Overview

- Introductions
- Overview
- Autonomous GNC
- Lego® Mindstorms Intro
- Lego® Mindstorms Challenge

9:00 – 10:00 – Overview (Mikel):

- Instructors Introductions
- Introduce Autonomous Guidance, Navigation, and Control Concept
  - Precision Farming Overview
  - ION's Robotic Lawn Mower Competition
  - Autonomous vehicle operation (DARPA Grand Challenge)
  - Mini-Urban Challenge
- Importance of Outreach – Next engineering generation

10:00 – 10:30 – Break

10:30 – 11:30 – GNC issues for autonomous vehicles (Mikel - 20 minutes)

- ION Robotic Lawn Mower – (Jade – 40 minutes)

11:30 – 12:30 – Global Challenge (Carrie and Casey)
12:30 – 1:00 – Mindstorm Robots at De Universite de Cocody

1:00 – 2:00 – Lunch

2:00 – 3:15 – Robotics Laboratory Tutorial (Jade)
•Hardware components, servo motors, sensors
•Software development environment: BrixCC
•Programming: NXC

3:15 – 3:30 – Break

3:30 – 5:30 Laboratory Continued (All)

- Challenge 1: Color line following
- Challenge 2: Use sonar for obstacle detection and avoidance

Autonomous Vehicle GNC Concept

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- **An autonomous ground vehicle is a vehicle that navigates and drives entirely on its own with no human driver and no remote control.**
- **Uses a variety of sensors to carry out the task it has been assigned.**




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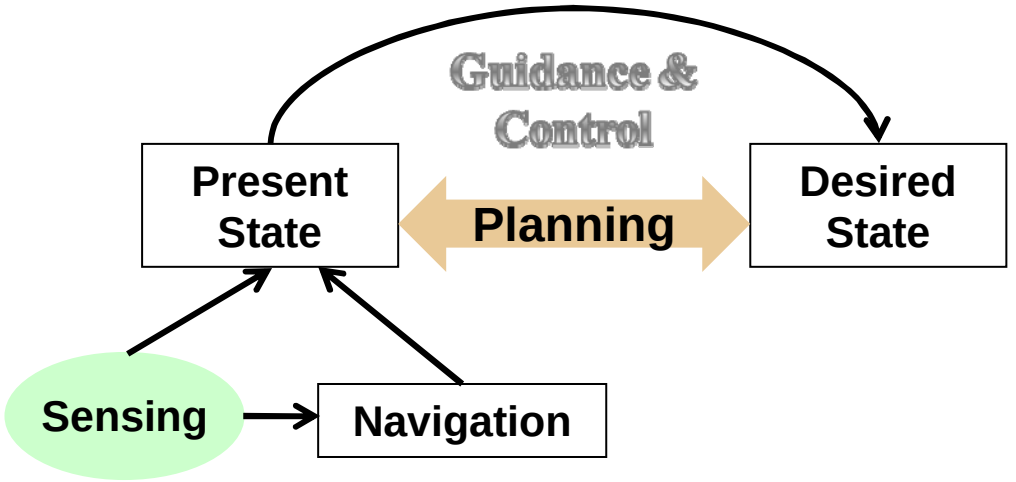
- What is the mission of the autonomous vehicle?
  - Farming, transportation, surveillance, etc..
- How does the vehicle accomplish the mission?



- What is the Present State?
  - Sensing
- What is the Desired State?
  - Planning
- How does the vehicle get from the present state to the desired state?
  - Guidance, Navigation, & Control

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Intelligent Vehicle Systems

JOHN DEERE

- **Guiding an intelligent vehicle requires global perception, local perception and vehicle control**
  - **Global perception - localization and path planning system**
    - **Identifies the vehicle position with respect to an available global map and the path that the vehicle has to track**
    - **Vehicle has to know its position and direction with respect to real world and series of positions in order to reach the destination**
    - **Due to environmental dynamics, global perception system alone is not enough to maneuver vehicle to move to its destination.**
  - **Local perception**
    - **Real-time sensing system required to perceive vehicle's surroundings**
    - **Avoid static and dynamic obstacles that block vehicle path – requires localization accuracy to detect small objects and coherently image scanned data**
  - **Vehicle control system**
    - **Integrates information from the global and local perception systems then determines an appropriate action of the vehicle**

RGATOR

Courtesy of
Bob Norris, John Deere

Autonomous Vehicle GNC Concept

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Intelligent Vehicle Systems

JOHN DEERE

Courtesy of
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Precision Farming

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Doing the right thing at the right place at the right time in the right way… and without the human interaction

Precision Farming: Concept

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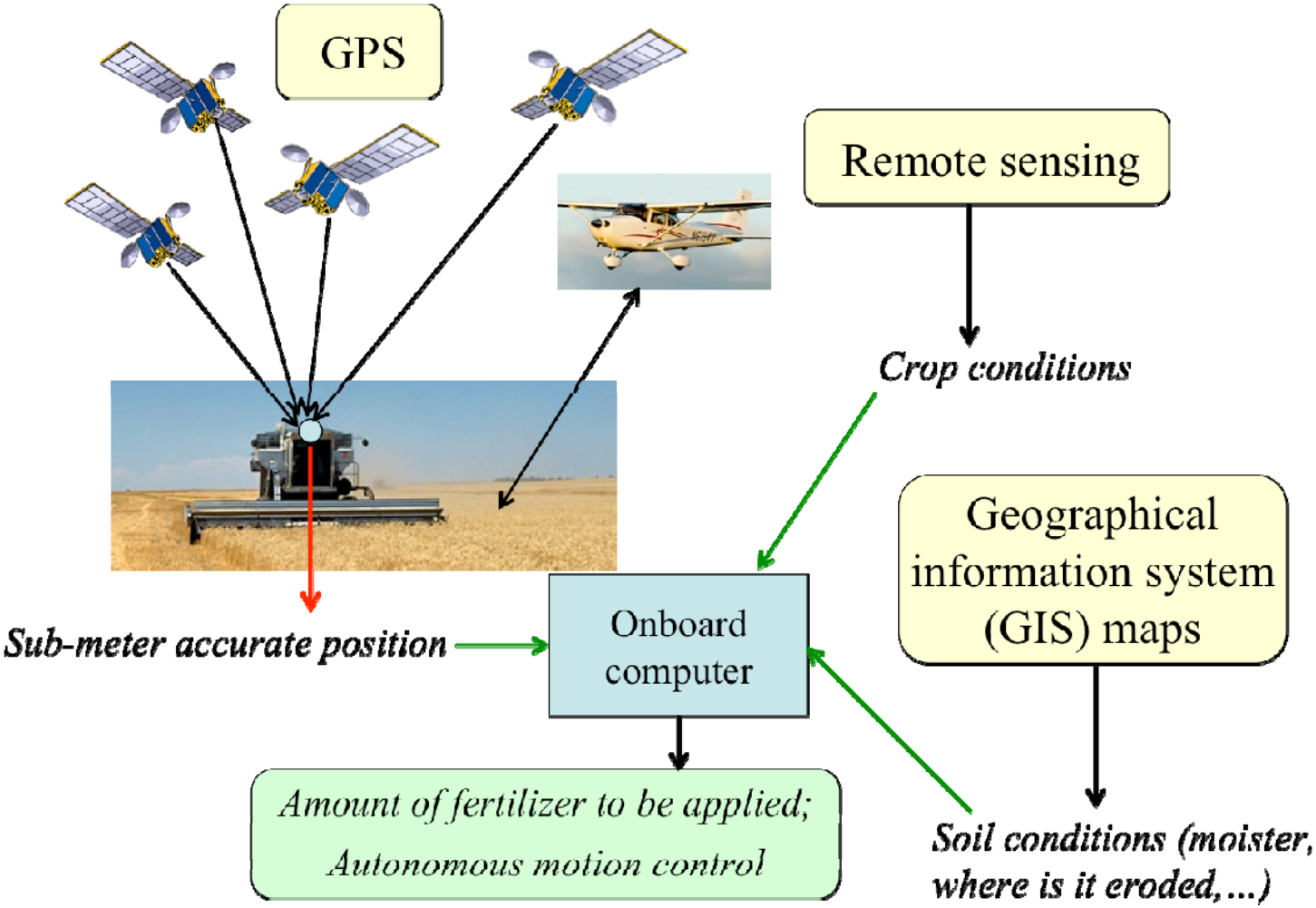

Use of GPS: Example

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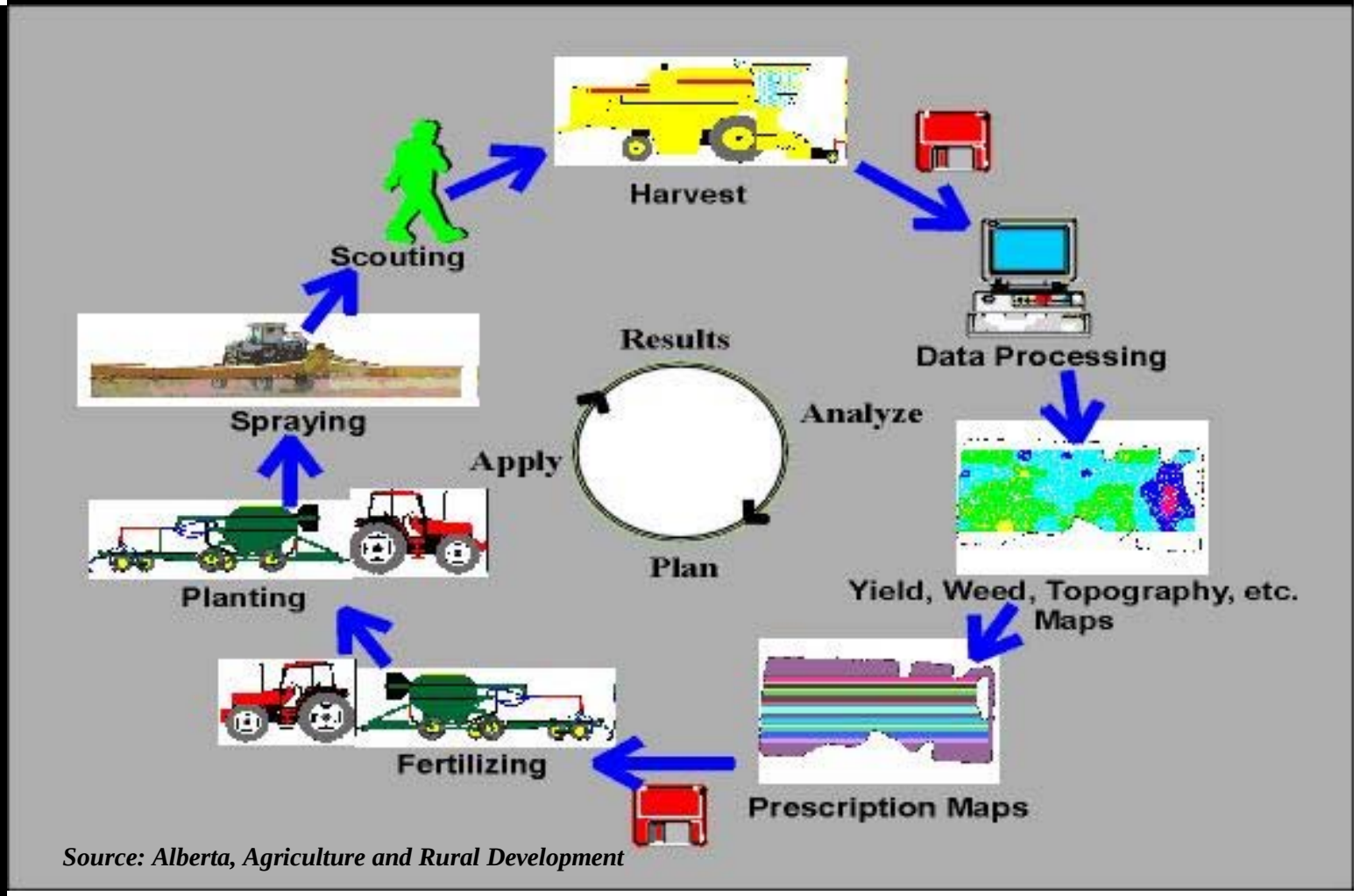
- **Cm-accurate position solution from GPS is used to automatically steer the vehicle**
- **GPS technology: Real-Time Kinematic (RTK) solution; involves differential GPS and carrier phase positioning concepts**

Image is from www.novariant.com – provider of the GPS RTK AutoSteer

Precision Farming Cycle



Source: Alberta, Agriculture and Rural Development

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- **Yield monitoring**
- **Yield mapping**
- **Variable rate fertilizer**
- **Weed mapping**
- **Variable spraying**

- **Topography and boundaries**
- **Salinity mapping**
- **Guidance systems**
- **Records and analyses**

ION Robotic Lawn Mower Competition

- The purpose of this competition is to design and operate a robotic unmanned lawn mower using the art and science of navigation to rapidly and accurately mow a field of grass.
- In the competition the lawn mowers maneuver through a mock lawn:
  - Cutting grass
  - Avoiding static obstacles like a flower bed
  - Avoiding moving obstacles like a pet dog
  - Traveling along a fence line

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2008 Robotic Lawn Mower Competition Video

movie

DARPA Urban Challenge

- The DARPA Urban Challenge is an autonomous vehicle research program developing technology to keep warfighters off the battlefield, out of harm's way.
- In the competition autonomous ground vehicles maneuver through a mock city environment:
  - Executing simulated supply missions
  - Merging into moving traffic
  - Navigating traffic circles
  - Negotiating busy intersections
  - Avoiding obstacles

DARPA Urban Challenge

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Movie Clip from
http://www.darpa.mil/grandchallenge/gallery.asp
called:
DARPA_highlight_preview3.wmv

movie

Mini-Urban Challenge

- National HS Competition held in conjunction with the ION college Robotic Lawnmower Competition (Dayton, OH)
- Challenge model based on DARPA's Urban Challenge
- HS Students must develop a robotic, autonomous ground vehicle using a LEGO® MindStorms kit to navigate through a LEGO® city
  - An autonomous ground vehicle is a vehicle that navigates and drives entirely on its own with no human driver and no remote control.
  - Uses a variety of sensors to carry out the task it has been assigned.
  - Autonomous vehicles are a focus point of DoD and it has been Congressionally mandated that "It shall be a goal of the Armed Forces to achieve the fielding of unmanned, remotely controlled technology such that… by 2015, one-third of the operational ground combat vehicles are unmanned."

DARPA Urban Challenge 2007

Mini-Urban Challenge

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- The purpose of this competition is to challenge high school students to design and operate a robotic unmanned car built from a LEGO® MindStorms kit that can accurately navigate through a LEGO® city.
- In the competition the LEGO® cars will maneuver through a mock LEGO® city:
  - Driving along the roads
  - Following traffic signs (stop signs, speed limits, etc.)
  - Stopping at stores
  - Avoiding pedestrians

Outreach – Next Generation Engineers

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Large need for more students to pursue engineering degrees

- Baby boomer retirements will deplete the science and engineering workforce by 50%
- “Over the next 18 months, 27 percent of the engineering work force will be eligible for retirement”
- Fewer than 6% of high school seniors plan to pursue engineering degrees
- One-third drop in the number of U.S. students interested in pursuing engineering degrees throughout the past decades

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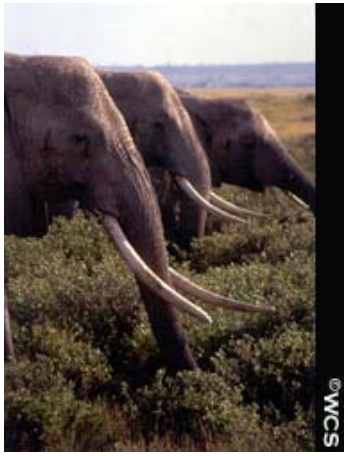
- To encourage the use of navigation technologies for societal and economic development and environmental protection
- To provide a knowledgeable engineering workforce in Africa
- To initiate international scientific collaborations

Disaster Relief

Air Navigation

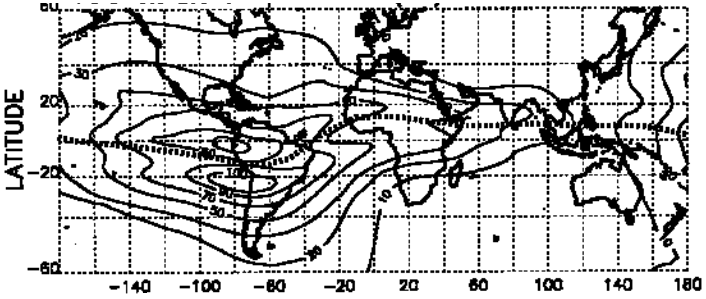
Land Navigation

Water Navigation



Wildlife Conservation

Precision Farming



Scientific Exploration