GEMSTONE
UNIVERSITY OF MARYLAND

Team Fixing Refrigeration Efficiency to Sustain Health

Vaccine Refrigeration for Developing Areas

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Overview

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  - Existing Cold Chain
- **Research Problem and Question**
- **Design Criteria**
- **Technical Background**
  - Compression
  - PCM
- **Design Concept**
- **Methodology**
- **Plan of Progress**

http://adviate.com/images/superstock_1309r-695.medium.jpg

Importance of Vaccination

Vaccine-preventable diseases have a costly impact, resulting in doctor's visits, hospitalizations, and premature deaths

Current immunization programs such as the World Health Organization’s (WHO) Extended Programs on Immunization (EPIs) are lacking due to holes in the current vaccine distribution system, or the “cold chain”

http://www.highlighthealth.com/wp-content/uploads/2007/11/flu_vaccine.jpg

Existing Cold Chain

- **Problems:**
  - Vaccines freeze throughout the cold chain
  - Unreliable energy at the local level
  - Lack of long-term storage at local facilities
  - One study showed that 70% of vaccines rendered impotent during transport (Techathawat, et al. 2007)
  - Cold boxes will not be able to meet future

Vaccine manufacturer

Primary Vaccine Store (Ministry of Public Health)

Intermediate Vaccine Store (Regional)

Intermediate Vaccine Store (Provincial)

Intermediate Vaccine Store (District)

Hospital/health centers

Cold box/vaccine carriers

(Based on WHO

Research Question

Research Problem

Shortage of potent vaccines in developing regions due to improper refrigeration throughout the cold chain

Research Question

How can we design and build a sustainable refrigeration device that better accommodates the storage requirements for vaccines?

Design Criteria

Temperature Stabilization

- Vaccines must be stored between 6±2°C
- Ambient Temperatures of 43°C and 27°C for WHO tests

Capacity

- Current Cold Boxes: 250L of space for 25 L of storage

Portability

- Road imperfections could cause damage during transportation
- Potential for long term storage outside the electric grid

Duration of Storage

- Store vaccines for at least 5 days

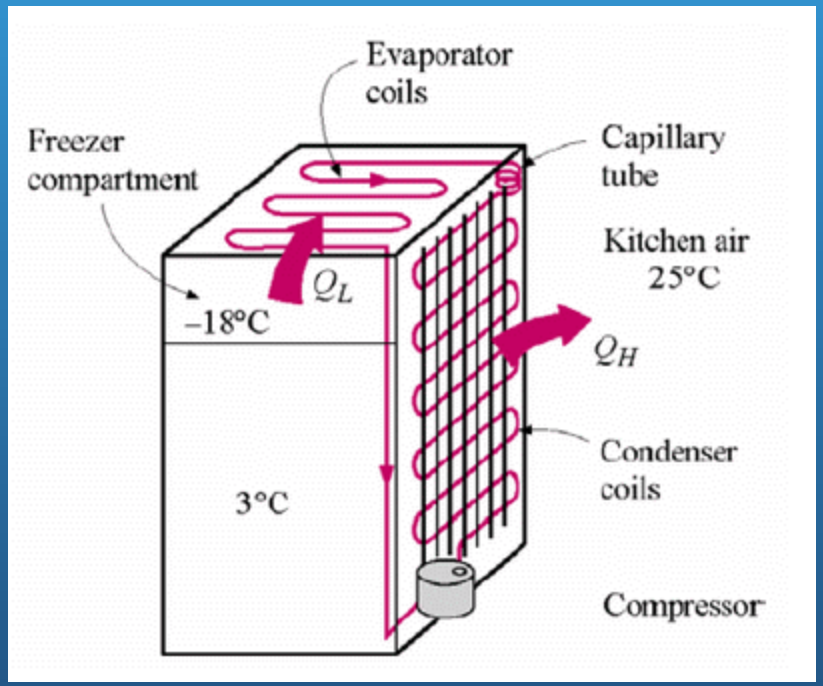
Easily Maintainable

- Should not need expert to repair

http://apexinternational.tradeindia.com/Exporters_Suppliers/Exporter15484.361658/Cold-Box.html

Compression Refrigeration

- Represents the majority of cooling systems in use today
- Refrigerant cycles through compression processes to transfer heat between fridge and ambient surroundings
- Electrical work is used to move energy

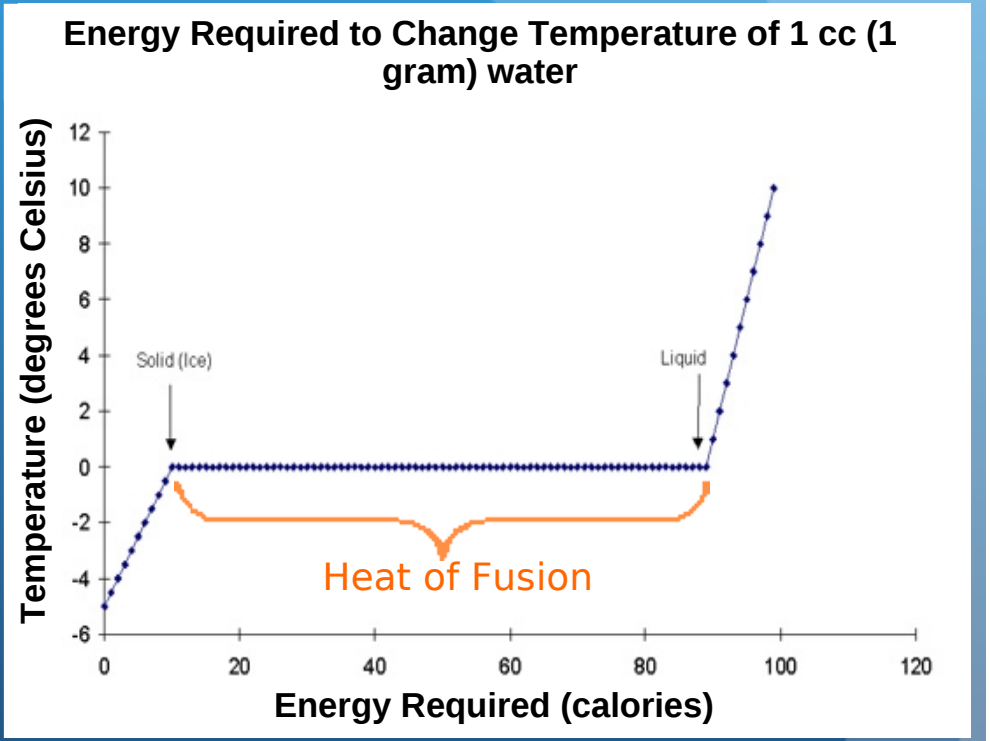


http://coolingdevice.net/images/a3.gif

Phase Change Material (PCM)

Functions as a barrier for outside energy in a two fold manner:

- Acts as an insulation as they typically have a low thermal conductivity
- Stabilizes temperature while melting: entering energy melts PCM, does not raise temperature
- Ice water is a good example



Design Concept

Employs PCM in conjunction with compression refrigeration

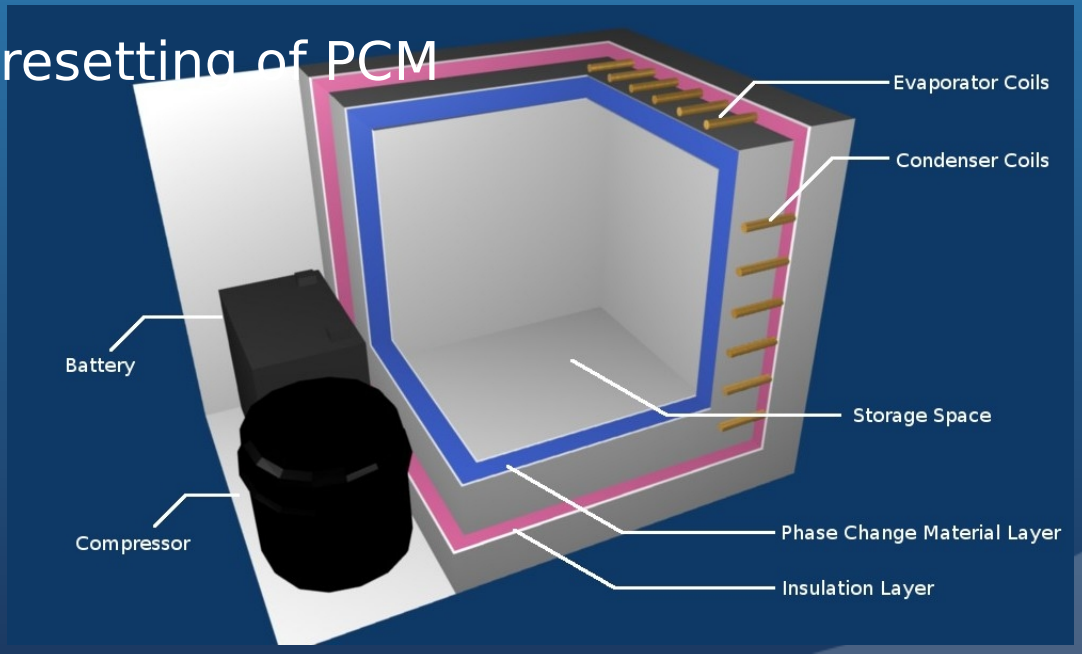
Uses battery for transit, but has an adaptable power supply

Allows for resetting of PCM

Runs compressor at night to save energy

Broadens cold chain

Potential for implementation as storage



General Methodology

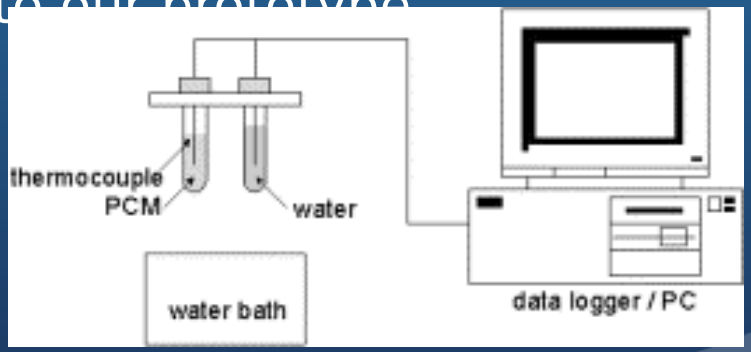
- Experimental Plan
- Selection and integration of appropriate PCM
- Modification of compression and electric system
- Product Design Methodology
- Integration and performance testing of system

http://th08.deviantart.net/fs11/300W/i/2006/214/f/b/Water_to_Ice_by_hippyofdoom.jpg

Experimental Plan: PCM

Evaluate PCMs

- Verify the given values for heat of fusion and melting point for prospective PCM's
- Test durability to ensure the material will last
- Take the material that displays the best overall characteristics of density, latent heat of fusion, melting point and cost, and integrate it into our prototype

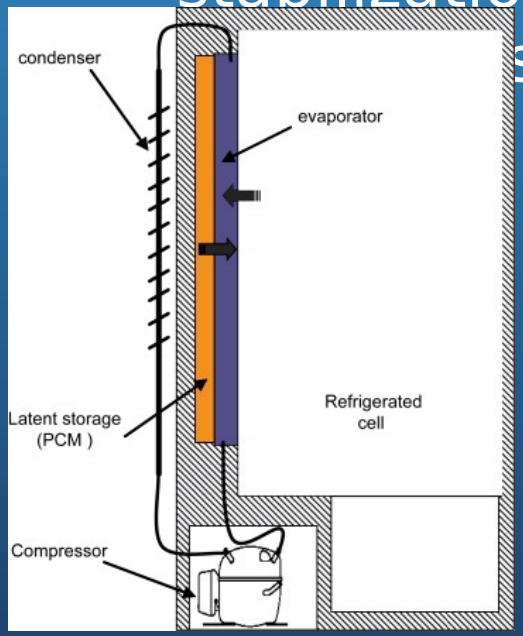


Hong, Kuk Kim & Kim 2004

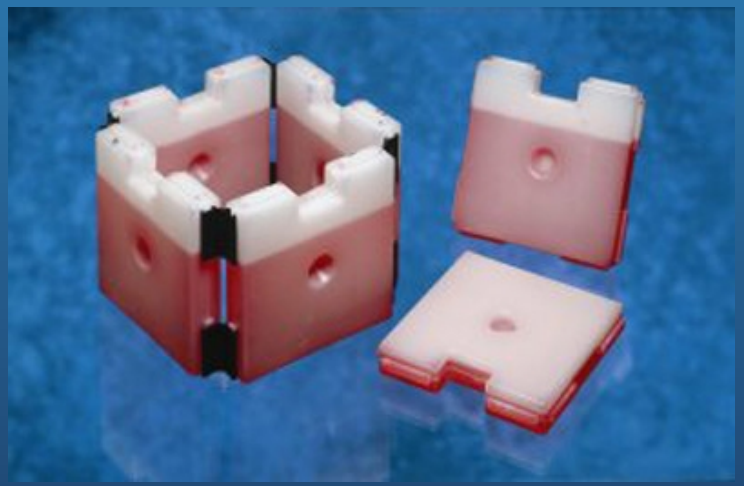
Experimental Plan: PCM Integration

Investigate Geometry of Storage

- Study difference in temperature stabilization with different
  s



One wall



Cubic Enclosure

PCM Shelves?

Experimental Plan: Electrical

Power Source

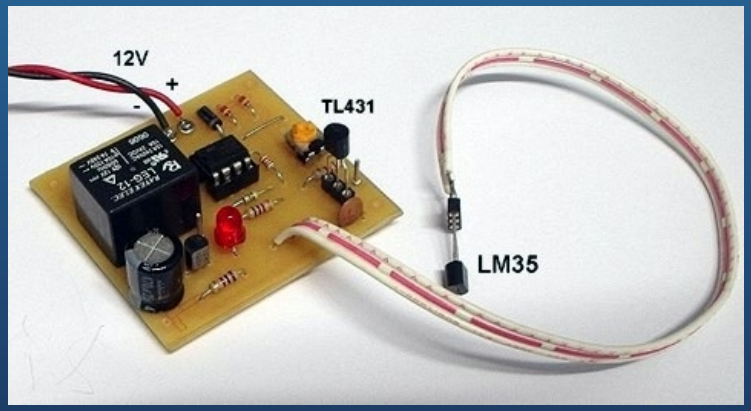
DC compressor vs. Inverter

Integration of various power supplies

Thermostat

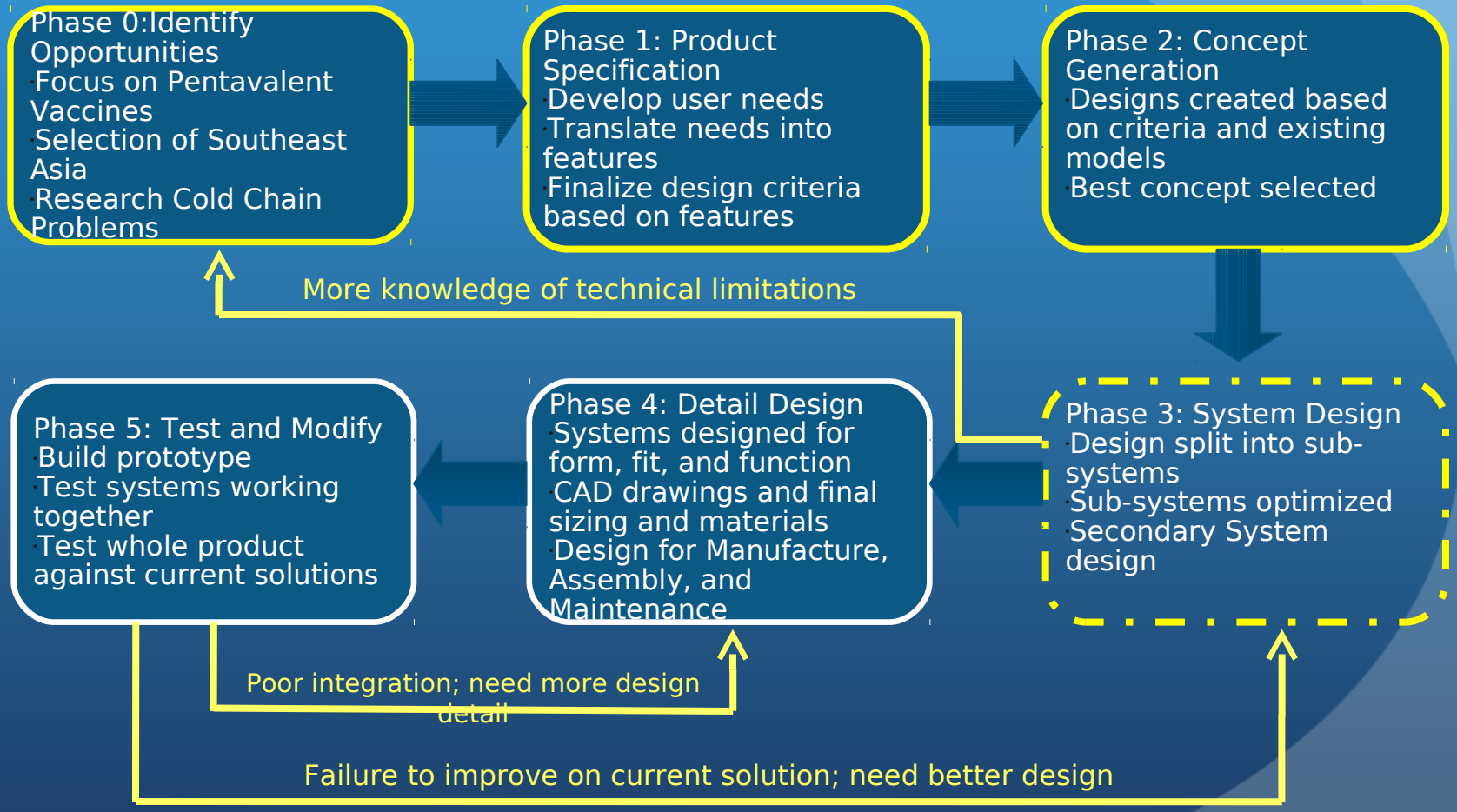
Inclusion of PCM may interfere with thermostat logic

Better ways to measure temperature and control system



http://www.electronics-lab.com/blog/wp content/uploads/2008/10/thermostat1.jpg

Methodology Flow Chart



Plan of Progress

Task	Spring 2010	Fall 2010	Spring 2011	Fall 2011	Spring 2012
Phase 3: System Design					
Phase 4: Detail Design					
Junior Colloquia					
Undergraduate Research Day					
Phase 5: Test and Modify					
Finalize Thesis and Thesis Conference					

Future Directions

Compression technology

Durability testing

Advanced control system and electrical design

Alternative power supply

Alternate uses (food storage and shipping)

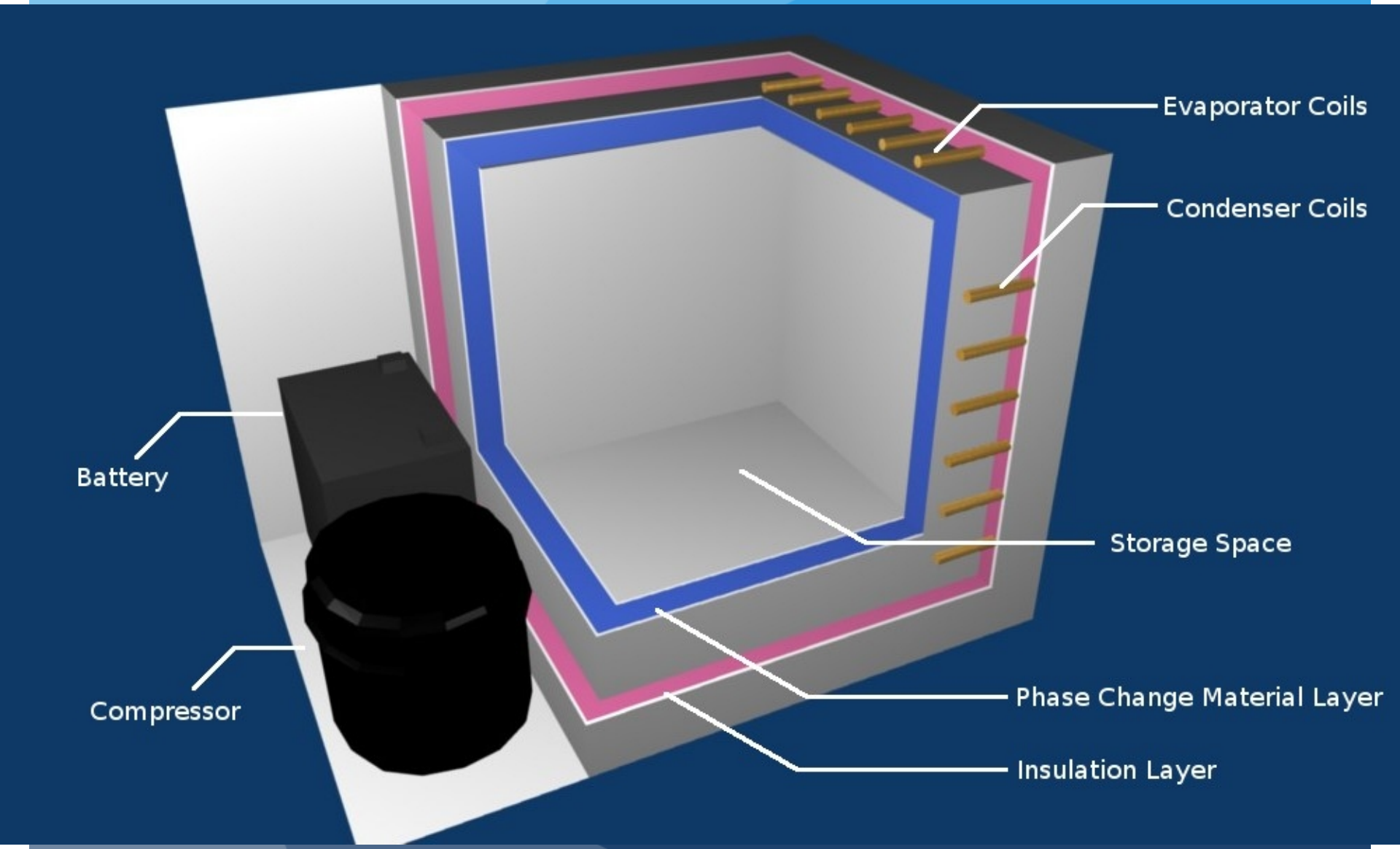
Cosmetics/Packaging

Acknowledgements

- Gemstone
  - Dr. Rebecca Thomas
  - Dr. James Wallace
  - Courtenay Barrett
- Experts
  - Dr. Muhiuddin Haider
  - Dr. Yunho Hwang

Questions?

Extra Slides


Evaporator Coils
Condenser Coils
Battery
Storage Space
Compressor
Phase Change Material Layer
Insulation Layer

Plan of Progress by Team

Click to edit Master text styles
- Second level
  - Third level
    - Fourth level
      - Fifth level

Team	Milestone/Deliverable	Spring 2010	Fall 2010	Spring 2011	Fall 2011	Spring 2012
PCM	Characterization and identification of PCM properties	X				
	Performance testing and selection of PCM		X			
	Integration of PCM into system and performance testing			X	X	
Structural and Electric	Determine fridge dimensions, materials, and energy sources	X	X			
	Integrate structural, electrical, mechanical and PCM components			X	X	
	Construct and test prototype			X	X	
Compression	Develop equations	X				
	Research and determine alterations and refrigerants	X	X			

Plan of Progress by Team

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Team	Milestone/Deliverable	Spring 2010	Fall 2010	Spring 2011	Fall 2011	Spring 2012
Proposal and Case Study	Apply for grants	X	X	X		
	Draft case study of cold chain		X	X	X	
Public Relations	Contact and establish connections with experts	X	X	X		
	Set up framework for education program	X	X	X	X	
	Research conferences	X	X	X		
Entire Team	Create design drawings of system		X	X	X	
	Simulate performance using a computer model		X	X	X	
	Fabricate integrated refrigeration system			X	X	
	Present at Fall Colloquia		X			
	Present at Undergraduate Research Day			X		
	Present at Senior Thesis Conference					X
	Finalize thesis					X