Electrical and Computer Engineering

UBC Radio Science Lab

MOOVEE

PropBot: An Automated Vehicle for Propagation Data Collection

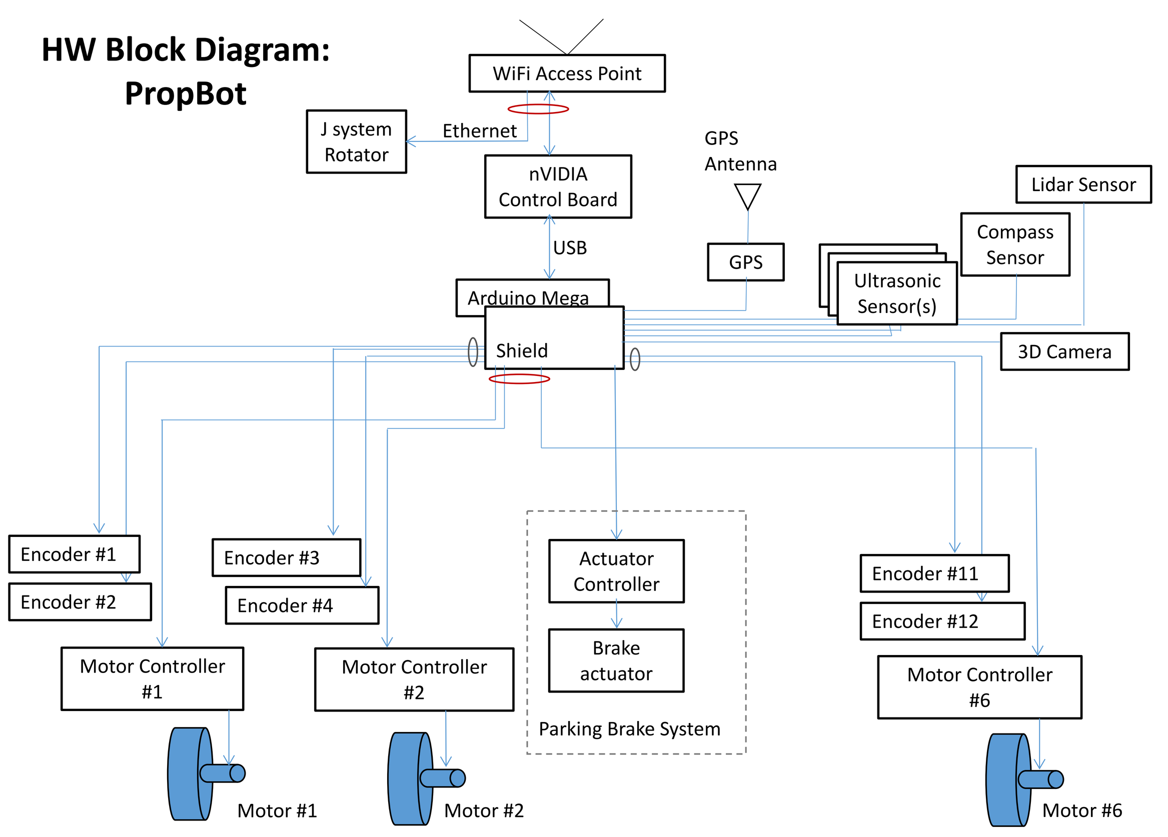
D. G. Michelson, D Fexio, A Jaydeep, H. Najjaran, M. O'Brien, D. Wong, S. Huang, B. Assadsanghabi, S. Bonyadi Ram and H. Noori

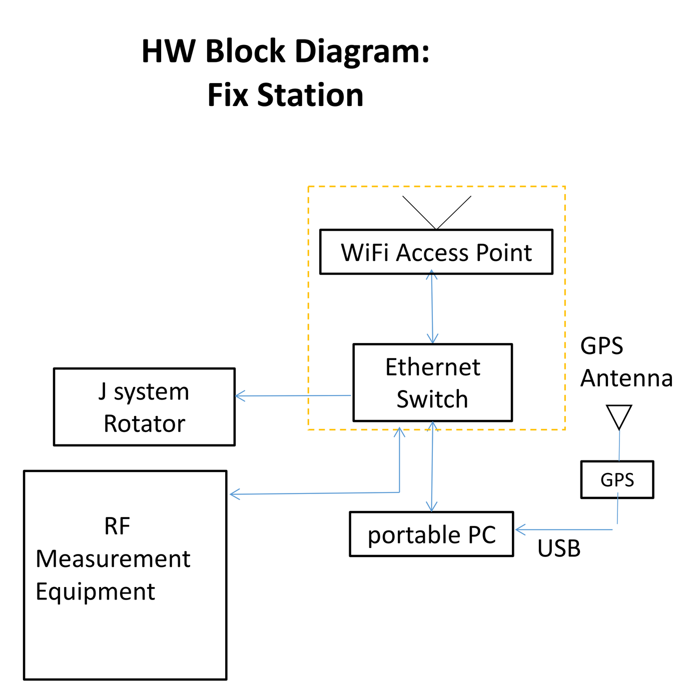
1. Introduction

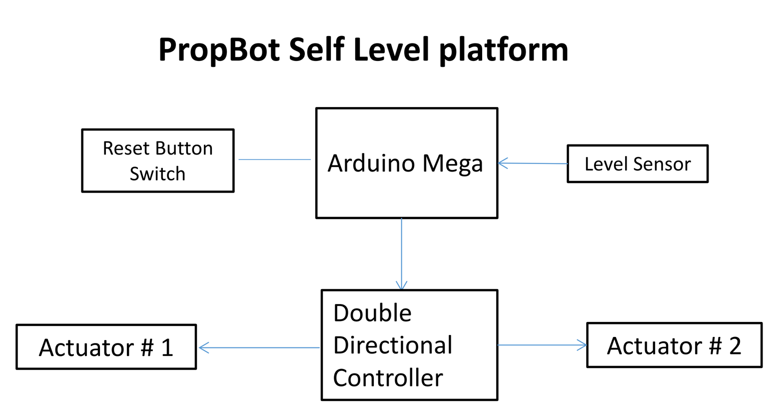
Development of measurement-based propagation models relies on the efficient collection of large sets of wireless channel response data. When conducted in indoor and microcell environments, measurement campaigns designed to collect such data tend to be labor-intensive, time consuming and expensive. A handful of groups have attended to simplify propagation data collection in indoor and microcell environment using small automated vehicle (AVs). Often, their platforms are based upon small AVs designed for other purposes, e.g., hobby applications, mail delivery in offices or parts delivery in factories. This tends to dramatically limit their payload, flexibility and ultimately their utility in wireless channel measurement applications. We have developed PropBot, an automated vehicle for propagation data collection in indoor, large indoor and microcell environment, in order to address the limitations of previous work.

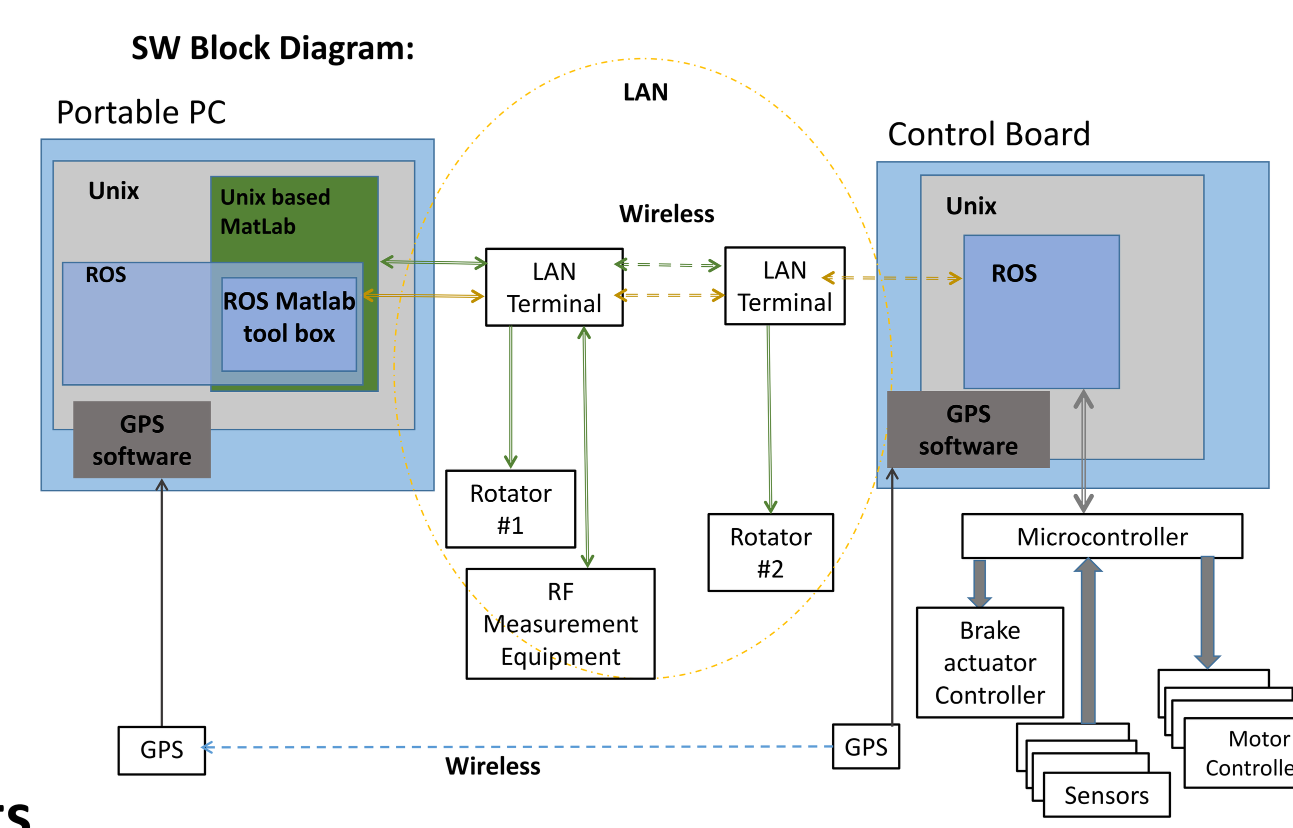
2. System Architecture and Block Diagrams

PropBot consist of three modules. The propulsion module comprises an aluminum frame that supports six electric motor wheel assemblies, six shock absorbers, four high power dry batteries, the QNX-based vehicle controller and a set of voltage/power inverter/converters. It uses differential drive to steer and its six wheels allow it to clime stairs or curbs. The equipment module is an easy detachable equipment rack that is mounted a top of the propulsion module via shock absorbing mounts. The payload rack is changeable depends on the mission and type of payload. The water proof version of the rack (prefabricated 21U) can protect the equipment from water and dust. It carried wireless channel sounding equipment as required for a given measurement campaign. The antenna is mounted atop the equipment rack and that employs a two-axis tilt meter, a pair of linear actuator and a ball joint to self level.









3. Operational Requirements

o **Fixed station**

- Record GPS data from the different GPS, odometer, laser sensor, process data and produce exact location of PropBot.
- Run data acquisition script, send move and stop command to PropBot and store the measurement data

o **Robot**

- Send GPS info to the fixed station.
- Send robot status to the fixed station.
- Receive commands from MatLAB to operate the rotator mounted on the robot.
- The communication between fixed station and robot is via a wireless connection established by a pair of access point (bridge mode).

Unexpected Situation (safety)

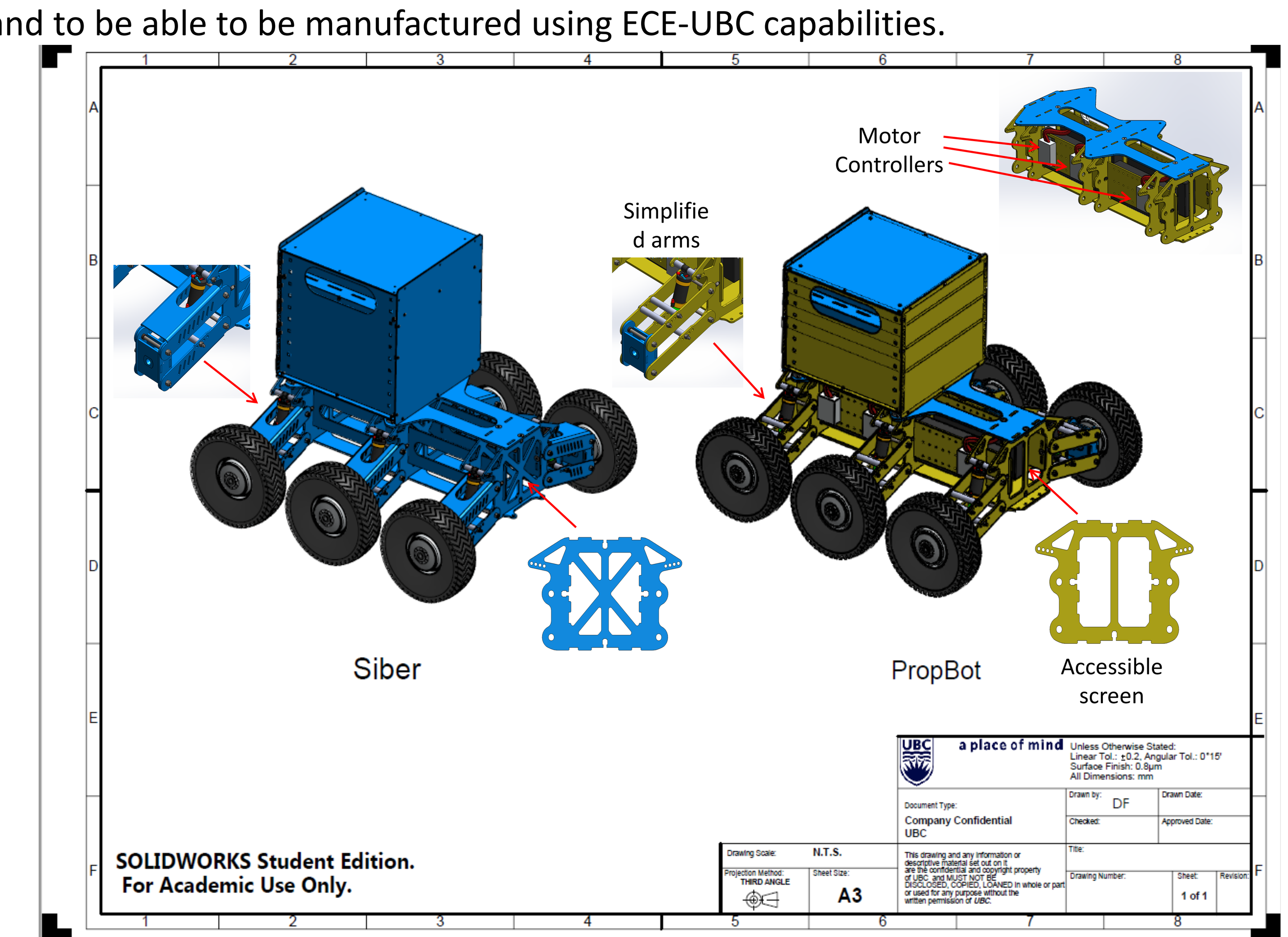
The robot will sense the environment using ultrasonic and laser sensors. If the robot faces an unexpected obstacle (Car, human, animal and…) during the trip, it stops. The operator can decide to wait, by pass the obstacle or cancel the whole measuring process. Otherwise, the robot waits till the path is clear again for a defined time duration. The measurement process will be terminated if the path is still blocked. The measurement can be started later from the point which the proceed is terminated.

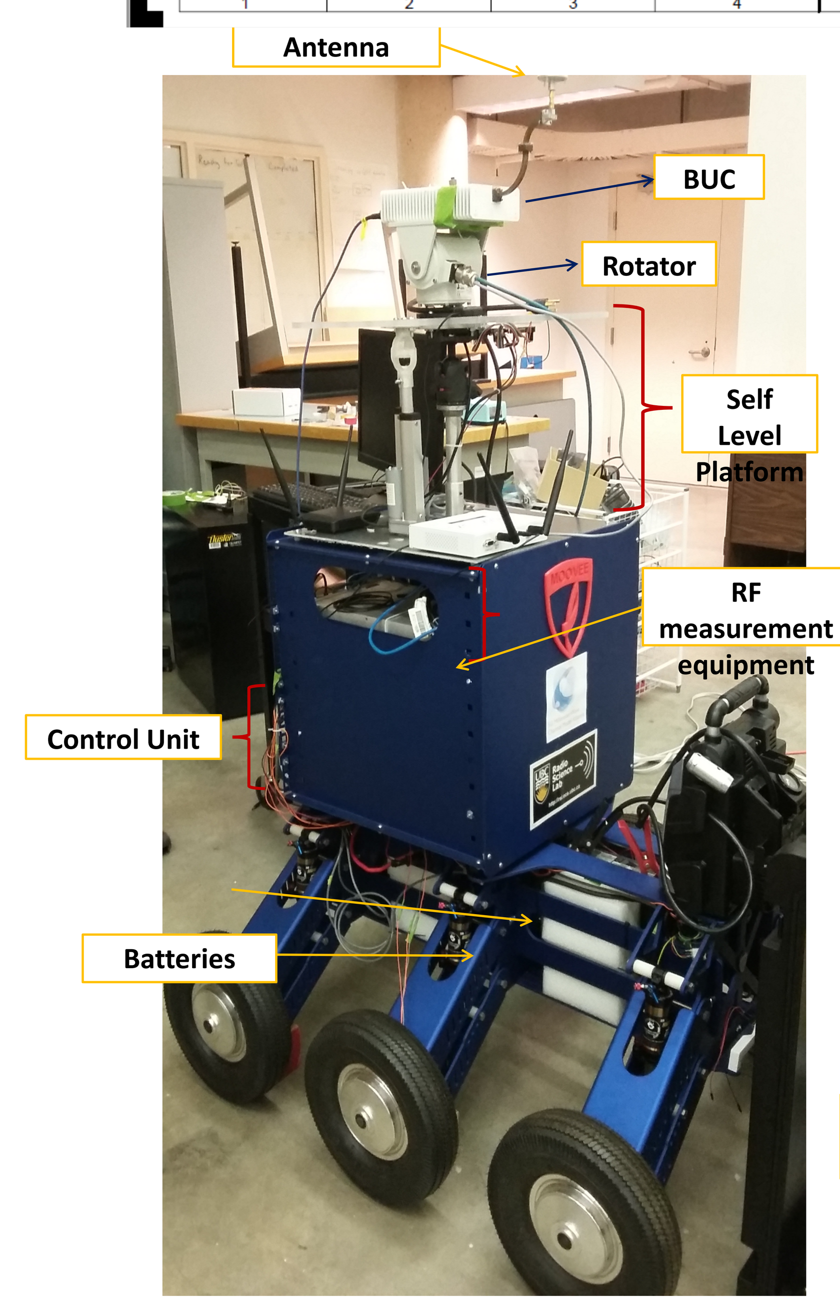
There will be a real time trip plan update in the next phases of PropBot development.

2016 AP-S/USNC-URSI IEEE Puerto Rico

4. Design and Manufacturing

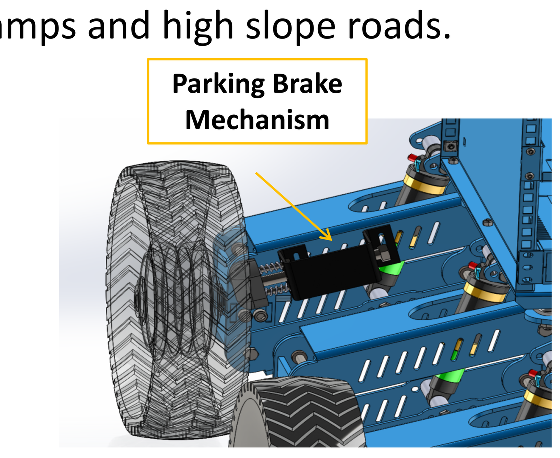
The original design of the robot is modified to meet the RF measurement requirement and to be able to be manufactured using ECE-UBC capabilities.

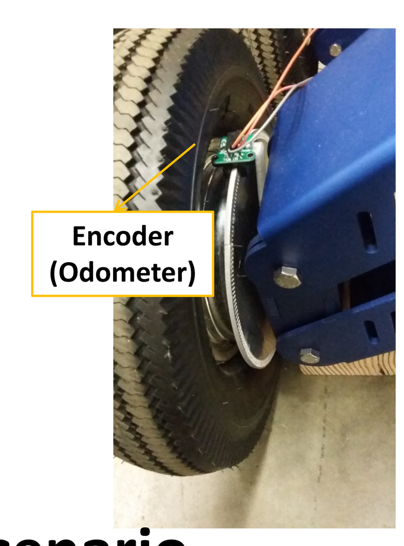




Parking Brake System

The parking time is much longer than the moving period of the robot. A PID controller system is used to provide smooth decrease in speed and accurately stop in the planned desired locations. We have also applied a parking brake system to stall robot in the ramps and high slope roads.





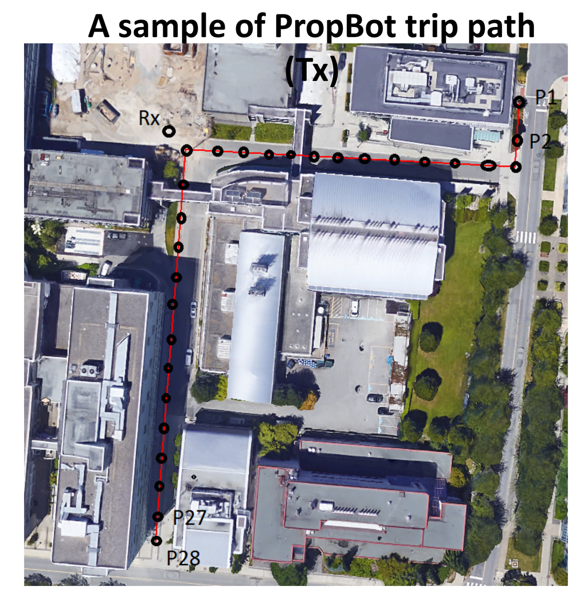
Odometer

The encoder installed inside of the wheels allow us to measure the speed and distance. It helps us to have accurate stop and also have better estimation of the robot location specially in indoor scenarios.

5. Typical Measurement Scenario

- PropBot automatically find the first point and go there, adjust the orientation toward the next point and starts the measurement.
- During its stop in each position, the mechanical brake system will be in effect.
- Self-level mechanism levels the RF antenna in real time.
- Handshaking between PropBot and fixed station indicates that the robot is located in its correct position and is ready for the job, or the job is done and robot should move to the next location.
- The trip path usually is a straight line or a broken line with several turns with arbitrary angles. The measuring points of (UTM coordination) are available and will be compared with the real coordination obtained from PropBot navigation system for further studies.

A sample of PropBot trip path



6. Conclusion

PropBot initial role is to support wireless propagation measurements for Next generation Intelligent Transportation System where it will both stand in for cyclists and pedestrians and allow more detailed survey of coverage and interference in vehicular environment than a full-sized vehicle would allow. It also supports millimeter wave propagation measurement in indoor, large indoor and microcell environment as part of an activity sponsored by NIST's 5G Millimeter-Wave Channel Model Alliance. It also serves as a research platform for further development of sensors for automated vehicle.