The Harvey Mudd College Clinic Program

Celebrating over 50 years of Clinic

HARVEY MUDD COLLEGE

Students: *Bright, Inventive, Fearless*

¾ of 2017's AmEx team…

HARVEY MUDD COLLEGE

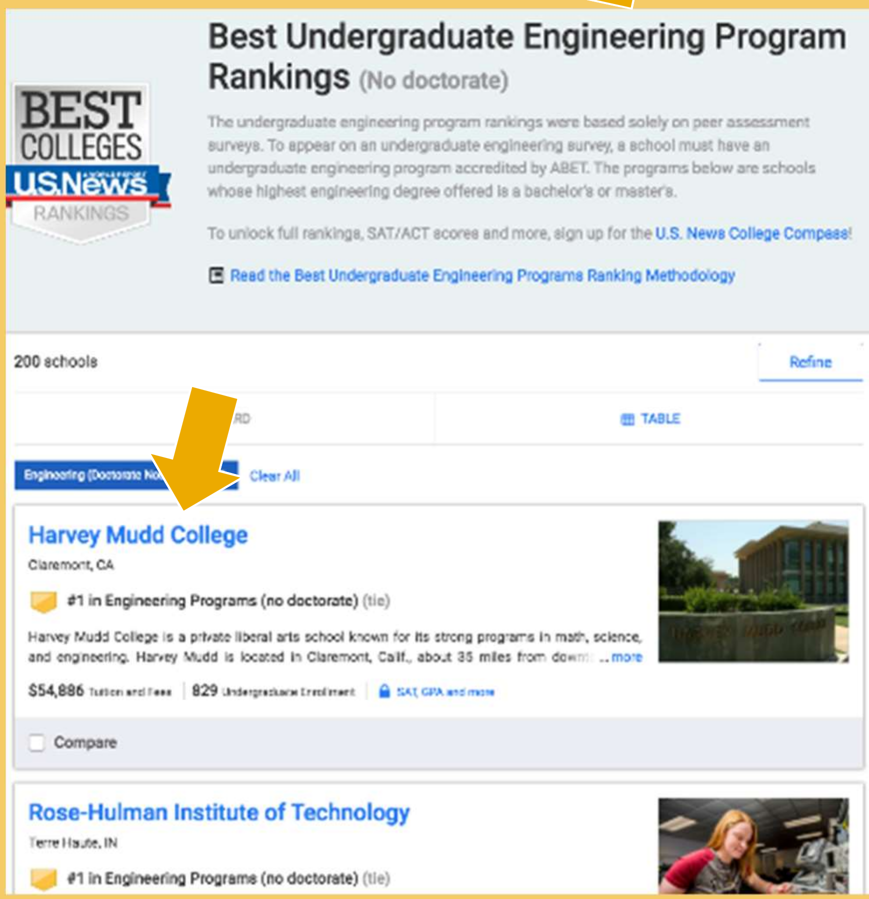
Students: *Bright, Inventive, Fearless*

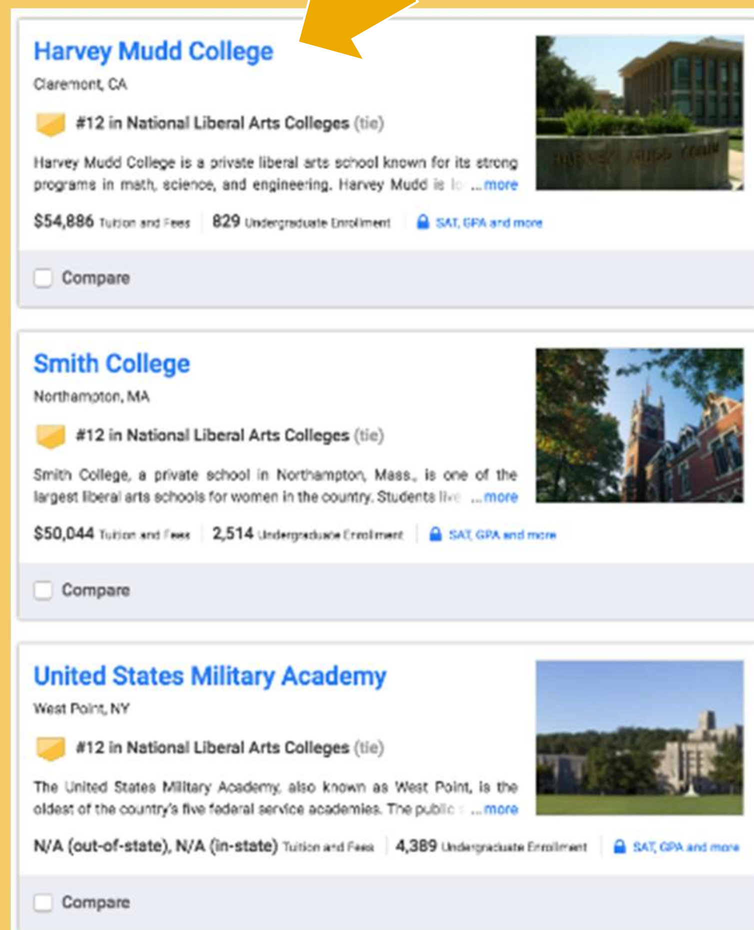
- **Most selective Liberal Arts College based on ACT/SAT**
  - 829 students   12% admit rate
  - Competition: Stanford, MIT, Caltech
  - Valedictorian or Salutatorian: 47%
- **45% go on to attain advanced degree**
  - Ranked #2 for Ph.D. pursuit
- **Mathematical and Interdisciplinary Contests in Modeling** (MCM / ICM)
  - Most "Outstandings" in the contests' history
- **ACM International Computer Programming Competition** (ACM)
  - Most recent US, only undergraduate school to win

Harvey S. Mudd,
mining engineer

HARVEY MUDD COLLEGE

Harvey Mudd College: prioritizing both Engineering and the Liberal Arts





Clinic Program ~ founded in 1963 as an Engineering Education Innovation

Over 1,500 projects completed to date…

Directors:

• *Engineering*	Profs. Kash Gokli & Qimin Yang
• *Mathematics*	Prof. Weiqing Gu
• *Physics*	Prof. Peter Saeta
• *Global Clinic*	Prof. Susan Martonosi
• *Computer Science*	Prof. Zach Dodds
• *Director of Corp. Relations*	Colleen Coxe

HARVEY MUDD COLLEGE

What *is* Clinic?

- **Sponsored Capstone-Project Course**

- starts in September, delivers in May
- team of 4 - 5 students & faculty advisor
- 10 hours/student/week: 1,200 - 1,500 hours total
- Fee is $50,000
- Sponsor owns all IP

HARVEY MUDD COLLEGE

Sponsor Benefits

- **Project deliverables**
  - All IP, patents, products
  - Mid-year and final report
  - All software, prototypes, documentation, hardware, …
- **Opportunities for recruiting**
- **Shaping student-education & -paths**

for Matterport: a custom-designed 3d game

HARVEY MUDD COLLEGE

Sponsor Obligations

- **Provides project idea / description**
  - We invite iteration on details, if you'd like…
- **Provides liaison** (~1-2 hrs/week)
- **Provides fee** ($50k, split into 3 payments)
- **Business agreement** (~3 pages)
- **Feedback at end of project**

HARVEY MUDD COLLEGE

Clinic's timeline

- **Fall, Winter, Spring** — Contact potential sponsors. Gather and iterate on project ideas
- **Jan. to April** — Prepare 1-2 page project statement, execute business agreement
- **by 1 July** — PS and BA due
- **July/August** — Post project statement for students, prepare for student teams
- **1st Tuesday in Sept.** — Projects start
- **1st Tuesday in May** — Projects Day

HARVEY MUDD COLLEGE

First Step: Identify a Project

- **Sponsor provides a written project statement**
  - tuned, if desired, with Clinic Director, for scope-matching to students' background, interests; 9-month academic span
  - *Recipe* ~ well-scaffolded start / MVP ; open-ended onward
- **Sponsor appoints a liaison to**
  - Monitor team progress, ~1 hr/week
  - Provide domain expertise, and
  - Ensure the path taken is of value to sponsor
- **Sponsor and HMC sign business agreement**
- **Faculty assigned, via interest and expertise**
- **Students assigned, via preferences and abilities**

HARVEY MUDD COLLEGE

The Year's Start: Orientation Day

- Liaisons invited to campus
- Meet with Clinic Director
  - Strategies and tips
- Meet with team and faculty advisor
  - Cover problem in detail
  - Discuss confidentiality
- Establish communication routine
  - Email/Slack/other
  - Weekly teleconferences
- Jumpstart the project, face-to-face
- Recruiting / internship opportunity

HARVEY MUDD COLLEGE

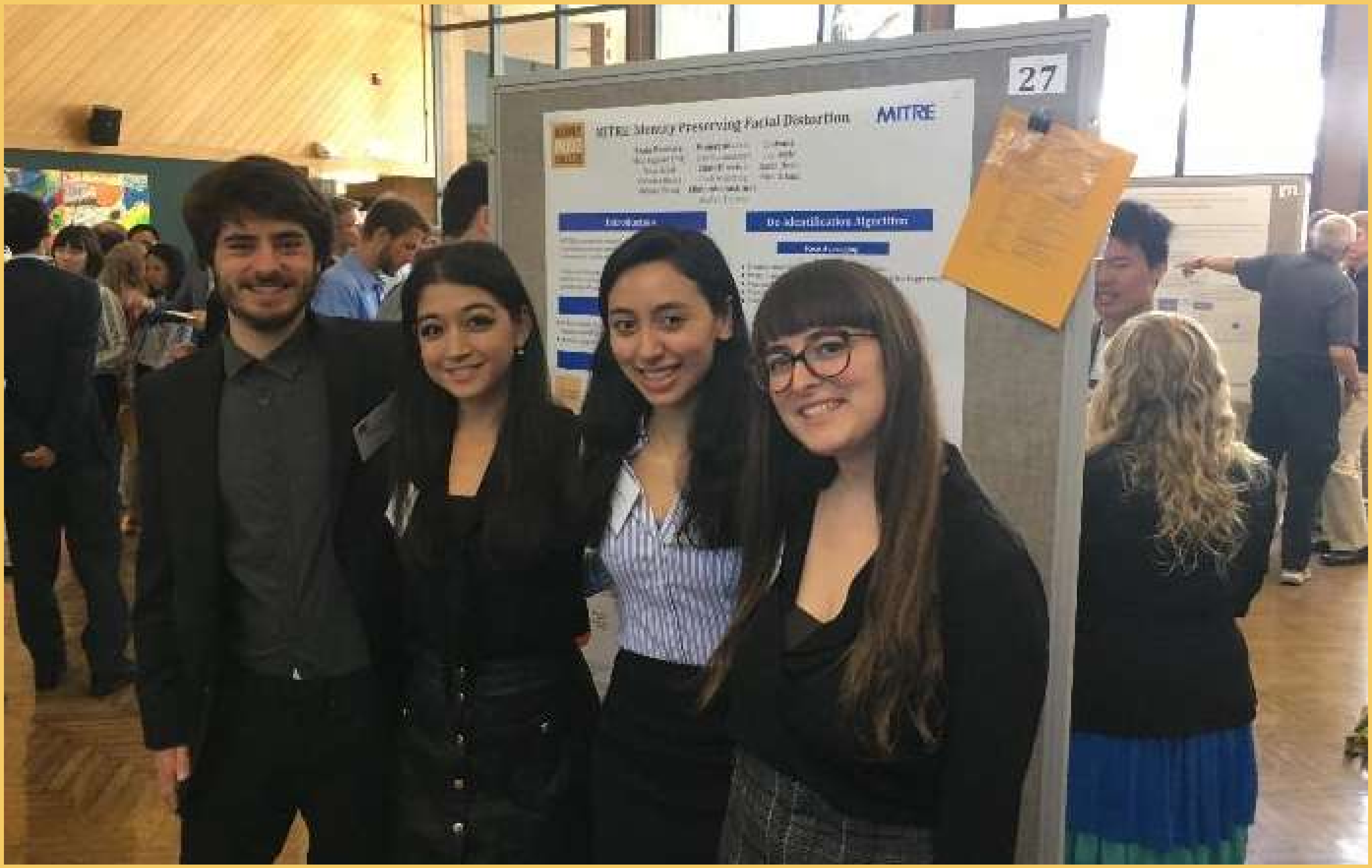
Year's End: Projects Day

- Sponsoring organizations invited to campus
- Presentations and poster sessions <u>*by all teams*</u>
- Celebration of student work and the year's progress

2006

2017

Year's End: Projects Day



MITRE team @ poster, 2017

HARVEY MUDD COLLEGE

2017 Clinic Sponsors

AEROSPACE
Assuring Mission Success

amazon
Lab126

AMERICAN EXPRESS

ARCONIC
Innovation, engineered.

at&t

BD
Advancing the world of health

BIG FISH

City of Hope

DOLBY

Dart NeuroScience
quality of mind

FICO

EDR

Genentech

GoDaddy

HRL LABORATORIES

hp

HARVEY MUDD COLLEGE

IBM

INTUITIVE SURGICAL

KAIAM

Laserfiche

LINCOLN LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

MOTIV

Microsoft

MISSION
connected, for good

MITRE

Computer Science, Engineering, Global, Mathematics and Physics Clinic Sponsors
2016 – 2017

NORTHROP GRUMMAN

New Relic.

niagara
BOTTLING, LLC

proofpoint.

proteus
DIGITAL HEALTH

REGENESIS

reddit

SoCalGas
A Sempra Energy utility

Sandia National Laboratories

SARACEN

TECHMATION
Innovation in Motion

TRIPLE RING technologies

TOYOTA

ULA
America's Ride to Space

WEBROOT

ZAM Helmets

Project? Recommendations:

- Sponsor value greater than fee
- Valuable, rather than critical …
- Job jar ~ speculative opportunities
    - *" If I had one more FTE"*
- No typical Clinic project:
    - *" R + D for our R & D"*
    - *" Optimizing – on a new axis..."*
    - *" Piloting hackathons' 2-5% "*

HARVEY MUDD COLLEGE

Thoughts?

2017 Clinic Sponsors

Computer Science, Engineering, Global, Mathematics and Physics Clinic Sponsors

2016 – 2017

Harvey Mudd College

- Aerospace – Assuring Mission Success
- amazon Lab126
- American Express
- Arconic – Innovation, engineered.
- at&t
- BD – Advancing the world of health
- Big Fish
- City of Hope
- Dolby
- Dart NeuroScience – quality of mind
- EDR
- FICO
- Genentech
- GoDaddy
- HRL Laboratories
- hp
- IBM
- Intuitive Surgical
- Kaiam
- Laserfiche
- Lincoln Laboratory – Massachusetts Institute of Technology
- Motiv
- Microsoft
- Mission Rubber Company – connected, for good
- MITRE
- Northrop Grumman
- New Relic.
- niagara Bottling, LLC
- proofpoint.
- proteus Digital Health
- Regenesis Biomedical
- reddit
- SoCalGas – A Sempra Energy utility
- Sandia National Laboratories
- Saracen
- Techmation – Innovation in Motion
- Triple Ring technologies
- Toyota
- ULA – America's Ride to Space
- Webroot
- ZAM Helmets

2016 Clinic Sponsors

AEROSPACE
Assuring Space Mission Success

amazon
Lab126

AMERICAN EXPRESS

at&t

BD
Advancing the world of health

bing

BiMBy Power Company, LLC

City of Hope

EDR

GIMBAL

HRL LABORATORIES

intel

Laserfiche

LINCOLN LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

KINOHI

Lawrence Livermore National Laboratory

HARVEY MUDD COLLEGE

mission
RUBBER COMPANY
connected, for good

niagara
EST.1963
BOTTLING, LLC

Los Alamos
NATIONAL LABORATORY
EST. 1943

MITRE

HARVEY MUDD COLLEGE

Computer Science, Engineering, Global, Mathematics and Physics Clinic Sponsors

2015-2016

OAKLEY

PHARMAVITE

TURN 10

NOAA
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE

NORTHROP GRUMMAN

Project Spock

Project Magneto

proteus
DIGITAL HEALTH

RainCatcher

REGENESIS
BIOMEDICAL

TAG
Technical Authentication & Grading

TELEDYNE CONTROLS
Everywhereyoulook

Sandia National Laboratories

SPACEX

Steelcase

THE WILDLANDS CONSERVANCY

yelp

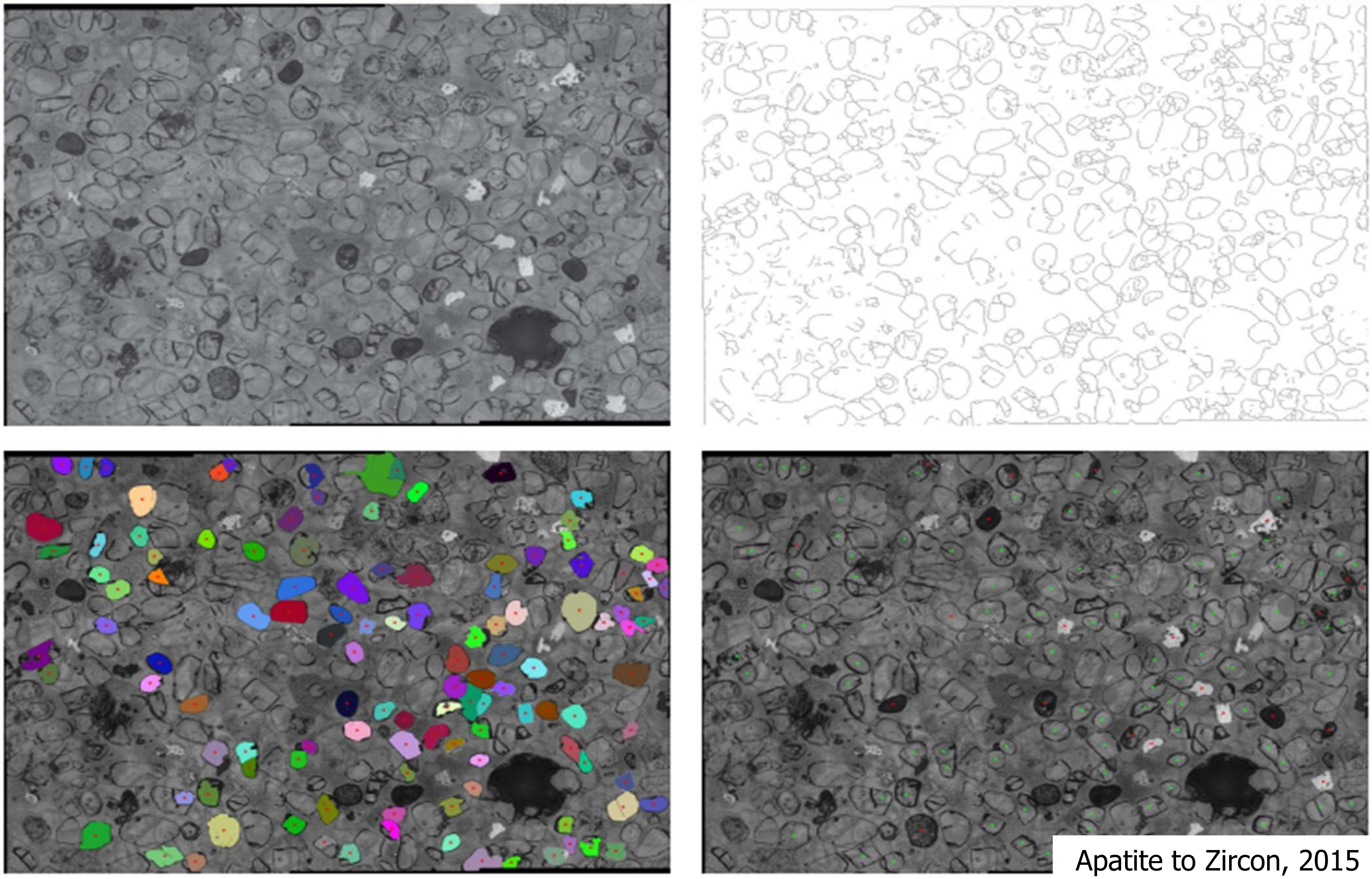
zendesk

Time Inc.

WEBROOT

Whistle

Example clinic projects...



Apatite to Zircon, 2015

Remaining slides are extra...

Computer Security (CS)

2011-2012 Aerospace CS Clinic

Improving Android Smartphone Security

HARVEY MUDD COLLEGE

AEROSPACE
Assuring Space Mission Success

Adam Cozzette, Kathryn Lingel, Steve Matsumoto, Oliver Ortlieb

Android phones are insecure

We have identified and addressed two common types of security vulnerabilities related to the Intents system (Android's application communication system).

Applications in Google's Android operating system communicate via messages called *Intents*. Novice developers often write code that creates security holes by misusing the Intents system.

Applications can leak your information

Sending the wrong kind of Intent can broadcast sensitive information to other applications.

Intents can be *explicit* (having a specific target) or *implicit* (with a target determined at run time). *Intent leakage* occurs when a malicious application intercepts an implicit Intent that it was not supposed to receive.

Apps can get hijacked by other apps

Trying to filter Intents makes an application publicly visible.

Android allows an application to declare an *Intent filter*, which specifies the types of Intents it can handle. Declaring an Intent filter causes an application to become *exported* (publicly visible). *Intent spoofing* occurs when an exported application receives and handles an Intent from an unexpected source. This behavior could cause the application to perform undesired operations.

Controlling Intents protects information

Only broadcast information if the sender can't process it.

If an application can handle an Intent it sends, we deliver the Intent only to the sender on the assumption that that it was meant for internal use. Otherwise, since the Intent was obviously meant for another application, it can be broadcast safely.

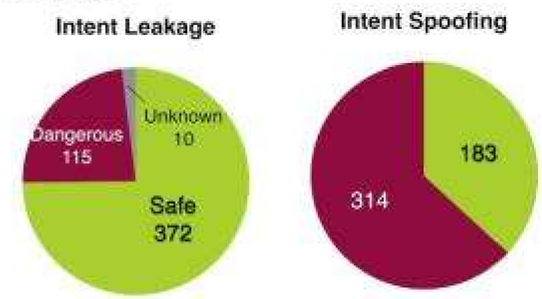
Controlling visibility protects applications

Only make an application visible if it deliberately says so or if it is clearly designed to receive Intents from other applications.

We changed Android so that an application is only exported if it deliberately exports itself or if it filters for Android system actions or Intents that contain data.

Are these problems widespread?

We developed two tools for analyzing application code and detecting applications that are likely to be at risk for Intent leakage or Intent spoofing. These tools look for applications that improperly use implicit Intents for internal communication that should be private.



We tested 497 apps and found 115 possible Intent leakage vulnerabilities and 314 possible Intent spoofing vulnerabilities.

The "dangerous" applications above have Intent leakage/spoofing vulnerabilities which may be able to be exploited by a malicious application. For compatibility reasons, we could not test 10 of the applications for Intent leakage.

The vulnerabilities we addressed are quite common, and our simple changes to Android fix many of them automatically. Furthermore, because our defense changed existing parts of Android rather than creating new parts, we had to do little to ensure that everything worked with the current system. Although backward compatibility is harder to test, the changes we made should maintain compatibility with most existing applications.

We can conclude that our improved Intents system is effective, easy to integrate into Android, and a step in the right direction.

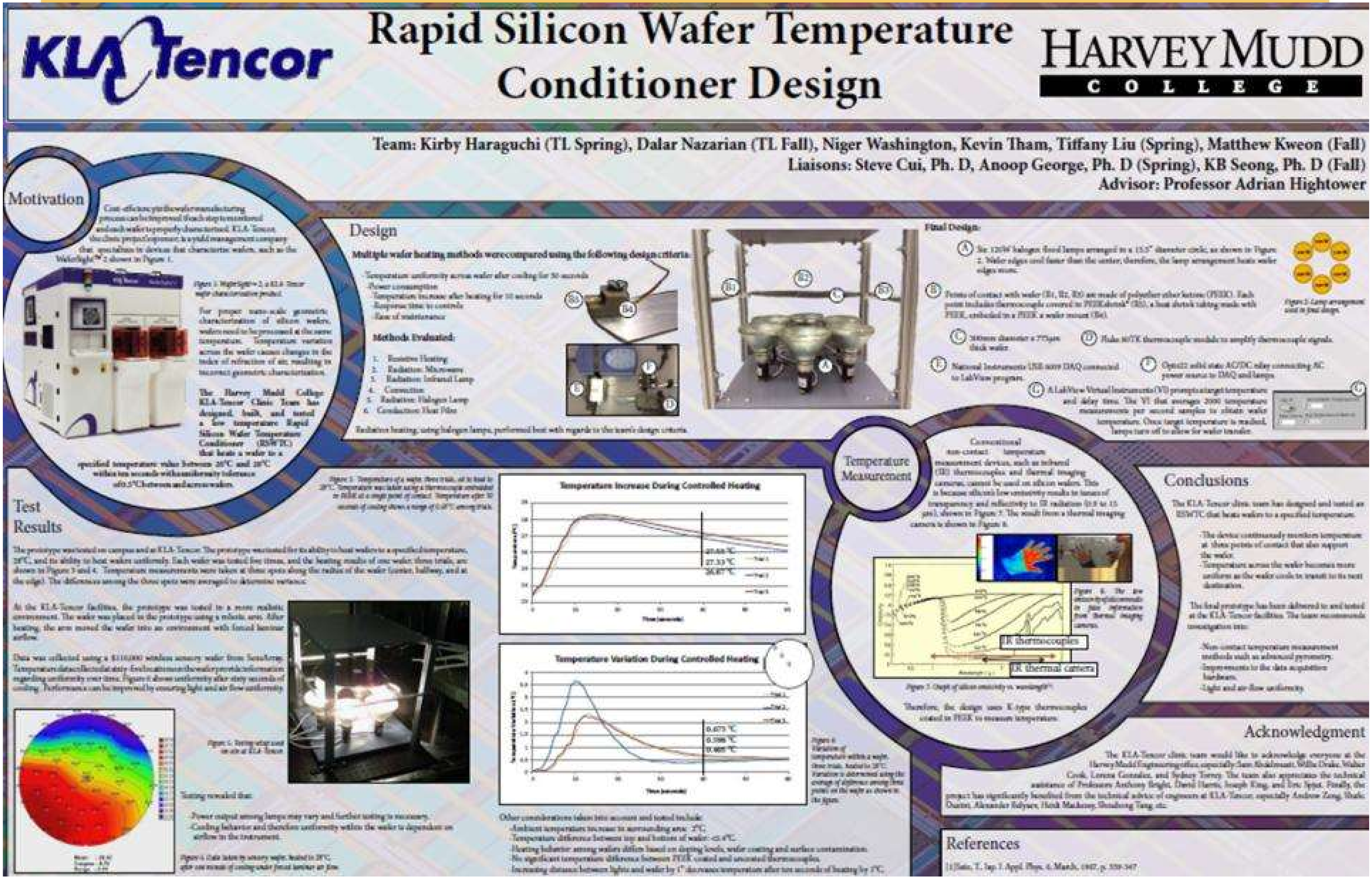
Acknowledgments

Our liaisons at Aerospace, for their technical expertise and constant support throughout the project: Joe Betser, Jandria Alexander, Luke Florer, Adam Jackson, John Nilles, Peter Reiher

The research team at UC Berkeley whose ideas inspired and laid the foundations for our work: Erika Chin, Adrienne Porter Felt, Kate Greenwood, David Wagner

Our faculty advisor, Geoff Kuenning, for his helpful advice and feedback at every stage of our project

Silicon Wafer Conditioner (Engineering)



IV Pump Control (Mathematics)

CardinalHealth

2005-2006 Cardinal Health Mathematics Clinic

Modeling and Control of the Next Generation of IV Pumps

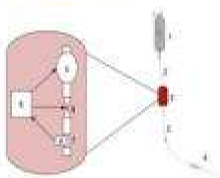
mathematics
harvey mudd college

Cardinal Health

Cardinal Health and the Alaris Product division seek to create a new generation of IV infusion systems that are more accurate, energy efficient, and compact than previous models. The Hybrid IV Infusion System diagrammed below has been proposed for this purpose.

Hybrid IV Infusion System

1. IV fluids bag
2. IV tubing
3. Pump device
4. Catheter
5. Motive Pump
6. Restrictor
7. Flow Sensor Channel
8. Flow Sensor
9. Control Algorithm



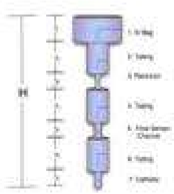
Problem Statement

Our task is to propose and develop a control algorithm for the above-diagrammed Hybrid IV Infusion System. It will query the flow sensor for the current flow rate and then adjust the restrictor and/or motive pump to maintain the desired flow profile. Our goal is to minimize power consumption while conforming to the specified accuracy goals.

Multiple Cylinders Model

To model fluid flow through the Hybrid IV Infusion System, we first derive the equation governing flow through a single cylinder assuming laminar Hagen-Poiseuille flow.

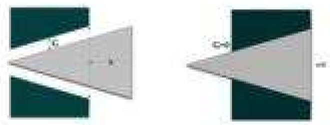
We can then model the system without the pump as a series of vertically aligned cylinders of varying height and radii. By modeling components in series, we can consider the resistance to fluid flow through each component. We then use the sum of these resistances to derive a flux equation. In order to have a complete, robust model of the system, we need to include the pump and better model the geometry of the restrictor.



Multiple Cylinders Model

Restrictor Model

The restrictor is a needle valve whose position is controlled by a DC gear motor. It consists of a conical needle which can be inserted into a conical flow channel to impede flow, or retracted out of the channel to allow greater flow. Below is a two-dimensional depiction of the needle valve, where x measures its position, and G the gap through which fluid flows.



We previously modeled the restrictor as a single cylinder, but we can more accurately model the needle and channel as inner and outer concentric cylinders, respectively. Thus fluid flows through gap G between the inner and outer cylinders, creating an annular flow region. We then find the resistance to flow in this annular region and incorporate it into the Multiple Cylinders Model as this restrictor resistance.

Pump Model

The pump consists of a chamber and two one-way valves, one above and one below. The chamber expands, pulling fluid into the pump from above, then contracts, driving fluid out of the pump. The geometry of the chamber is very complicated and is thus very difficult to model directly. Therefore we model the pump as a black box; we fit data provided by Cardinal Health to model the pump's effect on fluid flow. We then combine this pump model, the restrictor model, and the Multiple Cylinders Model to find an equation of flow through the entire Hybrid IV Infusion System.

Control Algorithm

The goal of our controller is to deliver the correct amount of fluid to the patient, within an error tolerance of 1%. To facilitate correct delivery, we have control over two variables: the position of the restrictor's needle and the duty cycle to the pump. With two control variables, many configurations will produce the desired flow rate, and part of our task was to strike a balance that minimizes power consumption while remaining accurate. Our algorithm combines feedback and adaptive feedforward techniques to control these two variables with power consumption in mind.

Restrictor Control

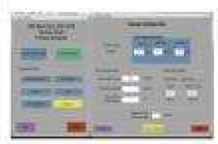
Moving the restrictor gives us fine control over flow rate. To determine the most appropriate needle position, we combine the outputs of an adaptive feedforward controller and a feedback controller. The feedforward controller determines the dependence of flow rate on restrictor position by taking successive readings from the flow meter, and outputs the restrictor position that it predicts will yield the desired rate. To eliminate accumulated error, we supplement this with the output from a PID feedback controller.

Pump Control

When conditions are such that opening the restrictor alone is not enough to obtain the desired flow rate, we must turn on the pump to increase downstream pressure. Our controller acts by incrementing or decrementing the duty cycle to the pump, using a number of heuristics to determine when it is appropriate. If the restrictor is wide open and flow is insufficient, we increase the pump activity; similarly, if the restrictor is closed beyond a certain threshold, we decrease activity. Additionally, our controller can shortcut these in an intelligent manner by predicting the maximum obtainable flow under a given pump regime, and effecting necessary changes in pump activity pre-emptively.

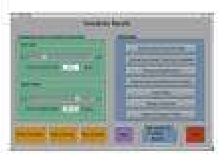
Performance Evaluation

In order to test the performance of the control algorithm and to facilitate further development, we have created a Graphical User Interface (GUI) to control the entire system in simulation. Through the GUI, users have access to the parameters that define a specific drug delivery scenario.



Before Delivering Fluid

Static parameters including the dimensions of system components and the type of fluid being delivered are set before a simulation run begins.

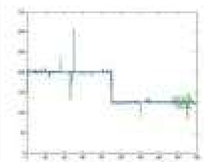


While Delivering Fluid

Other parameters such as the desired flow rate and the elevation of the bag above the patient can be adjusted dynamically while fluid is being delivered in order to stress the system.

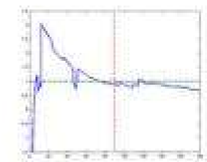
Results in Simulation

Even under many non-standard conditions, our control algorithm achieves the target accuracy goal. The following shows the results of a difficult scenario including both a change in flow rate and fluctuating bag height.



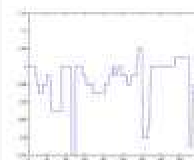
Flow Rate Over Time

The blue line is the desired flow profile. The green line tracks the actual flow rate through the system.



Percent Error in Fluid Delivered

The green line indicates a 1% error. The red line marks 5 mL of fluid delivered. The blue line shows the percent error in total fluid delivered over time.



Fluctuating Head Height

In the fluid delivery simulation shown above, the height of the IV bag fluctuates randomly. This may occur during patient transport. A drop in bag height can also simulate an increase in back pressure due to downstream occlusion.

Deliverables

- Mathematical model of Hybrid IV Infusion System including individual models of all system components
- Control algorithm and all necessary m-files
- GUI with supplemental help files

Acknowledgments

Cardinal Health Liaisons
Bob Butterfield
Paul Dewey

Team Members
Sarah Mann (Team Leader), Hope Runyeon, Susanna Ricco, Reid Howard

Faculty Advisor:
Andrew Bernoff

Tagged-Neutron Calibration Source (Physics)

Tagged-Neutron Calibration Source for a Prototype Car-Wash Neutron Detector

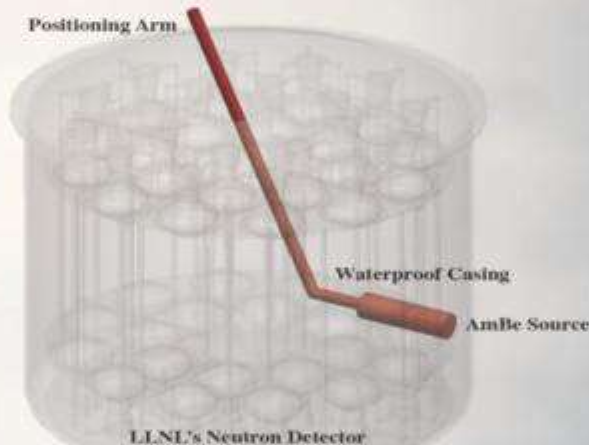
May 5th, 2009

Joint Engineering / Physics Clinic

Team Members: Lupita Bermudez, Elizabeth Ellis, Jonathan Hubbard, Rachael Martin, Reuben Villagomez
Project Advisors: Professor Richard Haskell, Professor Rnye Wang
Project Liaisons: Dr. Adam Bernstein, Dr. Steven Dazeley

Abstract

The Physics/Engineering Clinic team has designed and constructed a waterproof tagged-neutron source that allows LLNL to measure the efficiency of their water-based neutron detector prototype.

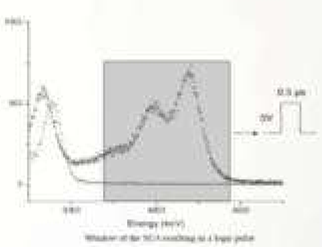


Project Statement

- AmBe source emits neutrons in time-coincidence with 4.4 MeV gamma rays, which we detect with a Bismuth Germanate (BGO) scintillation detector, thereby "tagging" neutrons.
- Electronic circuit transmits a signal to the LLNL neutron detector when a neutron is "tagged."
- Tagged-neutron source must be robust, waterproof, and movable within the detection cavity with < 1.5cm spatial resolution.
- Will be used by LLNL to measure the efficiency of their water-based neutron detector prototype.

AmBe Source: Three Peaks

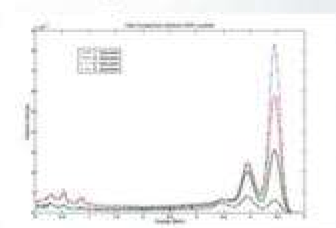
- "Tagging" gamma rays are absorbed through pair production events which results in three peaks (4.4, 3.9 and 3.4 MeV).
- These three peaks correspond to the existence of a neutron.



- A detection in this region produces a signal that indicates a coincident-neutron emission of the AmBe source.
- The signal is sent to LLNL's water-based detector.

Design Validation with MCNPX

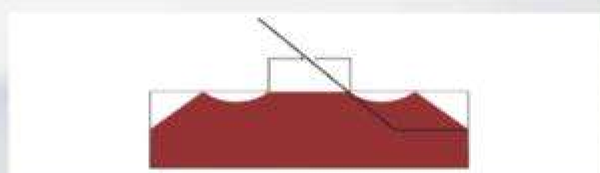
- Monte Carlo N-Particle eXtended was used to calculate theoretical gamma ray capture for a scintillation crystal to evaluate design selections.



- The dependence of gamma detection rate on crystal size was modeled.
- A crystal with height and radius 2" was chosen to balance efficiency with weight.

Positioning Arm

- A fixed-angle arm was chosen for operational simplicity. The arm covers the area shown in red.

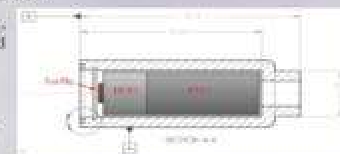


Special Thanks to:

Annie Atyeh, Professor King, Walter Cook, Dennis Carr, Mike Wheeler, Engineering Staff, Dr. Steven Dazeley, Dr. Adam Bernstein

Waterproof Casing

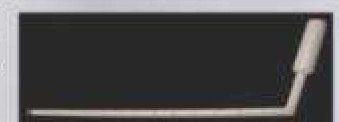
- LLNL's neutron detector uses gadolinium dissolved in water to capture and detect neutrons.
- A waterproof casing, sealed with a threaded plug and a rubber O-ring, protects the AmBe source, the BGO crystal, and the photomultiplier tube from the water.



Schematic of the waterproof casing

Positioning Procedure & Use

- LLNL wishes to move the tagged-neutron source within the water-based detector with a spatial resolution of 1.5cm in positioning accuracy.
- We will provide a coordinate measurement protocol for positioning our tagged-neutron source.
- A rotary clamp on a crossbar provides two degrees of freedom in position. A digital level and compass will be used to measure the position of the source.
- Current procedures result in an uncertainty of 1.7cm in the position of the tagged-neutron source, but this is expected to decrease with practice.



The positioning arm

Final Design

- Fixed-angle high-performance polyethylene positioning arm with aluminum reinforcement
- Coordinate measurement protocol for positioning the tagged-neutron source
- AmBe source
- BGO scintillation crystal
- Custom waterproof casing with O-ring
- Gamma ray detection signaling protocol

Prior Sponsor Recommendations Are Strong: You Can Ask Them

- **Becton, Dickinson and Company (BD):** *Robert D. Butterfield, Research Fellow, Infusion and Respiratory Systems, (858) 617-5787*
- **Honeywell:** *James Van Ackeren, Manager, Performance Analysis, (310) 512-4832*
- **Lawrence Livermore National Laboratory:** *Adam Bernstein, Advanced Detector Group, I-Division, (925) 422-5918*
- **Northrop Grumman Corporation:** *Charles Volk, Vice President and Chief Technologist, (818) 719-7765*

HARVEY MUDD COLLEGE

Prior Sponsor Recommendations Are Strong: You Can Ask Them (cont.)

- **Opto 22:** *Mark Engman, President and CEO, (951) 695-3000*
- **Oregon Biomedical Engineering Institute:** *Kenton Gregory, President, (503) 216-5210*
- **The Aerospace Corporation:** *Joseph Betser, Senior Project Leader, Business Development, (310) 336-0577*

HARVEY MUDD COLLEGE

Harvey Mudd College was first and still sets the standard

- Clinic gives Sponsor fresh ideas on an important problem
- Team of sharp, motivated and creative students working for a whole year
- Joint projects across specialties common
- Many projects lead to patents
- Many results are implemented
- Many sponsors return in subsequent years
- Student recruiting opportunities

HARVEY MUDD COLLEGE

Project Areas

Engineering strengths in:

- General Engineering
- Biomedical Engineering
- Computer Engineering, Embedded Processors
- Systems & Signals, Controls
- Conceptual Design

HARVEY MUDD COLLEGE

Project Areas (cont.)

Computer Science strengths in:

- User Interfaces
- Data Mining
- Artificial Intelligence / Robotics
- Distributed Systems / Parallel Processing
- Algorithms
- Computer Vision
- Graphics / Visualization
- Computer Games
- Systems and Networking

HARVEY MUDD COLLEGE

Project Areas (cont.)

Math strengths in:

- Operations Research/Statistical Models
- Algorithms
- Dynamic Models
- Bioinformatics
- Mathematical modeling and optimization
- Statistics and machine learning
- Fluid dynamics
- Numerical methods

HARVEY MUDD COLLEGE

Project Areas (cont.)

Physics strengths in:

- Nuclear
- Optics & E&M
- General Physics

HARVEY MUDD COLLEGE

HMC's Common Core
Makes Our Students Even Better

- **Calculus:** *Required prior to admission*
- **Mathematics:** *3 semesters (multivariate calculus, linear algebra, differential equations, probability and statistics)*
- **Physics:** *2-1/2 semesters with lab*
- **Chemistry:** *1-1/2 semesters with lab*
- **Biology:** *1 semester*
- **Engineering:** *1 semester (systems engineering)*
- **Computer Science:** *1 semester*
- **Writing:** *½ semester (Intro to Academic Writing)*
- **Choice Lab:** *Emphasizing experiential learning*
- **Humanities, Social Sciences and Arts:** *11 semesters*

HARVEY MUDD COLLEGE

Global Clinic at Harvey Mudd College

Partnerships with universities and sponsors in Puerto Rico, Singapore, Iceland, India, Japan & Israel since 2006

NANYANG TECHNOLOGICAL UNIVERSITY

NUS National University of Singapore

UNIVERSITY OF ICELAND

工学院大学 KOGAKUIN UNIVERSITY

TECHNION Israel Institute of Technology

HARVEY MUDD COLLEGE

Wastewater Treatment System Design (Global Clinic)

HARVEY MUDD COLLEGE

NANYANG TECHNOLOGICAL UNIVERSITY

2009–2010 LIFE Global Clinic

Wastewater Treatment in Rural China

LIEN Institute for the Environment

Fred Johnson Erin Partlan Cidney Scanlon Claire Walker

Abstract

The Lien Institute for the Environment (LIFE) works in individual communities within developing countries to produce appropriate and life saving water, sanitation, and shelter technologies. The Nanyang Technological University and Harvey Mudd College Global Clinic team has undertaken the project of designing a wastewater treatment system for household use in the Jiaoyuan village, in the Sichuan province of the People's Republic of China. People throughout rural China, and other countries, collect their blackwater in large pits and deposit the waste directly on their crops without treatment. This practice has led to millions of deaths worldwide. The team has evaluated the available options for blackwater treatment and is designing a composting system that will produce quality fertilizer while being easy to build and maintain in a local context.

Problem Statement

With the creation of the Three Gorges Dam and subsequent reservoir, China has had to face its new and preexisting water issues, such as:

- Maintaining high water quality standards within the reservoir. This is critical in order to supply safe drinking water to a vast section of China's population.
- Dealing with wastewater from rural communities. Though China has built numerous wastewater treatment plants, systems used in cities and suburban areas are not economical on a small scale.

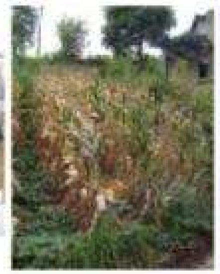
The team aims to devise a solution for rural wastewater treatment, based on the rural community of Jiaoyuan, located near Chongqing in the drainage basin of the Three Gorges Reservoir. The goals for the design are to:

- Reduce the pollution level of the river running through Jiaoyuan. Domestic greywater flows slowly along the ground and then into the river, which is eventually deposited into the Three Gorges Reservoir.
- Increase the quality and safety of the waste to which the villagers are exposed. In Jiaoyuan Village, blackwater is directly deposited in a manure pit and used when needed, without treatment, as fertilizer.
- Preserve as much of the waste as possible during the composting process and maximize the quality of the fertilizer.
- Be adaptable for different villages and household sizes in rural China, and for rural villages throughout the world.
- Be inexpensive and simple to operate and maintain in a local setting.

Jiaoyuan Village

Village Statistics:

- 812 households of 3-4 members per household
- Total land area of 2 sq. km, but total farmland is 1.44 sq. km
- Crops grown include corn, sweet potato, beans, rice and other fruits and vegetables. They also raise pigs, chickens and ducks.
- Trash and pollutants collect in the Liangtan river that runs through Jiaoyuan.



Wastewater:

Wastewater is collected in a manure pit built by individual families near the home toilet and the animal houses to collect the blackwater from both sources. Blackwater is wastewater from toilets, containing human and/or animal feces and urine. Blackwater is distinct from greywater, which consists of domestic wastewater produced by activities such as bathing, dish washing, and laundry.

There is no collective wastewater treatment facility in the village. The Chinese government offers some solutions such as septic tanks and anaerobic digesters, but these systems cannot be implemented without assistance.

Thermophilic Composting Latrines

The team has decided to use a Multrum composting latrine with several modifications for use in rural villages in China:

- Thermophilic processes instead of dehydration processes. This will decrease the time needed to produce safe fertilizer.
- A mechanical time-delay before the waste is made accessible. This will let the villagers know when the fertilizer is safe to be used on their crops.

The team is currently testing several aspects if this design.

- Construction of original Multrum composting latrines to test thermophilic processes.
- Mathematical and physical modeling to determine the exact dimensions and mechanics of the time-delay.

The team also plans to construct a full size latrine which will implement both design modifications.

Nanyang Technological University (NTU)

The team members working at NTU have fully designed and built constructed wetland facilities with the following specifications:

- Vertical, three layered, Sub-Surface Flow Constructed Wetland (SSFCW) system. Scalable to both household or cluster.
- Use of local plants to determine the maintenance requirements regarding management and harvesting, and to find solutions to mosquito breeding, clogging and odor problems that may arise.

The team members at NTU are also designing a solar-powered river aeration system for use downstream of the village. Water characteristics will be measured sequentially before entering the wetlands, after exiting the wetlands and again after going through the aeration process. Testing on a scaled system will:

- Measure the quality of the runoff after undergoing aeration.
- Determine the amount of power needed to increase the river quality in order to approximate the number of solar cells required.

Implementation

To ensure that the final product will actually be utilized by the Jiaoyuan village, the team will create a business plan for implementation that will include:

- Social considerations such as the daily activities of the villagers, customs regarding domestic activities and horticulture, and openness to foreign involvement.
- Economic considerations such as costs for the villagers (materials, initial fertilizing time lost) as well as the cost of education in presenting the new design to the village.
- Logistics, such as the actual presentation of the design from a trusted source and the transport of materials not readily available in the village.
- Recommendations for the design based on differences in weather and average diet between Jiaoyuan and Claremont.
- General recommendations for alterations that will make the design applicable to other locations as well.

Deliverables

We will deliver the following to LIFE:

- Thermophilic composting latrine design.
- Constructed wetland design for local Chongqing climate.
- Solar powered river aeration plan for the Liangtan River.
- Business plan for implementation, operation and maintenance of the wastewater treatment system.

Acknowledgments

LIFE Liaison
CHAI Kok Chiew

Faculty Advisor
Professor Lisette de Pillis

Thank you to the Bernard Field Station for the use of their facilities.

Thank you to Babcock Laboratories.

For More Information

https://www.hmc.edu/clinic

Director of Corporate Relations: Colleen Coxe

(909) 607-7015

colleen_coxe@hmc.edu

Corporate Relations Coordinator: Kelly Barker

(909) 607-0898

Fax: (909) 607-0900

kelly_barker@hmc.edu

HARVEY MUDD COLLEGE

The Year's End: Projects Day

GoDaddy team's presentation

HARVEY MUDD COLLEGE

Year's End: Projects Day

AmEx team's dinner

HARVEY MUDD COLLEGE

and beyond…

AmEx team's visit

The Year's Start: Orientation Day

- Liaisons invited to campus
- Meet with Clinic Director
  - Strategies and tips
- Meet with team and faculty advisor
  - Cover problem in detail
  - Discuss confidentiality
- Establish communication routine
  - Email/Slack/other
  - Weekly teleconferences
- Jumpstart the project, face-to-face
- Recruiting / internship opportunity

inside a weekly telecon

HARVEY MUDD COLLEGE