LAND-TECHNIK AgENG 2009

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Impact of Auto-Swath Technology on Agricultural Sprayer Boom Dynamics

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Presentation Outline

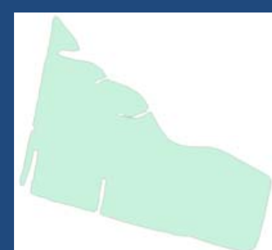
- Motivation
- Research Goal
- Methodology
- Results
- Conclusions
- Final thoughts

USA Trends

- $6.1 billion spent on chemical application in 2007
- Increasing pressure on environmental stewardship at the farm level:
  - Requirement to accurately maintain target rates (within 10% of target)
  - Minimize overlap and thereby over-application of pesticides and nutrients
    - Double and triple application occurs in areas
    - Application in unwanted areas (grassed waterways, outside boundary, etc.)
- Equipment size increasing
  - Planters: 24.4 m
  - Sprayers: 36.6 m
  - Spreaders: 27.4 m
- Farmers interests:
  - Reduce input costs
  - Maximize yield / profit

Field Boundaries

Crop Fields:
- Not square in the southern US
- Size varies (8 to 81 hectares)



Current Precision Ag. Trends across USA

- *Machine Control*
  - Autoguidance and Lightbars
  - Auto-swath control
  - Strip tillage, fertilizing, and planting
  - Implement control on sloped fields
- *Demand for high-level GPS accuracy* (few inches - RTK)
- *Input Management*
  - Precise fertilizer and pesticide application
  - Variable-rate fertilizer, seeding, etc.
- *Solutions for information management*

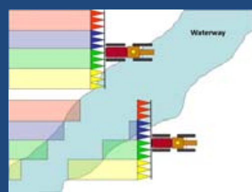
Current emphasis on automating machine / implement control

Sprayer Usage in the USA

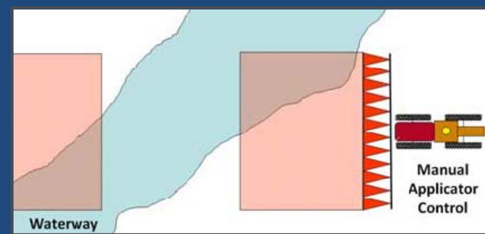
- Self-propelled sprayers used to cover a majority of US cropland.
- Sprayers equipped with modern spray controllers and technology
- Boom Widths:
  - Average: 27.5-m
  - Recent Adoption: 36.6-m

Auto-Swath Control Technology

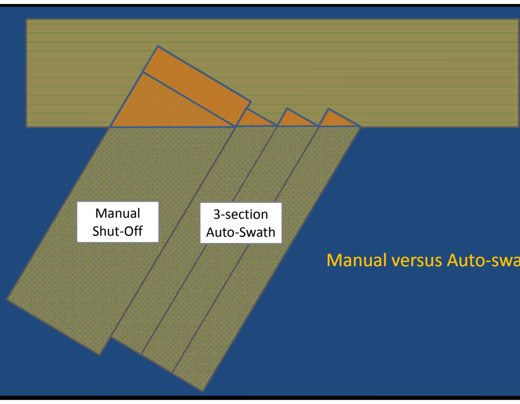
- *"Automatic section control"*
- Boom sections or individual nozzles are turned ON and OFF automatically through the use of GPS
- Benefits
  - Irregular shaped fields
  - Point-row and headland control
- Savings:
  - 2% to 12% per pass across field
  - Average farm input savings around 7%
- Increased adoption in the US



No Auto-Swath Control



Compromise not spraying vegetated waterway and cropland.



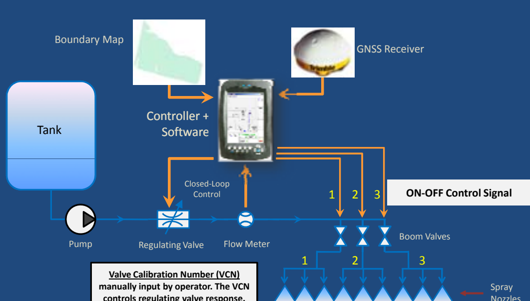
Manual versus Auto-swath

Field Application

Example of individual nozzle control (auto-nozzle) as sprayer moves out of the crop.

Source: Purdue University

Spray Control System with Auto-Swath

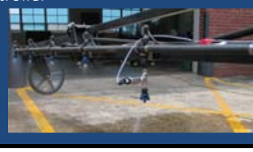


Research Goal

To evaluate sprayer boom dynamics when using auto-swath technology (both auto-boom and auto-nozzle) for basic simulated field operating conditions.

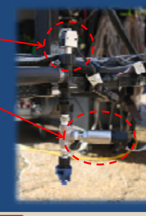
Overview: Sprayer and Controller

- Integral mounted sprayer
  - 18-m, 3 boom-sections with 51-cm nozzle spacing
  - Centrifugal pump
  - Dry boom setup
  - 2.5-cm diameter hose from boom valve to each section
  - 1.9-cmdiameter hose along each section
- Commercially available spray controller
  - Flow meter feedback
  - Butterfly flow control valve
  - With- and without flow compensation



Overview: Instrumentation

- Capstan solenoids on each nozzle
- Pressure sensors
  - PCB Piezotronics Inc. thin film pressure sensors (1-ms sampling freq.)
  - Pressure sensors on 10 nozzle locations
  - System pressure



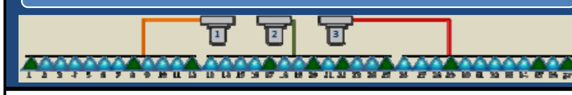
Sprayer plumbing configuration from the various tests with each nozzle assigned an ID between1 and 37, location of pressure sensors shown in green.

Control and Data Acquisition…

- Controller with analog & digital module
- LABVIEW program used to automatically actuate boom or nozzle controls.
  - Control ON/OFF timing
    - 3 boom valves
    - 37 nozzle solenoids
  - Data collected (50-Hz sampling rate)
    - Command input signals to solenoids
    - System flow rate
    - Pressure (system and nozzle)
- Ability to input various field operating conditions
- Data summary and analyses
  - MATLAB - data processing
  - SAS - statistical analysis

Experiments Conducted

- Boom-valve (section) 1 turned OFF then back ON
- Boom-valves (sections) 1 and 2 turned OFF simultaneously then back ON
- Nozzles 1 thru 12 (boom-section 1) shut OFF then back ON
- Nozzles 1 thru 25 (boom-sections 1 and 2) turned OFF then back on
- Test 2 using two difference VCNs; 2123 and 2213.
- Changing ground speed from 9.7 to 16.1 km/hr while maintaining an 84.2 L/ha application rate for VCNs 2123 and 2213.



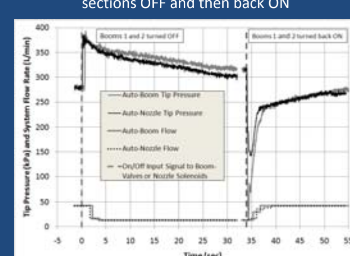
Results

- 2nd Order differential equations characterize system response
  - Auto-nozzle response different from Auto-Boom
- Response different for turning ON versus OFF - different damping coefficients
- VCN impacts system response
- Tip pressure (flow) Stabilization Times
  - Range: 2 to 30 seconds
  - Majority between 19 and 30 seconds
- System Flow Stabilization Times - Range: 1 to 4 seconds

❖ Large difference between tip and system response
  - Suggests regulating valve responds quickly but actual tip pressure / flow stabilization occurs well after valve has adjusted to target rate.

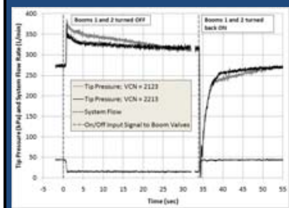
Results

Tip pressure response for auto-boom vs. auto-nozzle when turning 2 sections OFF and then back ON

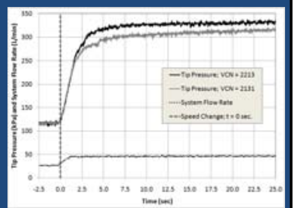


Results - Tip Pressure

VCN's - 2123 versus 2213

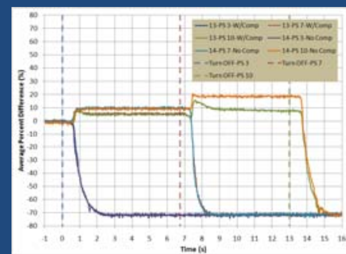


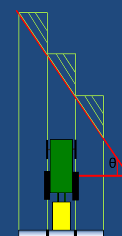
Changing from 9.7 km/hr to 16.1 km/hr



Results

Auto-Boom - Point Rows

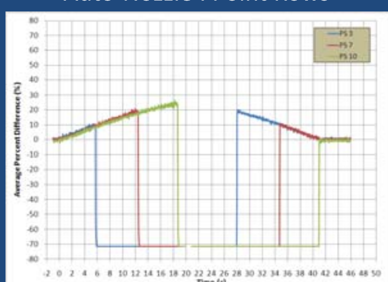




% Difference between Target and Actual tip flow

Results

Auto-Nozzle : Point Rows



1 nozzle presented per section (3-sections)

Conclusions

- Auto-nozzle produced quicker stabilization times
- Both auto-boom and –nozzle produced prolonged stabilization times under certain scenarios
- Tip pressure/flow stabilization times were significantly different from system flow stabilization times?
- Valve control number (VCN) impacts system response

Future Work

- Field evaluations looking boom dynamics and application uniformity
- Evaluation of various control systems and plumbing configurations.
- Test new hardware setups to address issues.
- Hose compliance testing using common hoses and tube sizes to determine their impact on energy transfer within plumbing.

❖ Ultimate goal: provide software / hardware suggestions and solutions to improve sprayer application accuracy.

Field Results

- Tip flow Coefficient of Variation (CVs) or Uniformity
- CVs impacted by:
  - Ground speed
  - Auto-swath engagement

Joint effort with University of Kentucky

Final Thoughts

- Proper setup and implementation of auto-swath
- Automatic valve calibration number procedure
  - Set *automatically* using feedback about system response
  - *Dynamic setting*: changes with sprayer setup, material being applied, and operating conditions
- Carefully consider boom plumbing boom (hose size, section plumbing, etc.)
- Match hardware (regulating valve, nozzle tips, etc.) to operating conditions

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Thank-You

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