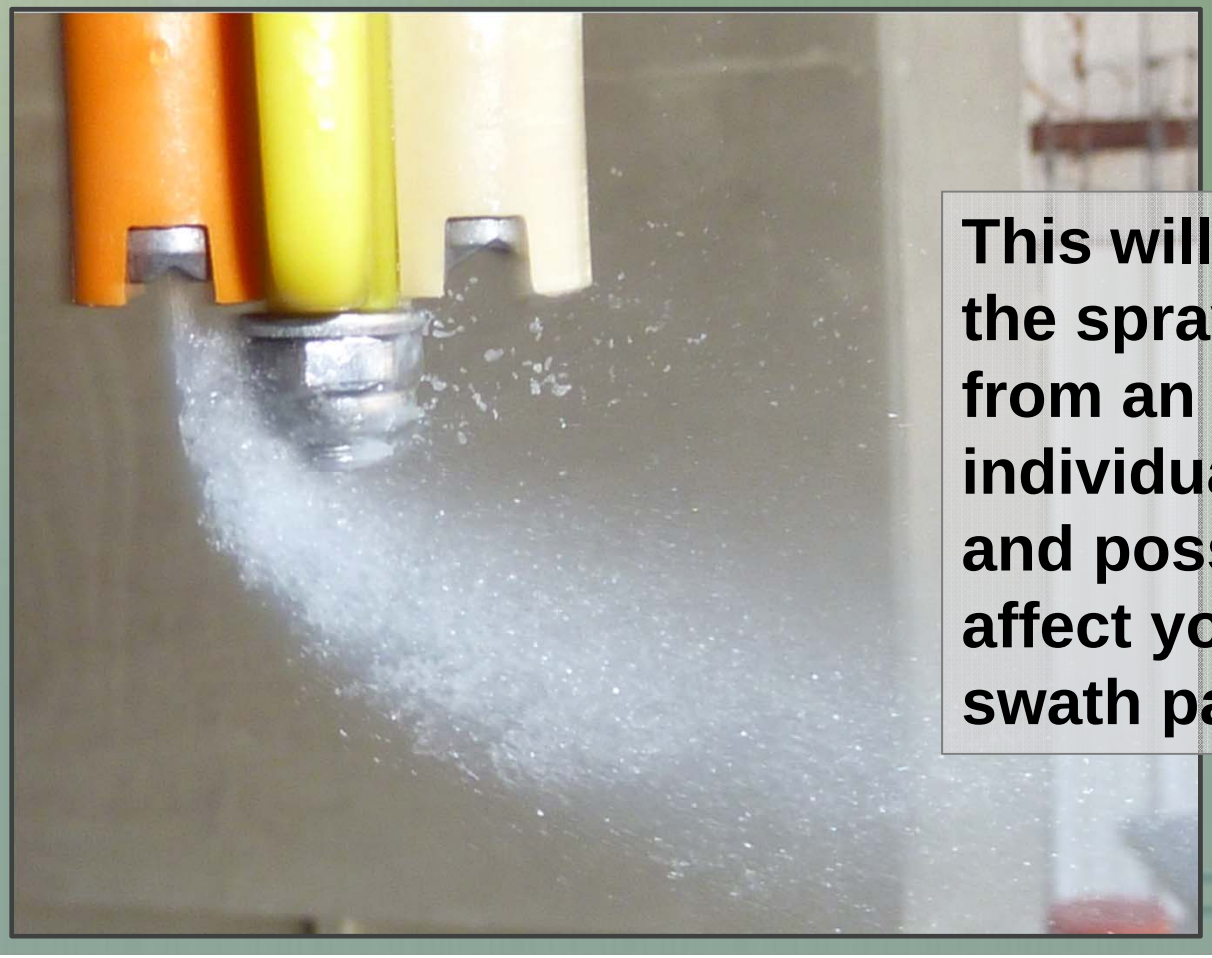
Higher airspeeds compress the spray fan angle.



How will this affect overall spray swath? Will you need to set up your booms differently?

What we saw…

Nozzle structure can effect the spray plume at higher airspeeds.



This will impact the spray pattern from an individual nozzle and possibly affect your spray swath pattern.

Examples

- 40 deg FF, 0 degree, 50 psi, 180 mph
  - As we increase orifice:

    4 → 30
  - DV50:

    190 → 199
  - %<100 µm (drift-able fines):

    15.1 → 15.9
  - FINE spray for all pressures

Examples

- 40 deg FF, #20 orifice, 0 degree, 180 mph
  - As we increase spray pressure:

    20 → 60
  - DV50:

    184 → 205
  - %<100 µm (drift-able fines):

    18.6 → 13.6
  - FINE spray for all pressures

Examples

- 40 deg FF, #12 orifice, 50 psi, 180 mph
  - As we increase orientation angle:

    0 → 90
  - DV50:

    203 → 102
  - %<100 µm (drift-able fines):

    13.8 → 44.8
  - FINE spray *until* 45 degrees then a VERY FINE spray.

Examples

- 40 deg FF, #12 orifice, 0 degree, 50 psi
  - As we increase airspeed:

    140 → 200
  - DV50:

    288 → 171
  - %<100 µm (drift-able fines):

    5.1 → 20.6
  - MEDIUM spray *until* 160 mph then a FINE spray.

Bottom Line

- Be very careful at or above 160 mph.
  - Generating a MEDIUM spray will be difficult with this nozzle.
- For applications at these higher airspeeds it may require:
  - New nozzle types
  - Changes in typical boom setups, especially at lower application rates.

Thanks.

Questions?