AOA- Ranging Signals

Alternatives to GPS for Ranging Signals

- Psuedolites
  - Ground Based
  - Aircraft Based
- Galileo
- Other National Satellite Systems

This Analysis is just Beginning

Initial Thoughts and Approach

- In each class (PL – air and ground, Galileo etc.) look at best (“Optimal”) system configuration and quantify effectiveness.
- Compare this with cost and operational effectiveness of 6 more GPS satellites (“30+X”)

History of PLs

- First Used at White Sands (1968-1971) to demonstrate the GPS signal structure
- Next Major Use – Cat III (“Blind”) Aircraft Landings at Stanford University 1993
- Occasionally used for Robotic Farming, but requires carrier tracking receivers.

PLs for CAT III Landing
(First Demonstrated at Stanford University 1993)

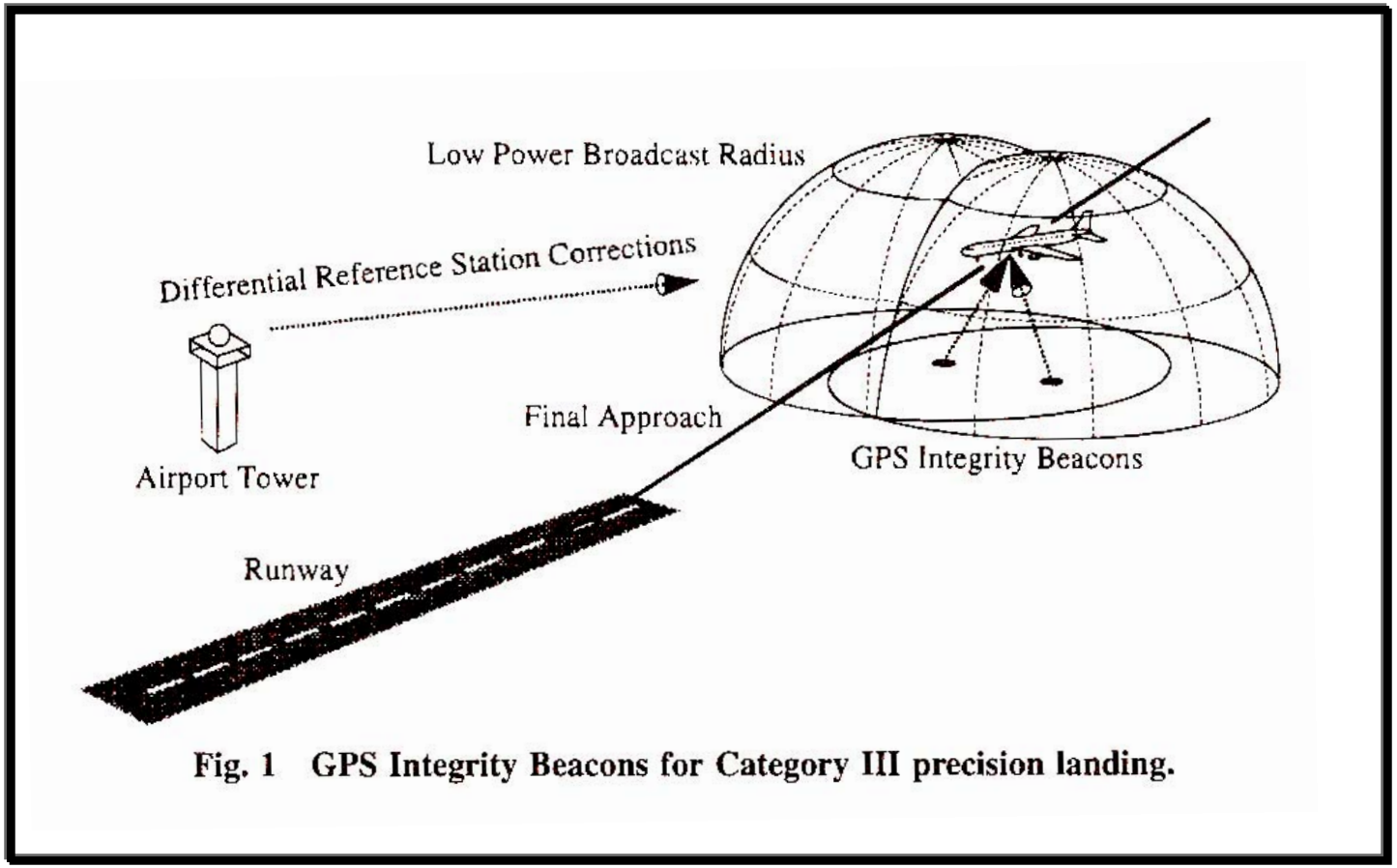

Fig. 1 GPS Integrity Beacons for Category III precision landing.

AOA: Pseudolites (PLs)

- PLs are ground or airborne transmitters - usually with GPS frequencies and characteristics
- To augment GPS, and meet full “Big 5” Characteristics, the PL signal must have equivalent capabilities
  (GPS offers an extremely stable 4 dimensional source of signals)
- Issues
  - Operational Concept
  - RF Frequency of Ranging Signal
  - Near-Far signal strength
  - Monitoring/Calibration and Comm. Link
  - PL location and Signal Geometry
  - Low-grazing angles & multipath
  - Initial Set-up and Deployment time
  - Update Rate and Age of Data
  - User Equipment Reception of PL signal
  - Interference and PL Power (both ways)

Note: Current GPS signal in Space accuracy (URE) for dual-frequency (military) receivers is ~0.9 Meters

PL Fundamental Issue - Ranging Accuracy

- GPS Signal Ranging Error is ~0.9 meters
- For a PL to augment, error ***should not be more that 4 times GPS*** (otherwise contribution is negligible) – An example of this constraint:
  - Position of PL known to less than 1 meter (WGS-84)
    - Extremely difficult for Aircraft based PL
  - Time synchronized to about 3 nano-seconds (GPS)
  - Multipath errors of less than 2 meters (Carrier Phase)
  - Integers resolved to within 1 meter

PL Fundamental Issues – Signal Geometry

- Measured by the “Dilution Factor”
  - Multiplier of Ranging accuracy (For free views typically 2 to 4)
  - For the impaired user (buildings, mountains etc.) may be many 10s
- For a PL to be *most useful* for the impaired user, would like the PL to be in the impaired directions
  - Unfortunately this is usually a direction denied to the PL as well
- We are running cases in Mountainous terrain to find optimal direction
  - Quantify the **best** improvement

PL Fundamental Issues – Operations

- Most impaired users are in “harms way”
  - Placing PLs in the Afghan Mountains not plausible
- One PL usually only benefits a narrow geographic area
- Support for PL requires monitoring
- GPS receivers must be specially configured to handle PL signal
  - Near-Far problem
- Airborne PLs suffer degraded accuracy, and complex support architecture

Comment on MOE 1: The Accuracy Payoff

- Reducing error by 3 improves P_K by up to **9**
- CNN wars dictate reduced collateral damage – the stray bomb is important
- Improve 1st round effectiveness = less US attrition.
- Sorties to destroy = ~ 1/ P_R

Issue: Need both TLE and WLE accuracy