Master Op-Doc/Test Plan

Power Supply

Define Engineering Specs

- •Establish battery life
- •Establish battery technology
- •Establish battery size
- •Establish number of batteries
- •Establish weight of batteries
- •Establish Cost
- •Identify Voltage/Current needs of other components

Determine where power is regulated for rechargeable batteries

Certain tradeoffs exist when determining the location of power regulation. If power is regulated directly from the wall, that saves space and weight from adding to the wheel. Unfortunately, that adds complications because a separate circuit board would have to be made and likely another micro-controller would be necessary. If power is regulated within the wheel, weight and size considerations will have to be made as well as sizing of the connector will be more complicated because higher voltages will be coming directly to the wheel.

Identify chips necessary to regulate power.

Different kinds of chips are made for different voltage and current characteristics. The switch-mode power regulator and the linear regulator have different advantages. Switch-mode is much more efficient which would allow for longer battery life, but it's drawback is the large amount of RF noise introduced. In contrast, the linear power regulator wastes a lot more power, but doesn't introduce much RF noise.

Determine voltage regulation needed for other components

All other on-board chips should be purchased to have the same input voltage to ensure power regulating simplicity.

Determine optimal port connector

If wall outlet voltage is to reach the wheel, a special higher-voltage connector must be used that will be durable and not pull out easy. If power is regulated before entering the wheel down to a low voltage level, then the port connector will be determined by the off-board power regulating system.

Create circuitry

- •Determine what components are necessary to get outlet voltage to the determined on-chip voltages.
- •Design circuitry to have small loop inductances.
- •Determine optimal method to allow battery to charge when plugged in.

Test circuit

- •Test voltage output to ensure voltage outputs 3.3±.1V.
- •Attach load to test current rating. Current draw should allow 0.5 Amps.
- •Cycle battery through the charging circuitry 5 times to verify battery and charging functionality.
- •Determine if voltages during different charging phases are optimal:
    - •Low Current phase C/10
    - •Constant Current Phase C/2
    - •Constant Voltage Phase

Microcontroller

Define Engineering Specs

- •Power
- •Speed
- •Size
- •Ports
- •OS Language
- •Step-through Debugging
- •Port protocols

Choose Microcontroller

- • Find microcontroller which fits within the given specs.

Obtain development board

Create programs to

- • interface with sensors
- • interface with RF module.
- • monitor battery life and quality.
- • Integrate other programs.

Prototype using development boards

- • Connect boards together through jumper wires.
- • Test battery program to see if internal read voltages match volt-meter readings.
- • Store sensor data to the internal memory to be read later by the computer. Use this data to ensure sensors are functioning correctly. One test for each axis (6 axes) will be done until data seen in the memory matches direction of motion.
- • Test communication with RF board by sending data to the computer Zigbee receiver.
- • Test integrated program by ensuring data transmitted corresponds to the correct direction of forces (6-axes).

Inertial Sensors

Define engineering Specs for Inertial Sensor

- •size
- •data rate
- •accuracy
- •power
- •data size
- •stress amount
- •range

Choose Inertial sensor based upon engineering specs

In choosing an inertial sensor, the limiting specs are size of the module and the sensitivity of the device. If these specs were not met than it would not fit in the wheel and it wouldn't be able to measure what was required. This is the reason that the accelerometer and gyroscope are separate.

Obtain development board

This board will be used to test the functionality of the accelerometers and the gyros. It is a board that has the chip connect with decoupling capacitors for changes in the supply current and has solder points or connectors for easy testing

Prototype using development boards

- •Test functionality of the accelerometer and the gyro separately
  - •Connect boards to the micro-stick with jumper wires and use of schematic
  - •Test integrated functionality with micro-stick and sensors

Test Plan for Accelerometer Functionality

The test plan would measure the acceleration on each axes separately. In order to do this, the chip could be placed in a tube to make sure that it would not rotate, but still remain in free fall. If calibrated correctly, the accelerometer would measure 1G. If it's within 10% within the given spec, then it passes.

Test Plan for Gyroscope Functionality

A test for the gyro would be more complicated to test than the accelerometer. A test setup that could be used could include a motor which could attach to the developement board and angular velocity could be measured. If it's within 10% of the spec, then it passes.

Test Plan for Mechanical Shock Tolerance

A test for the shock tolerance for the gyro and the accelerometer don’t need to be done, as the chips are already rated and tested before sent out. If somehow they are damaged from delivery, the functionality of the chips would be compromised and the functionality tests would cover this issue.

Integrate with microcontroller (see integration)

•Understand interfaces between micro-controller and sensors

•Understand Pinouts of micro-controller and sensors

•Create I2C interfacing circuit used for the gyroscope

•Create SPI interfacing cicruit used for accelerometer

Determine how often to reset to maintain accuracy

This test involves leaving the sensors running for an entire day just capturing data. After having done that, the data would be used to see if the chip needed to be reset in order to maintain accuracy. A test for this could be just letting the sensors stay in one spot collecting (0,0,0) data for an entire day and see if it deviates from that.

Wireless

-Define engineering specifications for wireless tech (power, distance, speed, size)

After discussing the project requirements with the customer and team, and a list of customer needs is made, engineering specs need to be determined. Wireless specifications of interest include antenna power, transmit distance, transmit speed, size of wireless circuitry and antenna.

-Choose Network Technology

A wireless technology needs to be chosen to meet the customer needs and engineering specifications. The technology chosen needs to be able to transmit all of the necessary data at a sufficient speed. This needs to be balances with output power and power consumption. A technology that uses a lot of power and drains the batteries is just an bad as one which cannot transmit the data properly.

-Determine antenna attachment method to Roue Wheel.

To transmit, the circuitry will need an antenna. This antenna will need to attach to the wheel in some way. This could be mounted on the wheel, on the PVC, grooved into the wheel, etc. The type of antenna used determines the attachment methods. A microstrip antenna can easily be mounted in a groove in the PVC, but some antenna types cannot . This requires collaboration with the ME team to ensure there is no structural compromise.

-Determine connection method between Wireless board and antenna

The electronic circuitry boards will most likely be mounted inside the wheel's diameter. The antenna cannot be in this location because the wheel will act like a Faraday Cage and prevent all transmission. There needs to be some connection from the boards inside the wheel to the antenna. This can be achieved by a flex cable through a hole in the wheel, or some sort of RF connector in a hole in the wheel. The ME team should provide input on this as well.

-Design and Simulation of antenna

Once a wireless technology has been chosen, an antenna needs to be designed. An omni-directional antenna is the best option for this project. The antenna design should be for the frequency of transmission, and should be simulated in an RF simulation tool for verification of design.

-Prototype antenna

Once the antenna has been simulated and verified, it needs to be prototyped. An RF vendor will need to be found. The vendor will need to build the design for the team for a reasonable cost.

-Test Antenna once made for range and directional ability

Once the prototyped antenna has been received, the team will need to run tests to ensure that the Antenna is transmitting properly in all directions as designed. RF tools such as spectrum analyzers can be used to measure the power output of the antenna, and field tests can be conducted to ensure that the proper range requirement is met.

-Modify module (circuitry) to fit into Roue Wheel

If a module or chip is purchased to handle the wireless transmission protocol, the module may have to be modified to fit the size constraints of the wheel. The ME team will have to provide size constraints in order to ensure all parts fit in the diameter of the rod properly.

Testing:

ES 13: Zigbee chip power output (0 dBm marginal, 18dBm ideal)

-Use a spectrum analyzer attached to the antenna port on the Zigbee chip to measure power output. The Zigbee chip outputs at 2.4GHz. Measure the power transmitted at this frequency. Also look at harmonic rejection and spur levels.

ES 14: Data Transmission Range (25 m marginal, 50 m ideal)

-Circuitry external to wheel:

Set the device to constantly transmit. Ensure the computer is receiving data. Start to move the receiver away from the transmitter until data is no longer received continuously. Measure the distance between receiver and transmitter at this point.

- Circuitry internal to wheel:

While the wheel is transmitting data, start to move the receiver away from the transmitting wheel until data is no longer received. Measure the distance between receiver and transmitter at this point. Repeat this for antenna location located at 4 different positions on the wheel (ie 12 o’clock, 3, 6, and 9 o’clock on the face of the wheel) at 6 different axis positions for a total of 24 tests.

Mechanical Test Plan

ES1 – ES3: Measure overall dimensions in x, y, and z of components.

ES4: Place Removable parts into roué wheel. Use a feeler gauge to measure clearance between components and roué wheel.

ES5: Weigh device using scale.

ES6: Time yourself with removal of device. (Removable parts only)

ES7: Measure the Center of Gravity of wheel without device, then measure the change of COG of wheel with device. Determine shift in COG. Determine if counter weights are required, and reevaluate ES5 and ES7.

ES8: Model the roué wheel through an environmental test representing about five years of use. Determine an acceptable shock test to evaluate appropriate life testing. Observe model results results, and propose design changed to accommodate any unwanted results.

ES9: Drop wheel from different increments up to given specification. Look for any damage, flex, or rubbing of components. Propose design solutions to accommodate any unwanted results.

ES10: Determine G's produced from max revolutions/sec. Choose sensor with appropriate specifications to handle accelerations. If undesired results occur, reevaluate sensor selection.

ES11: Measure sensor dimensions and determine if within specifications given. If undesired results occur, reevaluate sensor selection.

ES12: Plug in device with charger. Observe temperature after temperature reaches steady state. If undesired results occur, propose a design solution for temperature control.

Integration

Connect prototype boards together

All the pin assignments and the data going out from the RF module and sensors need to be known. It would probably be best to see if they worked separately with each other first than to combine all at once (RF/uProc, uProc/sensors, and then RF/uProc/sensors).

Create PCB

Test PCB functionality.

- •Verify power reaches all components.
- •Verify communication between each sensor and uProc.
- •Verify communication between RF board and uProc.
- •Verify Zigbee receiver receives data from transmitter.
- •Verify accelerometer and gyro give feasible outputs (a push in the x-direction corresponds to change in the x-axis force).

Place within prototype

This is having all parts in the prototype working. Again all tests from above should be done for this phase of the project. This should include putting all the modules and the PCB together in with the mechanical cradle to fit within the wheel.

Test integrated functionality

Once everything is completed and working in the prototype a final test of repeatability should be done. The wheel should be spun in a way that it can be easily and accurately repeated. Data collect from each iteration will be analysised against each other to determine if the device can show repeatable results.

Results from the collected data are to be used to predict the location of the wheel. The wheel is to be spun in a way such that the start and final locations are known. The data collected from the device is to be used to predict the final location as well as the tolerance to this location (error accumulation considered). Results from the data collection will be evaluated against the wheels actual location.