
Trusted Positioning
Positioning Everywhere





The Promise of MEMS to LBS and Navigation Applications

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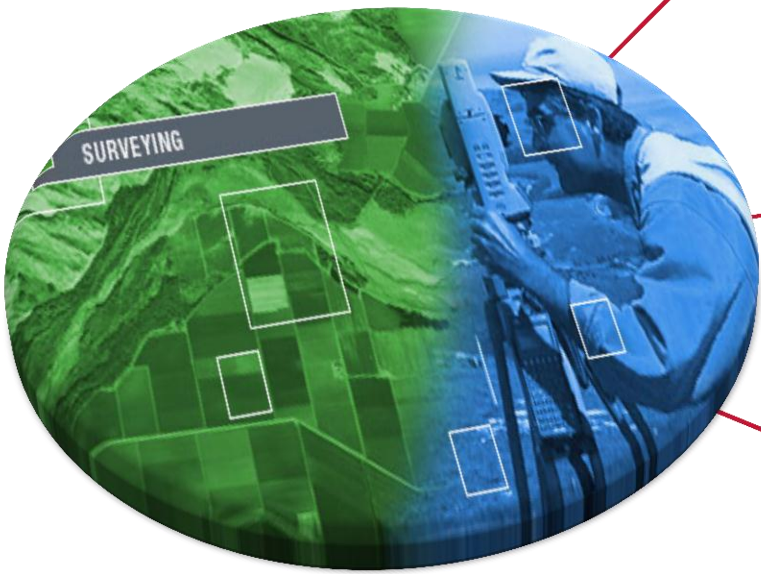
Status of RF Technologies

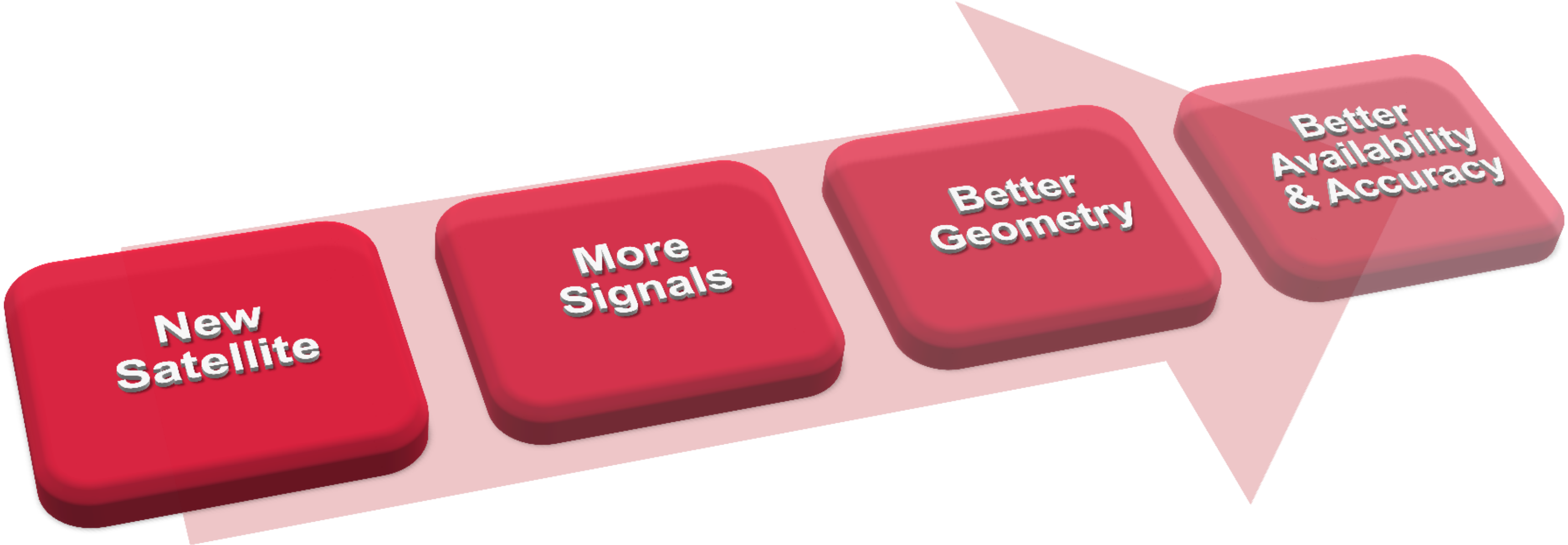


GNSS
- GPS
- GLONSS
- Galileo
- QZSS
- COMPASS
- IRNSS

Alternatives to GNSS
- Cellular Technology
- Wireless Sensor Network
- WiFi
- IMES

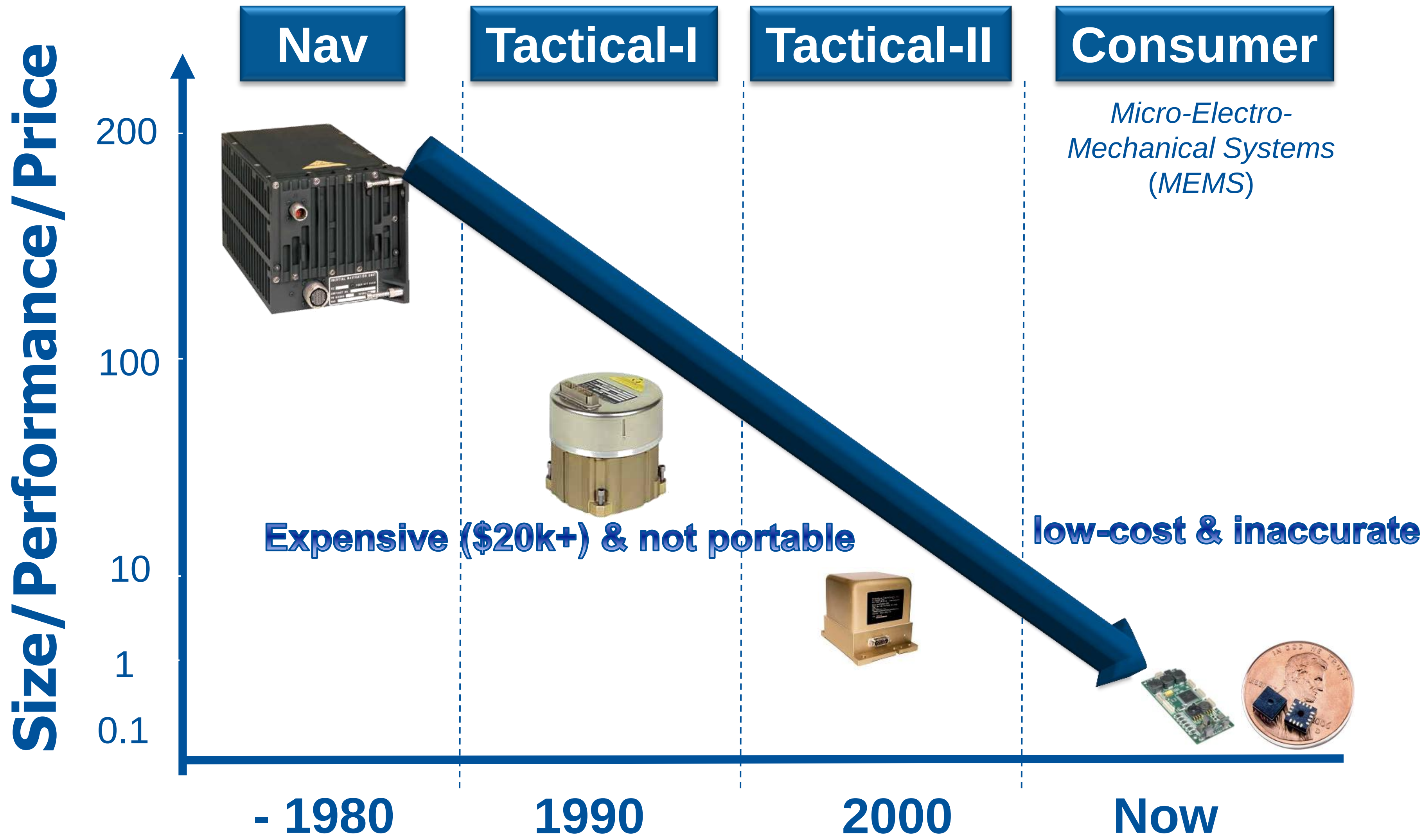
GNSS + Wireless Technologies
- Assisted GPS
- Enhanced GPS
- Ultra Wide Band

Impact of RF Revolution



- **With the increased number of satellites, more sophisticated GNSS receivers, and new wireless alternatives, consumers will be able to operate in a wider range of conditions (outdoor/indoor).**
- **However:**
  - GNSS - Not always available and inaccurate due to multipath
  - Wireless (Wi-Fi, cell location…):
    - Infrastructure is expensive and not always present
    - Sparse networks or poorly surveyed networks are inaccurate

Status of Inertial Technology



Harnessing the Power of Sensor ….

GPS

Barometer

Magnetometer

Accelerometers

Gyros

Wi-Fi

Cameras

Smartphones - Next Generation Navigators

- E.g. Samsung Galaxy Note
  - ST Micro. 3-gyroscopes
  - Kionix 3-accelerometers
  - Bosch barometer
  - Broadcom GPS
  - High resolution camera
- Processor
  - 1.5 GHz ARM
  - Android OS 2.3
  - 20-100 Hz sensor data

- Other Android devices such as Samsung Galaxy Nexus and Motorola Xoom phones are all have similar capabilities





Challenges Facing MEMS for Portable Navigation Applications

Constraint free navigation

- A user should be able to operate their mobile device in any orientation w.r.t. their body or vehicle frame while navigating

Limitation of Current Technology	Solution
Current solutions using sensors & wireless require constraining or tethering of the mobile to the platform in a defined orientation. E.g. fixed to belt or dash-mounted.	The misalignment between the moving platform frame (e.g. person or vehicle) and mobile device frame is continually corrected so the device can be used without constraints.

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Walking and driving

- A user should be able to operate their mobile device when walking, driving or on other moving platforms (e.g. subway) while navigating

Limitation of Current Technology	Solution
Current solutions using sensors for navigation are application specific and use different algorithms for walking and driving.	Optimal algorithms are chosen based on autonomous detection of walking or driving. Furthermore, when driving, the algorithms can accept any available vehicle sensor information to improve the navigation results.

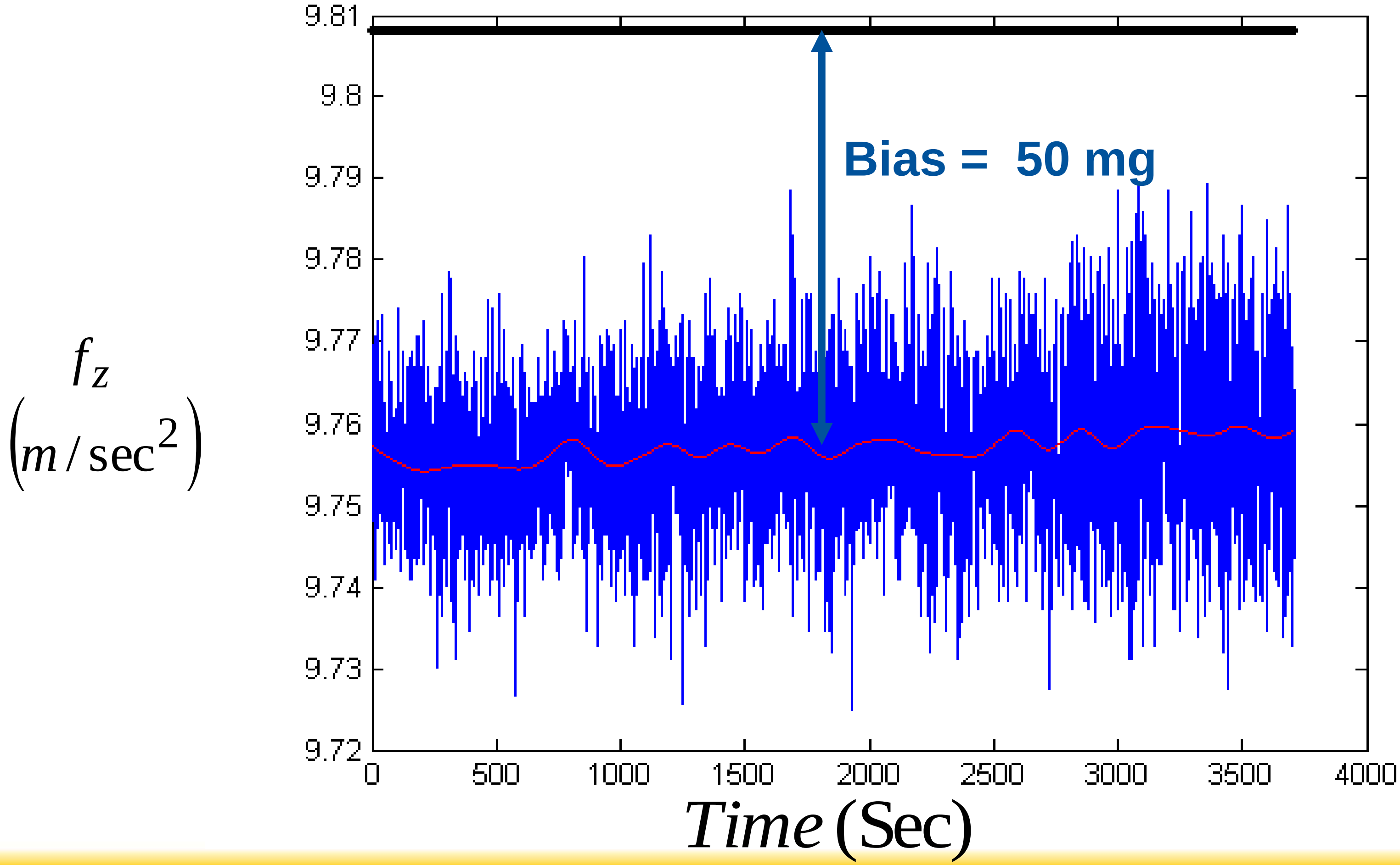
Infrastructure-free navigation

- The user should be provided with a seamless navigation solution in all scenarios and environments, even for long periods without any wireless positioning updates (e.g. from GPS, Wi-Fi, cell)

Limitation of Current Technology	Solution
Traditional navigation solutions drift very quickly w.r.t. time when navigating with sensors only and without wireless updates.	Advanced sensor error modelling and intelligent application of platform motion updates provide large enhancements when navigating without wireless updates, even for long durations.

MEMS Sensors Errors

- Example: A MEMS-based Accelerometer along the vertical direction (cost = $2-3)



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Possible Ways to Improve the Positional Accuracy?

- Use of additional velocity aiding in body frame
  - Zero Velocity Update (ZUPT) when possible
  - Non-holonomic constraints
  - Odometer
- Integration Filter Level - Advanced Algorithm
  - Unscented Kalman filter (UKF)
  - Integration of EKF/UKF and Artificial Neural Network (ANN)
- Sensor Level (multi-sensors, barometers, mags)
- Backward Smoothing

Portable

Mobile advertising

Mobile device and user orientation

Tracking applications

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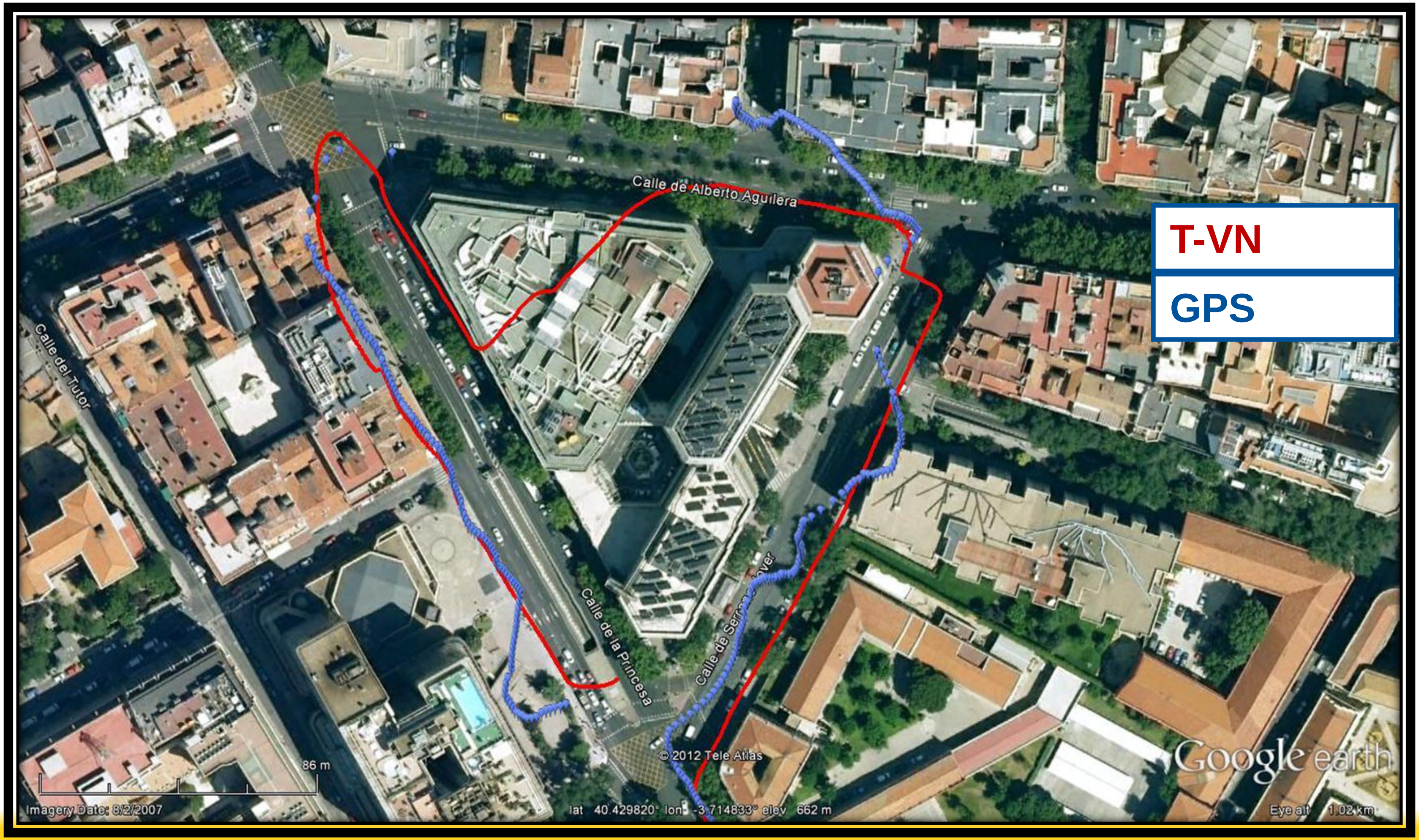
Running at Wuhan University with Samsung Galaxy Note

- Special thanks to our test subjects!

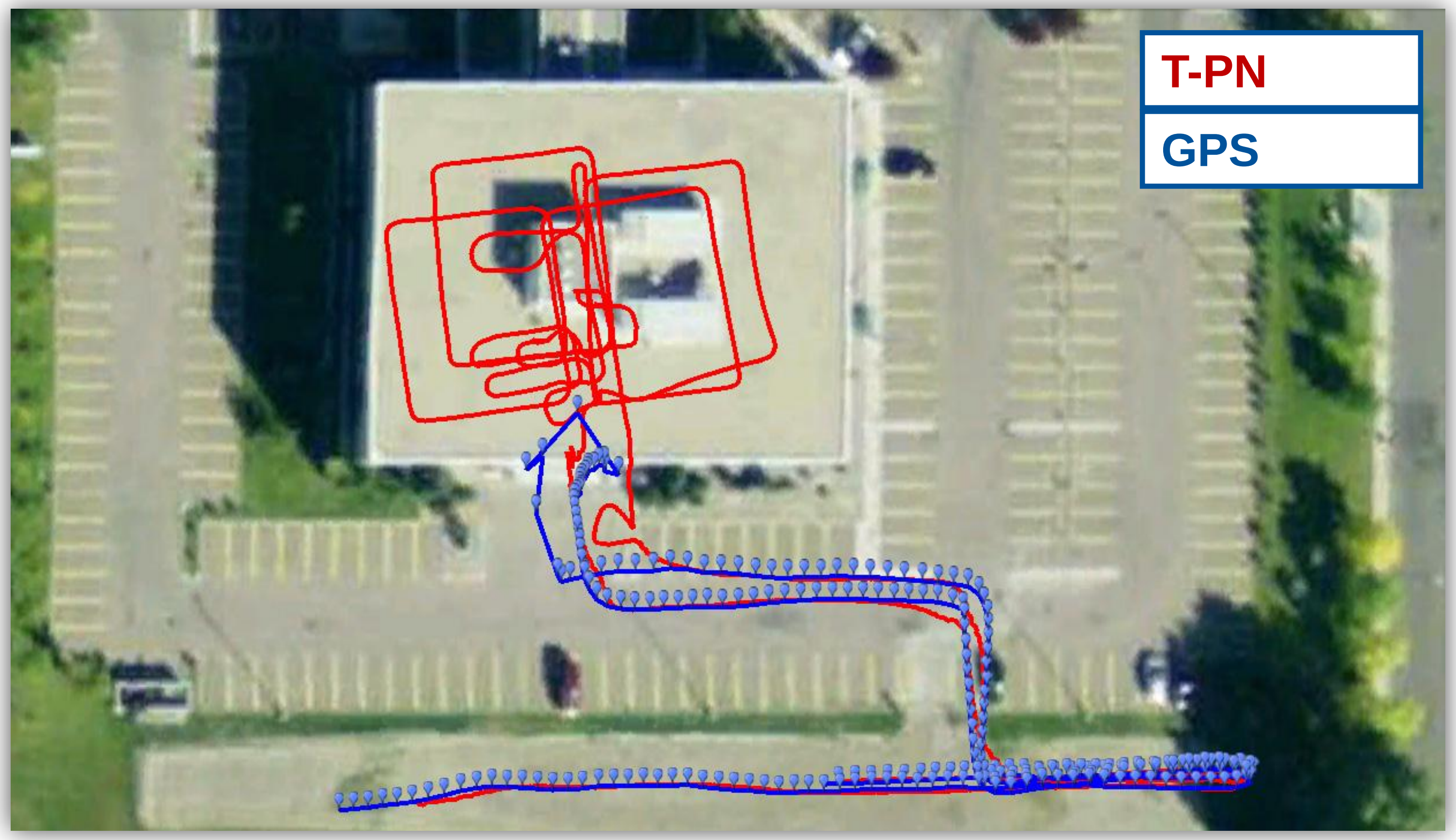
T-PN results in Madrid

- Samsung Galaxy Nexus: invensense MPU-3050 gyroscopes, BMA180 accelerometers, BMP085 barometer, and SiRF Star IV GPS

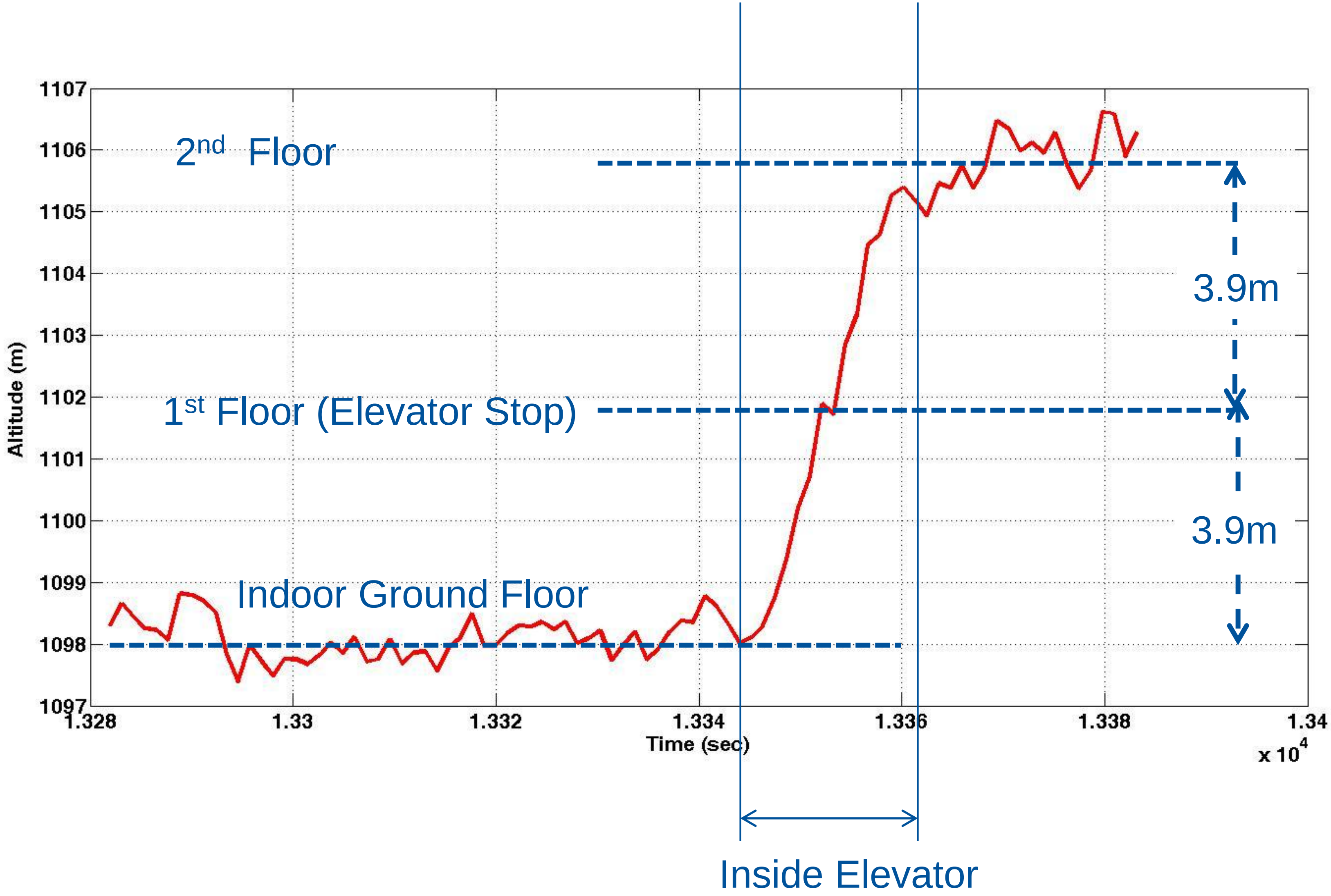


Indoor Navigation with Samsung Galaxy Nexus

- 9 minutes indoors without GPS or WiFi, multi-floor, stairs (up/down), elevator (up/down), total travel distance about 450 metres distance
- Maximum error of 6 metres, ~ 1.5% error of distance travelled



Samsung Note Indoor Elevation Estimation - Calgary



Vehicle

Assisted driving & enhanced safety

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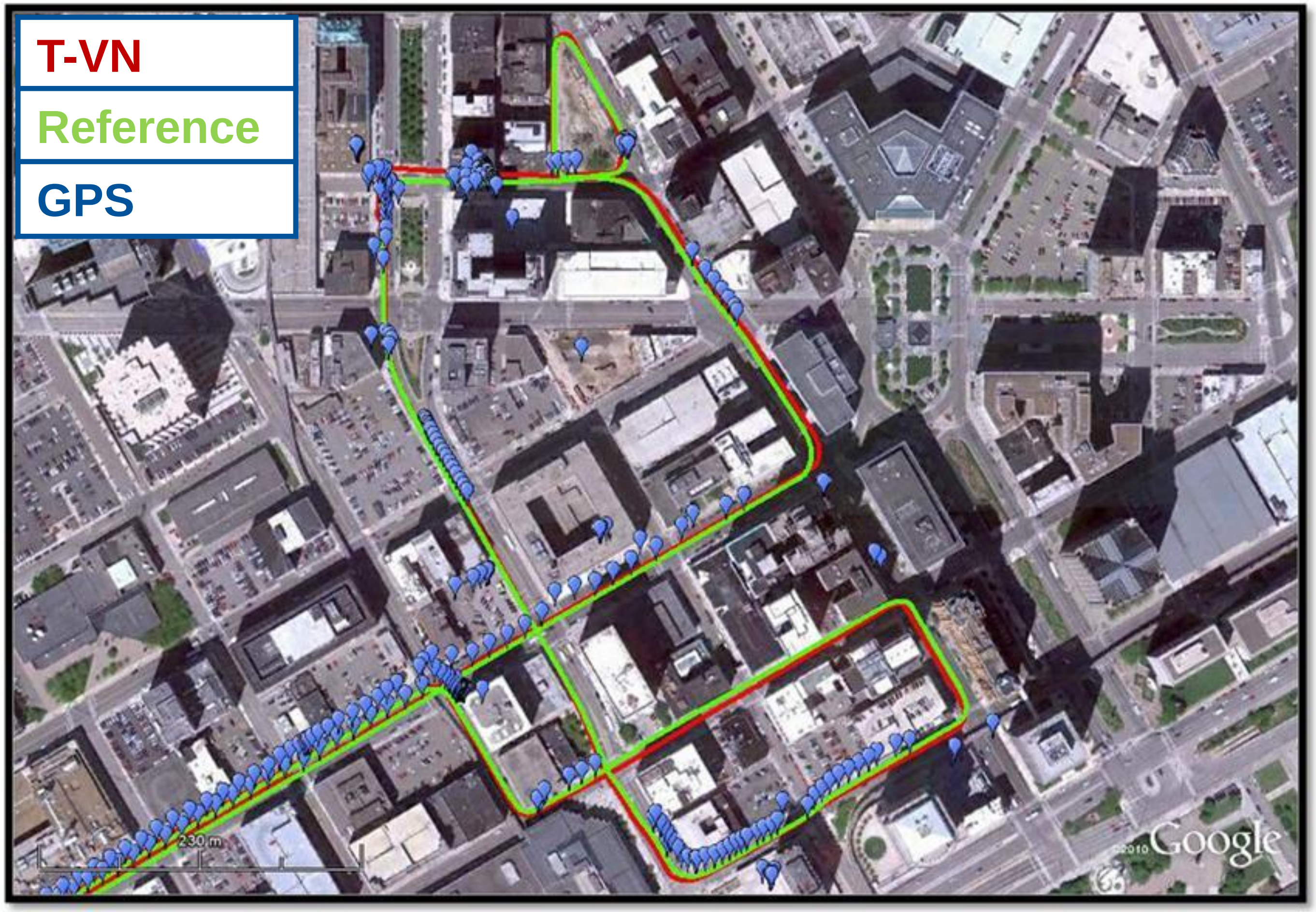
$100 T-VN vs $40,000 System

GPS-only > 100 metres

T-VN real-time (GPS+ 1G + 3A + OBDII) < 5.9 metres 95%

DGPS/INS: 1-2 m 95% in post mission





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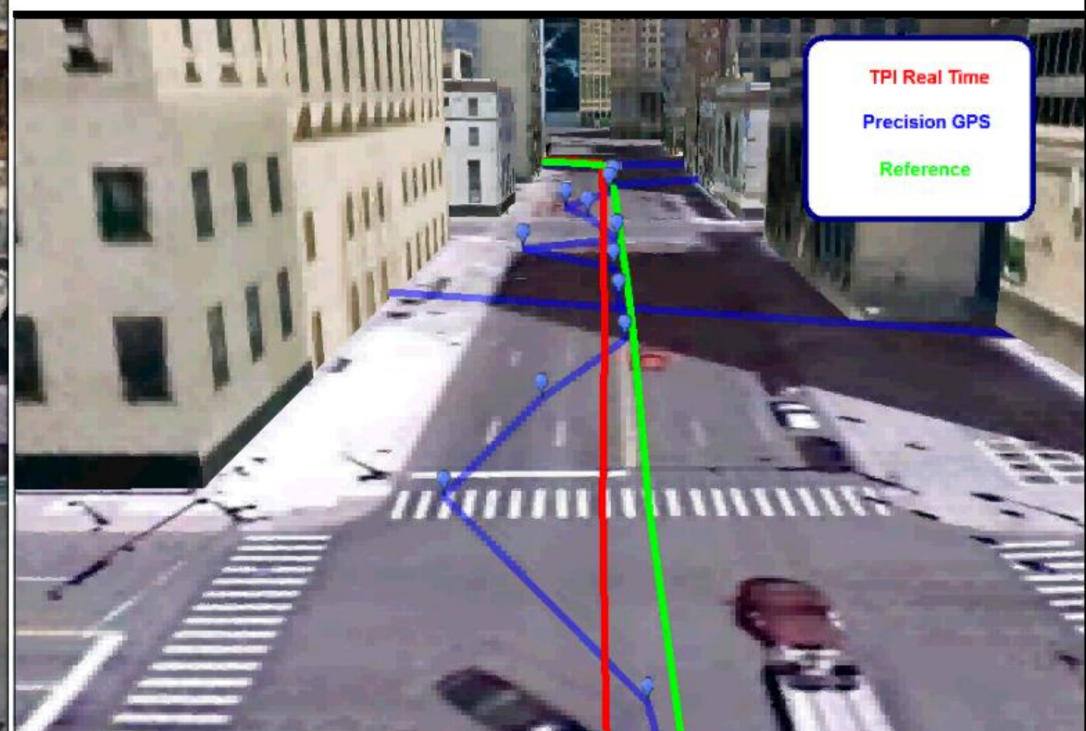

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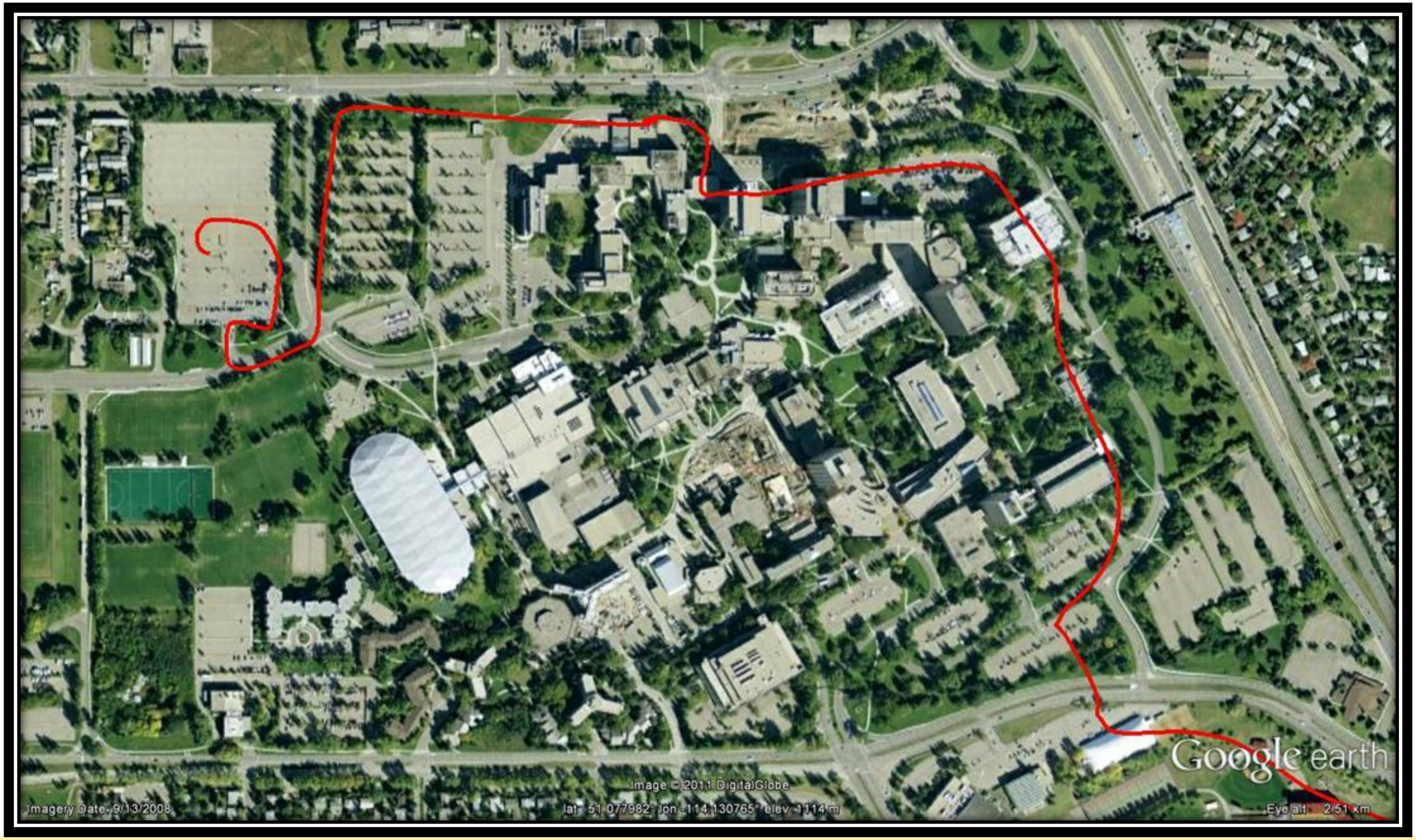
Smartphones - INS-only Performance

- 55 metres of error after 7 minutes and 2,200 metres distance travelled (about 2.5% of the traveled distance) – **NO speed sensors**



Summary

- MEMS inertial sensors have shown promising performance today for both mobile and vehicle applications.

- Testing of smart phone level MEMS-based sensors and Trusted Positioning sensor fusion software clearly shows that MEMS-based inertial sensors can meet the requirements for indoor LBS, consumer navigation applications and vehicle assisted driving applications.

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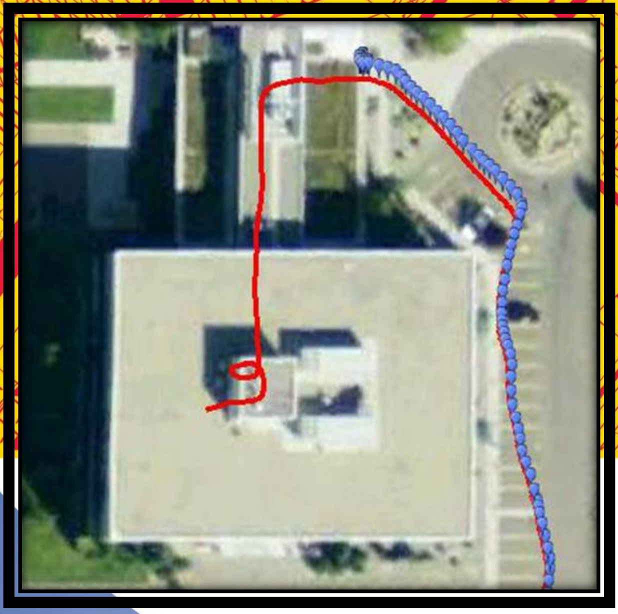

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