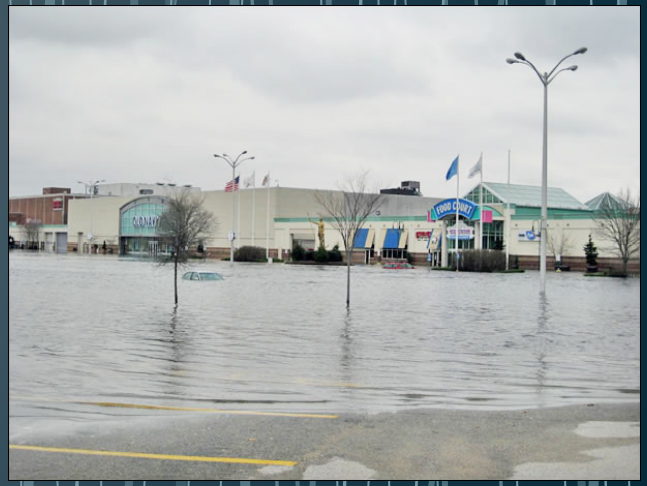
Challenge – Predict Street Flooding &Contamination "Hack That Flood"

Two part project: A smartphone application that predicts storm water runoff by integrating real-time NWS with DOT and GIS data into an easy-to-use download; plus a remote floating sensor platform that collects and transmits selected marine conditions.



Save lives by directing people away from flooded streets and contamination!

Hack The Flood - Sponsor-Rick Davids,
rcdavids1@verizon.net

Providence Journal Editorial 25 August 2014

By Patricia Jedele, VP Conservation Law Foundation. CLF is an advocate for clean water, oceans, energy and communities.

R.I.'s flooded streets are unacceptable

TRICIA K. JEDELE

The other day, it was raining again in Rhode Island, and the streets were flooded again.

I have to admit, ever since the March 2010 floods, I get anxious when it rains. A few inches of rain in an hour can create treacherous road conditions that make it unsafe to drive to and from work along the route one might typically travel. I start thinking about the roads before I leave home and before I leave work at the end of the day. I am deliberate in my efforts to avoid the low-lying areas and the spots that I know historically flood, but there are always unexpected problem spots.

I didn't anticipate the intersection at Park Avenue and Reservoir Avenue to be under water on Aug. 13, after just a day of heavy rain. A failure to provide advance notice to drivers that the roads may actually be under water is just one of the problems associated with localized street flooding.

All this water pooling in our urban roadways when a few inches of rain falls not only creates dangerous road conditions for drivers and paralyzes traffic, but it also has to go somewhere eventually. It channels over the pavement into our rivers and ponds and our Bay — carrying with it all the garbage and fecal matter and fuel left on the blacktop surfaces we've allowed all over the state.

Mashapaug Pond, for example, is described by most living near it as a "sick" pond. According to the Environmental Protection Agency, and our own state environmental agency, it is polluted by the runoff created after rain — in other words, "stormwater." Mashapaug Pond is located on the south side of Providence, bordered by Adelaide Avenue on its northeast edge, the Huntington Business Park on its northwest edge and Ocean State Job Lot off Reservoir Avenue to the south. It is a part of the Pawtuxet River Watershed — the largest watershed in Rhode Island. It is fed by the waters of Tongue and Spectacle Ponds in Cranston (and after this month's major rain event, was also fed by the run-off from the streets and parking lots in Cranston and Providence).

It feeds into the Roger Williams Park ponds, and from there, the water ultimately ends up in Narragansett Bay.

It seems unacceptable that in 2014 we continue to tolerate the fact that our urban watersheds are nothing more than filled in and paved over parking lots; that our municipal storm drainage systems don't function; that we can't seem to keep beaches open after a little rain; that our urban ponds aren't fishable and swimmable alternatives for Rhode Islanders who can't get to the beaches; or that we can't keep our major, high-traffic intersections from flooding.

The Clean Water Act requires all properties contributing to water quality violations to obtain and comply with permits to reduce this run-off. It is time to identify all of the users of the municipal stormwater systems contributing to these problems and require them to contribute to maintaining the system in proportion to the burden they are placing on it.

In Rhode Island, in 2014, our ponds and waterways should be healthy and useable and our roads should be passable.

Tricia K. Jedele is a vice president at the Conservation Law Foundation and the director of CLF's Rhode Island Advocacy Center.

The Problems and Challenges

- From a storm water management perspective:
  - More paved-over areas (parking lots, streets, sidewalks) channel water faster.
  - More garbage, gasoline, oil, salt and fecal matter channeled to ponds, streams, rivers and ocean.
  - More debris blocks storm drains increasing channel flow to alternate routes.
  - No small, inexpensive, multi-sensor floating platform to record marine conditions.
  - **Result: contaminated flash, river, and coastal flooding**
    - Read ProJo article: 10 September 2015
- From a user perspective:
  - No mobile, easy-to-use, inexpensive, real-time prediction smartphone app for flood conditions, 'first flush' areas, etc., in Rhode Island.
    - Innovyze does provide InfoWorks - very complicated, very expensive workstation models for utility company command and control rooms. http://www.innovyze.com

Your solution will identify flooded streets and contaminated storm water runoff!

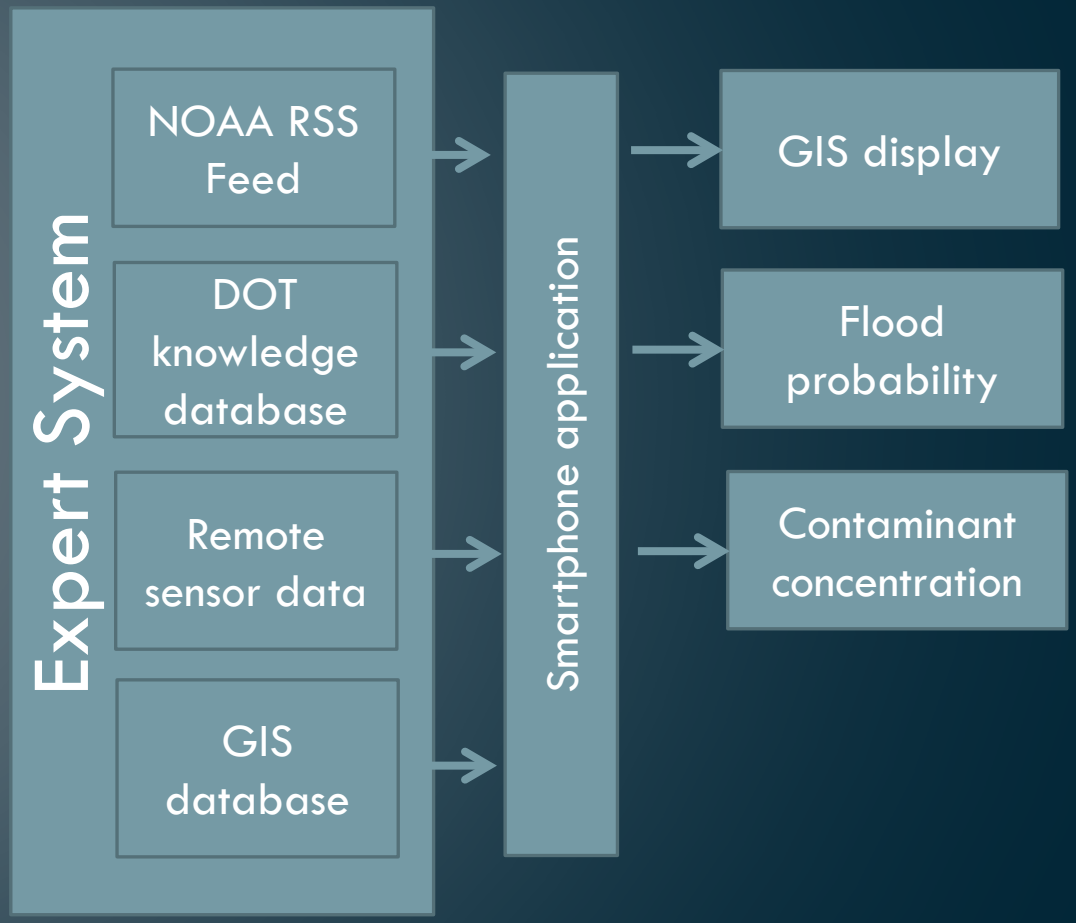
The Challenges

- Develop a smartphone application…
- And a remote, solar powered, integrated floating sensor platform…
- That integrates GIS and real time National Weather Service RSS feeds…
- With data about historic known flood areas…
- Using COTS software and data (open source SW)…
- To calculate a probability of flooding and water conditions…
- Along a user selected street track.

The key is to focus on a well-defined small set of parameters!

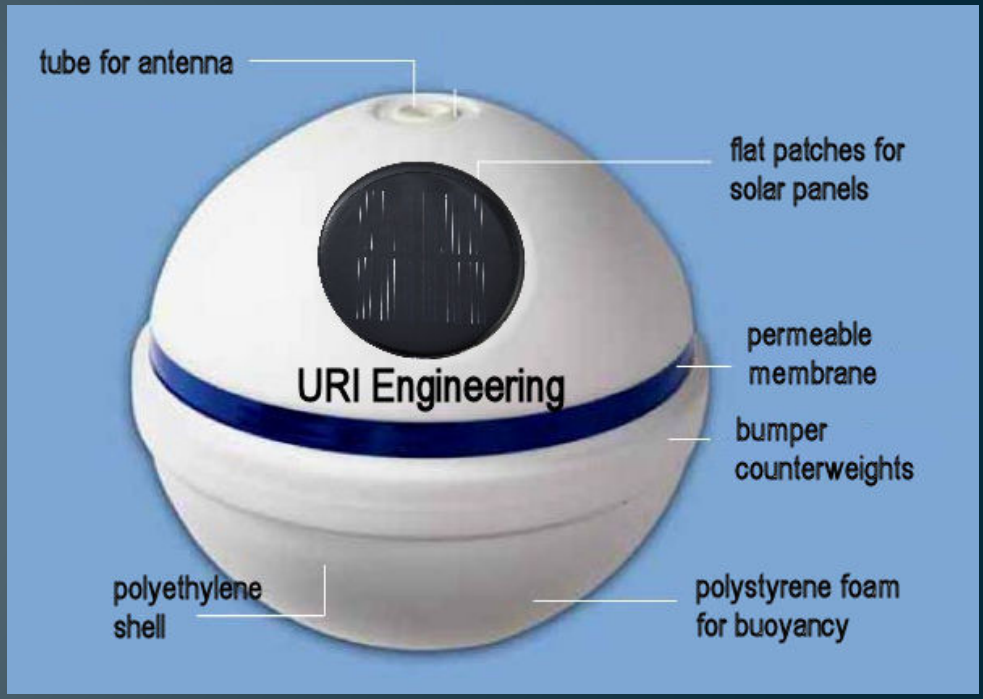
Notional Software Architecture

- The notional architecture consists of four major inputs.
  - Really Simple Syndication (RSS) feeds from National Weather Service.
  - DOT knowledge
  - Remote sensor data
  - Geographic imagery
- The expert system integrates data, algorithms and information.
- And sends results to the smartphone client.

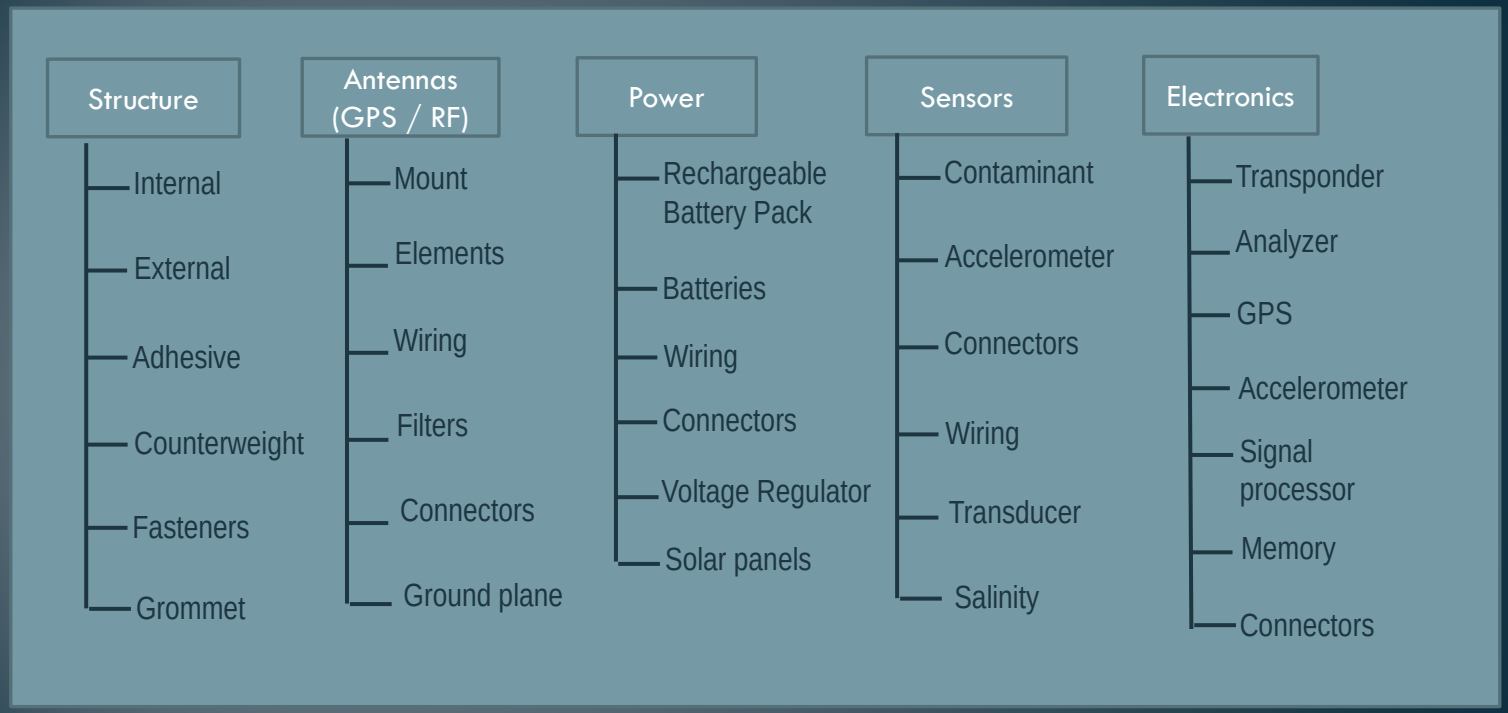


Remote Sensor Platform – Notional Design

- Modified COTS mooring buoy.
- Acts like a spacecraft 'bus' carrying sensors.
- Solar powered internal rechargeable battery supply.
- Membrane detects salt, oil or gasoline contaminants.
- Accelerometer to measure wave action.
- Waterproof outer shell.
- Uses cellphone carrier to transmit data.



Notional Remote Floating Sensor Platform Architecture



Approach – Smart Phone Application

- Develop a small pilot project for local (GSO) Narragansett Bay area.
  - Use Android OS platform (large US market share, good tools, etc.)
  - Determine server side and client functions, software.
  - Develop plan for hardware / software /people resources, schedule, budget, etc.
- Develop weighted algorithms for various factors
  - Ex: Known flood plains, NWS rainfall prediction, time and date, etc.
- Treat the storm water runoff as a problem in hydraulics engineering.
  - Use open channel (streets, highways) and conduit flow (storm drains)
  - Contact RIDOT Highway and Bridge Maintenance Department for information.
- Combine hydraulic model data with real-time meteorological (rainfall) predictions.
  - Requires collecting data from NOAA RSS weather feeds.
- Collect input from RIDOT and utility services (National Grid).
  - Requires personnel interviews, data collection and mapping.
- Use GIS imagery SW to create street overlays and calculate elevation, latitude, longitude, and user location.
- Integrate daily tidal flow, sensor data regarding contaminant concentration, wave action.

Benefits

- Ability to design a mobile application architecture and UI.
- Greater understanding of human influence on geology.
- Greater understanding of existing RI infrastructure.
- Greater understanding of state, municipal, and local roles in managing water quality, roads, etc.
- Greater understanding of role of hydraulic engineering in Civil Engineering.
- Develop methods for recording interviews, i. e., questionnaires.
- Develop interview techniques (questionnaires) using both face-to-face and remote (FaceTime, Skype, etc.) interviews.

Sample Notional Functional Analysis

Functions

- Start application
- Display geographic information
- Display user location
- Pan display
- Zoom display
- Store weather data
- Input DOT data
- Store DOT data
- Show weather data
- Show sensor data
- Record and display user track
- Calculate probability of street flooding
- Show street flooding

Sample Notional Task Analysis

Record and display user street track

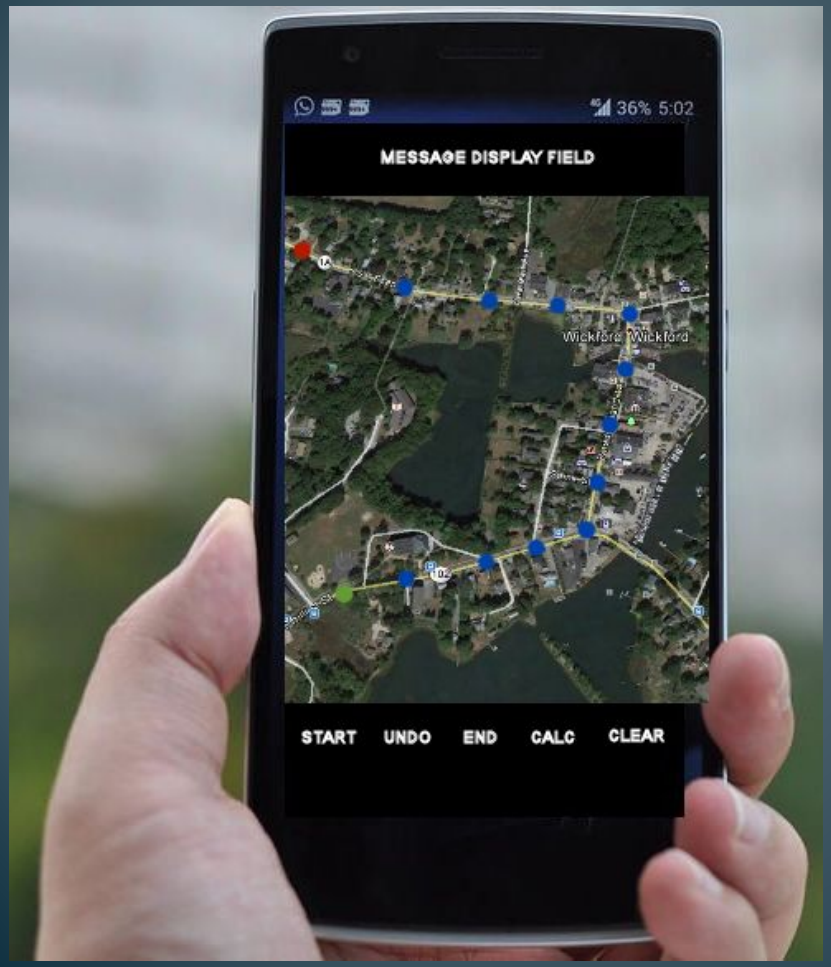
User Actions

- Locate ‘me’
- Locate road
- Zoom in
- Locate start
- Start ‘track’
- Tap pt.1
- Tap pt.2
- Tap pt.3
- Etc…
- End ‘track’
- Calculate p

Electronic Actions

- Display user location
- Track route taps
- Get geo database
- Get DOT / DEM data
- Get NOAA RSS feed data
- Display ‘tap’ route
- Get elevation
- Calculate elevation deltas
- End route
- Calculate user data
- Display results

Notional ‘Hack The Flood’ display

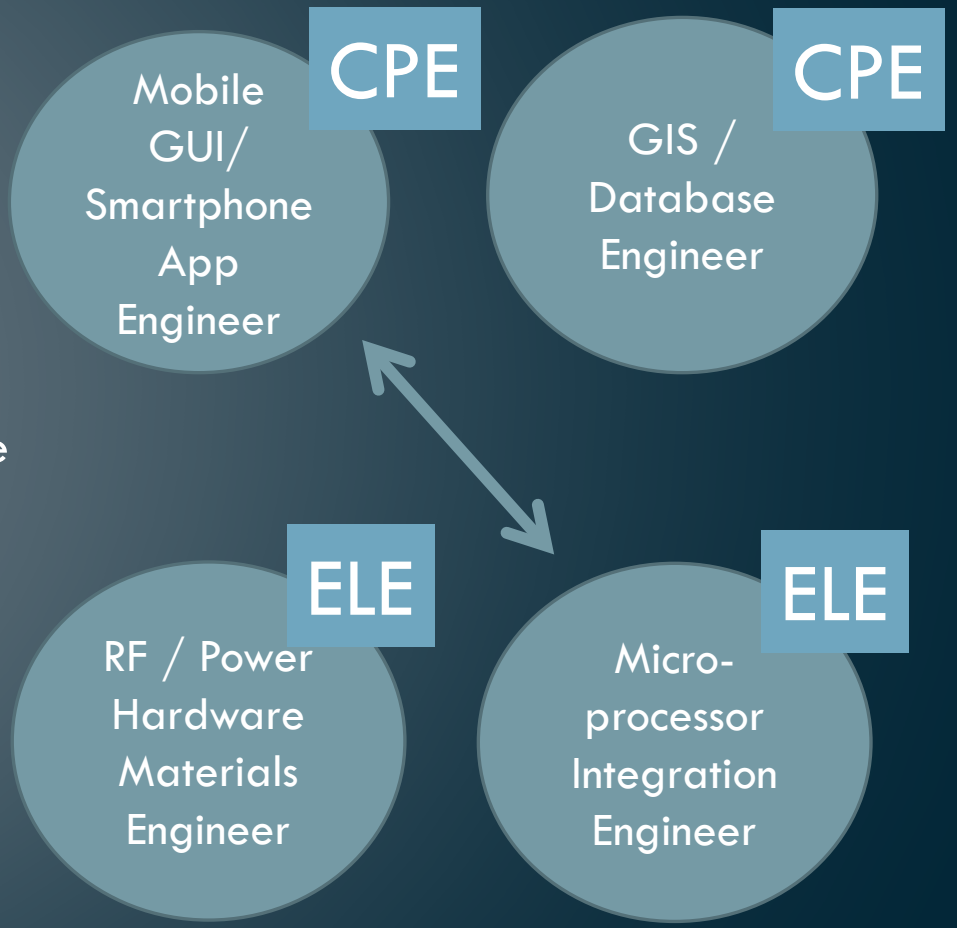


Suggested Features:

- Auto locator - ‘You Are Here’
- Touch screen display
- Common functions = zoom, pan
- Search capability by:
  - zip code
  - address destination
  - favorites
- Show probability of flooding
- Show weather forecast
- Show severity by color
- Show salt ‘hot spots’

Skills, Roles and Responsibilities

- Smartphone application skills
  - GIS knowledge, map overlays, digital elevation modeling
  - Database integration
  - Server software integration
  - Smartphone app building
- Sensor Platform skills
  - Hands-on circuit board experience
  - Power requirements
  - RF / GPS antennas
  - Hardware / software integration
  - Sensor experience
  - Instrumentation
  - 3D modeling / printing



Deliverables

- Smartphone Application
  - Phase One
    - System / detail requirements
    - Functional analysis
    - Tradeoff studies
    - Notional architecture / diagrams
    - Tool selection
    - Prototype / demonstration
    - Interim report
  - Phase Two
    - Iterate design and demonstrate compliance to top level requirements
    - Concept demonstration
    - Final report
- Remote Sensor Platform
  - Phase One
    - System / detail requirements
    - Functional analysis
    - Tradeoff studies
    - Notional architecture / schematics
    - Tool / material selection
    - Prototype / demonstration
    - Interim report
  - Phase Two
    - Iterate design and demonstrate compliance to top level requirements
    - Concept demonstration
    - Final report

Follow the '45 minute rule'; if you're stumped, then ask someone for help!

Resources

- Jessica Stimson; floodplain mapping coordinator for the RI Emergency Management Agency.
- RIDOT Highway & Bridge Maintenance, Warwick, RI. 401-222-2378
- Grover Fugate, RI Coastal Resources Management Council.
- Malcolm Spaulding, retired URI professor of ocean engineering.
- BeachSAMP. http://www.beachsamp.org/research/stormtools/
- RIEMA Floodplain Management: www.riema.ri.gov/prevention/floods
- StormSmart Rhode Island: http://ri.stormsmart.org/
- RI Inundation Surfaces (Sea Level Rise viewer): www.arcgis.com/home/webmap/viewer.html
- FEMA Flood Zones: www.fema.gov/floodplain-managment/flood-zones
- Floodsmart.gov: www.floodsmart.gov/floodsmart
- Semi Permeable Membranes: http://pubs.usgs.gov/tm/tm1d4/pdf/tm1d4.pdf

Notional Bill of Materials - Sensor

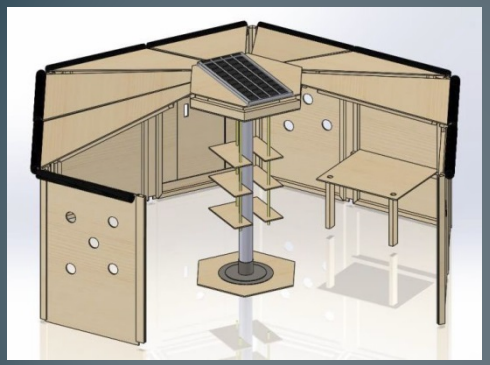
Item	Supplier	Cost ($)
Marine buoy, 12 inch diameter	Jan watercraft products	60
Gyro / Accelerometer	sparkfun	10
RF antenna	gearbest	10
Membrane / mesh / sleeve		50
CPU / microcontroller	sparkfun	10
Wiring harness, connectors	gearbest	10
Transmitter / receiver	gearbest	5
Memory	RS components	10
Barometric sensor	sparkfun	5
Solar panels, round, 6 inch diameter, (3)	Sundance solar	7 @
GPS antenna	Trimble	35
Transceiver		20
Rechargeable battery assembly	Motorola	60
Total		$306

Notional Bill of Materials - Smartphone

Item	Function	Supplier	Cost ($)
Mobiforms	Mobile application development environment	Mobiforms	149
Android Studio	Smartphone application building	Google	Free download
GIS software for mobile application	Data visualization, optimal route, directions, geocoding	ArcGIS Android API	Developers license
Smartphone	Development platform	Samsung, Motorola	100
Database	Support for geographic objects for object relational databases	PostgreSQL / PostGIS	Open source
Imagery	Service oriented architecture	Amazon AWS Free Tier	Free (12 months)
API documentation	Develop REST services, using web-based IPC	Apiary	Free for one (1) user (hacker)
Tools	Expert system	C Language Integrated Production System (CLIPS)	Public domain
Total			$249

Capstone projects I've sponsored

- **HOME Shelter**



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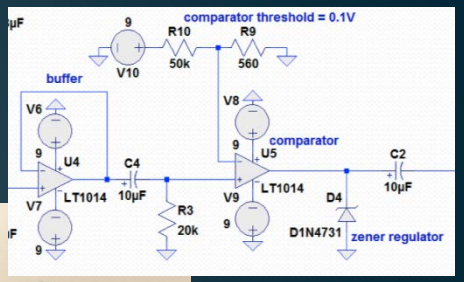
- **CircuiTree**



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- **InstaPlow**

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What I do as a Sponsor

- Assist developing system and detail requirements.
- Assist writing a System Specification, if required.
- Attend any team meetings.
- Offer advice on systems engineering, analytic tools, methods, metrics, progress, etc.
- Review any reports.
- Conduct reviews
  - Requirements, concept and design

My Background

- BA (Psychology, Biology), URI, 1971.
- MA (Engineering Psychology), NMSU, 1974.
- Senior Staff Human Factors and Systems Engineer, Lockheed Martin, Sunnyvale, CA, 1974-2007.
- Applied human factors engineering principles and design standards to mobile shelters, large facilities, missiles, ships, planes, spacecraft, command centers, equipment racks and consoles, transportation systems, handling fixtures, railcars, support equipment, and computer human interfaces.
- Worked with mechanical and electrical engineering, systems engineering, manufacturing, training, logistics, parts, materials and processes, facility and field engineering and DOD customers and suppliers.
- Taught Specialty Engineering, CONOPS, HFE classes.
- Certified Human Factors Engineer #529.
- Retired 2007 after 33 years in aerospace industry.
- Married Julie Yingling (URI 1970) September 2008.
- Moved to West Kingston, November 2008.

Rick and Julie at Turtle Soup.