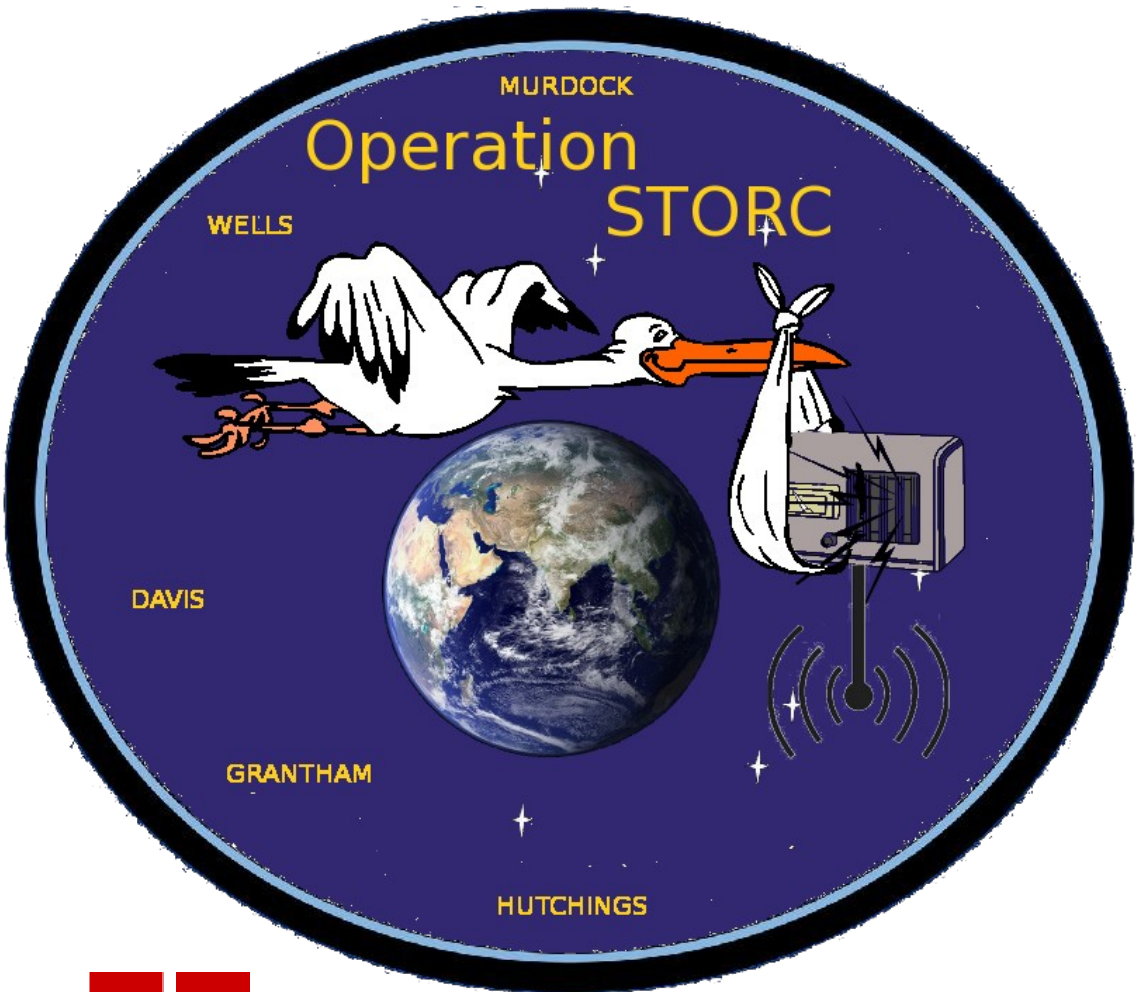
Operation STORC



THE UNIVERSITY OF UTAH

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Functional Description:

We propose a senior project consisting of a weather balloon with an attached payload for aerial weather observation and communication, thus the name Short Term Observational Communications (STORC). The payload will contain a software defined radio (SDR) transceiver for communication with a ground station and the transmission of weather sensing data (see Illustration 1: High Altitude Balloon Schematic(1)). The hardware component will be composed of the SDR interfacing with a micro-controller (MCU). The MCU will receive data from the sensors and pass it on to the SDR to be packaged for transmission to the ground-station.

The ground-station will also consist of a SDR and a computer terminal. The SDR attached to the ground-station will receive the data transmitted by the balloon payload and pass that data to the computer terminal, where the software component will be installed. The software component will then process the received data and represent it graphically. The operator of the ground-station should also be able to send commands through the computer terminal to its attached SDR and on to the balloon payload. The commands received by the balloon payload should instruct the on-board SDR to change up-link/down-link frequencies and turn sensor data transmissions on/off.

The software component will consist of the Verilog/HDL code that makes up the software portion of the SDR and is stored on the FPGA as the radio firmware. A secondary software component will also be some C/Assembly code in the MCU. The ground-station will also have a software component that will predict the drop-zone of the balloon based on weather data received from weather.gov, a prediction of where to launch the balloon for a specified drop-zone, and the protocol for interfacing the radio with the computer.

Hardware Component:

- SDR
- Sensors
- MCU
- Antenna

Software Component:

- Path Predictions
- Launch Predictions
- Radio Communication Protocol

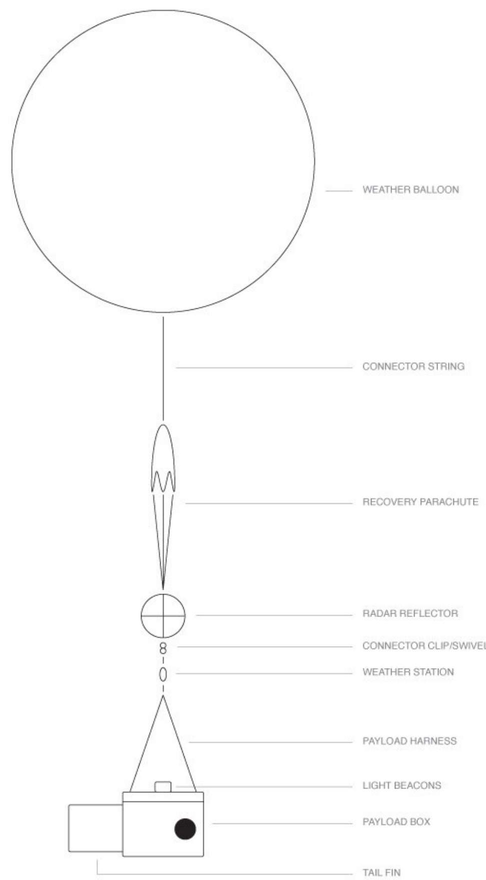

Illustration 1: High Altitude Balloon Schematic(1)

Preliminary Overview:

The SDR hardware component will be implemented with a board design and components received from Texas Instruments (TI). The MCU will be a CortexM3, combined within the SmartFusion package, wired to the sensors for data collection. The Antenna will be a simple wire at a length of 3 feet and will be tuned by the radio to the frequency commanded within the SDR.

The software component will be implemented on the SDR with community code provided by gnuradio.org to be customized for our board and design requirements of a two meter and seventy centimeter amateur radio band. The MCU will be programmed in C language to query the sensors for data. Once the data is received from the MCU, the data will be passed to the SDR to be prepared for transmission in packet form. The prediction software will be written in C++ or C# and take in weather data from weather.gov for wind conditions at different earth elevations.

Implementation:

We are establishing contacts with the Amateur Radio Community, engineers at L3 Communications, and professors at the University of Utah to provide consultation and potential sponsorship of this project. The consultants will provide an initial review of our project and our plan of attack in order to get us started in the right direction. We plan to continue meeting with our consultants as the development progresses for their input and expertise on the subject in order to achieve the best design possible within the time, scope, and budget allotted.

We have already established accounts with Texas Instruments and Analog Devices in order to receive free sample components for this project. The following components have already been ordered and are on-hand:

- Quadrature Modulator
- PLL/LO Generator
- DAC
- RX/TX/ADC/DAC Power
- DAC/ADC
- DUC/CFR/DPD
- DSP Core
- Clock
- OMAP Test Device

(see Illustration 3: TI SDR Block Diagram(2) for specified sections)

After discussing our project with Professor Schmid at the Unviersity of Utah, we were provided with schematics for a software defined radio that Dr. Schmid had been working on at the University of Michigan, see Illustration 5: SDR Provided by Dr. Schmid and the University of Michigan(4) for the board concept. This generosity has reduced the amount of work required to design the SDR from scratch. We will now be able to modify the existing design to meet our requirements, this should reduce the design time tremendously.

Initial Tasking:

James Murdock (ECE) – MCU/SDR Design and Integration, Control
(Amateur Radio Call: KE7SWA)

Kyle Hutchings (ECE) - MCU/SDR Design and Integration

Joe Grantham (EE) - SDR Design and Build

Neil Davis (EE) - SDR/DSP Design and Build

John Wells (CS) - Software Projection, Protocol Communication, and Data Processing
(with assistance by the ECE members.)

Preliminary Schedule:

- May 1, 2012: SDR design (highest risk)
- June 1, 2012: debug, implement, and test SDR
- June 8, 2012: MCU and sensor design and development
- June 24, 2012: debug, implement, and test MCU
- August 1, 2012: continue or begin software design
- September 1, 2012: debug, implement, and test GUI with entire project integration
- October 1 thru November 30, 2012: finalize project, documentation, and presentation

(see Illustration 2: Operation STORC Gantt Chart for a graphical representation)

ID	Task Name	Duration	Start	Finish
1	SDR Design	31 days	Tue 5/1/12	Thu 5/31/12
2	Debug / Implement / Test SDR	7 days	Fri 6/1/12	Thu 6/7/12
3	MCU and Sesor Design and Development	16 days	Fri 6/8/12	Sat 6/23/12
4	Debug / Implement / Test MCU	7 days	Sun 6/24/12	Sat 6/30/12
5	Prediction Software Design and Development	31 days	Sun 7/1/12	Tue 7/31/12
6	Debug / Implement / Test GUI and Entire Project Integration	31 days	Wed 8/1/12	Fri 8/31/12
7	Finalize Project, Documentation, and Presentation	91 days	Sat 9/1/12	Fri 11/30/12
8	Demo Preparation	16 days	Sat 12/1/12	Sun 12/16/12
9	Demo Day	1 day	Mon 12/17/12	Mon 12/17/12

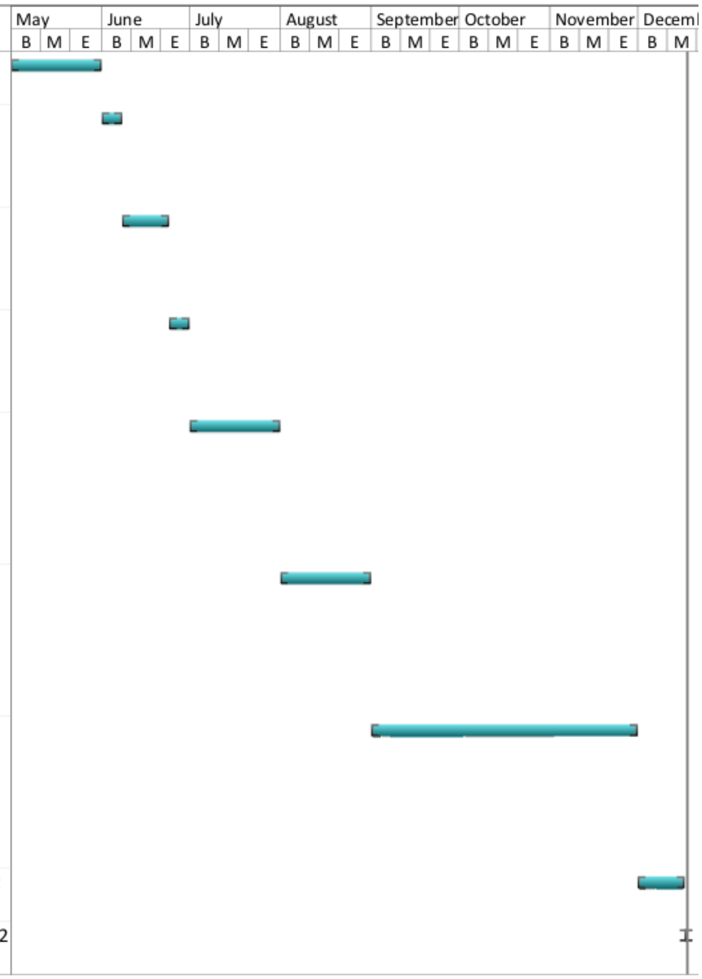

Illustration 2: Operation STORC Gantt Chart

Interface Specifications:

We propose to implement the following interfaces into our SDR and MCU design:

- SDR (see Illustration 3: TI SDR Block Diagram(2))
  - SamartFusion FPGA w/ CortexM3 MCU (see Illustration 4: SmartFusion Block Diagram(3))
- I2C
- UART / Serial
- APRS / AX.25 Protocol

The SDR will interface to the MCU via I2C for communication of sensor data to the SDR for packet preparation. The sensor components will also likely utilize the I2C interface, with the exception of the GPS receiver. The GPS receiver will communicate via serial, UART, to the MCU and also passed on to the SDR for packet preparation after which it will be transmitted to the ground-station.

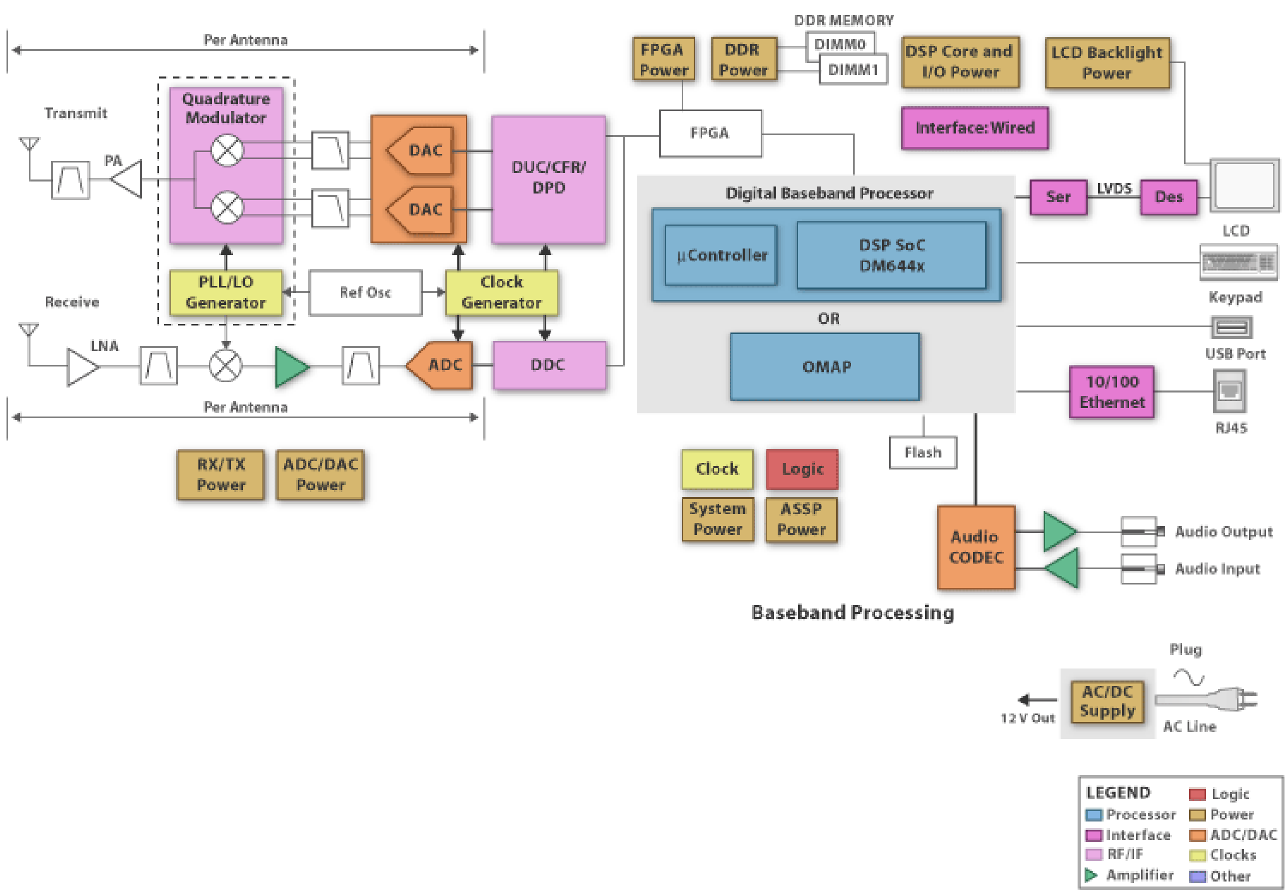

Illustration 3: TI SDR Block Diagram(2)

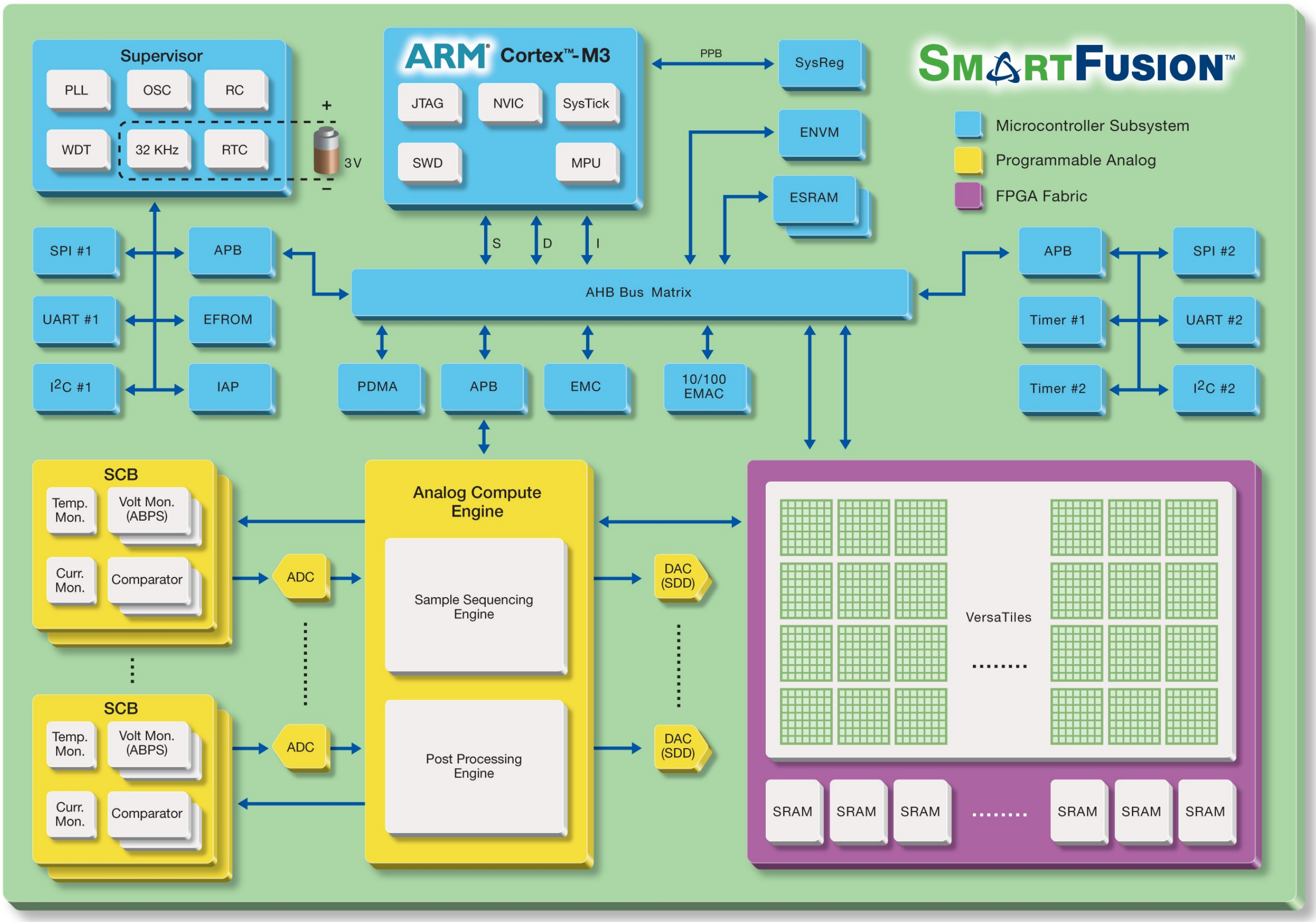

Illustration 4: SmartFusion Block Diagram(3)

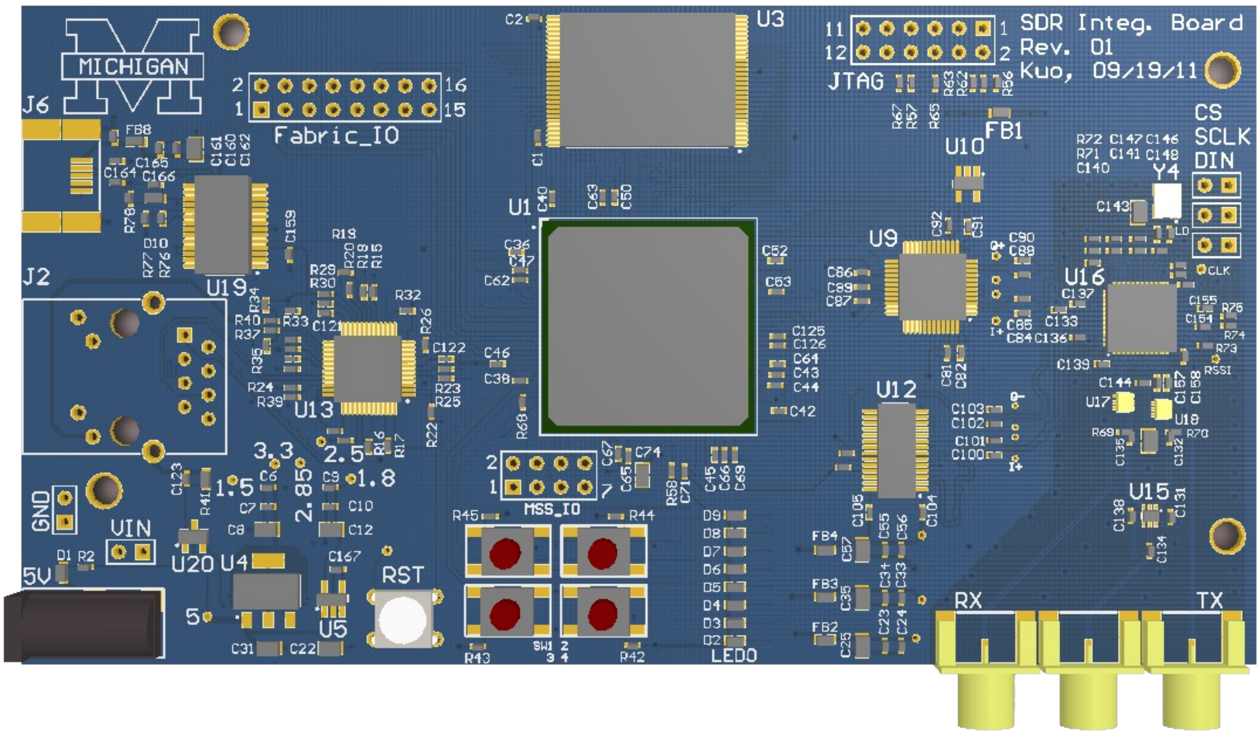

Illustration 5: SDR Provided by Dr. Schmid and the University of Michigan(4)

Risk Analysis:

Our greatest risk is loosing the project payload during our balloon launches, we are planning to implement an efficient method of recovery. We have also began thinking of some potential fail-safes we can implement to sever the payload from the balloon if it drifts further than our specified range, utilizing a parachute to bring it safely to the ground. After our first presentation, it was brought to your attention that our payload may need some sort of padding to protect a sensitive object the payload may hit on its way down. We believe Styrofoam might work in this case, plus it doubles as a flotation device if we land in a body of water.

There is also the risk that our SDR will not function or operate properly due to design, construction, or software flaws. We have a couple of potential backup solutions if this becomes a reality. Our options so far is to use an off the shelf transceiver or a kit that Al Davis has in his possession.

The cost of weather balloons and helium is also a risk if the funding for those items does not become available. We are currently working on our budget to see what kind of funding we will need from our sponsors/donations.

Bill Of Materials (BOM):

Our projects preliminary bill of materials are as follows:

Item	Price	Qty	Vendor
GPS	$38/each	5	Argent Data
FPGA SmartFusion 500 LBGA 500k (w/ CortexM3 MCU)	$42/each	5	Digikey
Accelerometer 80XL346	$8/each	5	Digikey
Digital Thermometer DS620	$6/each	5	Digikey
PCB 4 layer	$54/each	5	PCB Universe
Helium	$0.69/cu Ft	200cu Ft	Praxair
Balloon 350g	$40/each	5	
Parachute 36”	$15/each	5	Rocketchutes.com
Batteries 30137-0 Li-Polymer 3.7V 2400mAh	$7/each	10	All-Battery.com
Radar Reflector SD152	$50/each	5	Landfallnavigation.com

Bibliography:

(1) Weather Balloon Schematic, BESPIN, http://bespin.sevnthsin.com/wp-content/uploads/2010/12/balloonSchematic1.jpg (2012)

(2) SDR Block Diagram, Texas Instruments, http://www.ti.com/solution/software-defined-radio-sdr-diagram (2012)

(3) SmartFusion Block Diagram, Actel, http://www.actel.com/company/press/presskit/smartfusion/images/SmartFusion_block_diagram.jpg (2012)

(4) SDR Image provided by permission from University of Michigan via Dr. Schmid, University of Utah (2012)