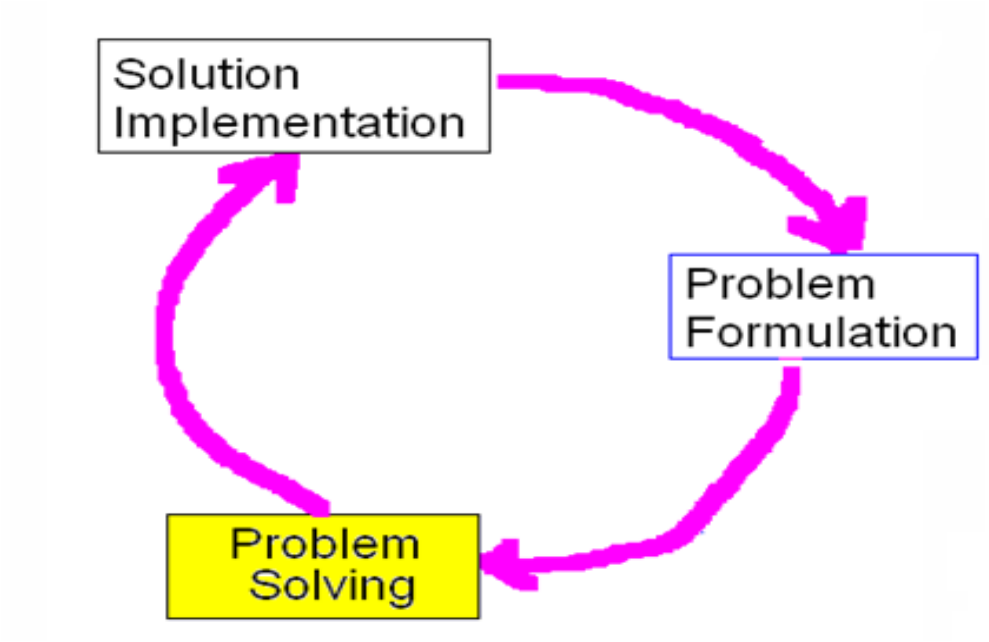
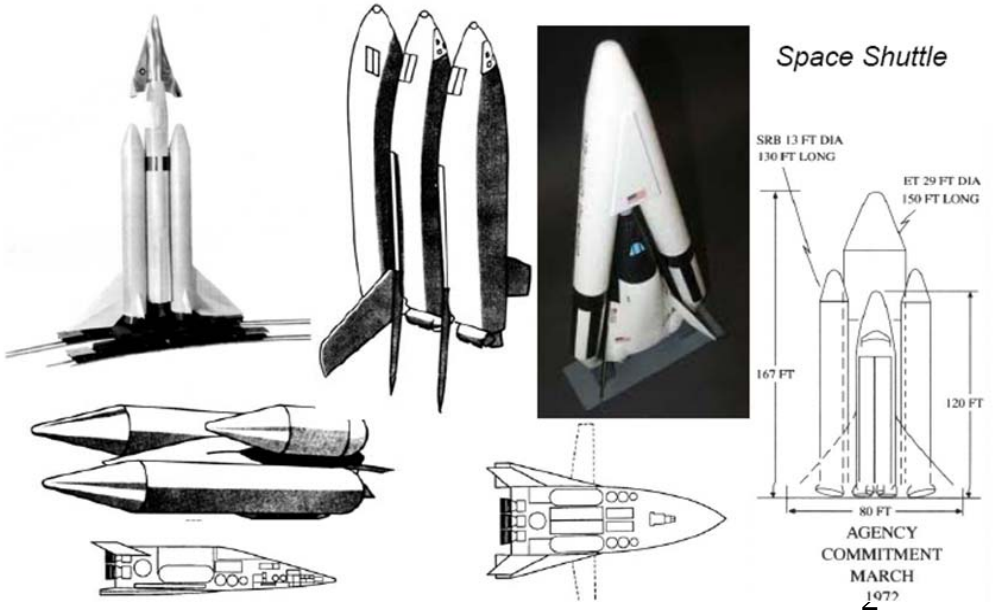
Alternative Designs and Decision Making for Top Design Selection



Step 1. Generation of Alternatives (>2 Conceptual Designs)

- Multiple Alternative conceptual designs
  - **Optimal Solution (by balanced capability, development cost, operating cost, and satisfying any constraints)**
  - Different Architecture
  - Different Components
  - Sensor selection
  - Data Speed selection
  - Interface Selection

Remember these alternatives Before reaching the final Shuttle design !!



Step 2. Analysis of the Alternative Conceptual Designs

- **Concept Screening**
  - Remove those that do not meet the functional requirements
- **Analysis Methods:** Choose based on the project characteristics
  - Modeling and simulation – Equations, Modeling and Simulation tools and Software
    - **What Software tool? Matlab, Pspice, COMSOL, etc, etc**
  - Experimentation (with prototype)
    - **What do we prototype? Entire system? A component?**
  - Qualitative Reasoning – Analytical Analysis and/or Expert Opinion
    - **What analytic methods? Who knows the best?**
  - Other Methods
    - **What? How?**

Which analysis approach to use? Example

- 3 types of sensors on the table and need to choose 1
  - **Datasheet & Experimentation**
- Can a red LED be used as a light source for photo-diode based measurement in place of white LED?
  - **Experimentation**
- In handling numerous inputs and outputs, which one do I use? Do I need an additional microcontroller?
  - **Datasheet and Qualitative reasoning**
  - **Experimentation with Prototype**
- Which motor is better for the project, 1/2hp with 5lb weight or ¼ hp with 1 lb weight?
  - **Simulation and Qualitative Reasoning**
  - **Experimentation with prototype**

Step 3. Selection of Top Designs

- Top Design Selection is decision-making
- Decision-making involves making trade-offs
  - The results of the analyses
  - Requirements from customer
  - Attribute Selection Criteria: which is more important in making decision?
- Decision Tool
  - Decision Matrix

Selection of Top Designs

- iPhone vs Android Phone --- Example

Samsung I9300 Galaxy S III	Better? ← or →	Apple iPhone 5
		
4.8" screen	←	4.0" screen
4G LTE	←→	4G LTE
HD Super Amoled Display	→	Retina Display
1280 x 720 HD Resolution	←	1136 x 640 Resolution
Up to 790 hours standby time	←	Up to 225 hours standby time
Up to 11.4 hours talk time	←	Up to 8 hours talk time
Full HD 1080p video recording	←→	Full HD 1080p Video recording
4.7 oz weight	→	3.95 oz weight
2GB RAM	←	1GB RAM
S Voice	←→	Siri
16 or 32 fixed + up to 64GB expandable storage	←	16, 32, or 64GB fixed internal storage
Android 4.0 OS	NA	iOS 6.0 OS
Standard micro USB cable	←	Requires new accessories/adaptors
Removable battery	←	Camera: 8 megapixel,1.2MP front facing,
Camera: 8.0 megapixel, 1.9 MP front-facing, Panoramic	←	Panoramic
$	←	$$

Attributes

Decision Matrix - Example

Purchase of a used car

CAR	COST	ODOMETER READING	MECHANIC'S RATING (1 - 10)	LOOKS (1 - 10)
RED	$2000	50,000	7	5
BLACK	$2500	40,000	5	6
BLUE	$3000	20,000	8	8

- Which car would you buy under the following two different weight scenarios (Choice of "Attributes")
  - You concerned about all four **attributes equally**.
  - You concerned about **cost** and fairly indifferent about looks. Mileage and the mechanic's ratings are equally important for you.

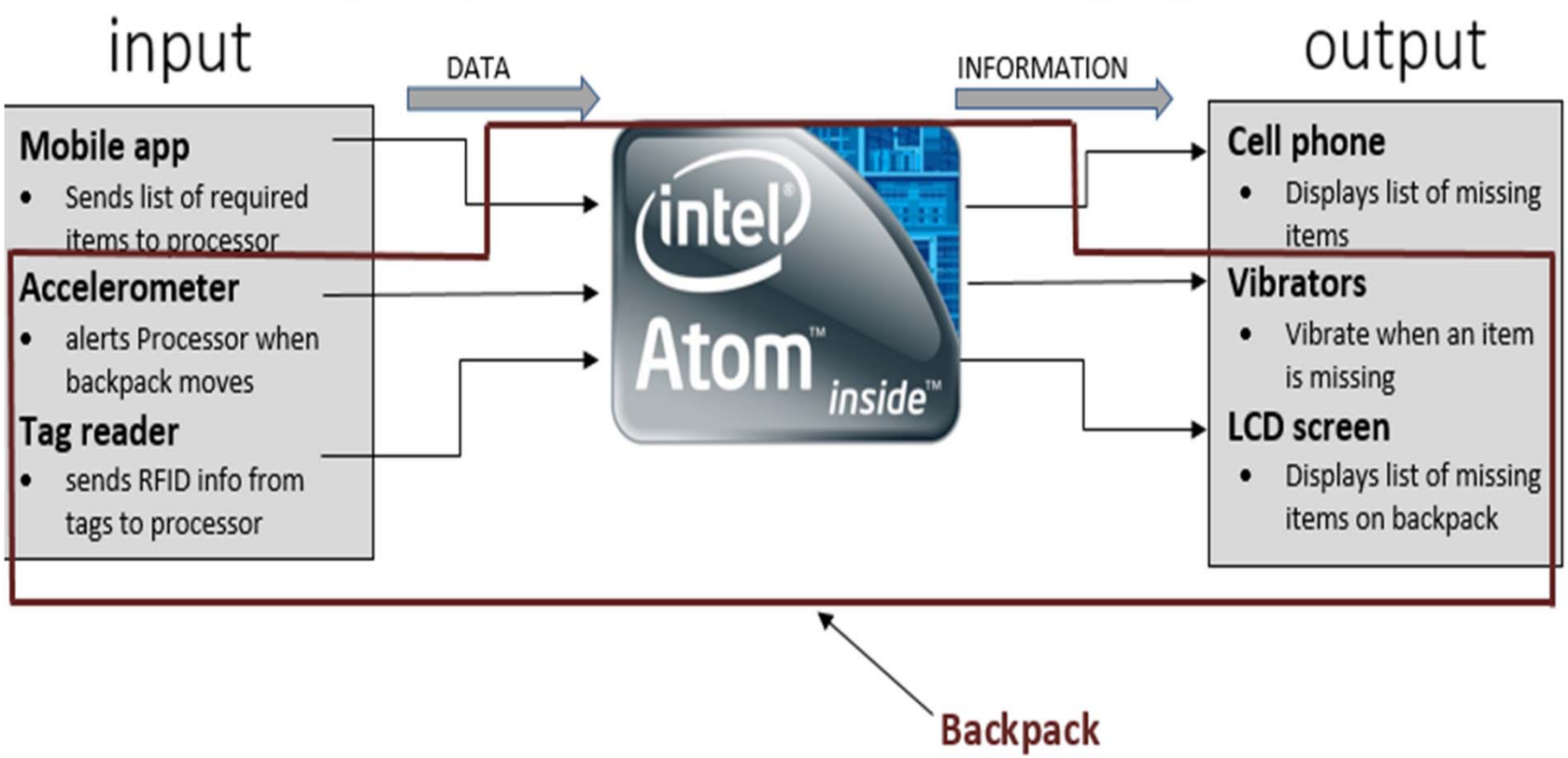
Alternative Designs and Decision Making

Examples

SMART BACKPACK

2013 Intel-Cornell Cup “Honorable Mention” & 2013 23rd ECE Day 1st Place

Conceptual Design



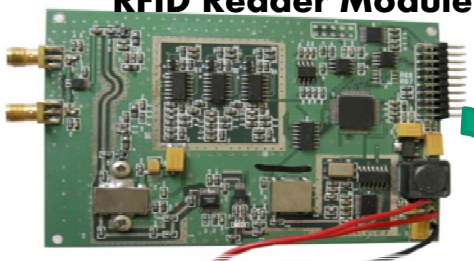
Design 1

Smart Phone

Bluetooth

Sticker Tags

RFID Reader Module



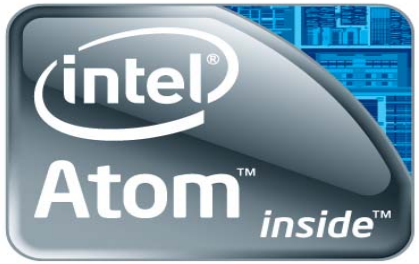
Serial Connection

Vibrating Motor

Wired

Arduino with Bluetooth shield

Wired



Intel Board with built in accelerometer

Pins

LCD Screen

Design 1 Pros and Cons

Pros	Cons
Convenient view/edit of schedule through smartphone	Interference with surrounding Wi-Fi using UHF tags and reader
Wireless connectivity through Bluetooth	Bluetooth battery consumption on the smartphone
Built in accelerometer to detect movement	Limited programming choice for application
Easy input and output connectivity through the Arduino	
Multiple notification (Smartphone, Vibrating motor, and LCD screen)	

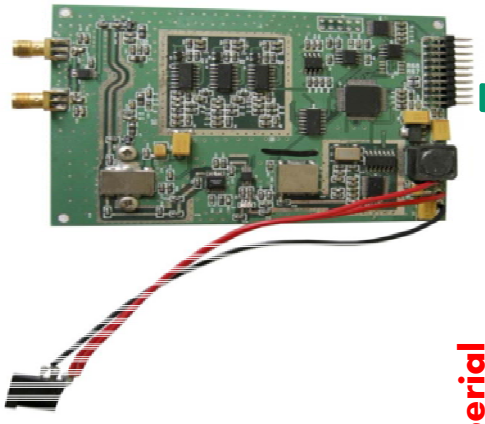
Design 2

Desktop/Laptop

LCD

RFID tags

RFID reader

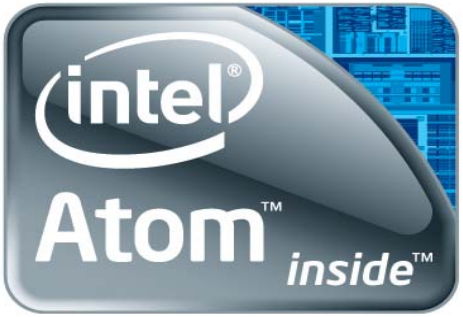


WiFi

Wired

Wired

Serial Connection



Intel Board with built in accelerometer

Actuator

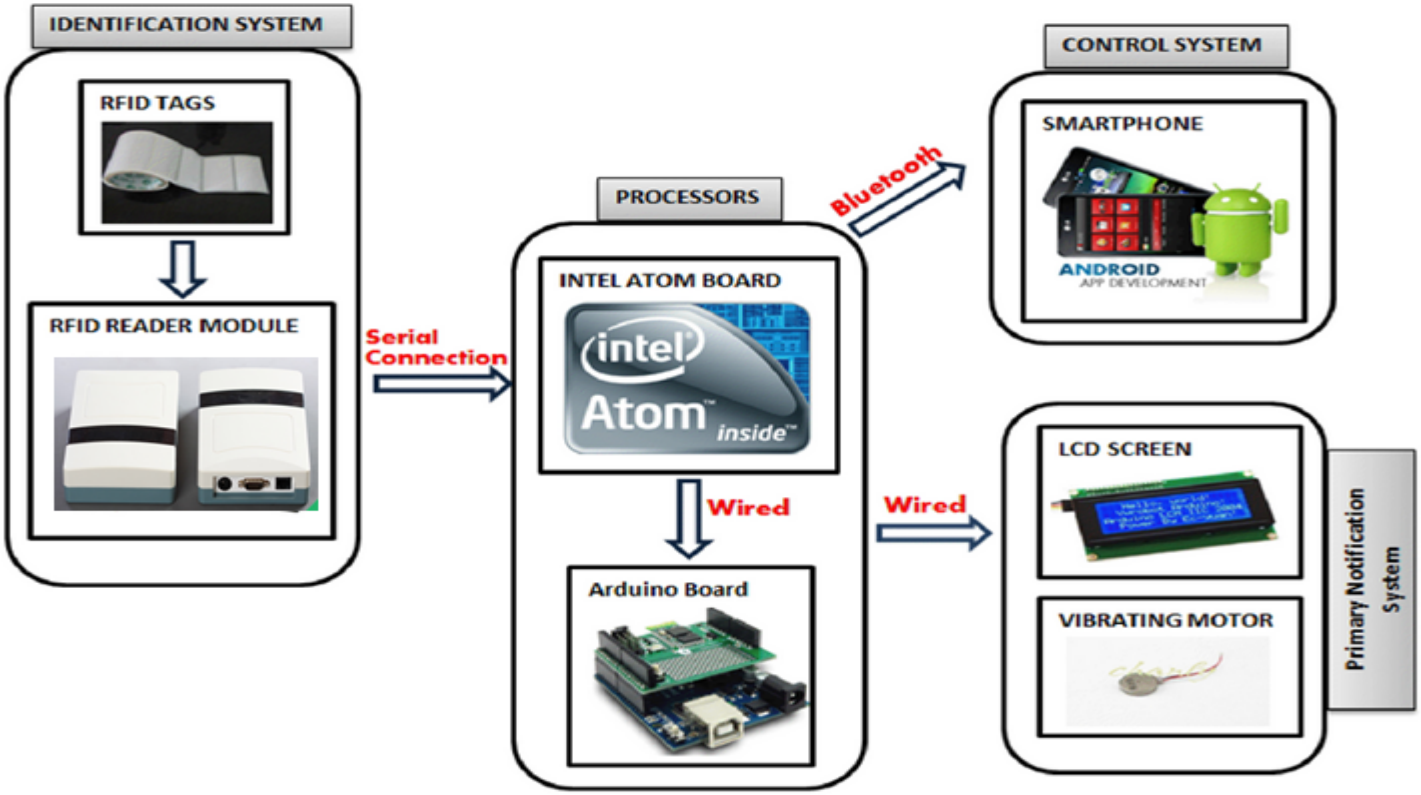
Design 2 Pros and Cons

Pros	Cons
More choices of programming languages for the application development	Since the user's schedule is pulled from a calendar on the desktop, changes cannot be made on the go.
Using the built-in accelerometer reduces cost.	Mode of communication between the backpack and the CPU is limited to Wi-Fi.
Desktop computers are less susceptible to theft than smartphones.	Standard ports on the Intel board (USB ports, VGA ports)

Design Decision Matrix

	Weight	Design 1	Score	Agg. Score	Design 2	Score	Agg. Score
Functionality	**5**	Smartphone Arduino Vibrating motor	**5**	**25**	Desktop Actuator	**3**	**15**
Connectivity	**2**	Bluetooth Wired Wi-Fi	**5**	**10**	Wired Wi-Fi	**3**	**6**
Weight	**3**	Approx. 940g	***4***	**12**	Approx. 890g	***5***	**15**
Power	**4**	More components to be powered	**3**	**12**	Fewer components to be powered	**5**	**20**
Convenience	**1**	On the go edit	**5**	**5**	At home edit	**3**	**3**
TOTAL				**64**			**59**

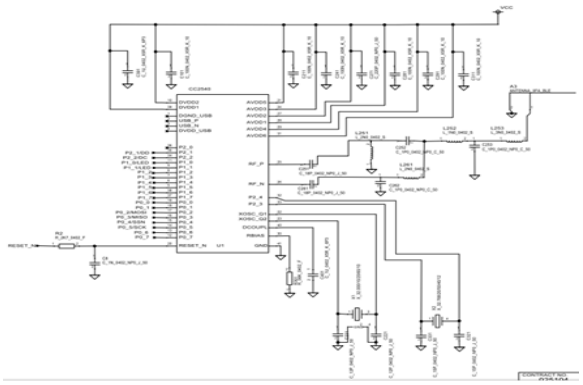
Final Design

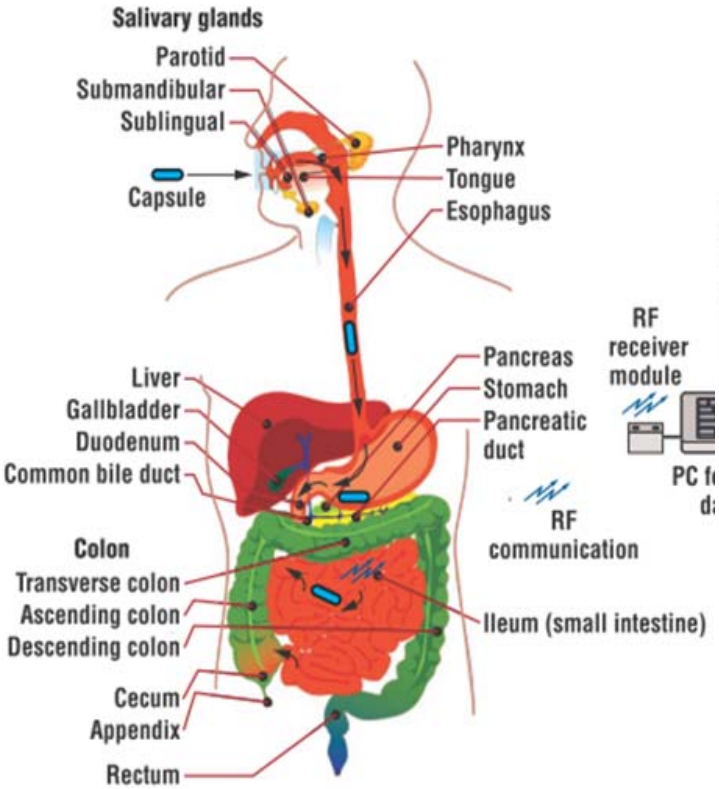


Final Result

Swallowable Capsule

- Capsule
- Receiver





2012 ECE Day 2nd Place

Microprocessor 1: EM250

- **Manufacturer**: Ember
- **Size**: 7 x 7 mm
- **RF Protocol**: ZigBee 802.15.4
  - **Max. Data Rate**: 250 kbps
- Surface Mount Technology (SMT)
- Dev. Kit: $2,500

Microprocessor 2: CC2540

- **Manufacturer**: Texas Instruments
- **Size**: 6 x 6 mm
- **RF Protocol**: Bluetooth Low Energy (BLE)
  - **Max. Data Rate**: 1 Mbps
- Surface Mount Technology (
- Dev. Kit: $299

Microprocessor 3: nRF8001

- **Manufacturer**: Nordic Semiconductor
- **Size**: 5 x 5 mm
- **RF Protocol**: Bluetooth Low Energy (BLE)
  - **Max. Data Rate**: 1 Mbps
- Surface Mount Technology (SI
- Dev. Kit: $400

Microprocessor Comparison

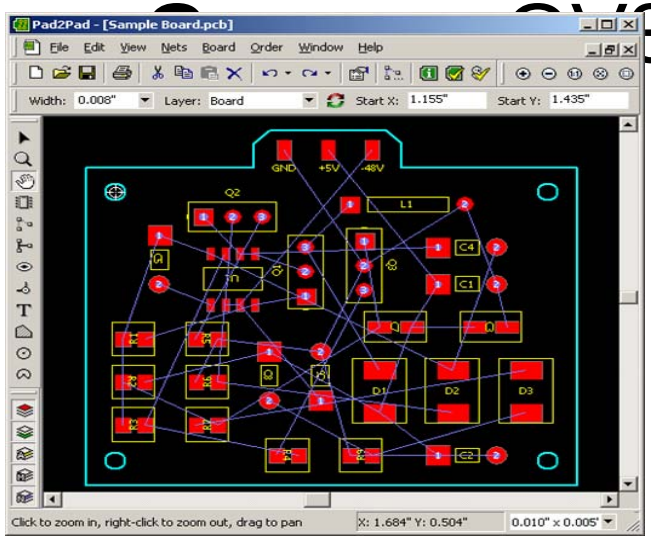
Name	CC2540	nRF8001	EM250
Manufacturer	Texas Instruments	Nordic Semiconductor	Ember
Size	6x6 mm	5x5 mm	7x7 mm
Packaging	SMT	SMT	SMT
Memory	128/256kB Flash, 8kB RAM	-	128kB Flash, 5kB SRAM
Comm. Protocol	Bluetooth Low Energy	Bluetooth Low Energy	802.15.4 Zigbee
Max. Data Rate	1 MBps	1 MBps	250 kbps
Frequency	2.4 GHz	2.4 GHz	2.4 GHz
Software	BTool	nRF8001 SDK	xIDE
Vendor	Digikey	Mouser	Digikey
Chip Price	$6.15	$4.56	$6.16
Kit Price	$299.00	$400.00	$2,500.00
Receiver	Bluetooth 4.0 Compatible Device (iPhone 4S)		WiFi Compatible Device

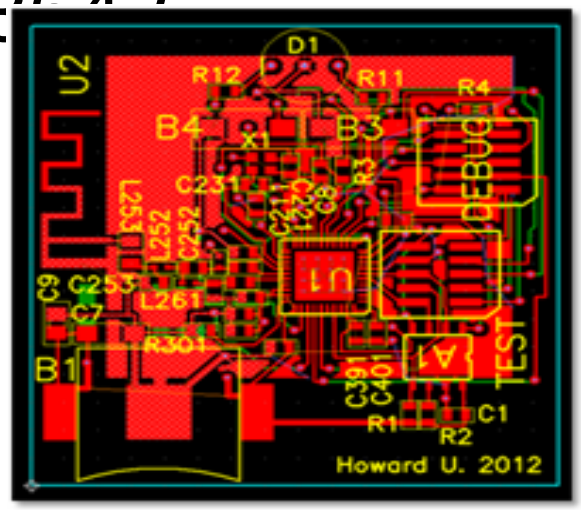
Microprocessor Decision Matrix

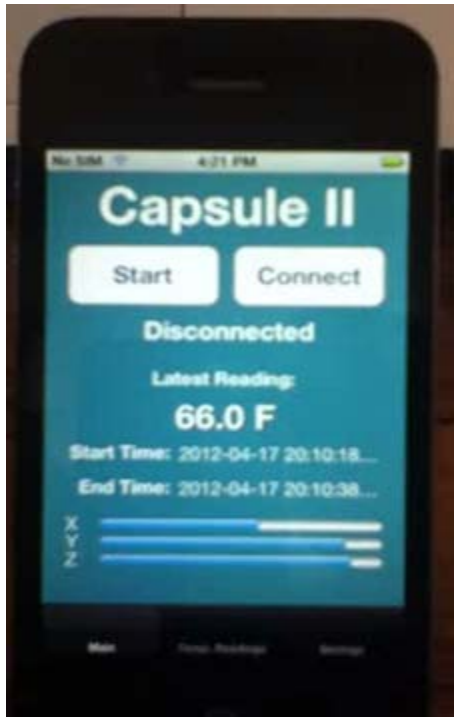
Criteria	Weight	TI CC2540		Nordic nRF8001		Ember EM250	
Cost	35	4	1.4	3	1.05	2	0.7
Programming	30	3	0.9	3	0.9	3	0.9
Receiver	10	2	0.2	2	0.2	4	0.4
Data Rate	25	3	0.75	3	0.75	2	0.5
Weighted Total		**3.25**		**2.9**		**2.5**	
Rank		**1**		**2**		**3**	

Final Design Components

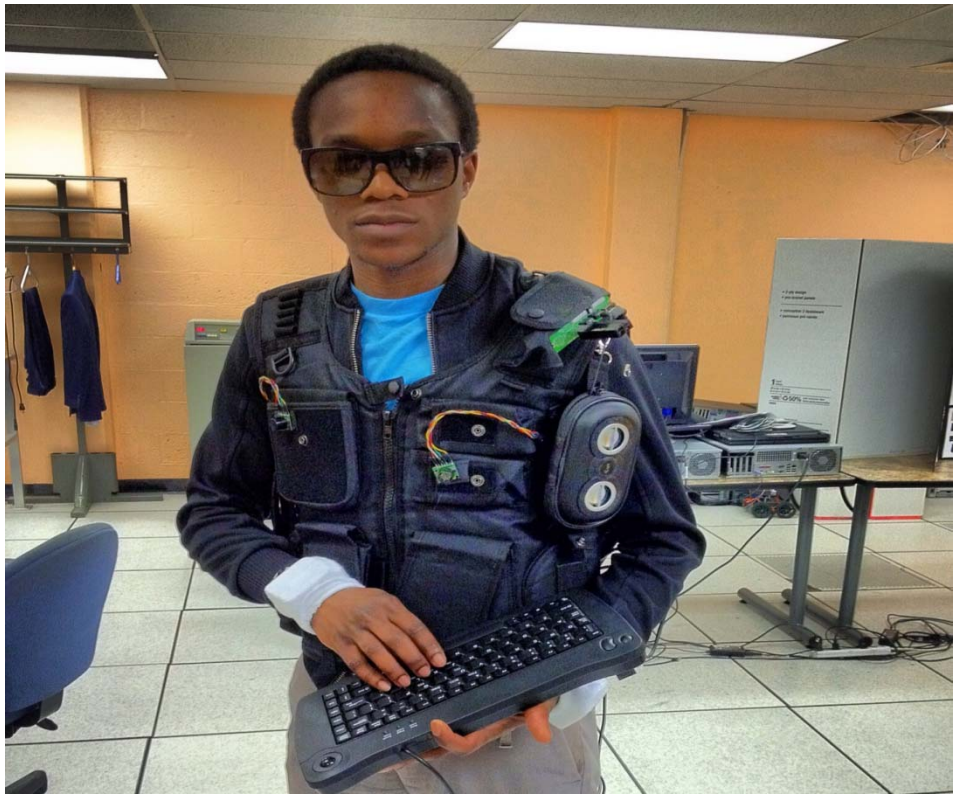
- **Microprocessor**: CC2540
- **Temperature Sensor**: TMP102
- **PCB Manufacturer**: Pad2Pad
- **Case Manufacturer**: [illegible]

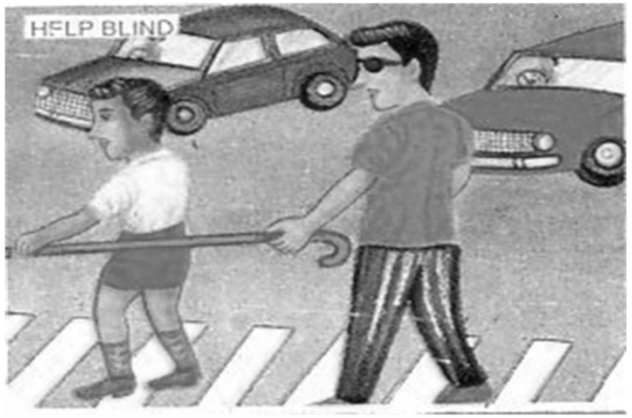


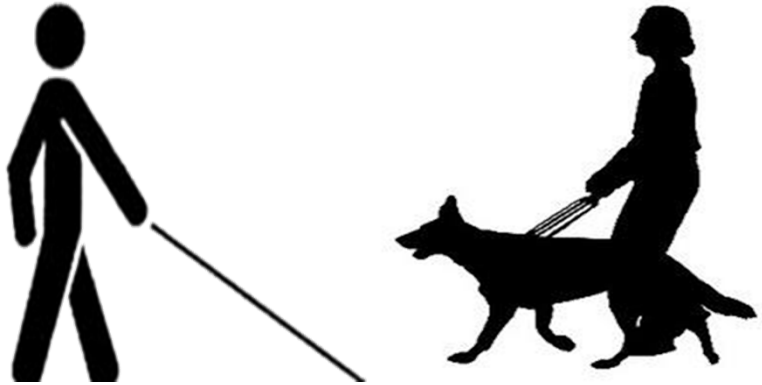




Blind Assistant

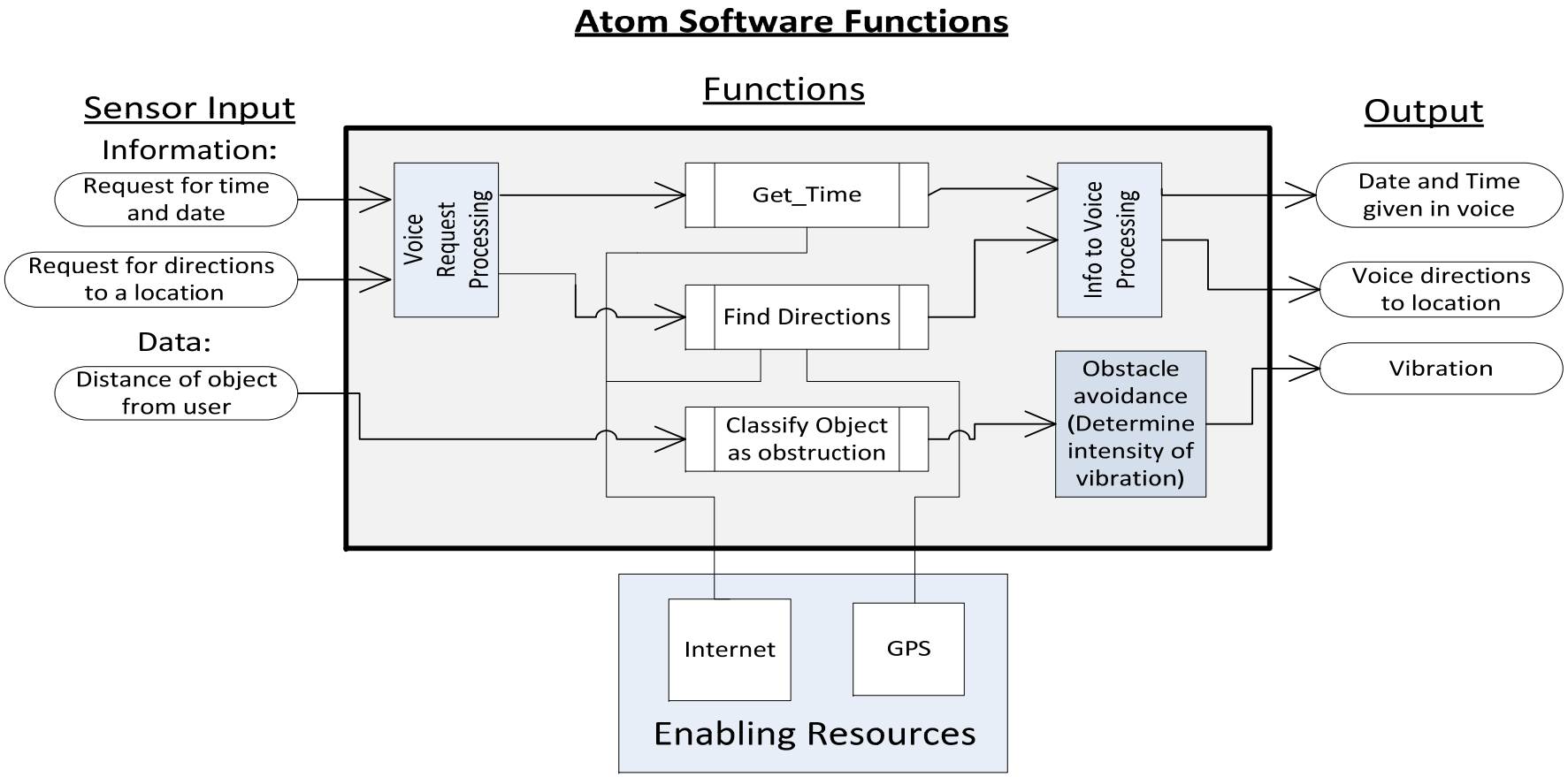






2012 Intel-Cornell Cup “Wild Card Winner” & 2012 ECE Day 1st Place

Conceptual Design



Analysis of Alternative components

OBSTACLE ALERT

- Vibration Modules
  - Availability of already designed modules
  - Ease of connection?
  - Wireless communication with module?
- Audible tones
  - Sounds are easy to make
  - Might be confusing while providing direction to locations (horrible user experience
  - D

Measure (Weight)	User Experience	Ease of Implementation	Total
Vibration Modules	9	6	**15**
Headset tones	5	8	**13**

Analysis of Alternative components

DISTANCE CALCULATION SENSOR

- Ultrasonic Sensor
  - Good widespread connection
  - Little interference based of weather (reliable)
- Infra red sensor
  - Easily affected by sunlight

Measure (Weight)	User Experience (0.7)	Ease of Implementation(0.9)	Accuracy (0.9)	Reliability (0.9)	Total
Ultrasonic Sensor	8	7	7	9	**26.3**
Infra red	6	8	9	6	**24.9**

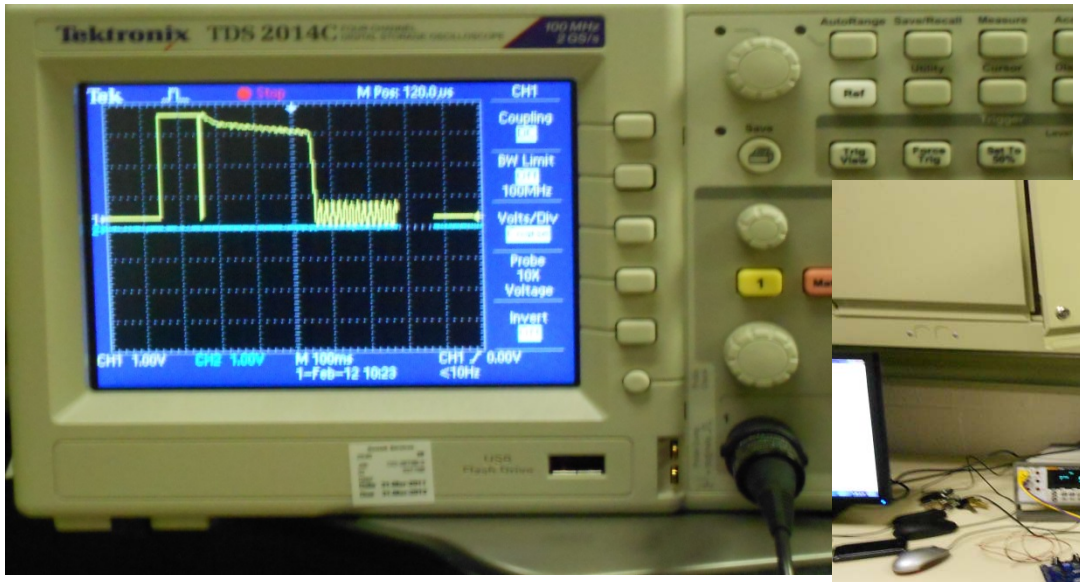
Analysis of Alternative components

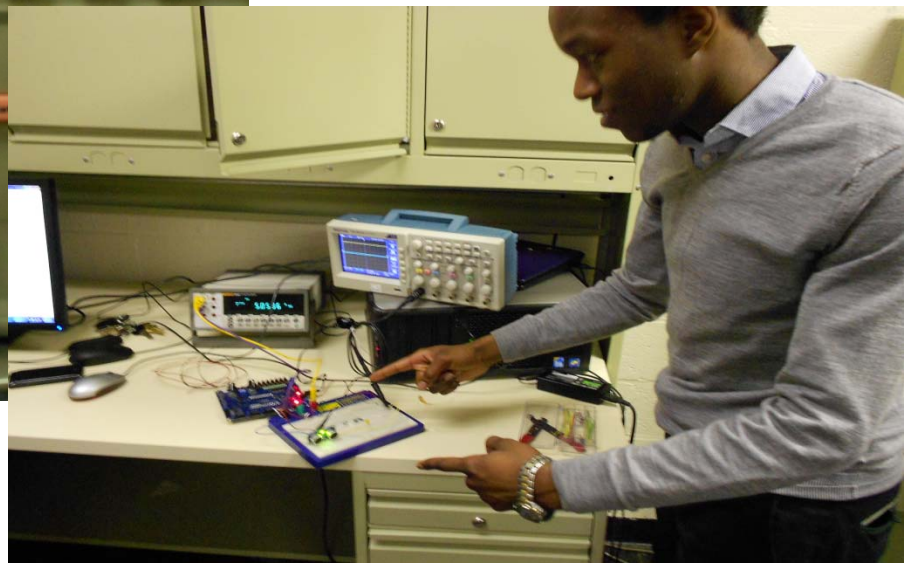
INPUTTING DESIRED ADDRESSES

- Braille Keyboard
  - Time to input address (poor user experience)
  - Easy to integrate with system
  - Allows for more accuracy
- Voice (voice synthesis)
  - Possible great user experience
  - Implementation requirements (we have time constraints)
  - [illegible]

Measure (Weight)	User Experience (0.9)	Ease of Implementation(0.8)	Reliability (0.8)	Total
Voice Operation	9	4	6	**16.1**
Braille Keyboard	4	8	8	**16.4**

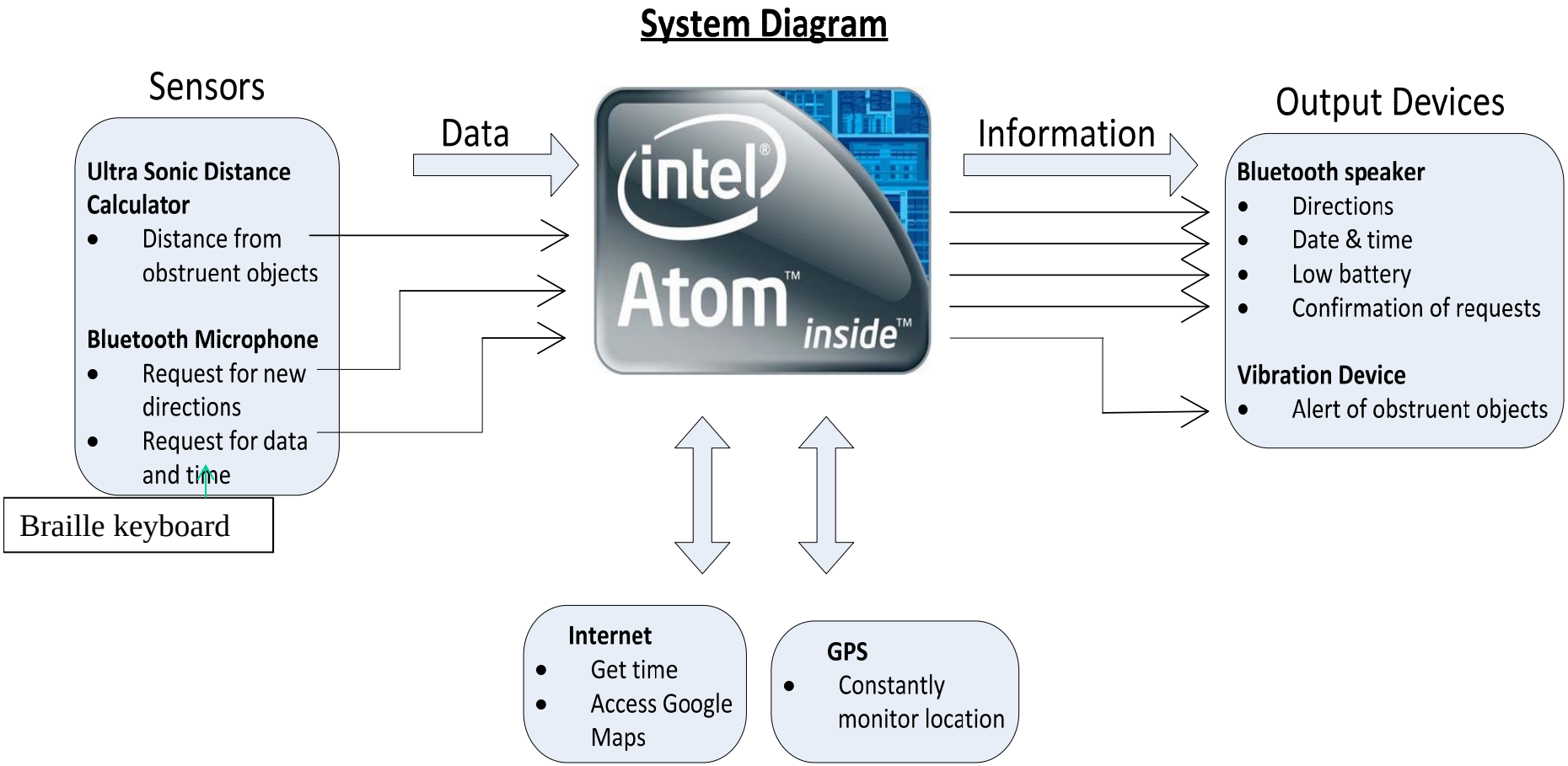
Experimentation for Sensors





I/O Controller and Ultrasonic sensor being tested on a PC

Final Design and Components



SUMMARY: 4-Step Activity for Final Conceptual Design Selection

- Step 1: Generation of Alternatives (> 2 conceptual designs)
  - What are the alternatives in the conceptual design that need to be addressed for the final, good solution? What are the key items, values, parameters, etc that have to be analyzed? How to analyze? What analysis method to be adopted and employed? What are the constraints?
- Step 2: Perform Analysis
- Step 3: Decision Making Matrix for final design selection & Report submission
- Step 4: Presentation for Conceptual Design

Team Activity

- >2 Conceptual Designs
- Analysis of the Alternatives
- Selection of the Top Design

Step 1 – Generation of at least 2 alternatives (Conceptual Designs)

- Bring up the conceptual designs
- Decide (in choosing the best) **criteria**:
  - What are the key items, values, parameters, etc, that have to be analyzed?
  - How to analyze?
  - What analysis method to be adopted and employed?
- Do this in the team meetings.

Step 2: Perform Analysis

- Using the analysis method(s), analyze the alternative designs approaches considering the functional requirements (speed, response time, weight, power, life, etc) and other pertinent criteria

Step 3: Decision Matrix for Top Design Selection

- Decision trade study – decision matrix
  - Selection of attributes which are relevant to meeting the design requirements
- Pick the top concept design and solution
- Refined the Final Solution Design with detailed description

Timeline

Date	Activities
Week of Oct 22 - 28	1. From **today**, each member individually generates a solution concept/idea. 2. **Bring it to a weekly team meeting** **3. Discuss the individual concepts/ideas in the team meeting**
	Incubation period – 1 week
Week of Oct 29 – Nov 4	Team meeting • Discuss individual ideas and develop into **2 team Solution Concepts/Ideas** • Describe [type] the ideas with figures to **2 conceptual designs**.
W 11/8/2017	Submission of (1) all individual concepts/ideas and (2) (2a) Team Conceptual Design #1 (2b) Team Conceptual Design #2
W 11/15/2017	Submission and **Presentation** of the ***Analysis of 2 designs and Selection of the Top Design***
W 11/29/2017	**Presentation** of **Solution and Conceptual Design**
F 12/1/2017	**Submission of (1) Peer Evaluation (via email) (2) Individual Project Note, (3) Team Project Binder**
W 12/6/2017	**Final Exam (10 am – 12 noon)**