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

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

Field Boundaries

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

Field Application

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

Manual versus Auto-swath

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-cm diameter hose along each section
- Commercially available spray controller
  - Flow monitor 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-m sampling freq.)
  - Pressure sensors on 10 nozzle locations
  - System pressure

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
  - 17 nozzle solenoids
  - Data collected (50-Hz sampling rate)
    - Command input signals to valves
    - System flow rate
    - Pressure (nozzle and system)
- Ability to input various field operating conditions
- Data summary and analyses
  - MATLAB - data processing
  - SAS - statistical analysis

Experiments Conducted

- Valve (section) 1 turned OFF then back ON
- Valve valves (sections 2 and 3) turned OFF simultaneously then back ON
- Valves 1 thru 12 (Booms-section 1) shut OFF then back ON
- Valves 1 thru 9 (Booms-section 1) and 2 turned OFF then back ON
- Test 2 using two different VCNs: 2123 and 2321
- Changing ground speed from 9.7 to 10.1 km/hr while maintaining an 84.2 L/ha application rate for VCNs 2123 and 2321

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 16 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.

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

VCNs - 2123 versus 2213
Changing from 9.7 km/hr to 16.1 km/hr

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.

Field Results

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

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

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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 settings 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

Thank-You

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