Positioning Buried Pipes and Cables in Urban Canyons Using an Integrated GNSS Approach

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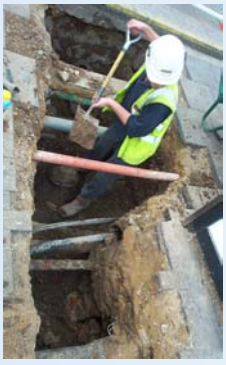
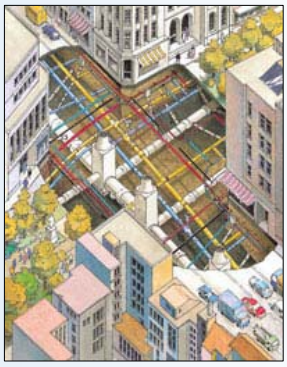
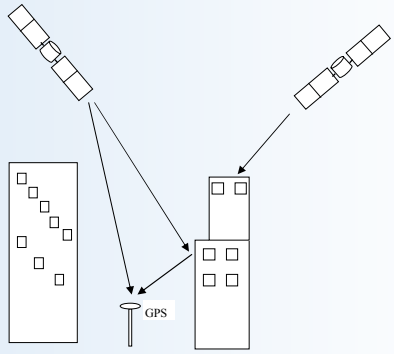
Buried Assets: The Problem

- Large network of buried services estimated at over 4million km in length and increasing.
- Many databases with varying accuracy and provenance.
- There are an estimated 4 million street openings p/a.
- Billions of pounds in direct and indirect cost. An estimate of traffic delay costs conducted in 1994 was put at £1.23-1.65 billion per year.


Urban Canyons

- The urban environment with its tall building and structures creates a canyon like environment which limits the line of sight to enough satellites required for positioning.
- In addition errors such as multipath are large in such environment.
- Therefore GPS alone is not always able to provide the positioning required.



Introduction

- GNSS Simulation Tool
  - GNSS Simulations
  - Multipath Simulations
- Continuous UPdating Technique (CUPT)
- High Sensitivity GPS
- GPS/INS Integration
- Locatalites
- Augmented Reality
- GPS/GPR Integration
- Laser Scanning

GNSS Simulation Tool

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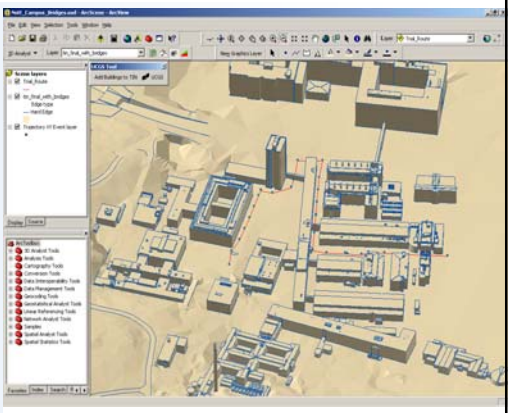
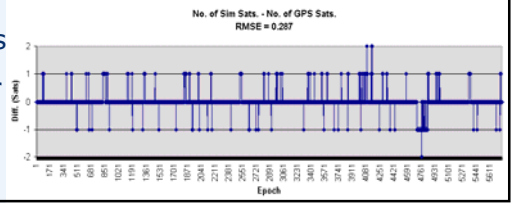
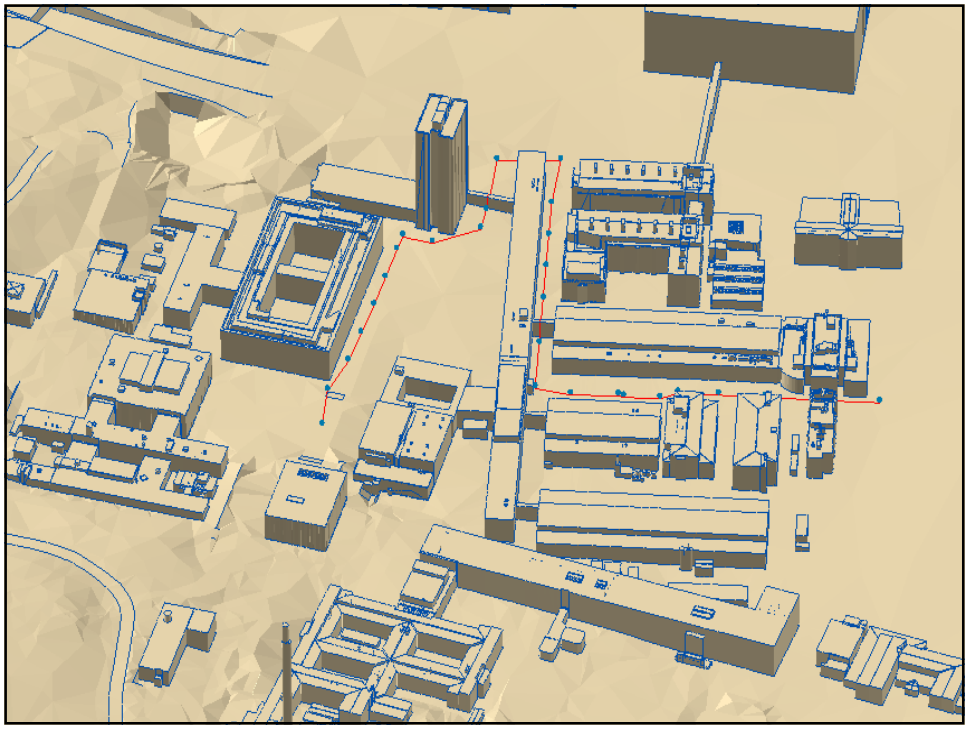
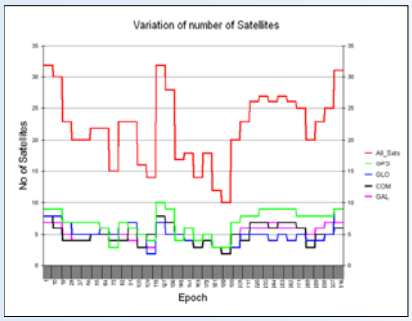
- Simulates 4 Different GNSS Constellations
  - GPS
  - GLONASS
  - Galileo
  - COMPASS
- Uses Vector Data created from Photography
- Does not include vegetation
- Calculates Line of Sight between antenna and Satellites
- Difference between simulator and real world calculated for GPS

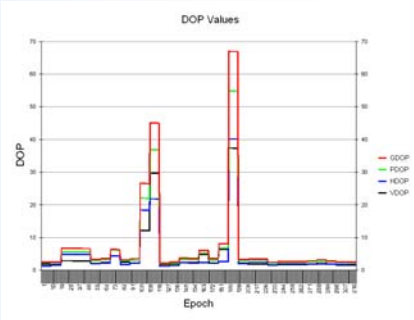






Tests Using Simulation Tool

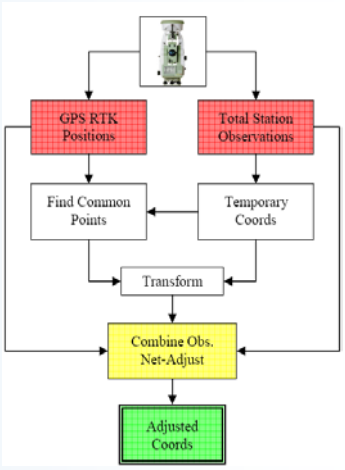




- Results from Trial on University of Nottingham's Campus
- A 3D multipath model is also being developed – this provides an indication of the level of multipath that can be expected at a given location at a particular time. It also indicates which satellite data will be most affected by the multipath error.

CUPT

- Continuous UPdating Technique
- Integrates RTK GPS with Total Station
- Collect RTK GPS and TPS Positions
- Find Common points and then transform coordinates from WGS84 TO OSGB36
- Use a least squares adjustments to combine the TPS observations and the GPS positions



CUPT – SmartPole Test

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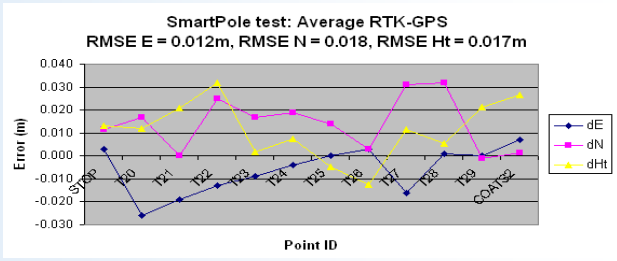

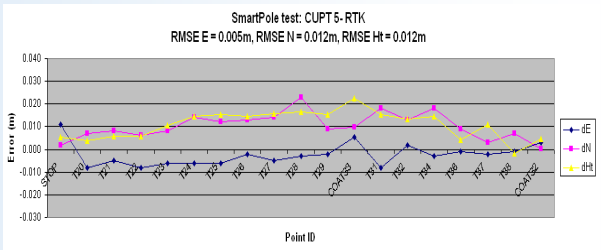

High Sensitivity GPS

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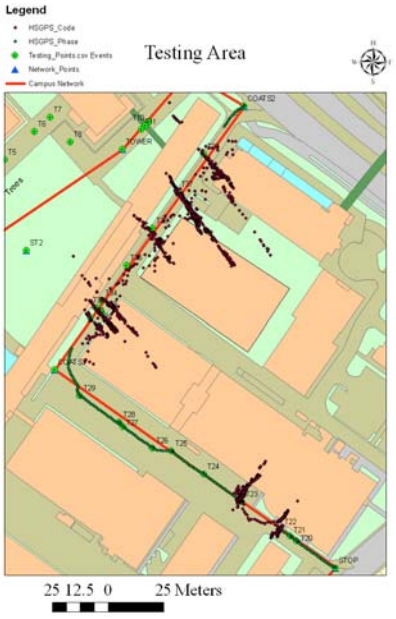
- Test using Ublox receiver
  - Single Frequency (L1)
  - Cheap - £100 approx
  - Small
  - Used a more expensive survey grade single frequency Antenna.
- Positions always available
  - Phase Positions good to Centimetre level
  - Reliability? Sometimes Phase sometimes not.
  - 57% phase (green)
  - 43% code (red)



High Sensitivity GPS

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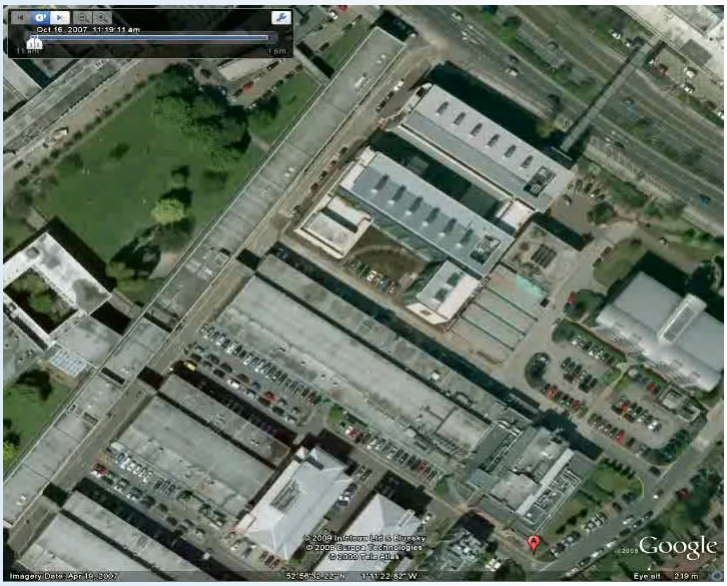

High Sensitivity GPS - CUPT

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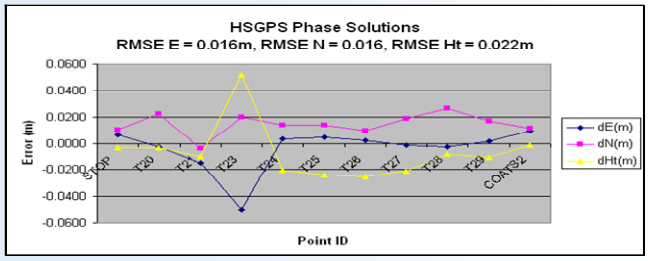
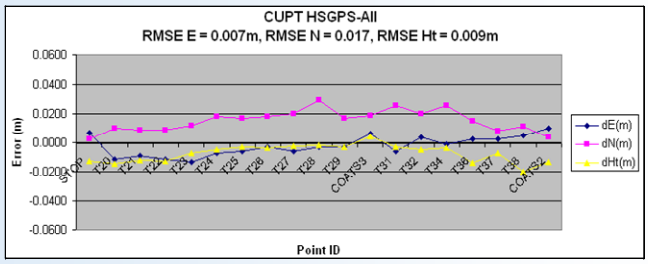
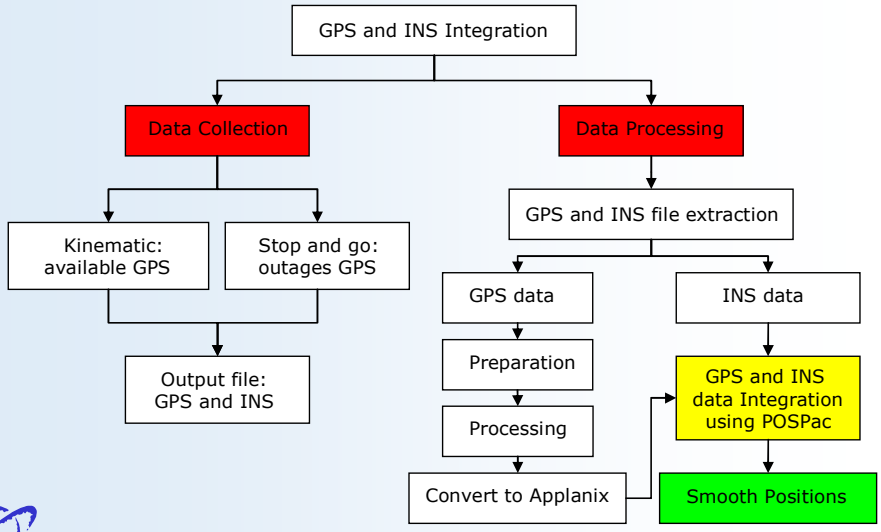


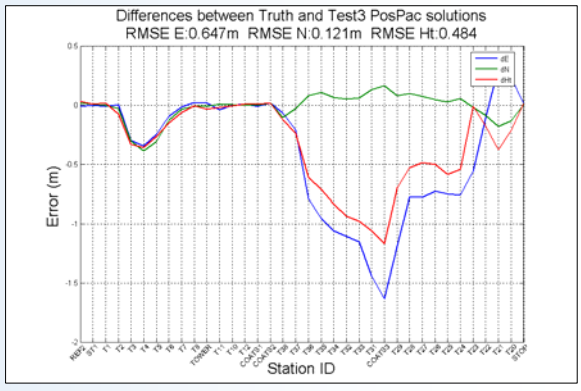


Integration of GPS and INS



Integration of GPS and INS

- Maximum time without GPS = 20 minutes.
- Loosely coupled integration.
- Post-processing the GPS/INS data with a conventional method using Applanix POSPac software, a maximum error of about 1.60m was achieved.



Integration of GPS and INS

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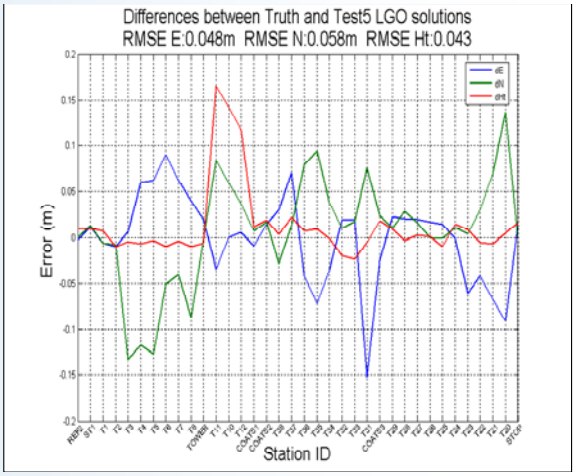
- However, when processing the same data using the Multiple Step Integration Technique (MSIT), a RMSE of better than 0.06m was achieved.
- Maximum differences of about 0.15m for plan coordinates and about 0.17m for the heights were found in the outage areas.
- Where GPS positions are available, the 3D accuracy is better than 0.03m.



Locata Technology

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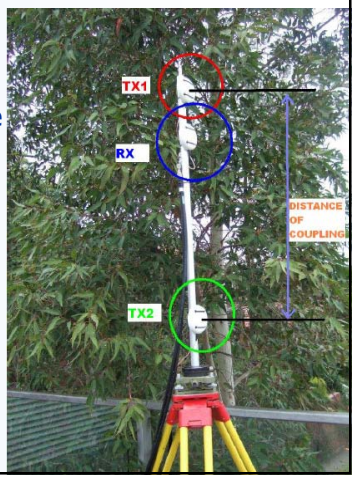
1. A network of several time-synchronized transceivers
2. Transmitting in the ISM band (2.4Ghz)
3. Dual frequency
4. Synchronized by TimeLoc (ns level)
5. Wireless technology
6. Master/Slave structure
7. Triangulation with carrier phase or code
8. Network can be designed by the user
9. Centimetre Accuracy can be achieved



Locatalite Network

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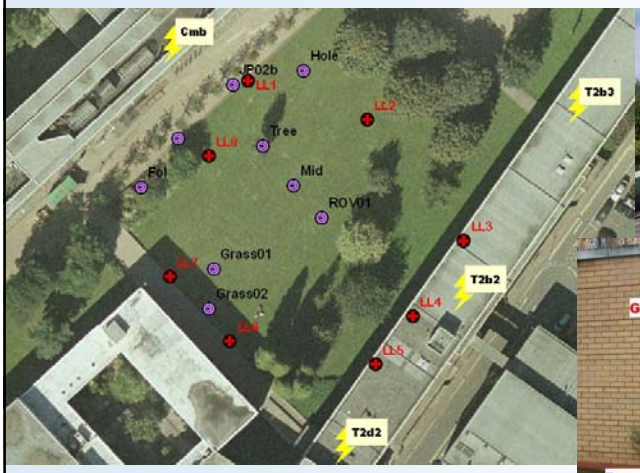
- A Test Facility at the University of Nottingham



Locata Experiments

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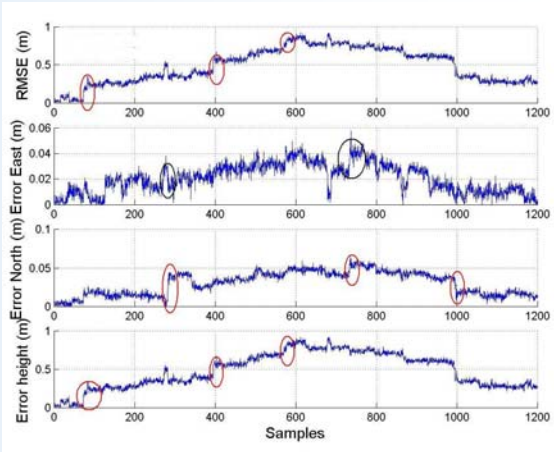
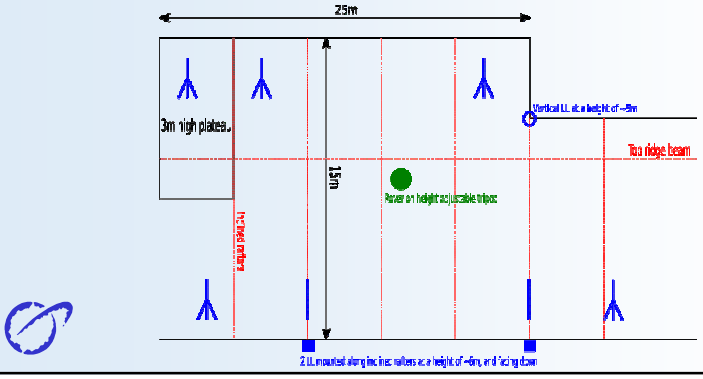
- Wi-fi interferences cause jumps in the data (circled areas).
- Largest errors are in the heights



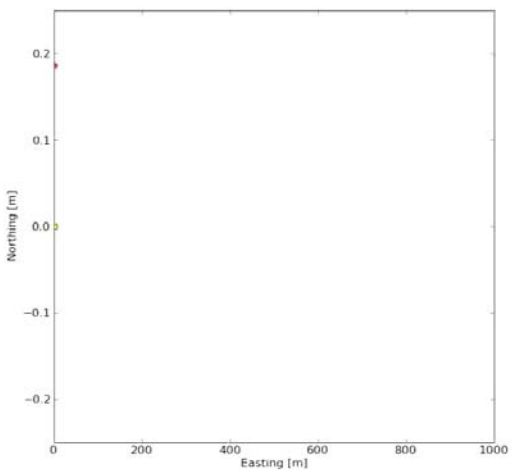
Locata Indoor Test

- Problems obtaining Heights
- Locata Network Setup Indoors
- Allowed some of the transmitters to be located on the roof
- Better Distribution of Transmitters = Better Vertical DOP
- No Wireless Internet was Present
- High Mulitpath Environment – Some problems synchronising



Locata Experiments

- **Locatalite Indoor Test Results**



Locata Experiments

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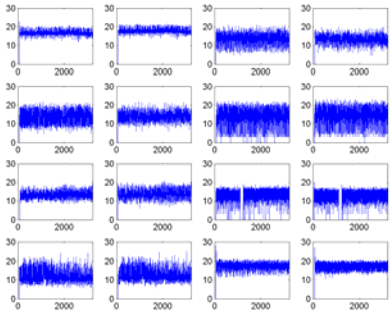
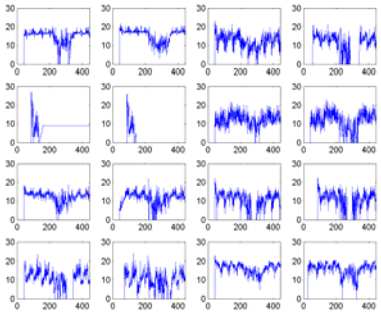
- **Results still not reliable – Compare SNR**
- **More Investigation Needed to understand the differences**

Stable



Unstable



Locata Experiments

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Integration of Locata and GPS

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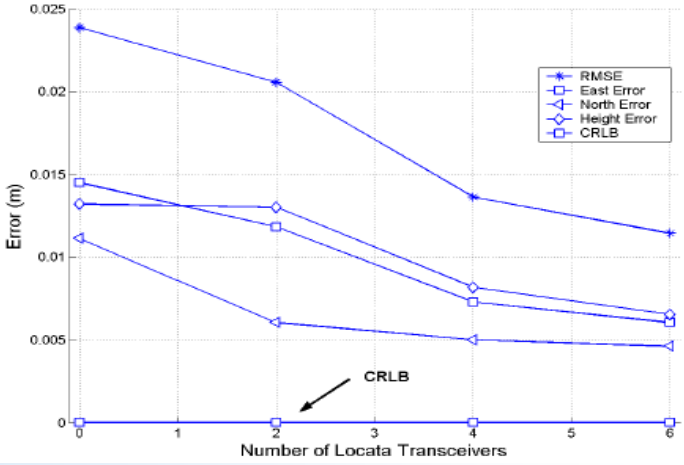
- Effect of Integrating 4 GPS satellites with changing number of Locatalites



Augmented Reality

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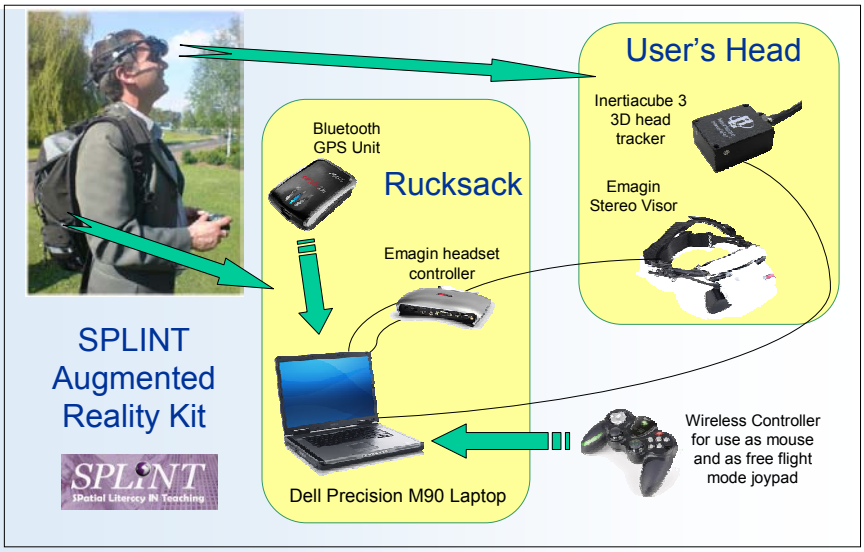

Augmented Reality

GPR

- Investigating Integration of GPS with GPR
- Experimented with SIR-3000 (ScottWilson)
  - GPS Position is tagged to the GPR file at the end of every line walked in the field
  - GPS times are tagged every 100 GPR readings
- Planning further investigations with Adien and Scott Wilson on the University of Nottingham's campus.
- Tests were conducted to assess the viability of using a digital compass for GPR tilt correction.

Tilt correction - Equipment

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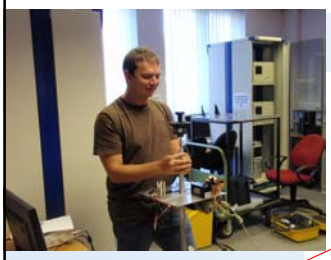

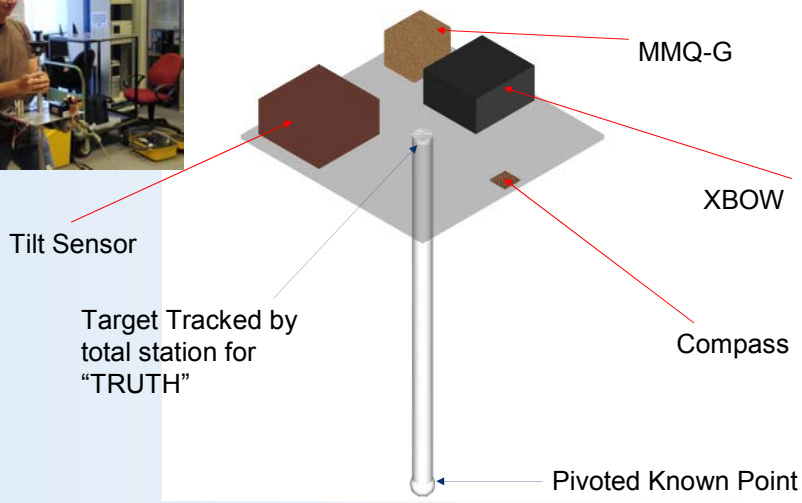

Laser Scanning – Detecting Pipe Material

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