AUTONOMOUS DRIVING IN AGRICULTURE LEADING TO AUTONOMOUS WORKSITE SOLUTIONS

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Dr. John F. Reid

…Experience and Perspective on Autonomous Driving: Off-road


- Vision-based guidance of Tractors on row crops

Professor at the University of Illinois (1986-2001)

- Research in Autonomous Systems in Agriculture

John Deere (2001-present)

- Field Robotics competency leader
- Developed and deployed autonomous systems business cases
- Forward-looking innovation strategy (today)
Autonomous Driving: Offroad

1. Past: 20 years of Automatic Guidance
2. Present: Machine Automation
3. Future: Paths to Autonomy
4. Summary
Productivity in Agriculture

Motorized Equipment

Increased productivity through mechanization

1920’s
Productivity in Agriculture

Self-propelled Machines

Increased productivity through mechanization
Productivity in Agriculture

Operator Environment

- 1920’s
- 1940’s
- 1970’s

Increased productivity through mechanization and operator comfort
Guidance was the foundation of automated agriculture enabled by the convergence of machine electronics and GNSS.
Autonomous Driving in Agriculture

Rapid Technology evolution: Increased precision and accuracy

Customer Value realized in Machine and Job Productivity that could be consistently achieved.
Automatic Guidance

Clear Customer Value:

- Reduce tillage and chemical application overlap
- Skill-level reduction
- Reduced operator fatigue
- Improved productivity
- Increased crop yield
- Fuel efficiency

Guidance was a Gamer Changer!
Autonomous Driving: Offroad

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Productivity in Agriculture

Integrated Solutions

Guidance has enabled *Machine and Job optimization*
Machine Productivity

Technology advances, access to information, and automation, enabling increased productivity and convenience.

Realized Accomplishments:
- Automation of machine functions
- Coordination of machine-to-machine operations
- Precision execution of field tasks
Coordinated Tasks

Machine path and task control

iTech Pro:
• A solution for Field Mission Planning
• Enabled by SW for area coverage plans
• Customer value:
  • Increases efficiency, resulting in input savings
  • Provides total equipment control
  • Reduces Operator Fatigue
Coordinated Machines

Machine-to-Machine work coordination

Machine Sync:

- Combine steers the tractor for managing the unloading process
- Enabled by GNSS and M2M communication
- Customer value:
  - Increased timeliness and reduced stress in on-the-go unloading
  - Guidance line and coverage map sharing between machines for systems optimization
Automatics Guidance leads to Optimized Machine Productivity

Transformation towards Autonomous Human-Machine Productivity
Autonomous Driving: Offroad

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Technology advances are significantly reducing the barriers to autonomous solutions in Agriculture.
Productivity in Agriculture

Information Agriculture

Increased optimization of the worksite through automation and data
Increasingly Integrated Solutions
Realized Accomplishments:

- Increased machine systems automation
- Real-time optimization of worksite systems
- Information management and decision support
Two Pathways to Increasingly Integrated Solutions

- Machine State Sensing
- Self-Calibrating Machines
- Self-Adjusting Machines
- Coordinated Tasks
- Machine Logistics
- M2M Coordination
- Sensor-Enabled Management
- Coordinated Machines
- Optimized Human-Machine Solutions
- Autonomy-as-a Service
- Automated (lean) worksites

Time
Sensor-Enabled Management

- Precision machines that provide site-specific control
- Telematics that connects machines to Cloud for worksite management
- UAS enables new forms of data to drive precision agriculture operations
Task Optimization

Optimizing Operator Performance in Machine Operation

Performance Benchmarking:
• Recommendations to optimize machine performance

Customer-Value:
• Helps maximize the performance of the machine for varying field/crop conditions
Vehicle Mission Planning increases field efficiency and optimizes activities

Mission Planning includes:
- Path Planning
- Vehicle Actions
- Payload Actions
- Contingency plans

System Integration:
- Pre-planned or Real-time
Situation-Awareness provides solutions for the environmental influences

Perception Sensing:
- Augments/replaces human for situation awareness (e.g., obstacle detection)

Customer Value:
- Task automation
- Autonomous operation
Customer Problem

- Achieve asset optimization for field operations through autonomous systems integration
- Increase Worksite Productivity

Solution Concept

- Multiple autonomous vehicle managed by a remote supervisor replace operators on individual machines
Autonomous Orchard: Multi-vehicle mission

Driven over 1500 km autonomously over 18 months customer trial
Multiple vehicles controlled by single supervisor

Shorter paths due to optimal planner

Autonomous vehicle spends greater portion of time at maximum speed

Demonstrated productivity improvement

Productivity Improvements

Cumulative Percentile Speeds

Productivity improvement (%)
Customer Problem
- Core pain point is productivity driven by labor availability
- Manage cost of operations through automation

Solution Concept
- Multiple sets of autonomous vehicle managed by a ground-based supervisor who manages the harvesting task of a fleet
Autonomous Peat Moss Harvesting Solution
Autonomous Solutions enables new products and services to emerge:

**From Productive Machines to Productive Worksite Solutions:**

- Autonomous machines vs. Delivering Job Optimization Services
- High-productivity machine systems vs. Autonomy-as-a-service

**Digital Disruption is a Reality Now...**

1. The world’s largest taxi company (Uber) owns no taxis
2. The world’s largest accommodation provider (Airbnb) owns no real estate
3. The largest communications companies (Skype, WhatsApp, Facebook Messenger, Viber) own no infrastructure
4. The world’s most valuable retailer (Alibaba) has no inventory
5. The most popular media platform (Facebook) creates no content
6. The fastest-growing banks actually have no money
7. The world’s largest movie house (Netflix) owns no cinemas
8. The largest software vendors don’t write the apps (Apple, Google, Facebook)

Autonomous Solutions transforms our perspective of agricultural systems productivity
Autonomous Driving: Offroad

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4. Summary
• **Autonomous Driving Success**: Automatic Guidance Technologies have demonstrated success over the last 20 years in delivering customer value in agriculture.

• **Autonomous Machine Productivity**: Automatic guidance has enabled continued growth in machine systems productivity.

• **Autonomous Worksite Solutions**: The future of autonomous systems has multiple opportunities as integrated worksite solutions.

• **Business Model Innovation**: Autonomy will create opportunities to transform the business model for off-road equipment.