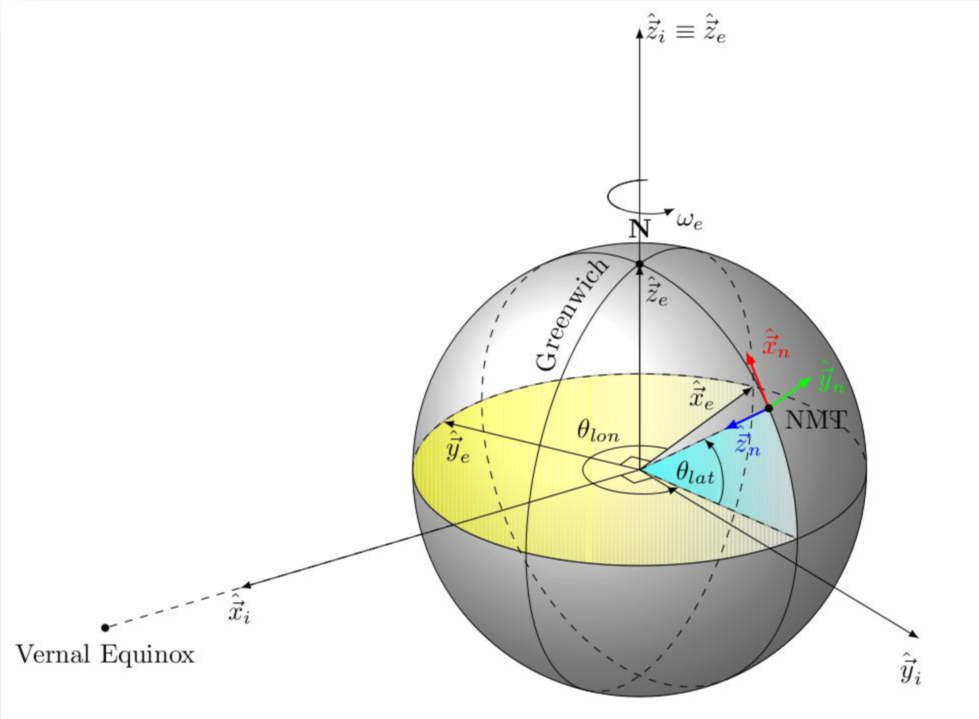
EE 570: Location and Navigation: Theory & Practice

Course Outline

- Required Textbook:
  - Principles of GNSS, Inertial, and Multisensor Integrated Navigation Systems, by Paul Groves, Artech House, 2008.
- Recommended Software:
  - MATLAB Student Version
- Lectures:
  - Tue/Thur 11am - 12:15pm in CRAMER 123
- Instructors:
  - Dr. Stephen Bruder
  - Prof. Aly El-Osery

Course Outline

- Course Description
  - This course will cover the basics of terrestrial location and navigation with an emphasis on practical exposure to the technology. In particular, the class will collaborate on the design, integration, and testing of a UGV or UAV.



Course Outline

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- Course Description
  - Key components of the course include:
    - GPS fundamentals;
    - an overview of inertial navigation technology;
    - principles of strapdown inertial navigation systems including coordinate frames, attitude representation, and mechanization in various coordinate frames;
    - sensor technology covering a wide range of accelerometers and gyroscopes;
    - sensor specifications and characterization;
    - testing and calibration approaches;
    - effects of inertial sensor error and compensation methods; and
    - introduction to unmanned systems; analysis of real sensor data and simulation and modeling using MATLAB/Simulink.

Course Outline

- Grading Scheme
  - Homework Assignments: 30%
  - Three mini-projects: 10% each
  - Final Project and report: 30%
  - Class Participation: 10%

Course Outline

- Navigation Mathematics (Dr. Bruder)
  - Introduction to Navigation
  - Coordinate frames
  - Kinematics
  - Earth surface and Gravity
  - Frame Transformations

Part II: Chapter 2 of the textbook

Course Outline

- Navigation Sensors and INS Mechanization (Dr. Bruder / Prof. El-Osery)
  - Accelerometers
  - Gyroscopes
  - Error Characteristics
  - Inertial Navigation Equations

Part III: Chapters 4 & 5 of the textbook

Course Outline

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- INS/GPS Integration (Prof. El-Osery)
  - GPS
  - Kalman Filtering
  - Integration Architectures
  - System Model
  - Measurement Model
- System Example (All)

Part III: Chapter 6

Part II: Chapter 3

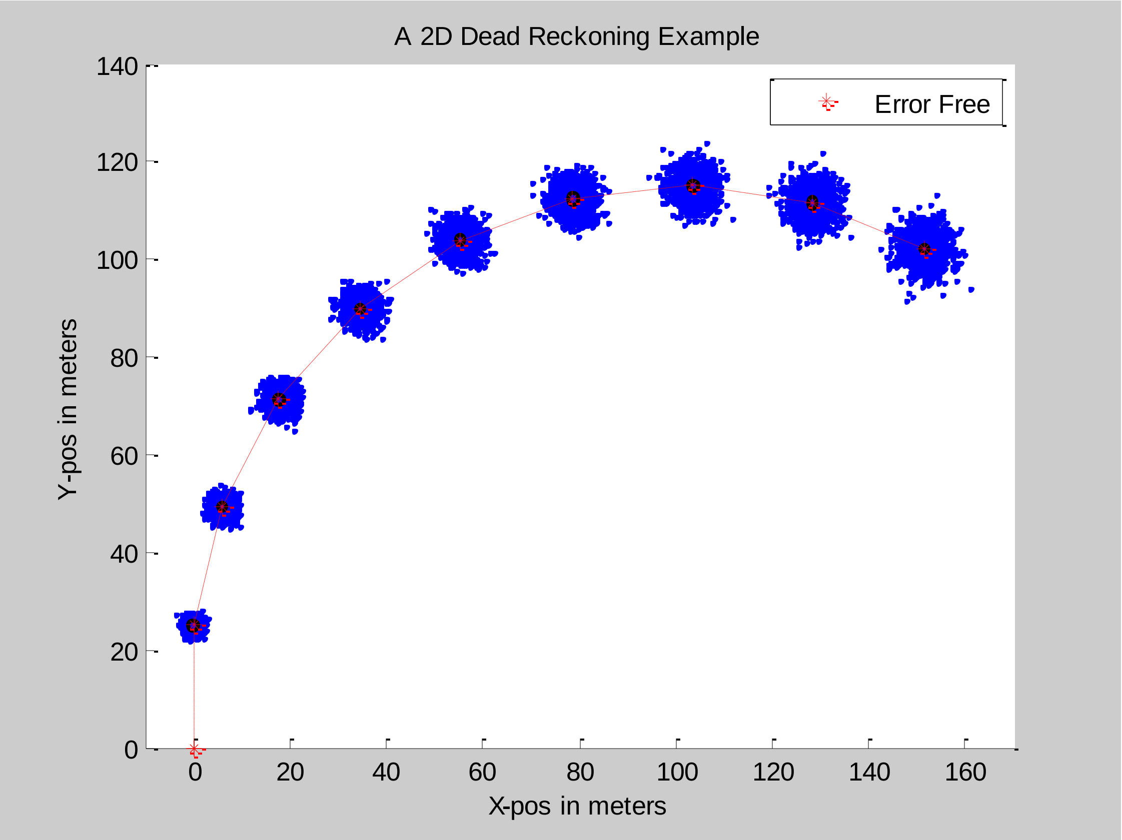
Part IV: Chapter 12

EE 570: Location and Navigation: Theory & Practice

Introduction to Navigation

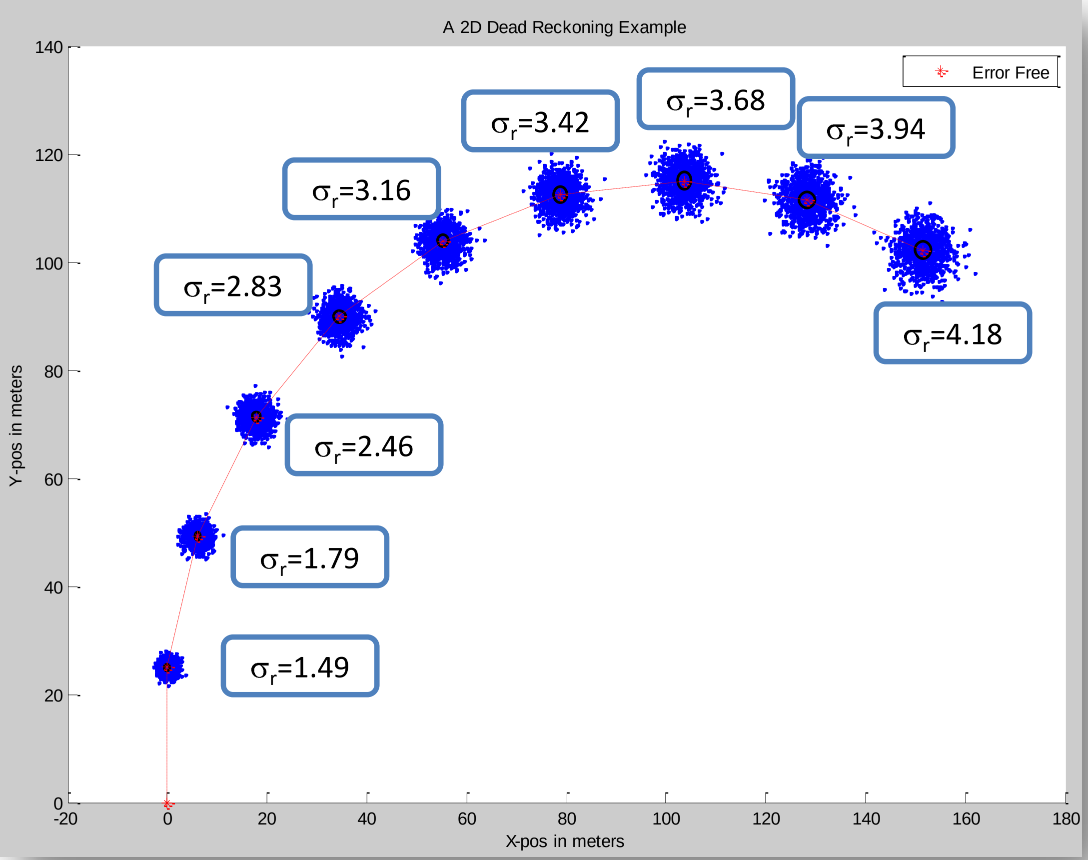
- What is Navigation?
  - The process of determining a vehicle's "course" by geometry, astronomy, radio signals, or other means
    - Often described by Position, Velocity, and Attitude (PVA)
  - This can be accomplished via "position fixing" or "dead reckoning"
    - Position Fixing - Directly measuring location
    - Dead Reckoning - Measures changes in position and/or attitude
      - Need to be initialized and then "integrate" the Δ's
      - Inertial sensors measure the Δ's without requiring an external reference

- A Dead Reckoning Example:
  - At each epoc we measure Δx and Δy with noise (σ=1m)
  - Then add to the prior location

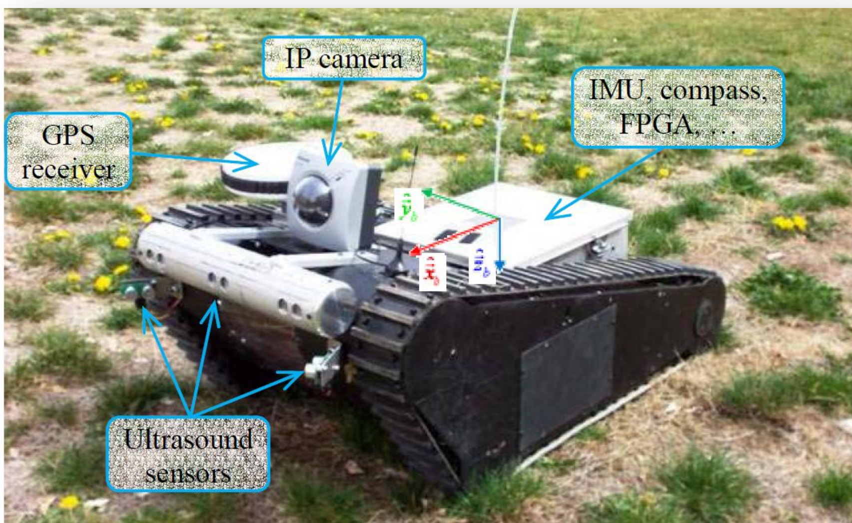


- A Dead Reckoning Example
  - Radial error at each update (in m):
    - 1.49, 1.97, 2.46, 2.83, 3.16, 3.42, 3.68, 3.94, 4.18

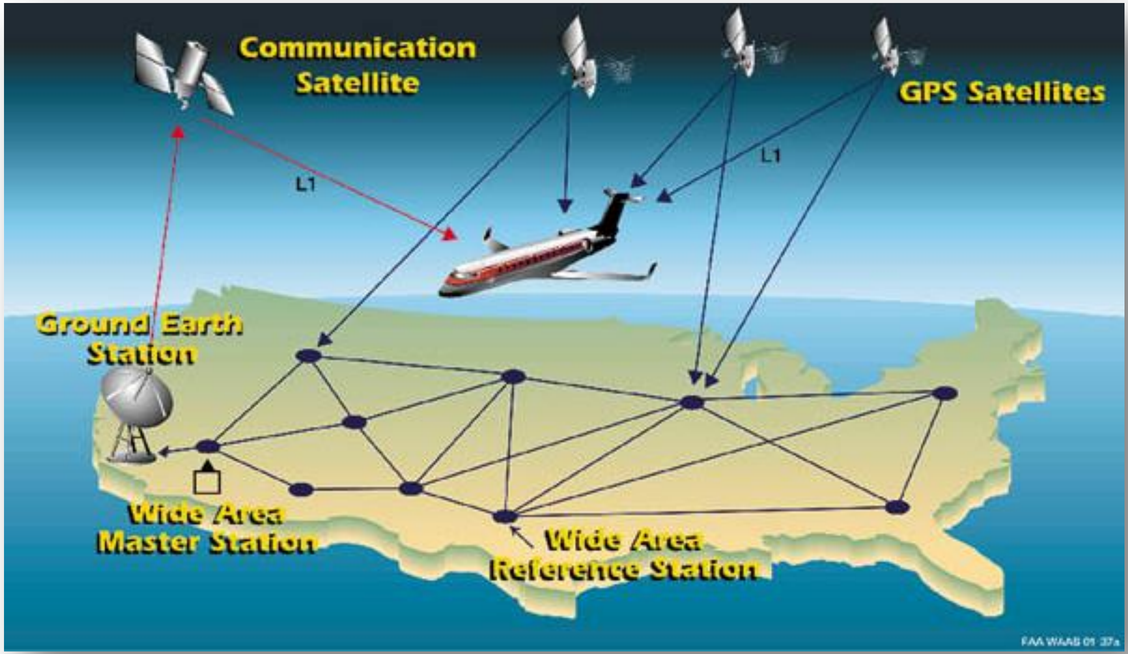
1,000 Monte Carlo Runs



- DARPA Grand Challenge
  - PVA needed in terms of a local datum
    - **Local coordinate system**



- Aircraft or UAV
  - Location relative to the earth
    - **Earth Centered Earth Fixed coord. Sys.**



- Spacecraft
  - Relative to inertial or space coords
    - **Earth Centered Inertial coordinate system**

- There exists a wide variety of information sources (*i.e.* sensors)
  - Inertial, Doppler, GPS, radar, compass, cameras, odometry, barometric, …
- How should I describe my location?
  - Position, velocity, and attitude?
    - Orientation can get a bit tricky!!
- When answering the question of "Where am I?" the *wrt* must be very clearly defined!!!
  - Lead in to the notion of coordinate systems

Introduction to Navigation:
Navigation Sensors/Instruments

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- Navigation Sensors: Past, Current, and Future

Sextant

Compass

Lat/Lon

Star Tracker

MEMS Inertial Sensors

GPS Receiver