

Opportunities and Challenges for autonomous systems and field robots in crop production

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JOHN DEERE

Agenda

- Overview John Deere
- GNSS and automatic steering
- Status and recent announcements
- Drivers for autonomy
- Opportunities for field robots
- Challenges
- Outlook & summary

John Deere at a glance 2022

- Headquarters: Moline, Illinois, United States
- Employees worldwide: 82,200
- Total net sales and revenues: \$52,58 billion US
- Net income: \$7,13 billion US



Portfolio

John Deere solutions

- Agricultural Equipment
- Construction Equipment
- Turf Equipment
- Forestry Equipment
- Financial Services
- Power Systems
- Intelligent Solutions
- Worldwide Parts Services





European Technology Innovation Center Kaiserslautern - Germany

- Opened in 2010 in Kaiserslautern
- Engineers, IT and marketing specialists develop 'intelligent solutions' for precision farming and other future technologies
- Cooperation with universities & research institutions
- 210 employees

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Global Navigation Satellite Systems (GNSS)

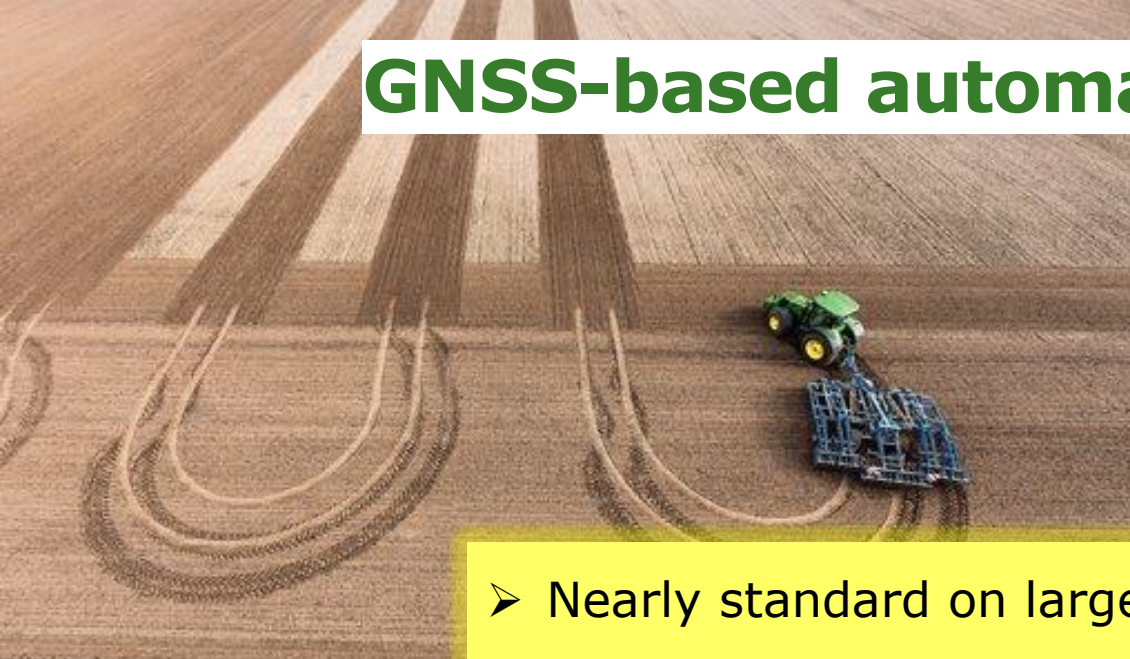
Use of GNSS is key for successful future farming

- Acquisition of NavCom Technologies in late 1990s
- Development of Dual Frequency StarFire Receiver and StarFire Correction Data

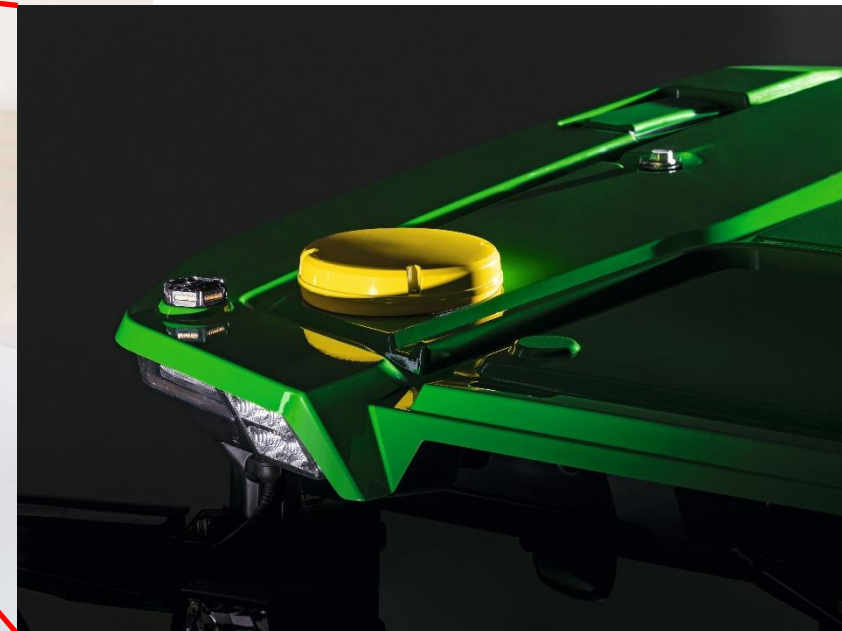


GNSS-based automatic steering systems

- Nearly standard on larger agricultural machines
- Trend towards higher accuracy (RTK)



Receiver Integration in Cab Roof



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University Research Field Robots



Source: Robotics Business review

Source:
University of Sidney



Source: University of Helsinki



Source: Hochschule Osnabrück

Trend to autonomous (driverless) vehicles?



Source: Continental

Case ACV – Auto

John Deere Future Technology Zone



John Deere Prototypes



Fully autonomous John





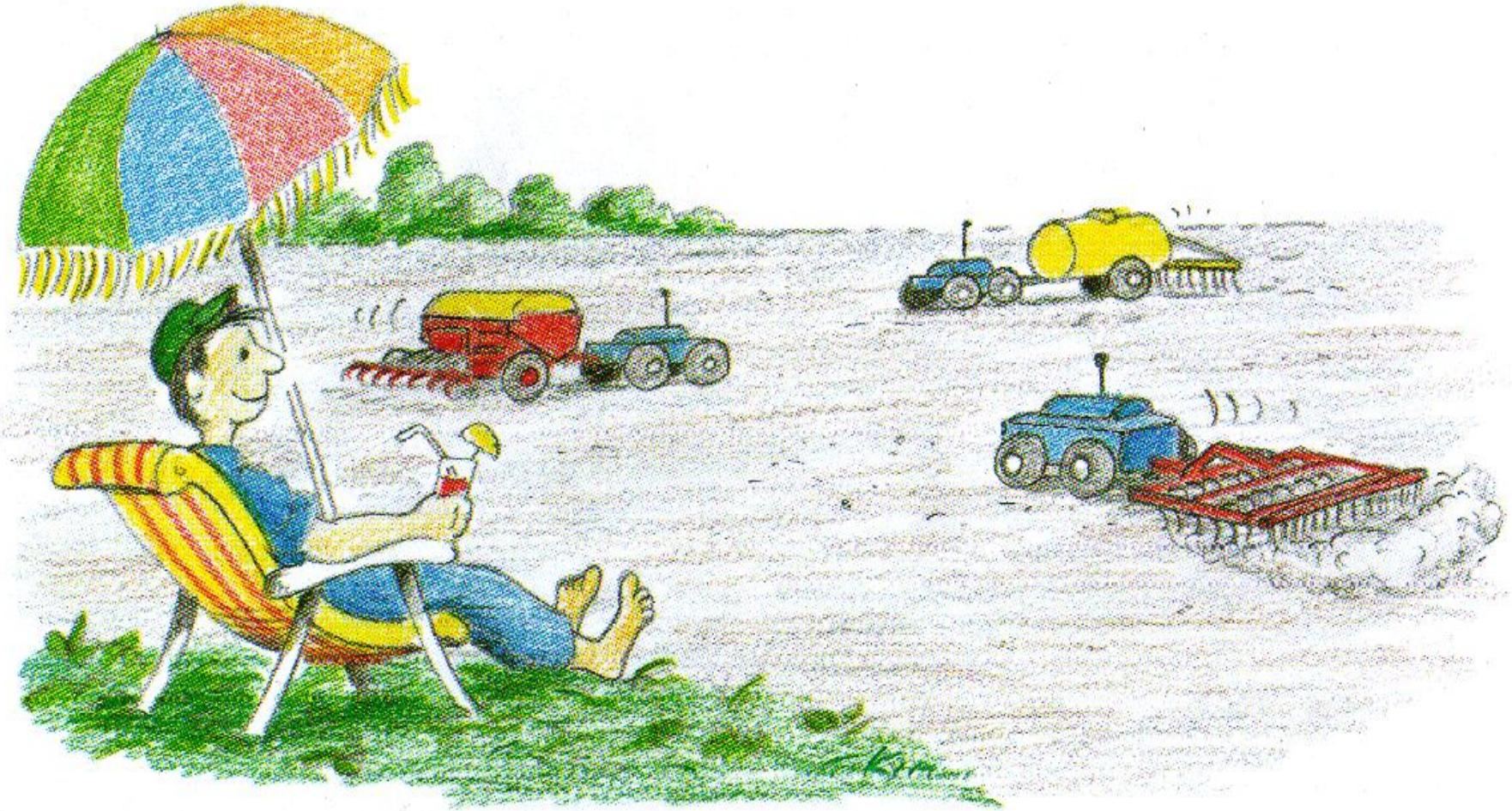
Acquisition Bear Flag Robotics



GUSS Joint Venture



Is this the future?



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Drivers for autonomous vehicles



- Shortage and cost of educated labor
 - Large arable farming vs. specialty crops
- Cost reduction of driverless machine
 - No cab needed
- Soil compaction reduction
 - Controlled traffic farming vs. light weight robots
- Reduction of input costs (seed, fertilizer, pesticides) through precise placement up to single plant treatment
- Autonomous cars & trucks
 - Strong cost reduction of safeguarding sensors
 - Facilitates legal approval discussion
- Strong focus of venture capital and startup companies on agricultural robotics

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Crop/Phenology Scouting



Source: Small Robot Company



Source: Symington Family Estates

Seeding & Tillage



Source:
FarmDroid



Source: AgXeed



Source:
DOT



Source: AgroIntelli

Weed Control



Source: EcoRobotix



Source:
Carré



Source:
Saga Robotics



Source:
Naio Technologies

Spraying

Source: GUSS



Source:
Jacto



Source: SwarmFarm Robotics

Harvesting

Source:
FFRobotics



Source:
Tevl Robotis

Source:
YieldTec



Source:
AGROBOT

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Challenges for autonomous vehicles



- Product liability
- Legal situation
 - Driving on public roads
- Safeguarding sensors
 - Challenging environment (dust, dirt, fog, vibrations)
- Monitoring of other machine functionality
- Logistics
 - Handling of harvested material or inputs (seed, fertilizer)
 - Transport to/from field
- Complete re-design of machines
 - Optimal machine size depends on application
 - New cropping systems?

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Outlook and Summary

- GNSS-based automatic steering solutions are mainstream.
- Growing research and venture capital investment in fully autonomous vehicles.
- There are a lot of opportunities for autonomous vehicles, but a lot of challenges are still ahead of us.
- Field robots have higher focus and priority in specialty crops due to labor cost and labor shortage.



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