Trusted Positioning

Positioning Everywhere




High rate machine navigation and control using low-cost MEMS and GPS

and a lot of other information about technology and commercialization

www.trustedpositioning.com

Agenda

- Non-technical (business/commercial)
  - Starting a Geomatics company in Alberta
    - In particular, spinning off from the UofC
  - How to get through the first 2-3 years

- Technical
  - Low-cost MEMS/GPS for machine control
    - A real-world example of building an entire multi-sensor navigation system
  - Future work

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Non-Technical

Company creation and business advice

Trusted Positioning Roots

- **A spin-off company from the University of Calgary**
  - Geomatics Engineering Department
  - Mobile Multi-Sensor Systems Research Group (Dr. El-Sheimy)
- **Incorporated in 2009**
  - 3 co-founders (Dr. El-Sheimy, Dr. Syed and myself)
  - Operational in 2010 (first hire)
- **Trusted Positioning accomplishments to date**
  - 19 employees
  - Several paying customers
  - Patents
- **The first 2-3 years of a new company are really difficult and risky.**
  - How did Trusted Positioning get through the first 2-3 years?

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Areas of Advice

1. Building a team
2. Meaning
3. Company structure
4. Company uniqueness and niche
5. Business model (getting $ from customers)
6. Financing the meaning (getting money any way you can to start)
7. Getting technology out of the University
8. Three P words

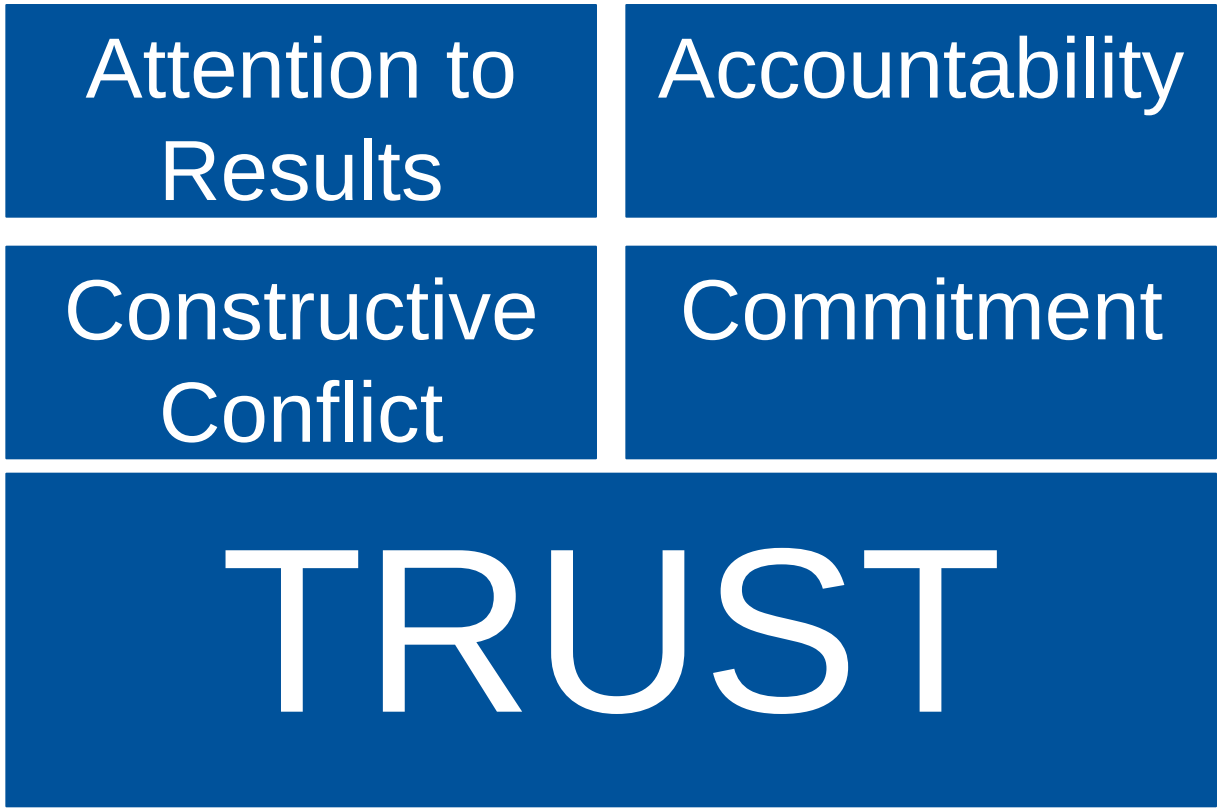
Getting a Team Together

1. **Building a team**
   - 3 co-founders: Naser El-Sheimy (professor)
     - Zainab Syed (Ph.D.)
     - Myself
   - Our values aligned
   - Our timing aligned
   - We trust one another

   - A common meaning united us: the desire to create positioning systems that work everywhere

Foundations of a Good Team

- A team is built from Trust



Forgotten leaders

- Who was Darwin Smith?
  - CEO of the leading paper-based consumer products company in the world!
  - Kimberley Clark, i.e. Kleenex
- Who was Colman Mockler?
  - CEO of the company that created the most coveted business model – the razor blade model.
  - Gillette

A test

- Who was the CEO of the leading paper-based consumer products company in the world?

- Who was the CEO of the company that created the razor blade business model?

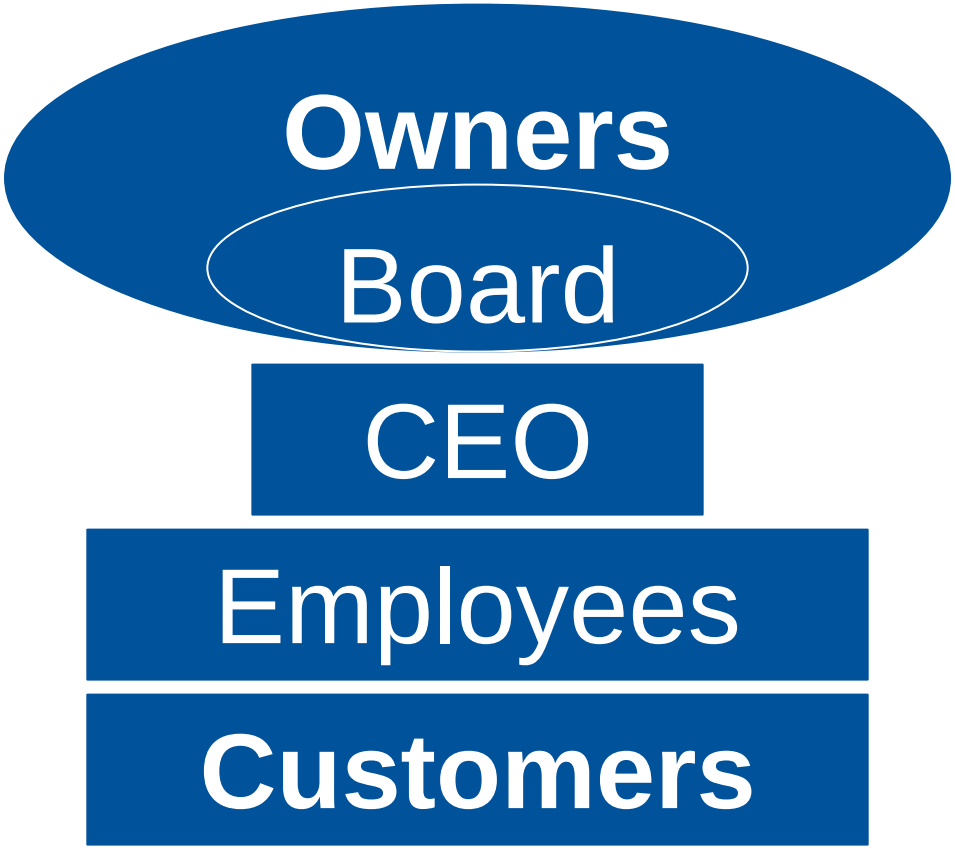
Meaning

2. **Meaning** is most important in the long run. Teams are built around meaning. A 'great idea' comes and goes.
   - HP: purpose beyond profit
   - Marriott: excellent service (even hot dogs!)
   - Motorola: superior products at a fair price
   - Sony: to elevate the Japanese culture and national status

- Been to a Marriott hot dog stand lately?

Beyond Licensing: Structure

3. Company Structure



Niche

4. Company Uniqueness and Niche

- What are you the best at in the world?

- Some interesting niches were:
  - Microsoft: BASIC for OS called CPM
  - Hewlett-Packard: welding equipment for WWII
  - Marriott: great service food vendor
  - Motorola: battery eliminators for radios
  - Sony: heating pads
- These niches allowed the companies to survive the first few years

Define a Business Model

5. **Business model.** Niche your model too.

- Simplify it as much as possible
  - Define an economic scale that you pursue (e.g. yearly license fee)
  - E-bay: charges a listing fee plus a commission
- Copy someone
  - People have been in business for thousands of years…there aren't too many new models
  - Google: far from free and not a new model.

Funding

6. Financing the meaning

- For a University start-up you may want to look into the following:
  - NSERC Idea to Innovation ($125k-$350k)
  - NRC IRAP (up to $250k)
  - Tecterra (up to $300k)
  - CICP (up to $500k)
  - ISTP Canada (up to $600k)

- Or raise money (good luck in Calgary)

Technology Transfer

7. Technology transfer out of the University

- This could cancel about 9/10 good ideas
- Failure a combination of
  - Inventors and tech transfer office are on opposite ends of the spectrum
    - Inventor: “I invented and created this so I should own it.”
    - Tech transfer: “We deserve X% due to that nice lab and research environment you’ve been using for four years.”
  - Both sides are somewhat correct. A balance has to be met between sides.
    - The tech transfer office can take a LONG time to agree to something – be prepared

Ask these Questions

- Before you file a patent through your tech transfer office do the following
  - Go to their website, read their policies
  - Ask some detailed questions:
    - Are you assigning ownership & rights of use?
    - If you want the patent back, will you have to repay?
    - Are they going to market your IP or is that up to you?
    - Do they have the knowledge & capability to take your patent to the commercial level?
    - What if you want to file your patent with another firm?

The Good of Tech Transfer

- The tech transfer office ***should be*** available to you for good reasons. Typically,
  - To commercialize research coming out of the University to provide returns to the University, inventors and the community as a whole so that future research and commercialization may flourish.
  - Just make sure they actually follow their meaning and are not misaligned with it.

P Words

8. **Three P words**: Passion, Persistence, and Patience
   - Like what you do
   - Confront the brutal facts, get accurate information, and adjust accordingly
     - e.g. Intel left memory to pursue microcontrollers
   - Be able to make decisions and follow them through with perfect alignment
   - Keep faith that you will prevail in the end (if you've confronted the facts and adjusted accordingly)

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Technical

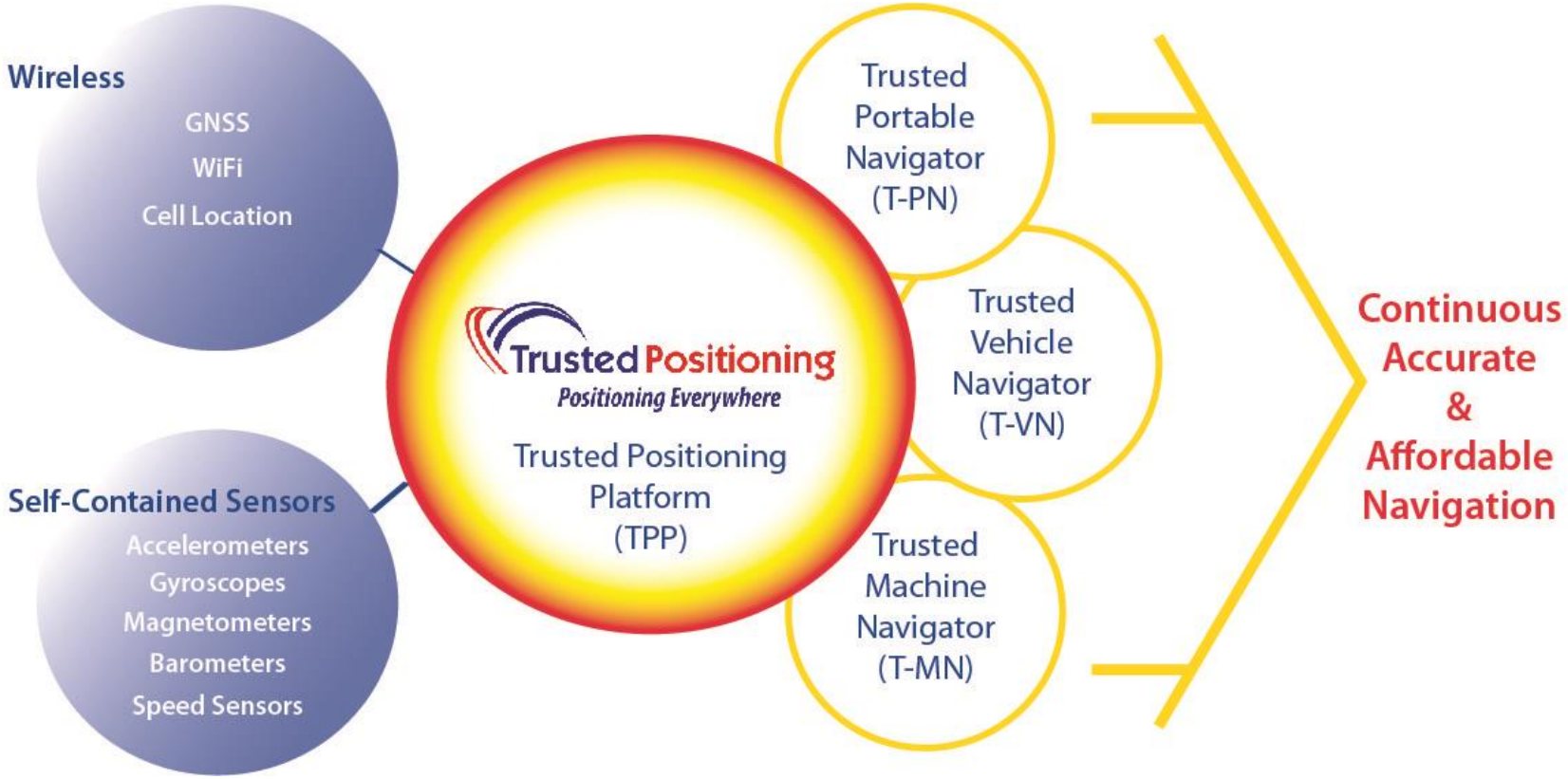
A navigation product lifecycle example

Navigation status

- **Continuous, accurate and cost effective navigation systems are not available**
- GNSS-only
  - Not always available
  - Inaccurate due to multipath
- Wireless (Wi-Fi, cell location…)
  - Infrastructure is expensive and not always present
  - Sparse networks or poorly surveyed networks are inaccurate
- INS/GNSS, either
  - Expensive ($20k+) & not portable
  - Or low-cost & inaccurate

Trusted Positioning Platform

- Different product lifecycles for each product.
- The following technical slides cover the T-MN which touches on many technical aspects of creating a navigation product.



Trusted Machine Navigator

- A few details
  - Essentially a strapdown INS/GNSS with additional magnetometer and barometer
  - INS uses low-cost MEMS ($10-$1,000)
  - GNSS (single or multiple antennas)
- Applications
  - Machine control & guidance
    - Precision agriculture (heading & velocity)
    - Antenna array stabilization (attitude)
  - Vehicle performance monitoring
  - Earthworks

Pieces of the Product

1. System design.
   - Choosing sensors, GNSS and processor(s).
2. Hardware design.
   - Including layout, fabrication and assembly.
3. Operating system or kernel.
4. Firmware creation
   - Timing of the various signals in real-time.
5. Navigation software (offline & real-time).
6. End user software and display (GUI).

Customer Specs

- Attitude determination product
  - Technical requirement:
    - 0.1-0.3 degrees accuracy required at 1,000 Hz
    - Vehicle mounted
    - Can be used in a variety of environments, including off-road
  - Commercial requirements:
    - Parts list must be under $5,000
    - Cannot use ITAR or Controlled Goods

System & Hardware Design

- Constraints
  - Throughput @ 1,000 Hz
  - Performance vs cost (MEMS + GPS)

- Hardware
  - Fast clock speed on processor (1 GHz)
  - Microcontrollers for accurate timing synchronization and to offload the main processor for 1,000 Hz operation

Sensors and GNSS

- Sensors
  - IMU from Analog Devices Inc. ~ $800
    - Good MEMS gyros (avg. 15 deg/hr in run stability)
    - Accels are average for MEMS
  - HMC5883L magnetometer ~ $30
  - MEMS barometer ~ $25

- GPS
  - Trimble BD982 with dual antennas ~ $4,000
  - 0.1-0.2 deg accuracy for heading when RTK fixed
  - ~60 cm accuracy for position with SBAS

Operating System

- The OS resides on the ARM Cortex A-8
  - The OS coordinates getting the sensor and GNSS data and processing the navigation solution.
  - This is all happening at high rates (1,000 Hz)

- OS options
  - Android (not enough low-level control)
  - RTOS (very expensive and hard to customize)
  - Embedded Linux (inexpensive and customizable)

Firmware

- Firmware is the software in the microcontrollers that sets the timing of the sensors
  - IMU: 1024 Hz
  - Barometer: 10 Hz
  - Magnetometer: 1 Hz
- If the firmware is not done properly, the timing will not be correct, and the multi-sensor navigation solution will be badly affected

Navigation Software

- The core of the system
  - Navigation state estimation (3D PVA)
  - Sensor and GNSS error modelling
  - Magnetometer calibration
  - Multi-sensor filter
  - Various alignment techniques
  - Multi-threaded software application
  - **All hardware, OS and firmware has to be nearly perfect if the navigation software has any chance of performing to specification**

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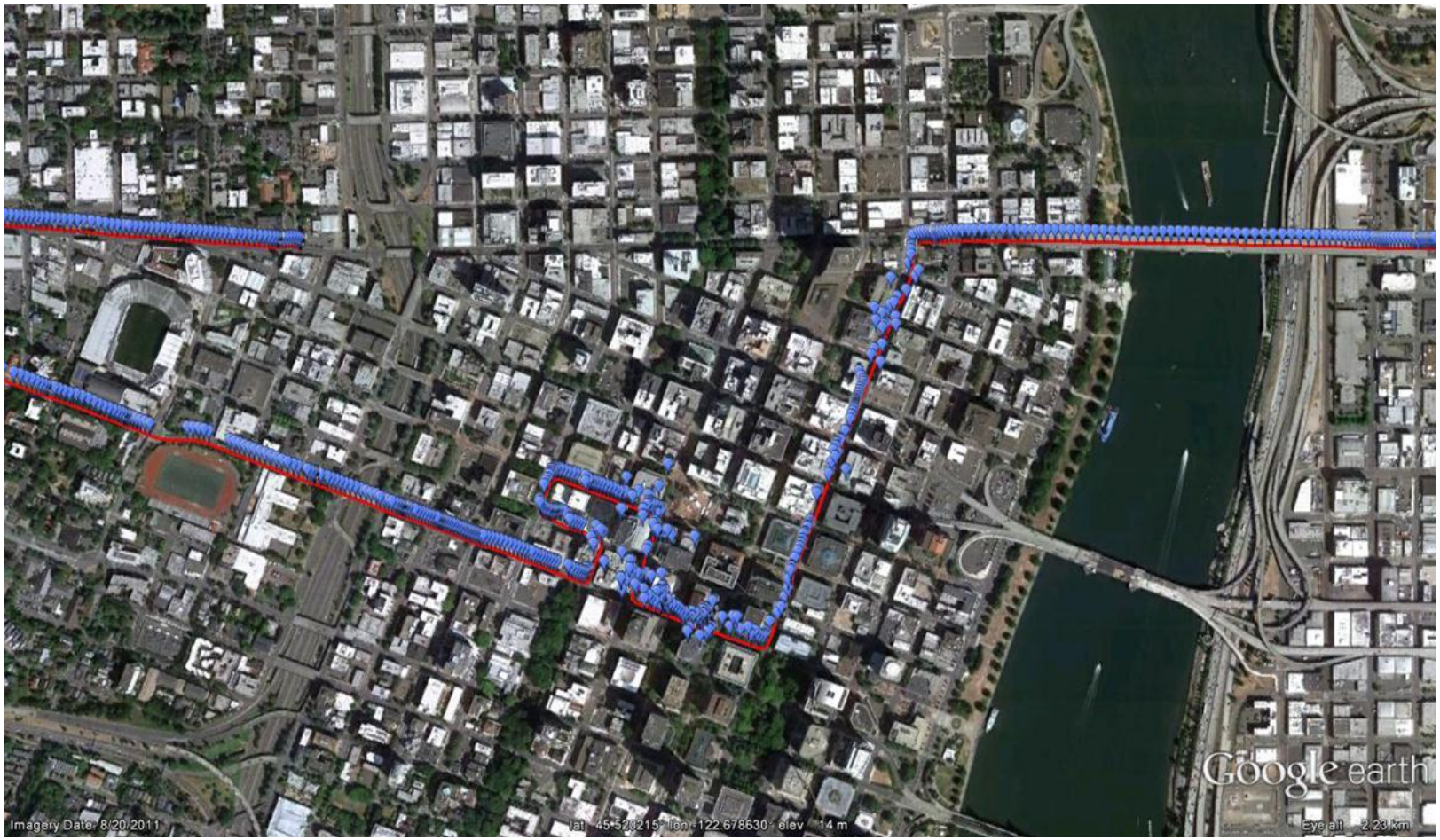
Trusted Machine Navigator (T-MN) results

Downtown environments (multipath)

No GNSS environments (INS only)

Downtown Portland

- Major challenge is filtering of GPS noise



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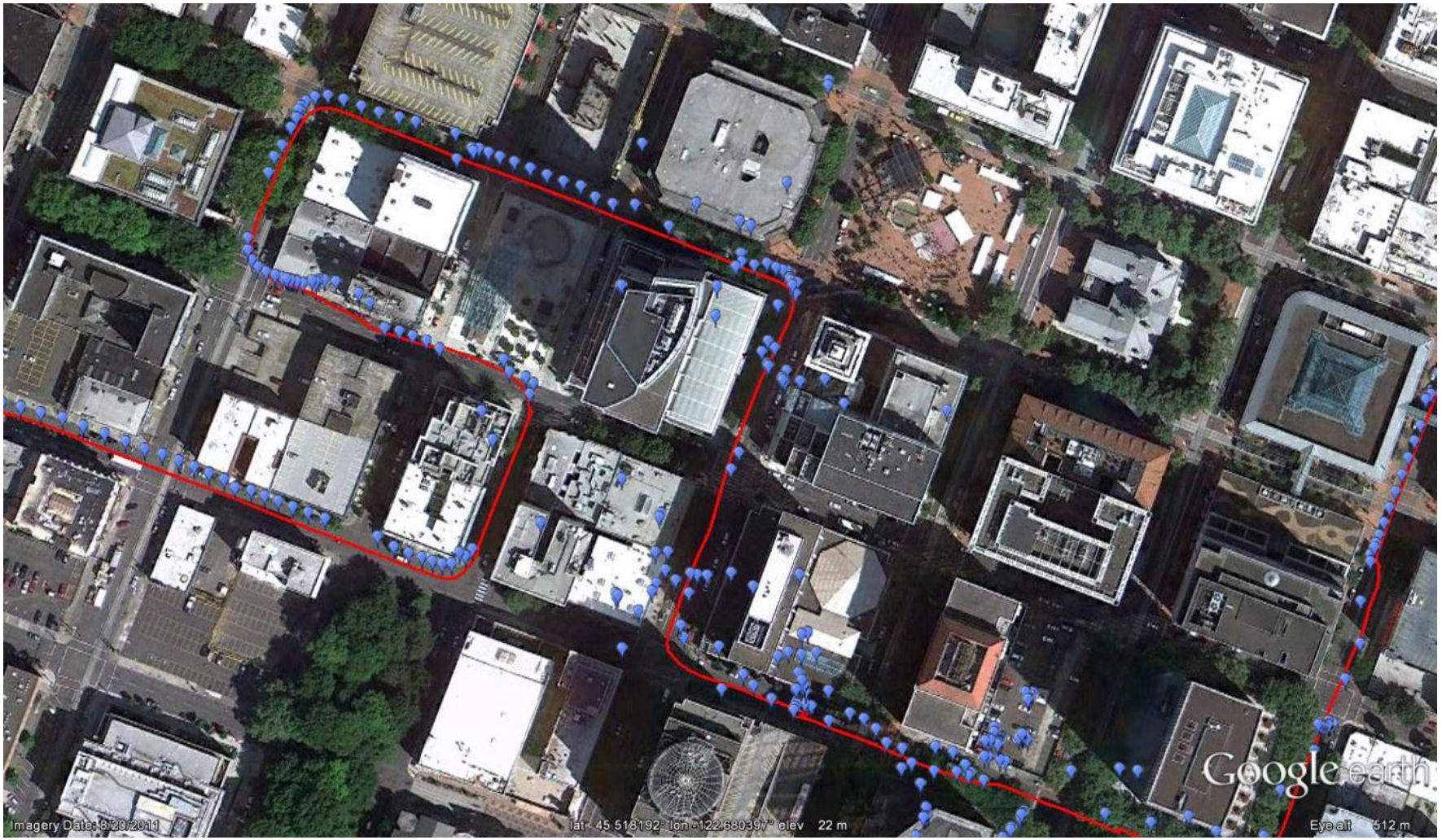
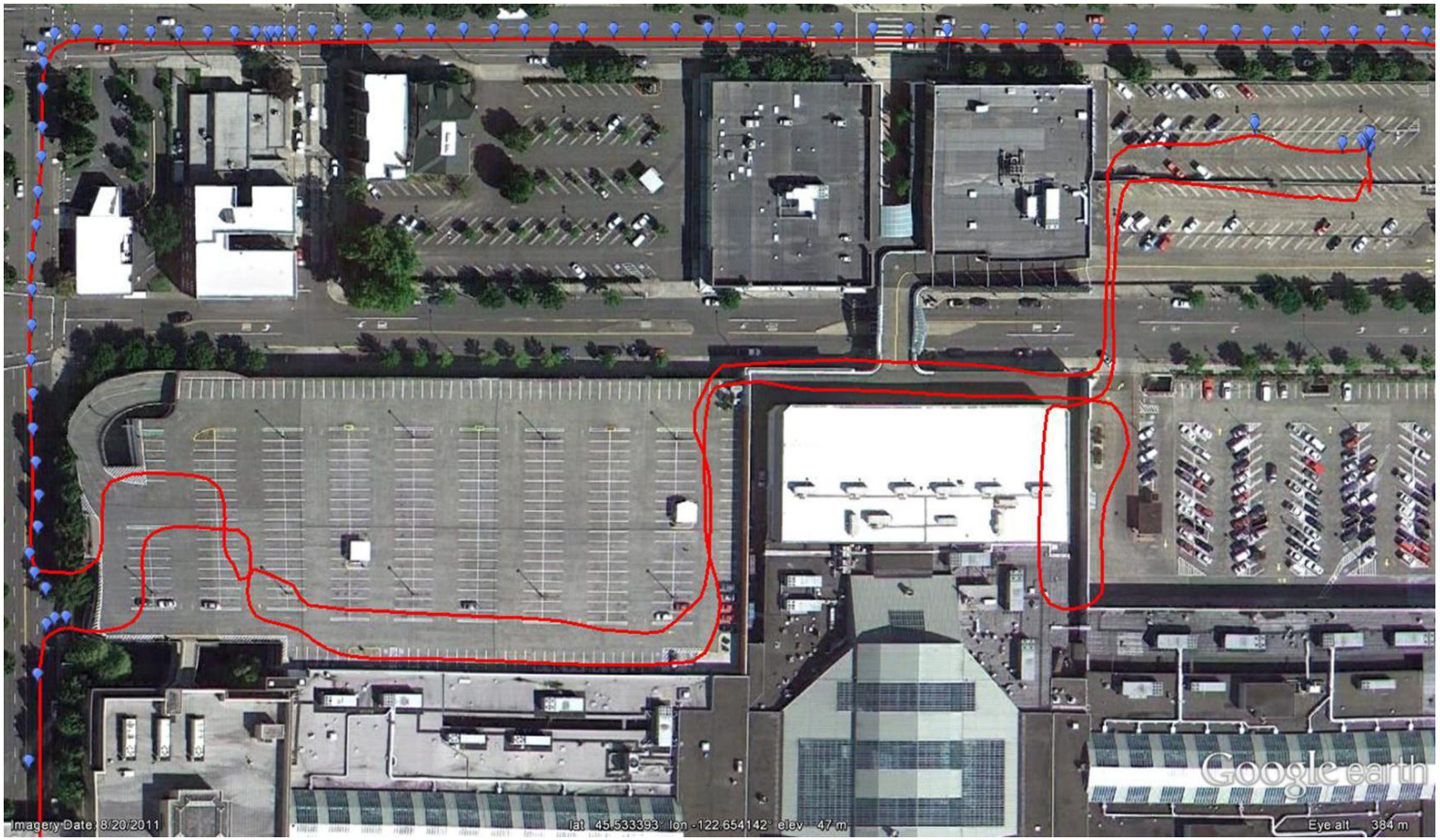
Downtown Portland (zoom)



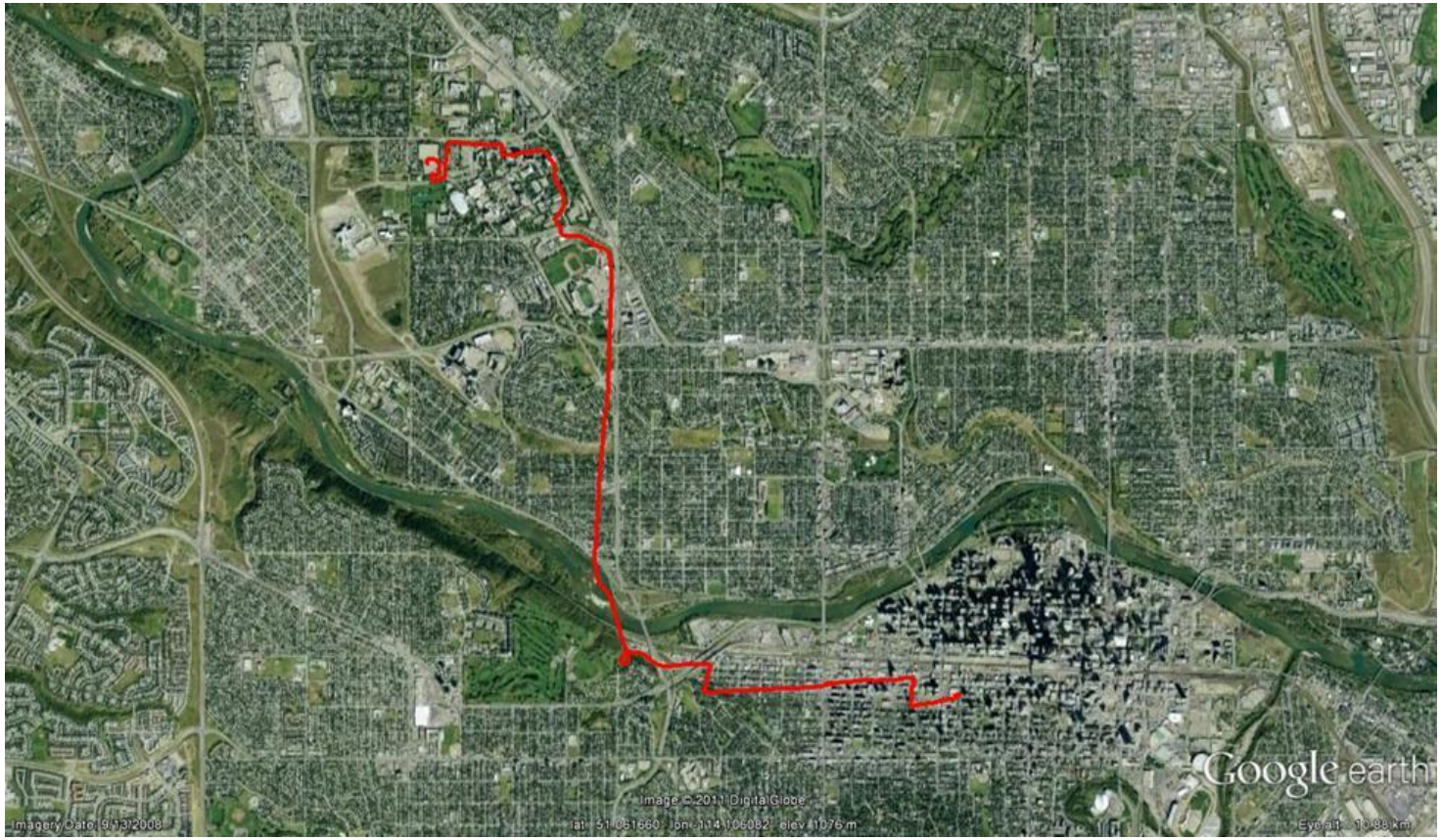
Underground Parking Lot

- Drift of INS with good initialization



INS-only solution

- Does the INS drift more with poor initialization?



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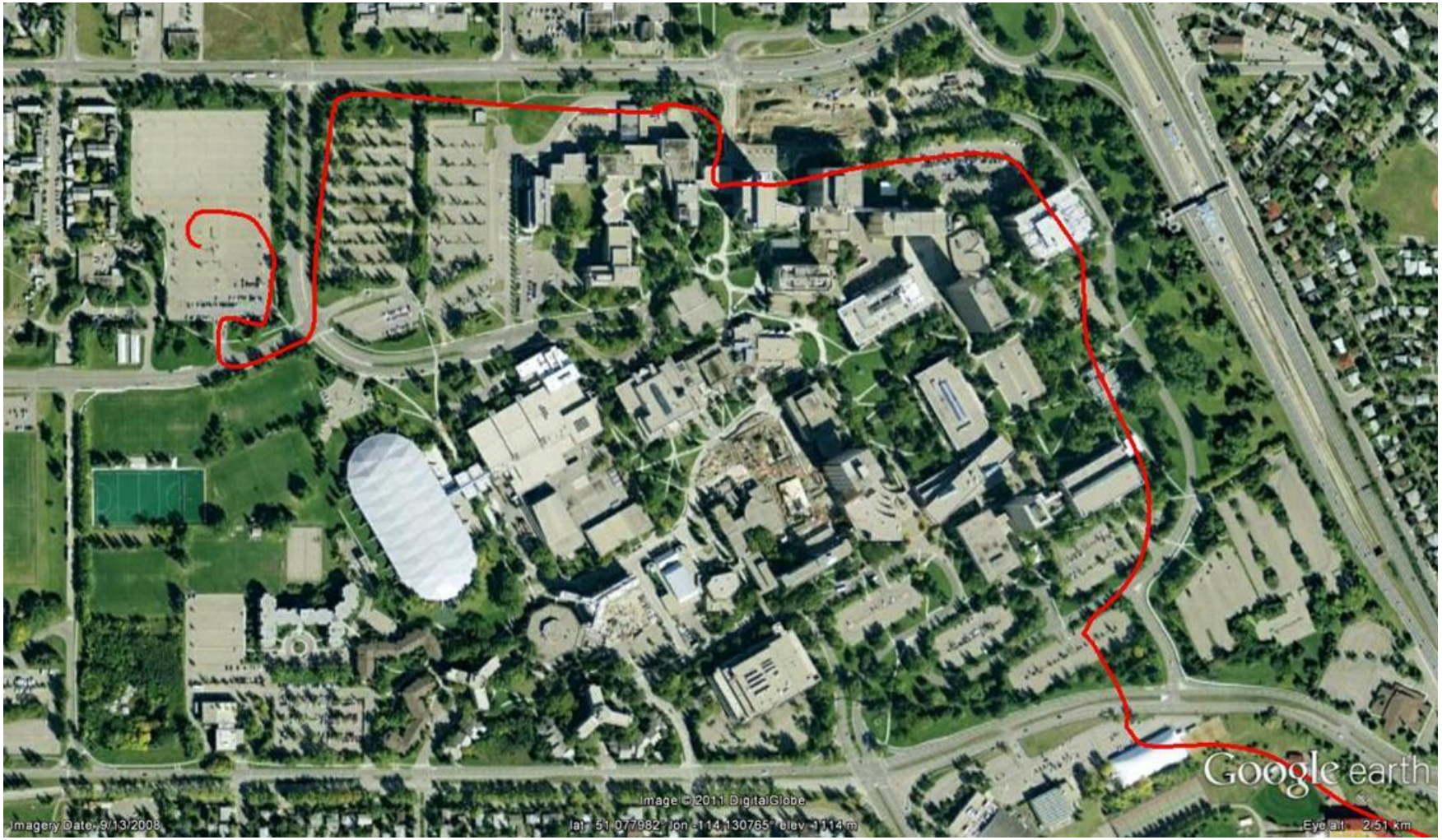
INS-only (zoom start)



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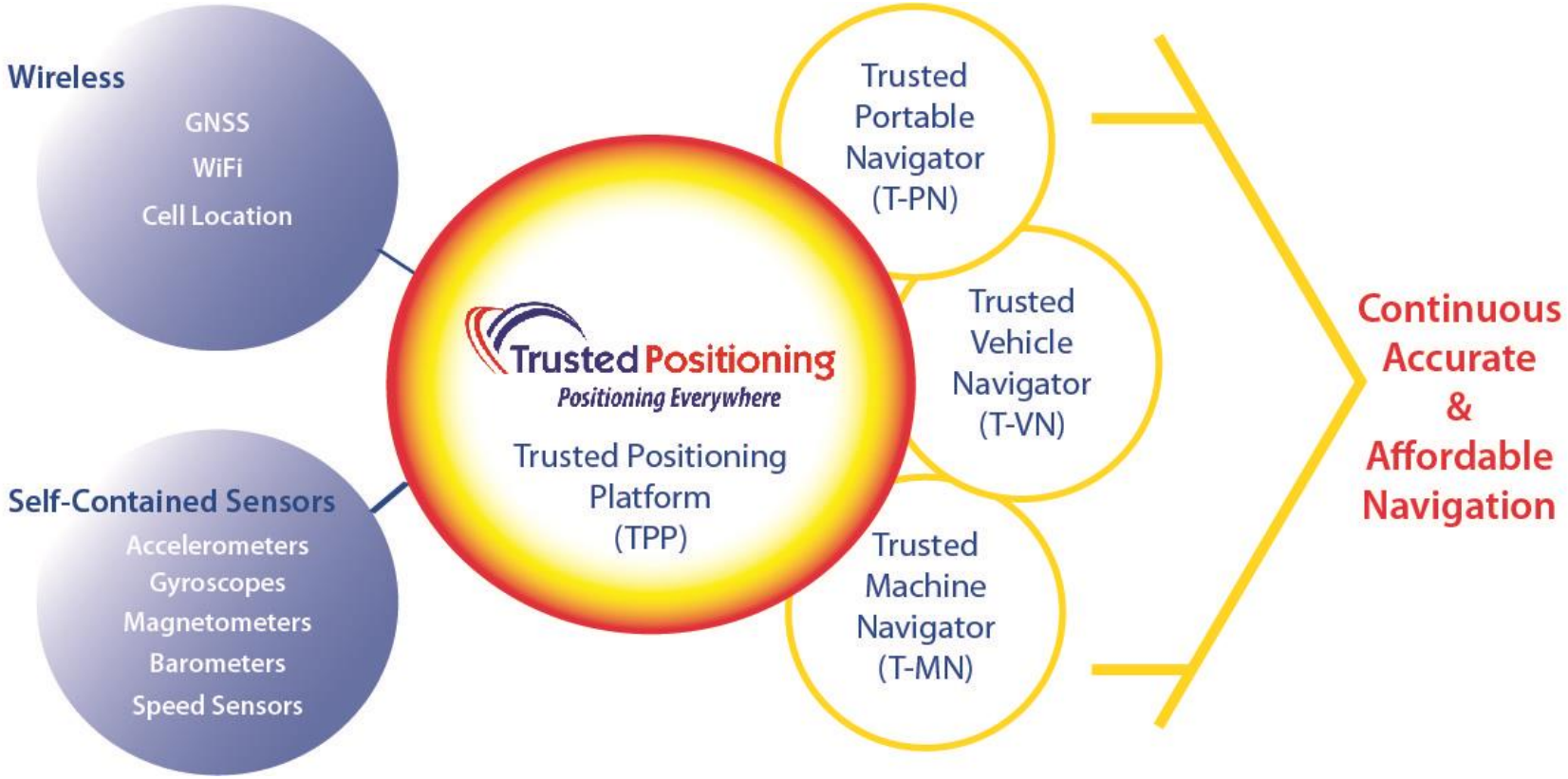
INS-only (zoom end)

Looking forward

- Upcoming releases for consumer products in 2012
- We need smart & hard working people that are aligned with our meaning

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