



ERTH 491-01 / GEOP 572-02
Geodetic Methods

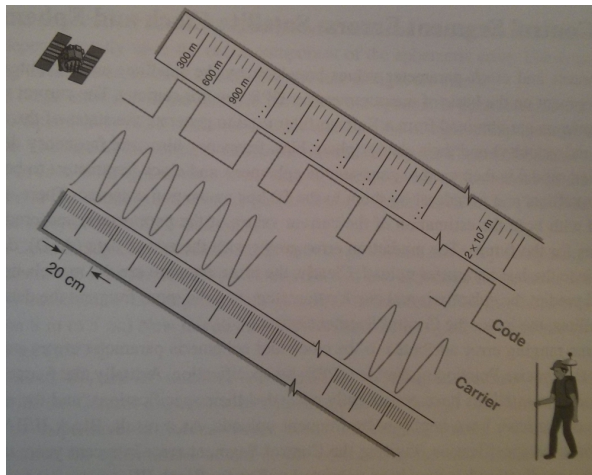
– Lecture 05: GPS Measurement Models, Position Estimation –

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Measurement Models

- Code Phase Measurement (today)
- Carrier Phase Measurement



Misra and Enge, 2011, *GPS-Signals, Measurements, and Performance*

Position Estimation w/ Pseudoranges

- Positioning by (pseudo-)ranging
- range: geometric distance between satellite and receiver
- pseudorange: includes distance, clock error effects, path delays

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$$\rho = r + c(\delta t_u - \delta t^s) + I + T + \epsilon$$

ρ - pseudorange

r - true range to satellite

c - speed of light

δt_u - receiver clock bias

δt^s - satellite clock bias

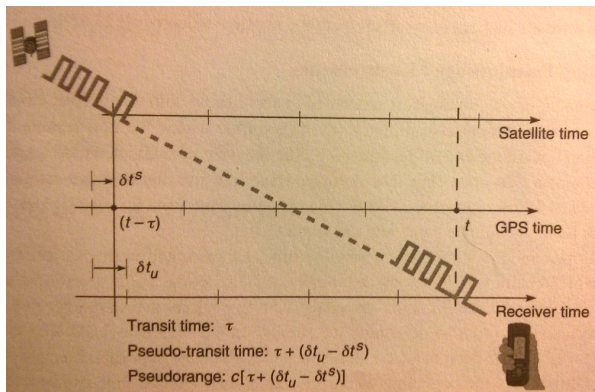
I, T - Ionospheric and tropospheric delays

ϵ - unmodeled effects, measurement errors, etc.

Position Estimation w/ Pseudoranges

- Want range, get pseudorange: noisy and biased
- quality of range estimate depends on ability to deal with biases, errors
- more on those later!

Pseudorange Measurement Model

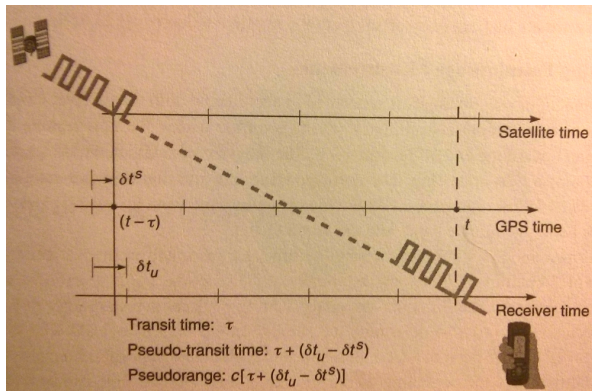


Misra and Enge, 2011, *GPS-Signals, Measurements, and Performance*

- need to deal with receiver t_U , satellite clocks t_S , and GPS time (t)
- τ - travel time of specific code
- PRN correlation shift gives estimate of τ
- receiver: $t_U = t + \delta t_U \dots |\delta t_U| \leq 1 \text{ ms}$ ($\approx 300 \text{ km}$)
- satellite: $t^S = t + \delta t^S \dots |\delta t^S|$ small (atomic clock)

Pseudorange Measurement Model

$$\rho = c(\tau +)$$

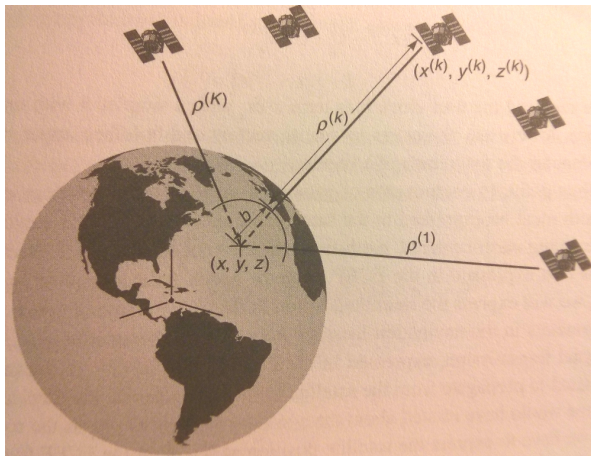


Misra and Enge, 2011, *GPS-Signals, Measurements, and Performance*

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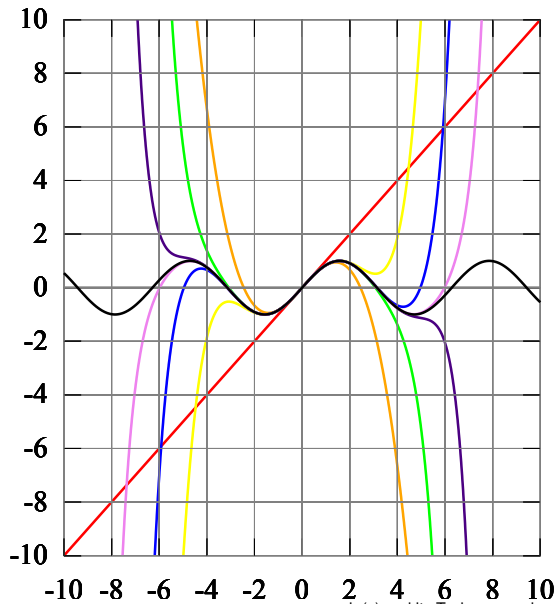
Pseudorange Measurement Model

Derivation in notes . . .



Misra and Enge, 2011, GPS-Signals, Measurements, and Performance

Taylor expansion



$\sin(x)$ and its Taylor approximations; source wikipedia