

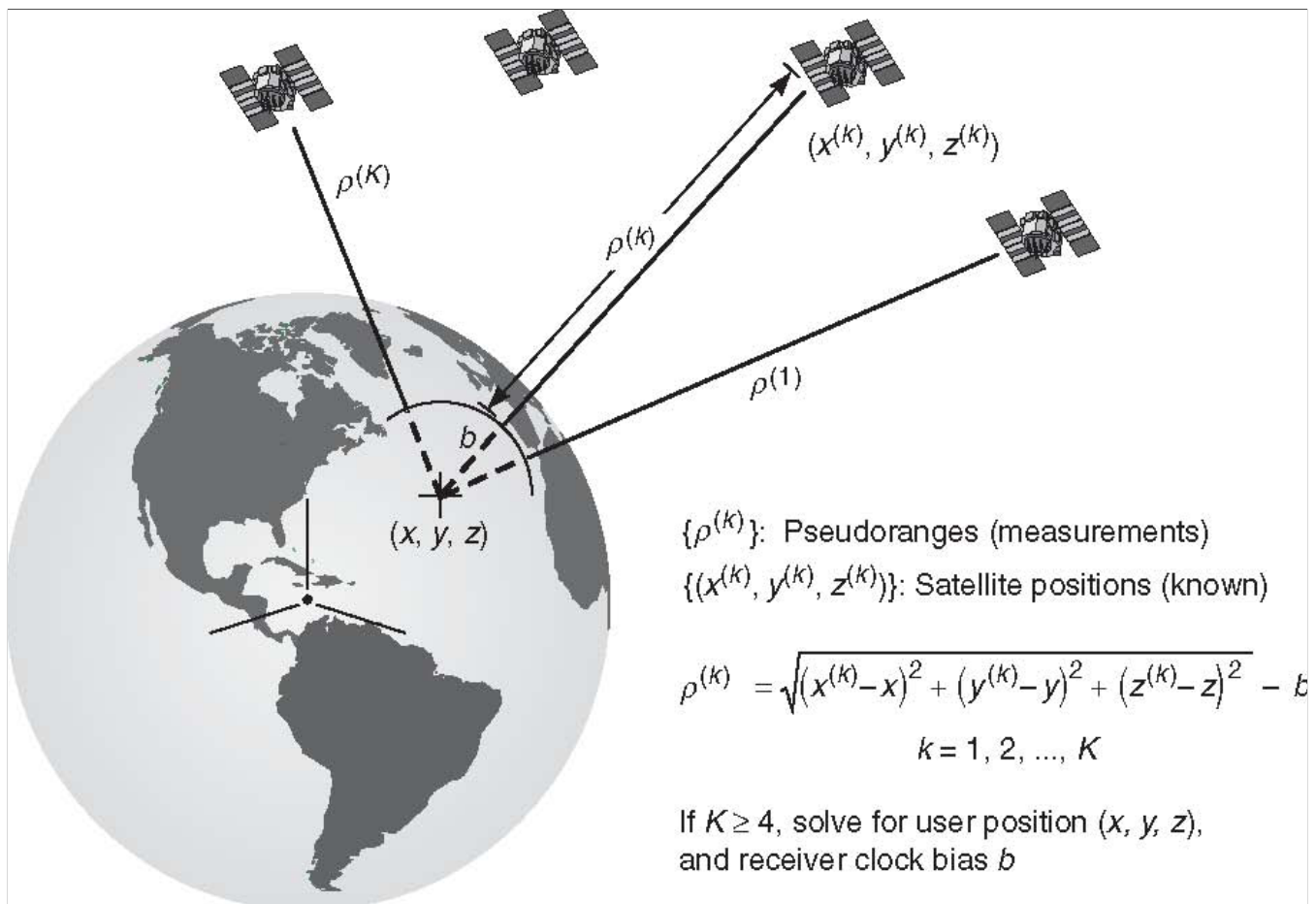


# Satellites Will Suffice?

for the Invitational Workshop on  
Opportunistic RF Localization for Next  
Generation Wireless Devices

June 16-17, 2008

by Per Enge  
Dept of Aeronautics & Astronautics  
Stanford University





## Evolution of Service

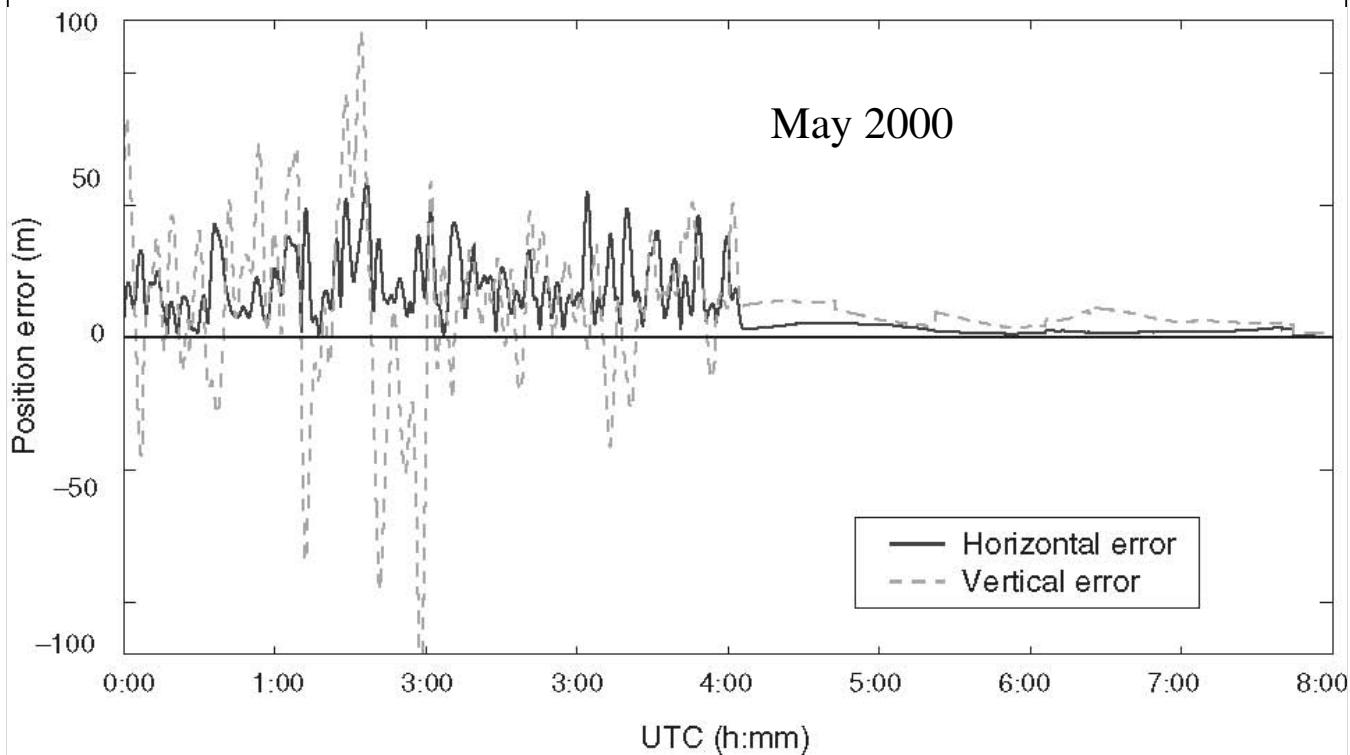
- Availability (Sparse constellation)
- Accuracy (Selective Availability)
- Integrity (Aviation)
- Coverage (Downtown & Indoors)
- Security (Geo-fencing & geo-encryption)



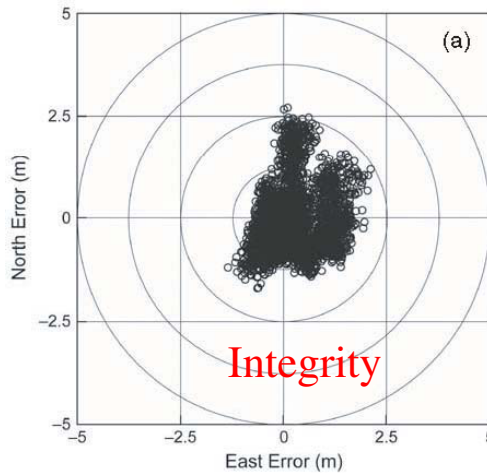
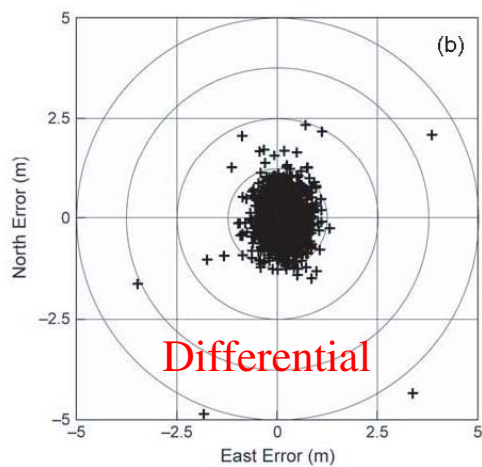
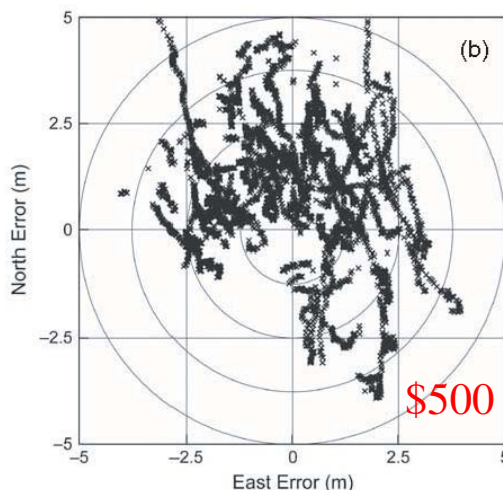
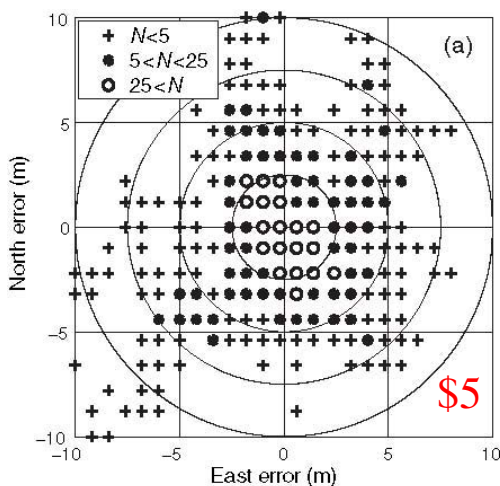
Availability



# Accuracy



from Sherman Lo, Stanford University





# Coverage for the Consumer



## GPS Indoor Survey Locations

A collaboration with Polaris Wireless

149 sampling locations on Stanford University campus

37 % of sites have  $C/N_0 > 15$  dB-Hz

Durand



24 % of sites have  $C/N_0 > 15$  dB-Hz

Mitchell



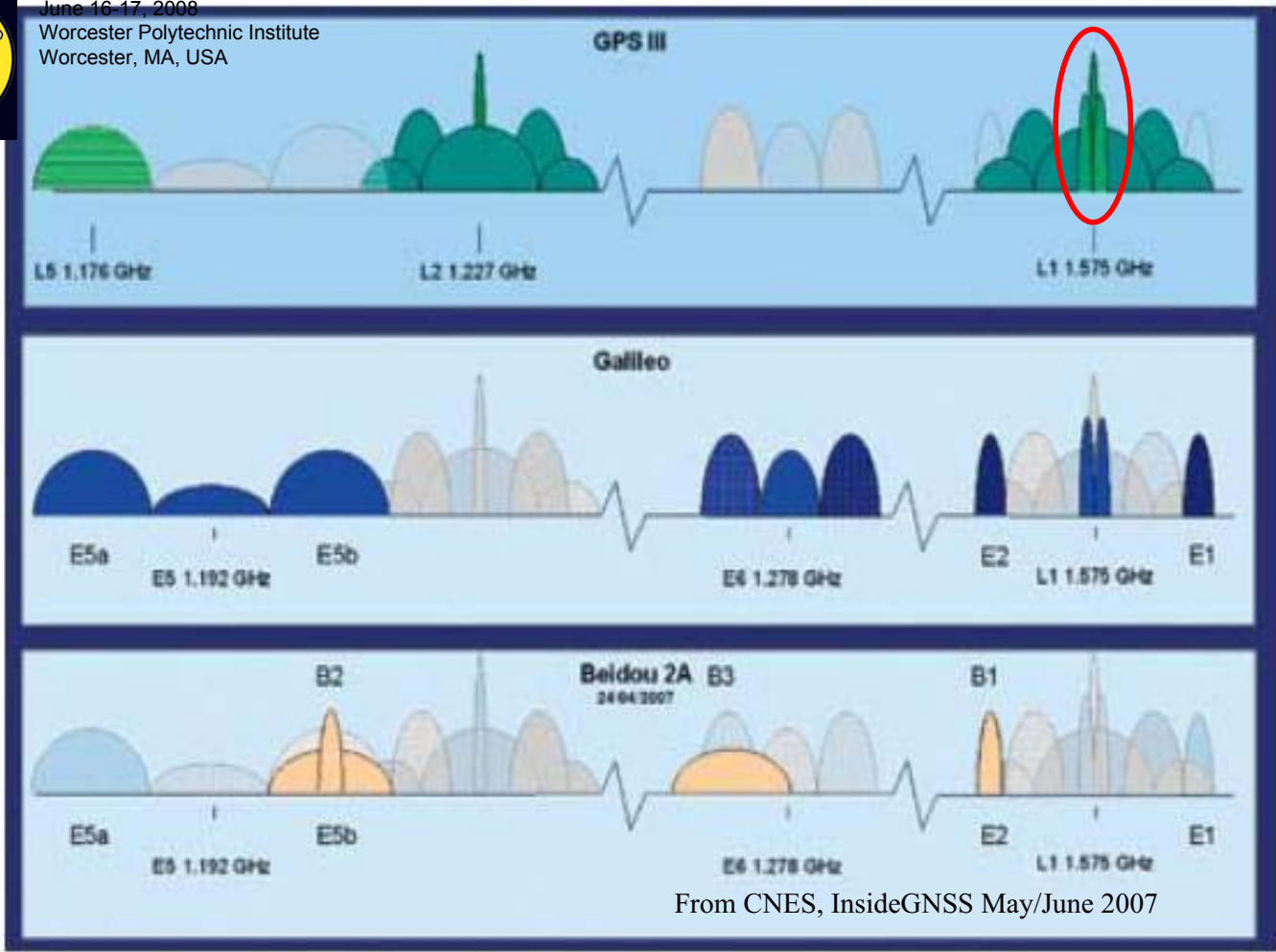
Terman

63 % of sites have  $C/N_0 > 15$  dB-Hz



Quillen

9 % of sites have  $C/N_0 > 15$  dB-Hz



From CNES, InsideGNSS May/June 2007

about the codes ....



The image shows the cover of the May/June 2005 issue of InsideGNSS magazine. The cover features the title 'InsideGNSS' in large blue letters, with 'GPS | GALILEO | GLONASS' underneath. Below the title is the subtitle 'Engineering Solutions for the Global Navigation Satellite System Community'. The main article title is 'New GNSS Signals & Spectrum' in white text on a blue background, with 'GPS, Galileo, GLONASS, Beidou' listed below it. The cover image is a photograph of a large satellite dish antenna. At the bottom of the cover, there are three small icons and their corresponding article titles: 'MULTIPLIED BOC: New Vision For Common GPS/Galileo Civil Signal', 'MOBILE RTK: North's Search For Low-Cost Accuracy', and 'PSEUDO-ALTITUDE: A More Than Make-Believe Solution For Aviation Back-Up'.



# Next Frontier: Security

## Physical Security

- Police & fire
- Hazardous materials
- Olympic athletes

## Cyber Security

- Synchronization for telecom & the power grid
- Road tolling
- Electronic communication (secure source & destination by location & time)
- Data (enable access by location & time)

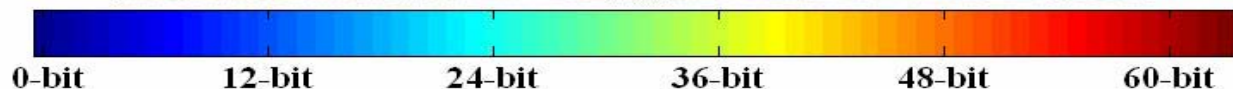
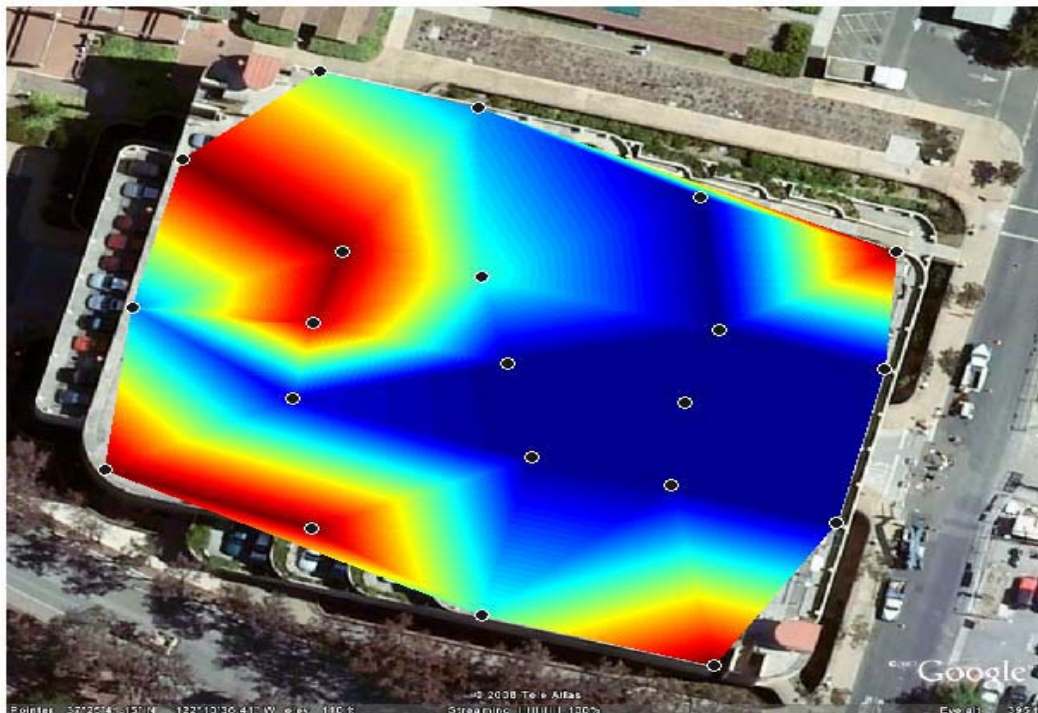
## Spoofing

- Mock signals
- How do **you know** you are where you **think** you are?
- How do **I know** you are where you **say** you are?
- Authentication required

## Jamming

- Denial of service
- Satellite signals are weak
- Anti-jam required

## Geo-encryption Based on Loran-C (Di Qui co-advised by Profs. Enge & Boneh)





# Summary

- GPS has a wonderful history
- New signals & constellations are coming
  - MEO & perhaps LEO
  - more from Dr. Misra
- Security for and from GNSS
  - Geo-fencing
  - Geo-encryption
- Terrestrial signals will be needed

