Vehicle Guidance

SOIL 4213

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What is Guidance?

• Guidance is information used to arrive at a specific point.

• There are many guidance aids/devices available:
  – Cell Phones
  – Car GPS Navigation Systems
  – Handheld GPS Devices
  – Handheld/Laptop Computers
  – Lightbars
  – Auto-Steer
Cell Phones

• Almost every phone has GPS in it:
  – Can be used by Emergency Services for tracking the phone
  – Can be used to collect single to multiple points
  – Can be used to track paths, points, and boundaries
  – Depending on the software the GPS can be used as a walking or driving navigation system
  – Typical accuracy is about ±50 ft.
Car Navigation Systems

• Used to get you from “current” location to a defined point or location.

• Have preload road maps and use a distance vs. time navigation algorithm to determine the shortest distance/fastest time to get one to their destination.

• Pretty useless for anything but road and straight line navigation.

• Typical accuracy ±50 ft, have you ever missed a turn or not been able to find a destination using one of these?
Handheld GPS Device

• Good for getting you to marked or downloaded points.
• Collecting points, paths, and boundaries.
• Pretty cheap.
• WAAS capable.
• Not good as a “vehicle navigation aid”.
• Accuracy ±10 ft.
Handheld/Laptop Computer

• Good for getting you to marked or downloaded points.
• Can have Ag software such as Farmworks that can be used for mapping or as a VR controller.
• Pretty cheap.
• WAAS/DGPS capable.
• Not good as a “vehicle navigation aid”.
• Accuracy $\pm$3 ft.
Ag Vehicle Steering Aids

- Two types:
  - Lightbars
  - Auto-Steer
Operator Interface

• GPS accuracy is irrelevant if the operator cannot interpret the signal and make timely steering corrections.

• Two basic designs
  – Light based
  – Image Based
Lightbars

• Great as an operator controlled steering aid.
• Increased productivity, reduced application errors.
Auto-Steer

• Up to this point all of the guidance aids are just “aids” it is still up to the machine operator to do the driving of the vehicle.

• As it sounds auto-steer is an automatic control system either from factory or retro-fitted to a machine for the purpose of automatically controlling the steering of the vehicle along a user defined path.
Features and Abilities

• Straight line guidance
  – Back and forth or racetrack patterns

• Contour guidance
  – Curved swaths
  – Center Pivot patterns

• Return to a point
  – Stopped a field operation and need to restart where you left off.
Straight Line Guidance

- Set an A-B line in a location that you can drive straight.
- Other passes are relative to the initial A-B line.
- What if your field isn’t straight lines?
Contour Guidance

• Drive any pass- possibly along a terrace or around the obstacle causing the curved rows.
• Each subsequent pass is parallel to the previous pass.
Auto-Steer GPS Options

• Current Auto-Steer systems offer two GPS options with varying levels of accuracy:
  – RTK (Real Time Kinematic: Corrections are sent through either radio or cell phone signals).
  – DGPS (differential GPS: Corrections are picked up through the GPS antenna and receiver).
Auto-Steer Benefits

• Reduced Overlap
• Reduction in skips
• Lessened driver fatigue
• Operate at a faster speed
• More precise placement of fertilizers, chemicals, seeds, inputs etc…
Auto-Steer Hardware

- Controls and operator interface
- Navigation controller and GPS receiver
- Steering valve
- Steering sensor
- Vehicle posture sensors
- GPS antenna and radio (Base station for RTK correction).
Controls and Operator Interface
Navigation Controller and GPS Receiver
Steering Valve

This is a retrofit system, if the system comes from the factory Auto-Steer ready then this valve is usually internal and harder to find.
Steering Sensor

This is a retrofit system, if the system comes from the factory Auto-Steer ready then this valve is usually internal and harder to find.
Vehicle Posture Sensors

This is a gyroscope, that give information about the vehicle’s position.
GPS Antenna and Base Station
Why do we need all these components just to steer?

• Let’s quickly look at vehicle dynamics:
  – Vehicles are made up of many components
  – However we usually treat the entire vehicle as a lumped mass located at the center of gravity.
  – Use the right hand orthogonal coordinate system by SAE convention:
    • x: forward on the longitudinal plane
    • y: lateral out the right side of the vehicle
    • z: downward with respect to the vehicle
    • p: roll velocity about the x-axis
    • q: pitch velocity about the y-axis
    • r: yaw velocity about the z-axis
Vehicle Dynamics: Vehicle Fixed Coordinate System
Motion Variables

• Vehicle motion is usually described by velocities with respect to the VFCS
  – Forward, lateral, vertical, roll, pitch, yaw

• The velocities are referenced to the earth fixed coordinate system
GPS Drift Problems

• Precision degrades with time
• Short periods of high relative accuracy followed by larger drifts
• Drift is critical
## Pass to Pass Accuracy (inches)

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GPS Mounting Location

![Graph showing the relationship between slope and slope-induced error for different mounting heights. The x-axis represents the slope (0% to 14%), and the y-axis represents the slope-induced error (0.0 to 1.6 ft). There are three lines representing different mounting heights:

- Blue line for 6 ft
- Red line for 9 ft
- Green line for 12 ft

The graph indicates that as the slope increases, the slope-induced error also increases for all mounting heights. The error is more significant at higher slopes and mounting heights.]
GPS Updates

- Update Rate
  - How fast (often) is the signal or position updated?
- Faster update generally means better accuracy.
- 5-10 Hz (times per second) is generally sufficient
- Some receivers update at 1 Hz.
  - 4 mph = 5.9 ft/s
  - 8 mph = 11.7 ft/s
  - 20 mph = 29.3 ft/s