To: Professor Merz
From: Benjamin Nitkin
Subject: IGVC Progress Report
Date: October 9, 2013

This past week, I looked over the sensors selected last week, checking for compatibility between the sensors and microcontroller. I checked supply voltage, communication protocol, current draw, and connections on board. After checking over everything, I swapped a few sensors for different models that would interface better with each other.

There are two popular voltages for modern electronic components: 5 and 3.3 volts. Over the past years, logic-level voltages have gradually fallen, from ±12V with RS232 (the serial port in old computers) to 5V TTL (discrete chip logic) and USB to a 3.3 volts today. As compoments are built smaller, they're better able to discern signals, and the lower voltages allow for further miniaturization of silicon dies. More important for the robot, the sensors and microcontroller must operate on the same voltage, or use a level converter between them. I checked over datasheets and verified that all sensors used 3.3 volts.

The sensors selected use several communication protocols: *(See Table II)*

- analog voltages (a continous range)
- PWM (square wave with data encoded in the duty cycle)
- Serial (digital protocol for transmitting data in bytes without a clock signal)
- I2C or TWI (protocol that supports many devices on a single 2-wire bus)

The compass and accelerometer both use I2C (pronounced I squared C) to communicate; the Xbee, GPS, and laptop will speak to the Arduino over serial. Since I2C supports a common bus, these devices will both connect to two wires from the Arduino. Unlike I2C, each serial connection needs its own hardware port. With 3.3 volt logic levels, four hardware serial ports, and I2C support, the Arduino Due was a natural choice.

A few of the peripheral sensors draw substantial current. I was a little concerned about supplying all of the sensors with power, so I looked up draw for each (*Table II*). The GPS pulls 50mA; the radio draws 250mA, and the other sensors draw nearly nothing. The Duo can source up to 800mA through its 3.3V regulated output. Our sensors won't exhaust that supply, so all of them will be powered through the Arduino. The Arduino's power comes from either USB or a 7-20V transformer. USB can supply no more than 500mA, which provides a slim margin of safety above our 300mA consumption, especially since the voltage is likely regulated by an inefficient linear regulator. As not to overload the computer's USB power, the Arduino will be separately powered.

The sensors must physically interface with the Arduino. The Arduino's based on 0.1” pitch spaced pins (standard for breadboards). While not essencial, it'll be easier to work with sensors with 0.1” spaced pins, so I explicitly looked for those.

All of our electronic components run on the same voltage and should be capable of interfacing with each other without additional hardware (voltage regulators, level converters, connectors). Our sensor suite is within budget and should meet our needs.

Table I: Electronics – Components and Costs

Part no.	Catalog Name	Role	Cost/unit	Quantity	Total
DEV-11589	Arduino Due	Microcontroller	$49.95	1	$49.95
WRL-11216	XBee Shield	Arduino-xbee br	$24.95	1	$24.95
DEV-07914	Arduino ProtoShield Kit	Sensor breakou	$9.95	1	$9.95
PRT-09279	Arduino Stackable Header - 8 Pin	Connections	$0.50	2	$1.00
PRT-09280	Arduino Stackable Header - 6 Pin	Connections	$0.50	2	$1.00
PRT-00116	Break Away Headers - Straight	Jacks	$1.50	2	$3.00
PRT-00115	Female Headers	Jacks	$1.50	2	$3.00
GPS-08975	66 Channel LS20031 GPS 5Hz Receiver	GPS	$59.95	1	$59.95
SEN-08502	Ultrasonic Range Finder - Maxbotix LV-EZ0	Rangefinder	$27.95	3	$83.85
SEN-10888	LSM303DLMTR Breakout Board - Tilt Compensated Compass	Compass	$29.95	1	$29.95
SEN-11486	9 Degrees of Freedom - MPU-9150 Breakout	Accelerometer	$49.95	1	$49.95
WRL-09819	XBee Explorer Dongle	Radio-USB	$24.95	1	$24.95
WRL-11216	XBee Pro 60mW PCB Antenna - Series 1 (802.15.4)	Radio	$37.95	2	$75.90
Total					$417.40

Table II: Electronics – Connections, Communications, and Current

Name	Connection	Communication	Current (mA @ 3.3 v)
GPS Receiver	0.1" bare board	Serial, 9600bps	41
Ultrasonic Range Finder	0.1" bare board	Serial, Analog (Vcc/512 v/in), PWM (147uS/in)	6 (2mA each)
Tilt Compensated Compass	0.1" bare board	I2C, address 0x18	1
9 Degrees of Freedom Accelerometer	0.1" bare board	I2C, address 0x68 with AD0 grounded	1
XBee Explorer Dongle	USB		
XBee Pro 60mW PCB Antenna - Series 1 (802.15.	Header pins	Serial, 9600bps default, up to 115,200	250 (max)
			299 (total draw)

P.S. Looking at the radio's bandwidth, we should be able to transmit low quality camera images back to the base station. That would enable teleoperated control out of line of sight, and would be a cool project. More on this as software develops.