



**THEORY**

**PRACTICE**

**IMPACT**

**Center for Global Public Safety**

September 17, 2018

# Agenda

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- Mission & Vision
- Five Year Strategy
- Phase I: Initiate
- Phase II: Growth
- Phase III: Scale & Sustain

# CENTER FOR GLOBAL PUBLIC SAFETY





# Mission: Making the World a Safer Place.....

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With an initial focus in key areas such as:

**FIRE PROTECTION**

**WATER SECURITY**

**FOOD SAFETY**

**ENERGY INNOVATION**

**TRANSPORTATION**

**FIRST RESPONDER TECHNOLOGIES**

# Vision: To be a Global Leader in Creating a More Resilient World

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World-wide safety is our focus



- Research and innovation
- Training and education
- Partnering with industry, government, academia and NGO's

# Five Year Center Growth Strategy

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# Phase I: Initiate *(Up to Sept 2017)*

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- Presidents Leshin and Qiu envision and launch the Center in 2016
- MQP project with Siemens China on Smart Field Devices for Flow of HVAC Units in Buildings
- 1st Symposium on ***Resilient and Smart Cities*** in Beijing at Tsinghua in 2017
- Graduate student exchange with Tsinghua in FPE – Prof. Ali Rangwala
- Supporting WPI PhD ME Fire Resistance of Geo-polymers – Prof. Jianyu Liang
- Initial Center funding secured from JENSEN HUGHES, Lion Inc., Mickey Reiss and anonymous donor



# Phase II: Growth *(Oct 2017 – Sept 2018)*

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- Hiring of Administrator and securing space
- Tsinghua PhD student working w/WPI Prof. Rangwala will present at upcoming US Combustion Conference
- Award of CGPS Seed Grants
- UAE initiatives
  - Retained local consultant
  - Khalifa University
  - UAE Civil Defense
  - American University of Sharjah (AUS)
- CGPS Reception on March 8 on WPI campus
- Industry Stakeholders Forum at WPI on April 30, 2018





# Phase II: Growth *(Continued)*

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- Populate CGPS Advisory Board
- Establish relationships with Government Agencies in the Public Safety Space
- ECE TA w/Prof Huang to work on 3D model area for Smart Fire Truck Project
- WPI ME PhD Student will conduct research at Tsinghua (Summer 2018)
- 2 WPI IQP teams at Tsinghua (Summer 2018) Smart Fire Truck Project  
Liang/Huang
- 2nd CGPS Symposium at WPI on Sept 17, 2018
- Continue to fundraise

# Phase III: Scale & Sustain (Sept 2018 – 2020)

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- Expand opportunities with industry engagement
- Build on Seed Grant research
- Establish expertise in key areas of global safety
- Deliver *Global Safety Index* (risk indices by country)
- Formalize joint WPI/Tsinghua MS/PhD and research programs
- Functioning BS/MS and certificate program in FPE with Khalifa University
- On-site implementation of project-based learning at AUS



# Phase III: Scale & Sustain *(Continued)*

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- Scaling of **research** and **innovation** opportunities at Tsinghua, Khalifa, UAE Civil Defense and AUS
- Annual CGPS Symposiums with academic and industry partners
- Target other strategic universities (Latin America, Africa) for expanding the BS/MS and certificate program model
- Establish sustainable funding model (blend of membership, philanthropy, and group funded programs)

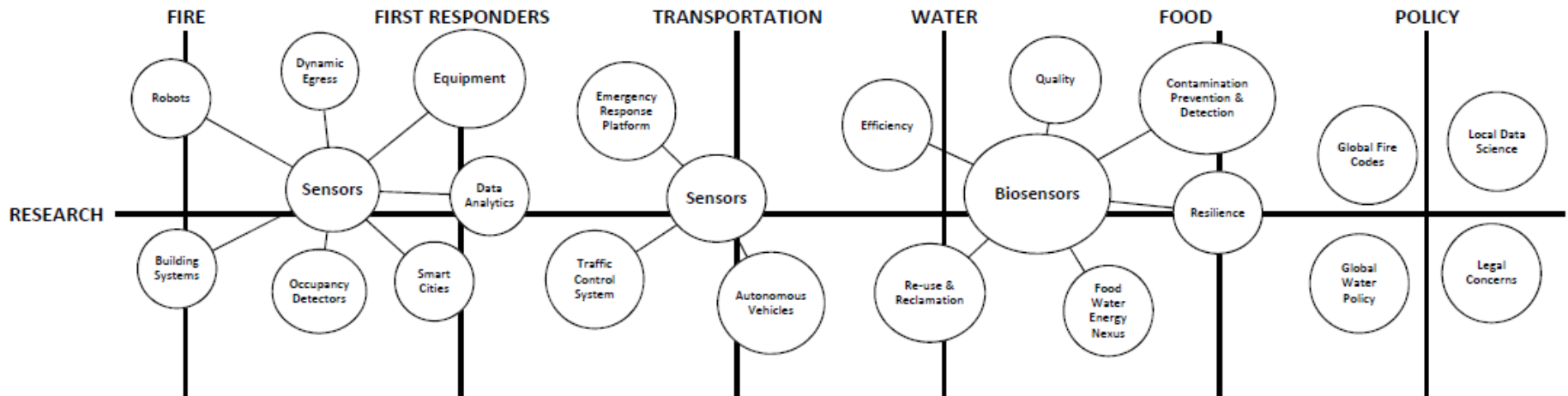
# Feedback from April Forum

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- Significant feedback received from multiple stakeholders during the Stakeholders Forum that was held at WPI in April
- Stakeholders provided inputs on Research and Innovation, Education, Outreach to Industry, Government and Development Partners
- Analyses of multiple inputs provided new insights for the development of the Center for Global Public Safety
  - Strong interest in the development of multi-functional sensors
  - Opportunity to build multi-disciplinary groups in water and energy resilience (from ideas to markets and policy)
  - Further engagement of companies, donors and development partners e.g. World Bank

# Strong Interest in Sensors

- Participants expressed strong interest in the development of sensors for the detection of hazards
  - Fire
  - Chemical contaminants in water e.g. Pb
  - Biological contaminants in water and food





# Multidisciplinary Water Research and Education

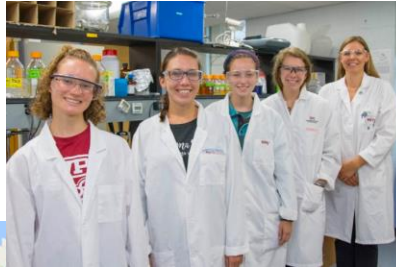
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- Multidisciplinary Research Team Initiated – Natalie Farny, Jeanine Plummer, John Bergendahl, Paul Mathisen, Eric Young, Xinming Huang, Jeannine Coburn, Danielle Cote
- Synthetic biology approaches being explored for the detection of chemical contaminants such as lead
- Builds on prior work by Natalie Farny and Eric Young
- Leverages the experience of Plummer, Bergendahl and Mathisen in water research
- Potential to link WPI teams to Tsinghua Synthetic Biology teams in iGEM competition

# What is iGEM?



- International Genetically Engineered Machines Competition
- “Synthetic Biology” – applying engineering design principles to the creation of novel biological systems



In 2017:

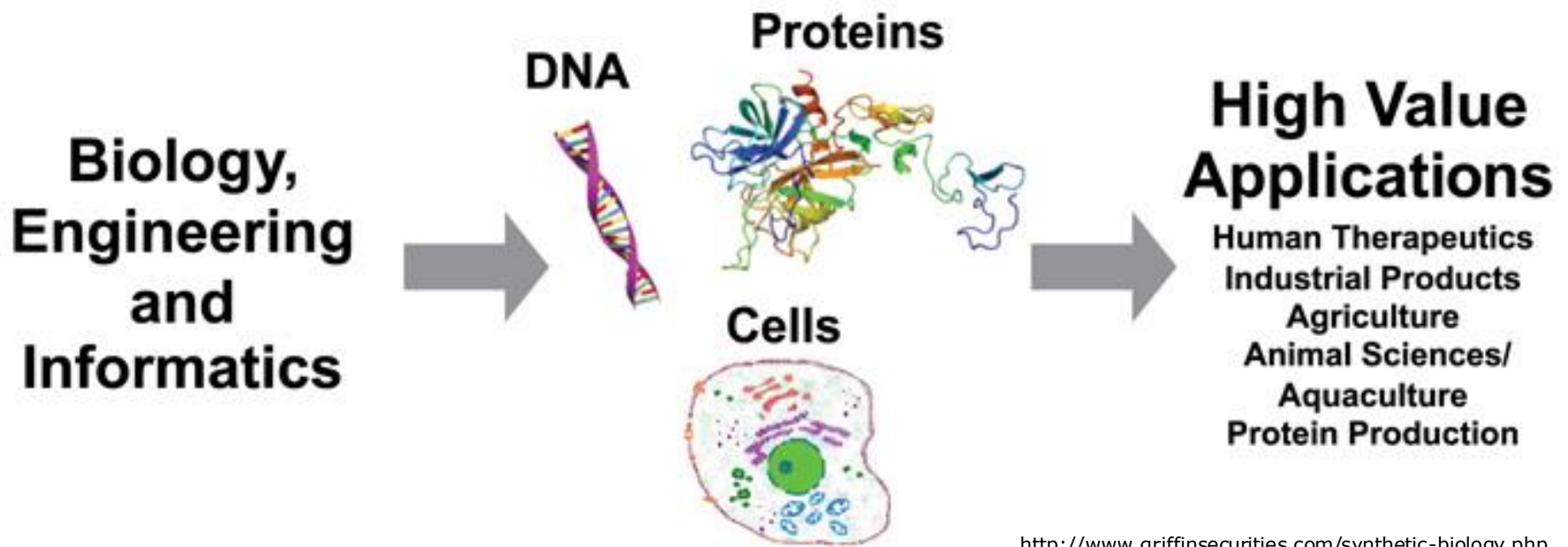
- 339 teams
- 45 countries
- 5000+ participants

# **iGEM 2017: Building a Better Biosensor for Detecting Lead in Water**

Natalie Farny, Biology/Biotechnology (advisor)

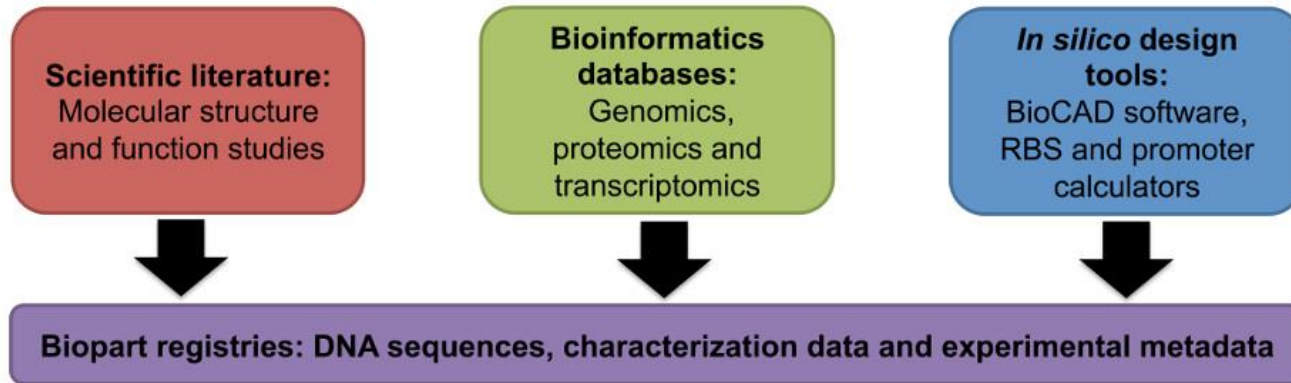
WPI undergraduate students: Locke Bonomo, Haylea Northcott, Aylin Padir, Michael Savoie, Edith Sawyer and Catherine Sherman

# What is Synthetic Biology?

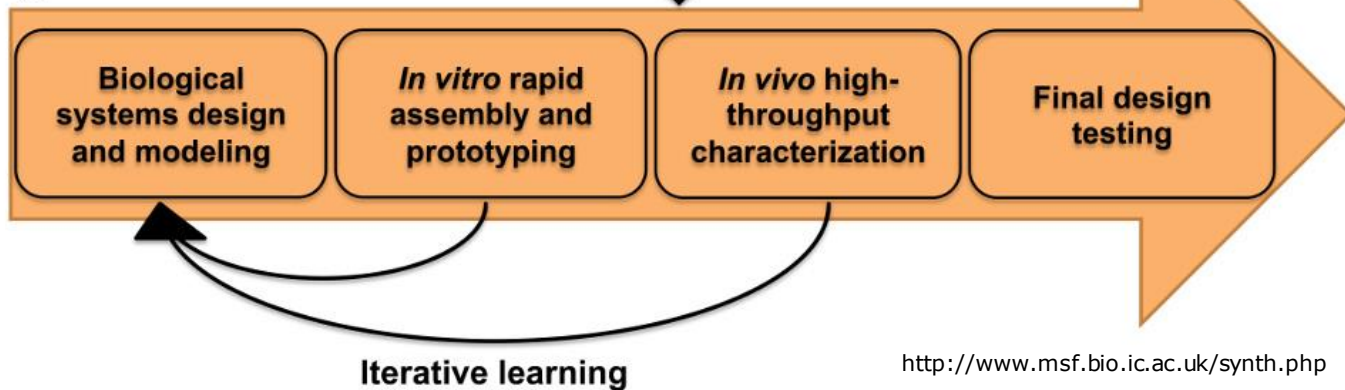


# Synthetic Biology Applies Engineering Design Principles to Living Systems

## Data Sources

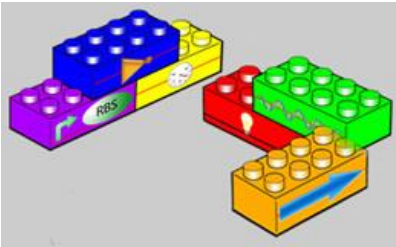


## Design-Build-Test





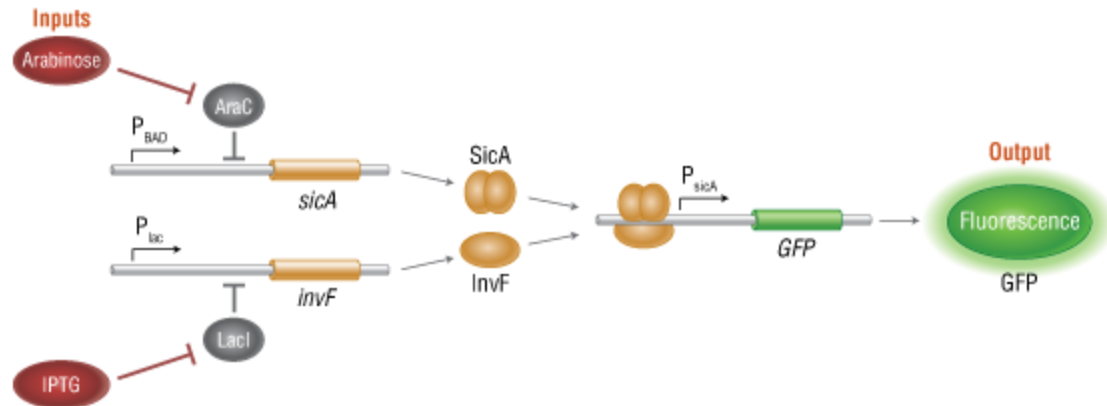
# BioBricks: The Building Blocks of Synthetic Biology



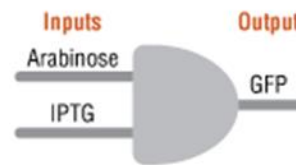
- Standardized DNA sequences
- Ideally fully characterized, measureable and interchangeable

Assembly of BioBricks into functional, predictable circuits

A. Molecular Diagram of a Biological Circuit



B. Schematic of an "AND" Gate



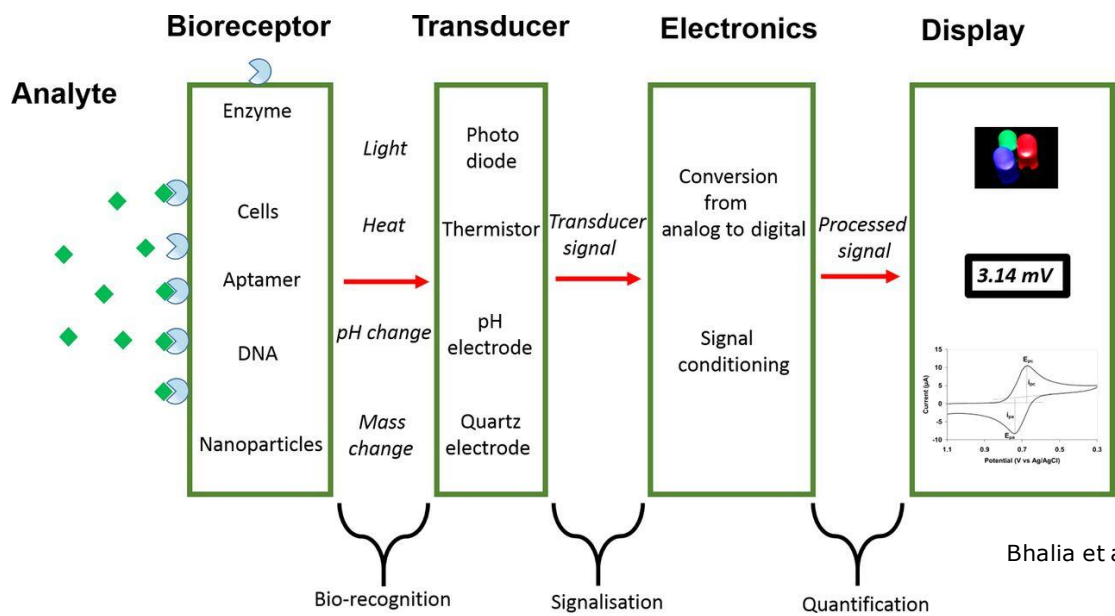
Inputs		Output
Arabinose	IPTG	GFP
-	-	-
+	-	-
-	+	-
+	+	+

C. Higher-order Circuit

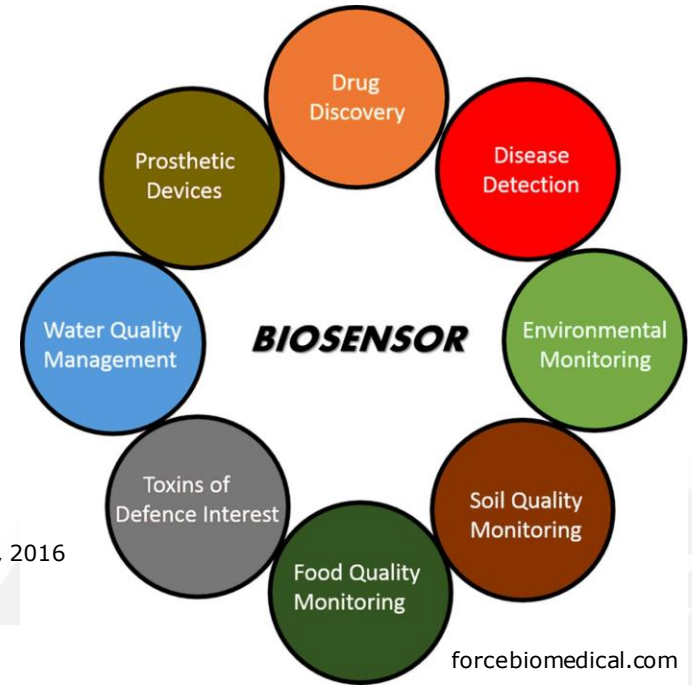


neb.com

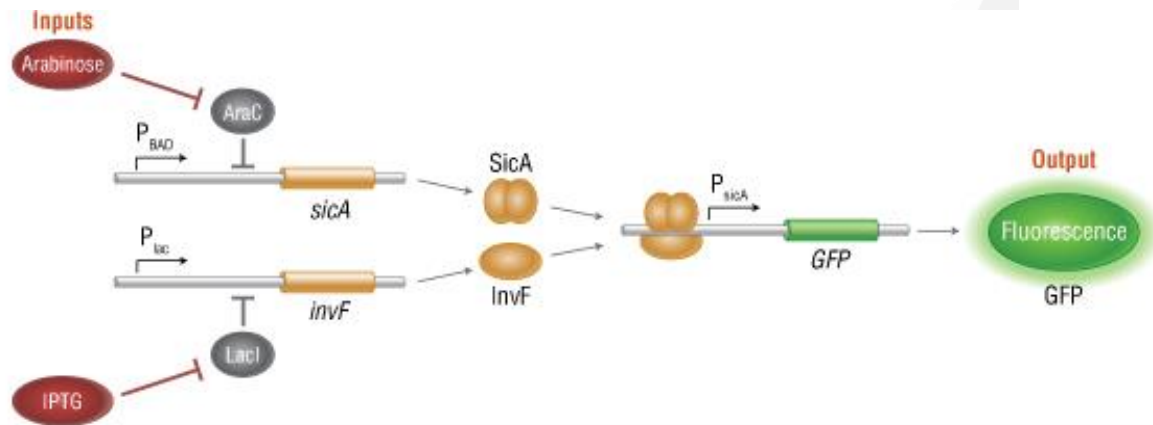
# Biosensors



Bhalia et al., 2016



forcebiomedical.com



# Building a Better Biosensor for Lead

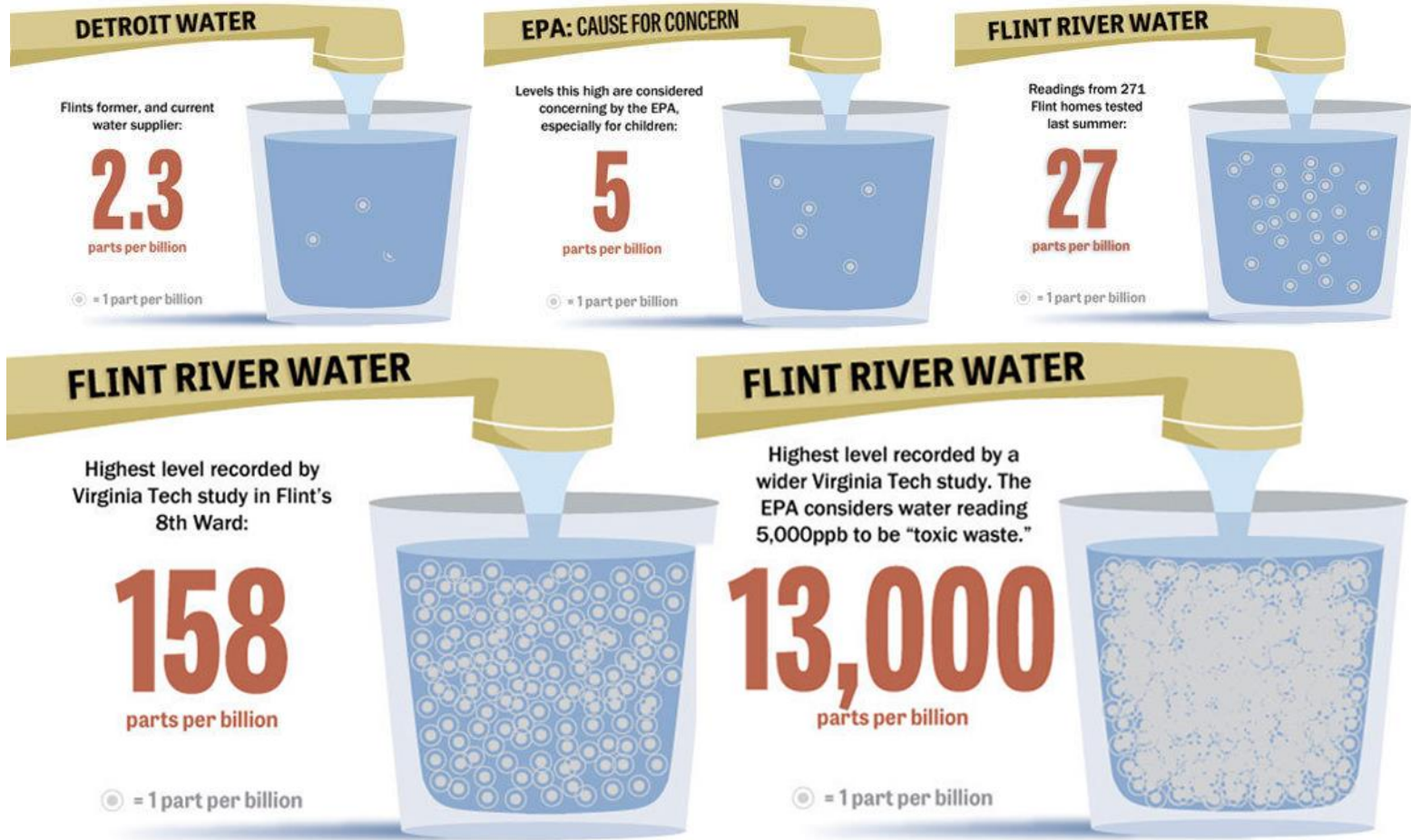


Tap water in a Flint hospital on Oct. 16, 2015.  
JOYCE ZHU / FLINTWATERSTUDY.ORG





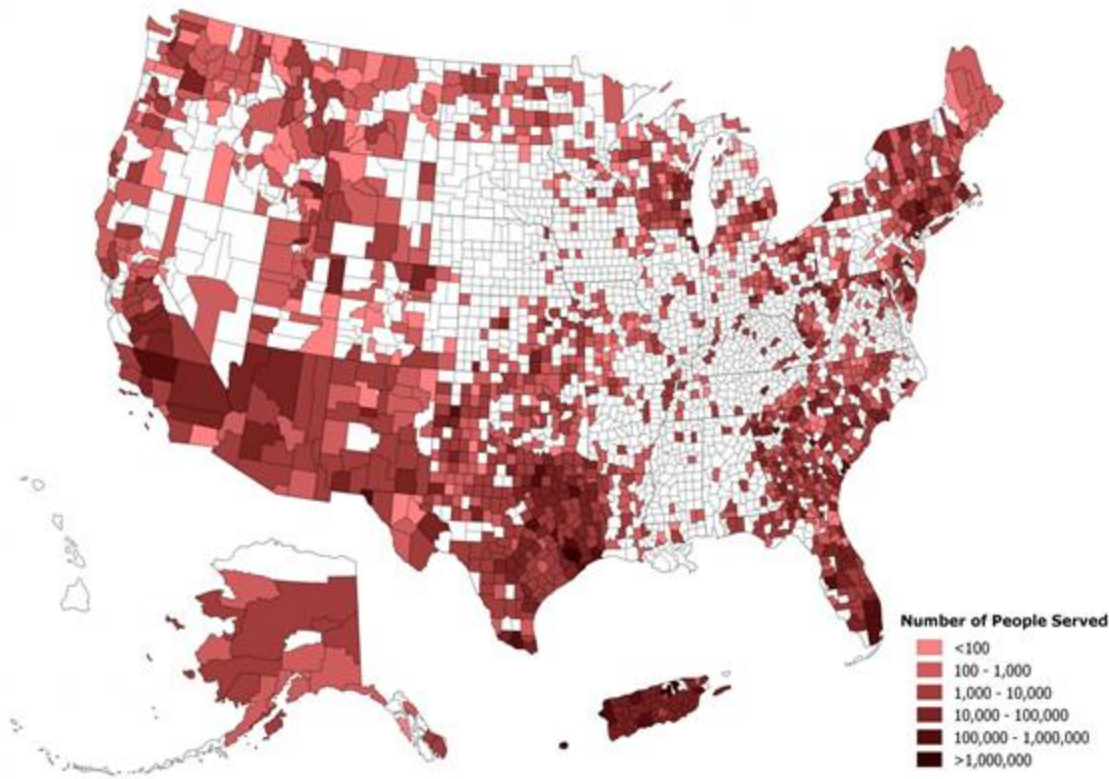
# Flint, Michigan



Graphic by Milt Klingensmith | MLive.com

# Lead Contamination is a National Problem

## Number of People Served Water with over 15 ppb of Lead



*In Massachusetts:*  
Many school districts including Boston and Worcester must provide bottled water for students

## The Boston Globe

High lead levels found more than 160 school buildings in Mass.



SHUTTERSTOCK

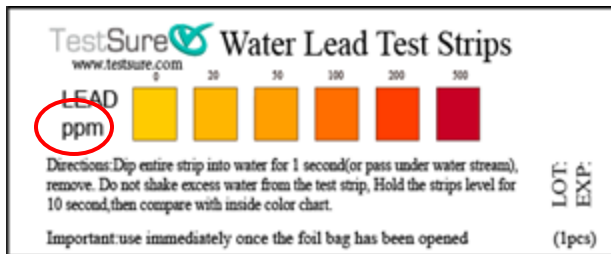
By [Matt Rocheleau](#) and [Travis Andersen](#) | GLOBE STAFF NOVEMBER 16, 2016



# Can't We Already Test for Lead?

- Cause for concern: **5 ppb**
- EPA Action level: **15 ppb**
- Irreversible neurological damage: **800 ppb**
- EPA hazardous waste: **5,000 ppb**

## Home Testing



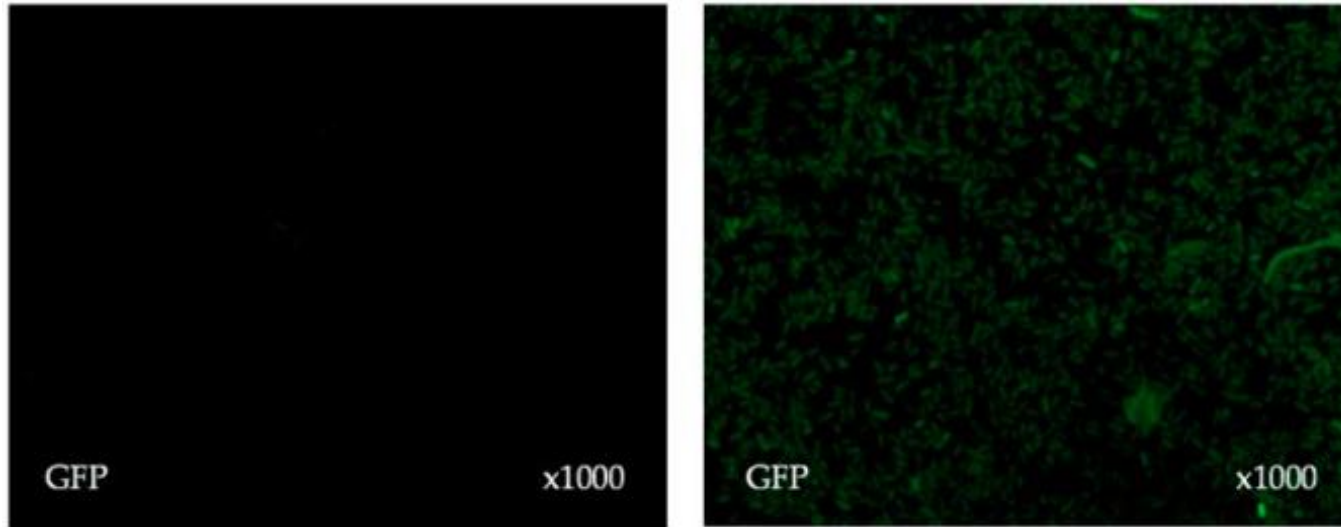
- Yes/No answers
- Not sensitive enough in the actionable range

## Laboratory Testing



- Expensive
- Off-site

# Existing Lead Biosensors



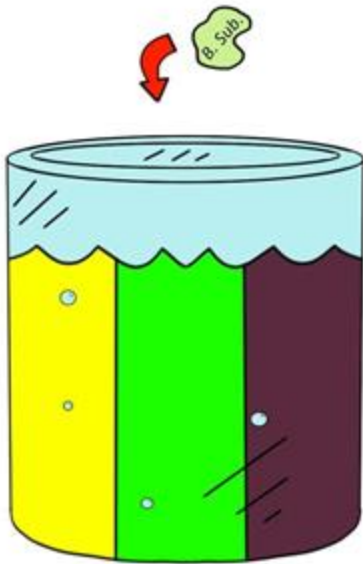
(a)  $0 \mu\text{g ml}^{-1} \text{Pb(II)}$

(b)  $100 \mu\text{g ml}^{-1} \text{Pb(II)}$

Bereza-Malcolm et al., 2015

- Can we create a biosensor that gives quantitative (or semi-quantitative) information about lead concentration?
- Can a lead biosensor be sensitive within the necessary detection range (5-15 ppb)?

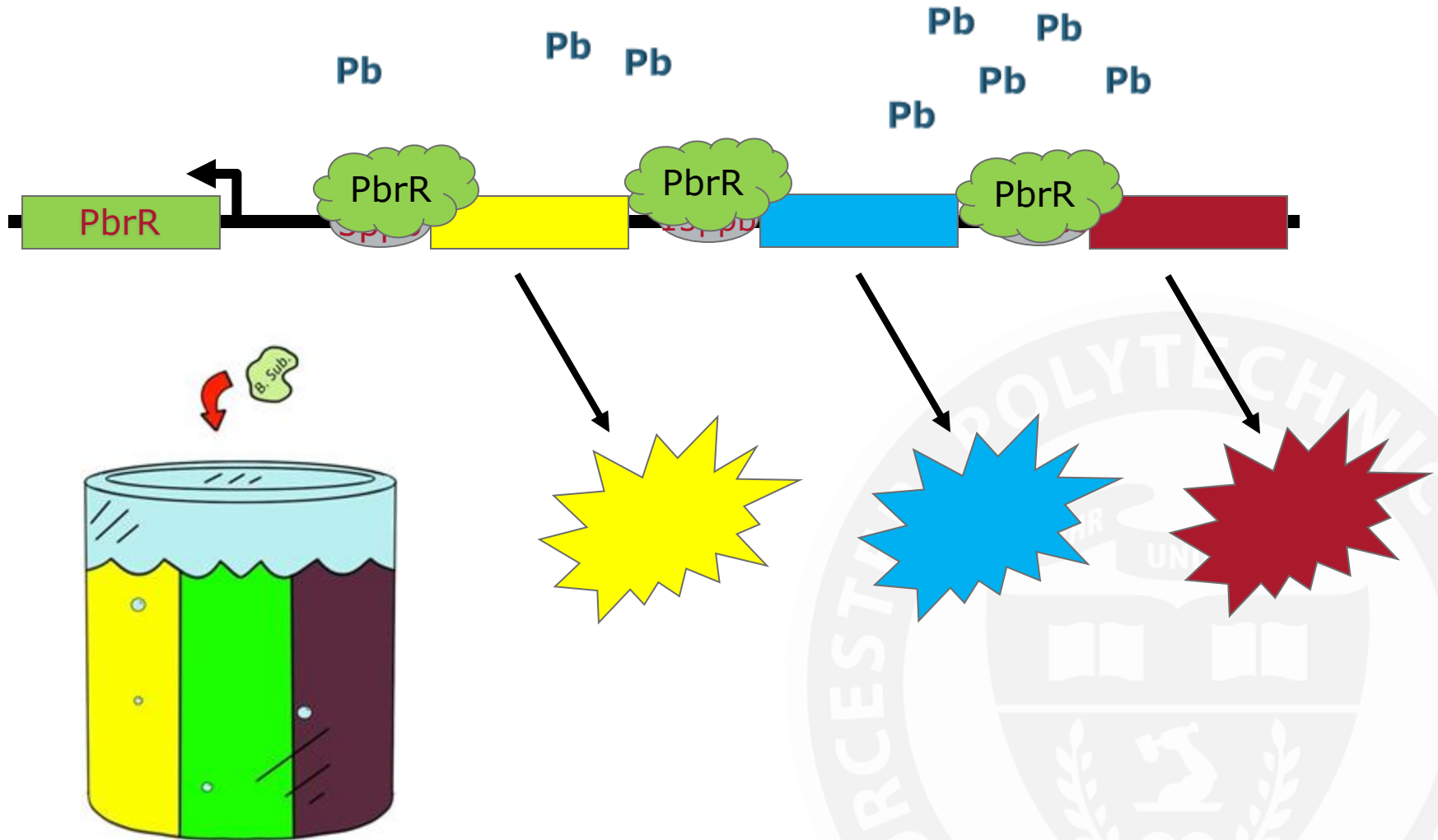
# Experimental Approach



Goal: Create a biosensor that produces different chromoproteins (pigments) in response to different lead concentrations:

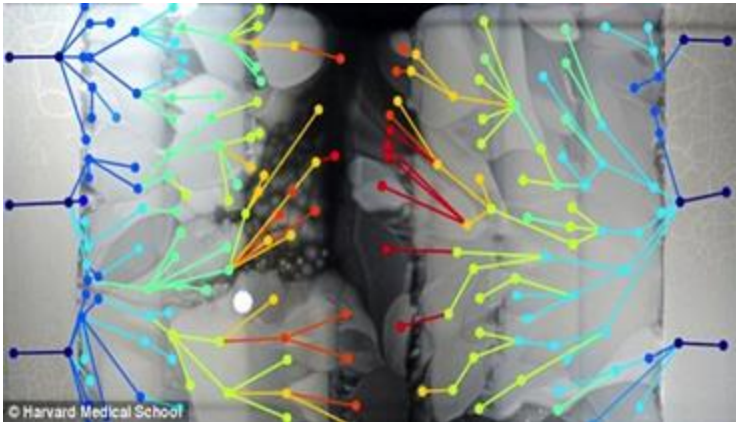
1. 5 ppb = yellow
2. 15 ppb = yellow + blue (transition to green)
3. 800 ppb = yellow + blue + red (transition to brown)

# Biosensor Design

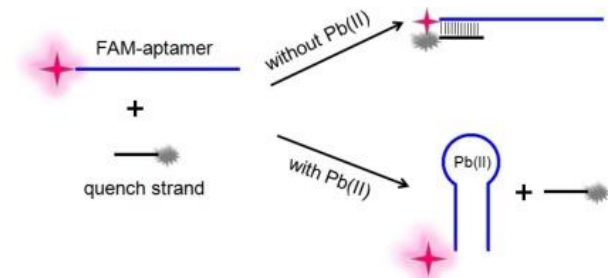


# Ideas for Generating Novel Biosensors

## Facilitated Evolution

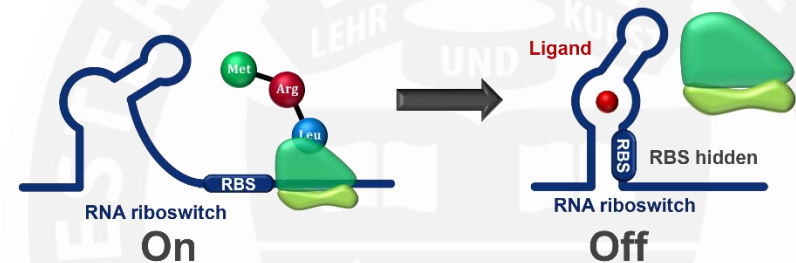
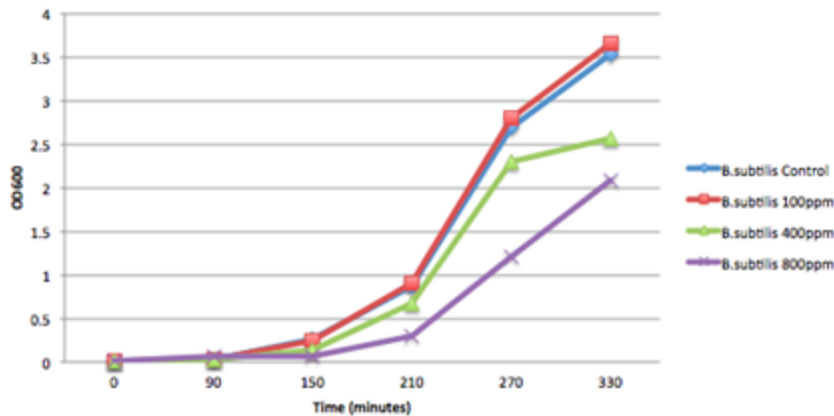


## Lead-binding Nucleic Acids



Chen et al., 2018

## B.subtilis Average Growth in Lead LB



Exeter iGEM 2015

# Seed Grant Activities

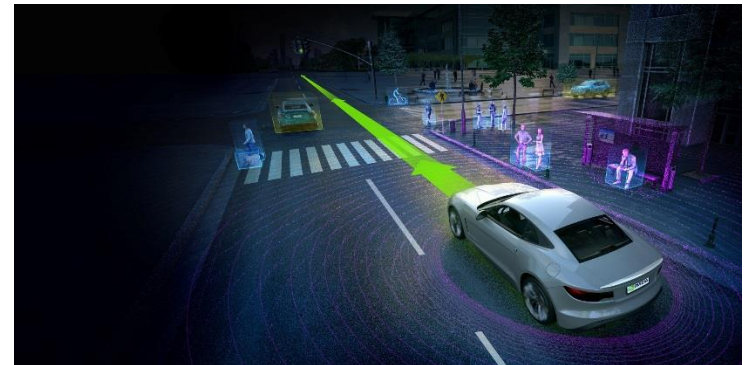
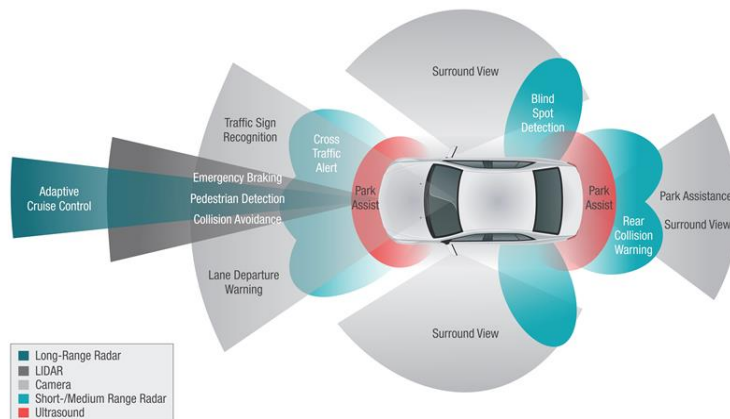
Funds will support the 2018 iGEM team:

- Design and test the next generation of biosensors
- Expanded and more interdisciplinary team, and additional resources
- Support dissemination of the work at the 2018 iGEM Jamboree
- Foster a collaboration and joint activities with Tsinghua iGEM



# Autonomous Vehicles Research

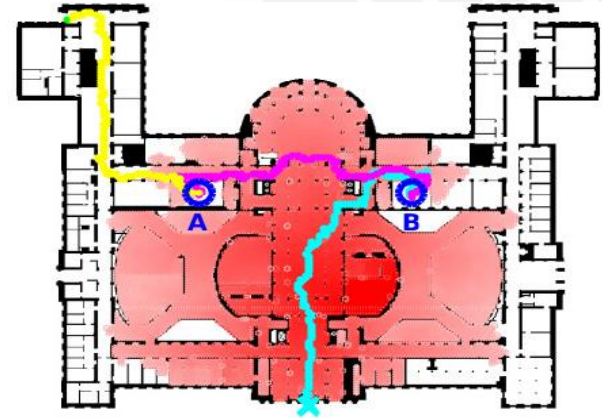
- Computer Vision & Deep Learning (since 2013)
  - Graduated 5 MS thesis, currently 3 PhD students in progress
  - Both software algorithms and hardware implementations
- IEEE Intelligent Transportation Sys. Mag. (2016)
- Funding: NSF; MathWorks; Nissan; NVidia



# Objectives/Value Proposition

- Smart fire trucks with sensors and intelligence
  - Introduce sensors, i.e. cameras, radars, LiDARs, to detect pedestrians and obstacles in all blind spots of a truck driver.
  - Develop intelligent algorithms for cross traffic monitoring, collision avoidance, and advanced driver assistance.
  - Evaluate the technology on WPI's autonomous vehicle platform.
- Wearable device for firefighter tracking
  - Build on WPI's previous research experience from the "Precision Personnel Localization" (PPL) project.
  - Develop new sensor prototype by combining GPS, inertial measurement unit, laser rangefinder, infrared cameras, etc.
  - Propose new algorithms of precise motion tracking using machine learning, simultaneous localization and mapping.

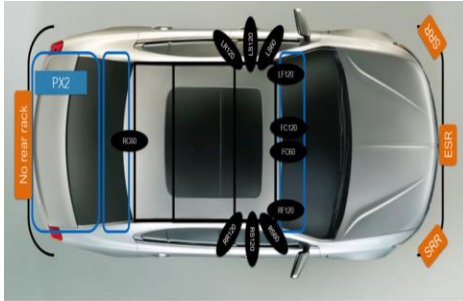
# Motivation



Smart fire truck: add sensors and intelligence from our current research on autonomous vehicles

Wearable firefighter tracker: multi-sensor fusion and machine learning for precise localization

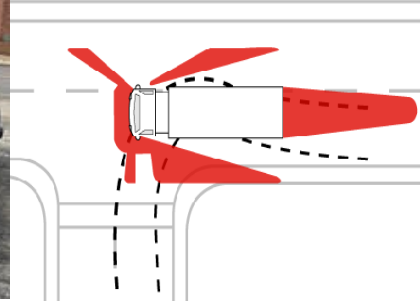
# Approach



Autonomous vehicle sensors



Data collection and experiments



Collision avoidance



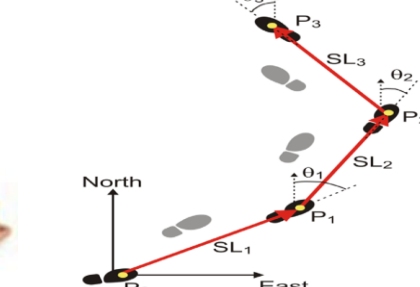
Fire truck applications



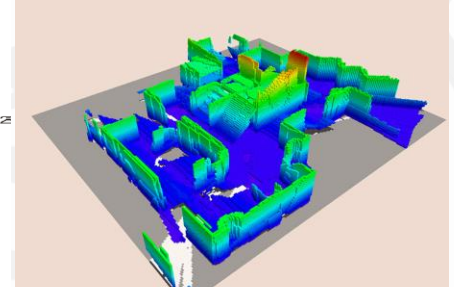
Firefighter localization



Wearable sensors



Classification and tracking



3D building mapping



# Seed Grant Activities

- Formed multi-disciplinary research team
  - Faculty members from FPE, ECE, ME, and CEE
- Recruited 2 PhD, 2 MS, and 2 MQP and IQP teams.
  - Student team at Tsinghua - Summer, 2018
- Conducted preliminary research
  - Review WPI's Personnel Localization (PPL) project and Michigan's Pedestrian Dead Reckoning (PDR) project.
  - Research on vehicle perception from camera data and LiDAR data for pedestrian/vehicle/road detections.
  - Build deep learning platform on DrivePX2 embedded platform for in-vehicle high-speed data processing.
  - Experiment outdoor localization using GPS, IMU, and simultaneous localization and mapping.

# Autonomous Vehicles and Smart Fire Trucks

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- Significant efforts being made to develop autonomous vehicles at WPI – Xinming Huang
- Can be linked with assistive throwable robots - Pincorelli
- New efforts to link these with the development of Smart Fire Trucks and Smart Roads/Pavements
- Link to E-One Fire Truck Company – Dirk Steyn
- Interest in technologies for fighting Wild Fires and also technologies that could enable the escape of fire fighters
- Emerging collaboration with Worcester and Marlborough Fire Stations



# Energy Resilience Group

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- Energy resilience identified as a key area for CGPS
- This has stimulated efforts to form an Energy Resilience Group
- The group includes faculty from multiple disciplines including CEE, ME, ChE, SSPS, and Business
- Holistic approach to energy resilience – from thermodynamic cycles to smart grids, renewable energy, fossil/sustainable fuels and geothermal energy
- Efforts to link with industry being enabled by Mark Macaulay (CGPS Member for Company ZHP Systems)

# Emerging Collaborations With Tsinghua University

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- PhD projects in collaboration with Prof. Jianyu Liang, Prof. Ali Rangwala and Prof. Xinming Huang
  - Fire science and engineering
  - Smart fire trucks
  - Materials for fire safety
- MQPs and IQPs
- Visits to Tsinghua by Professors Jamal Yagoobi, Albert Simeoni and Jianyu Liang
- Potential collaboration with Tsinghua in the area of food safety (CARD – Jamal Yagoobi)

# A Global Public Safety Index

Gbetonmasse Somasse, SSPS

Patricia Stapleton, SSPS

Jianyu Liang, ME

Albert Simeoni, FPE

Hui Zhang, Tsinghua University

Jianguo Chen, Tsinghua University

Hong Huang, Tsinghua University

# Objectives/Value Proposition

Leverage complementary expertise between WPI & Tsinghua University

**Identify key indicators to assess public safety by country**

**Analyze state of public safety around the world**

**Promote best practices in civil protection & public safety**



# Motivation



Over the past 30 years, more than 2.5 million people and almost \$4 trillion have been lost to natural disasters, with global losses quadrupling from \$50 billion a year in the 1980s to \$200 billion in the last decade.

2017 marked an even more alarming milestone in this trend, with **\$330 billion in global losses** from adverse natural events (World Bank 2018).

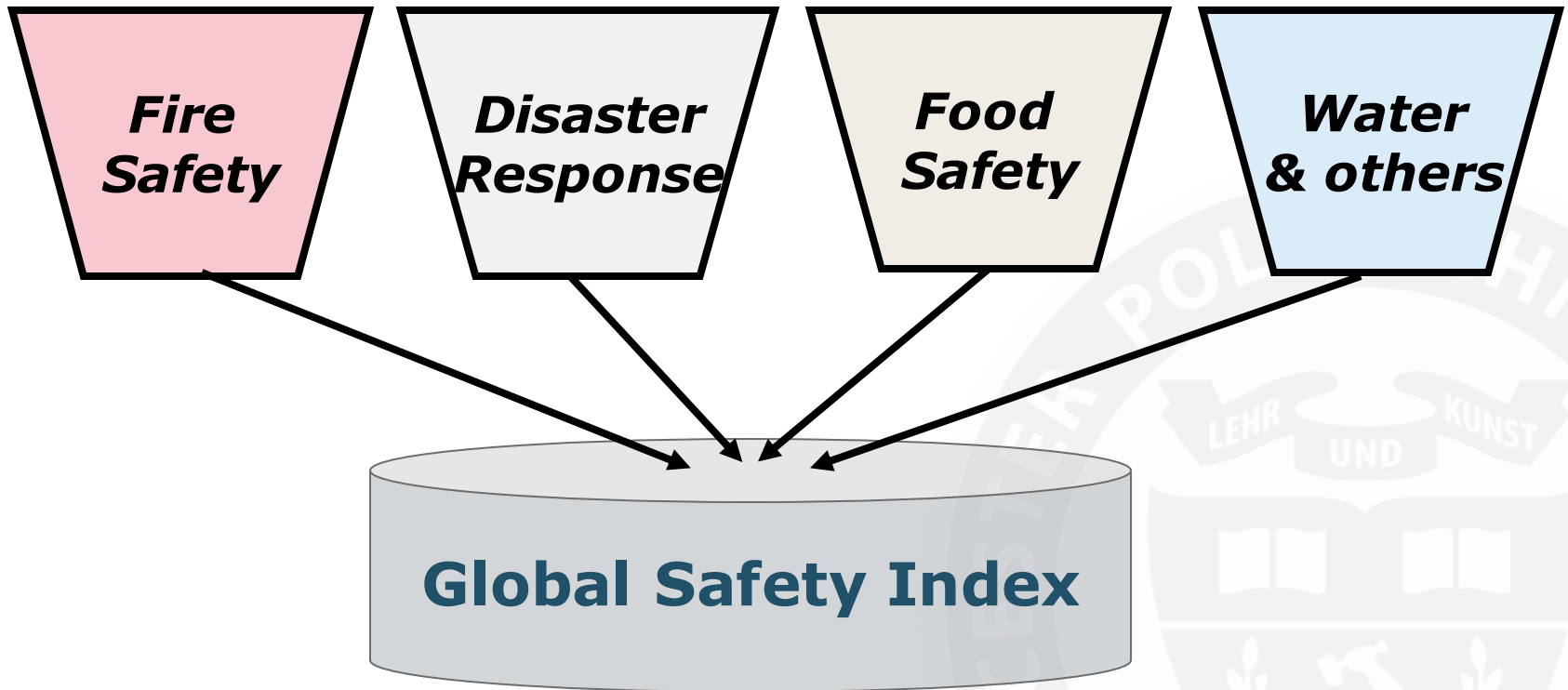


Stuart Palley for the US Forest Service

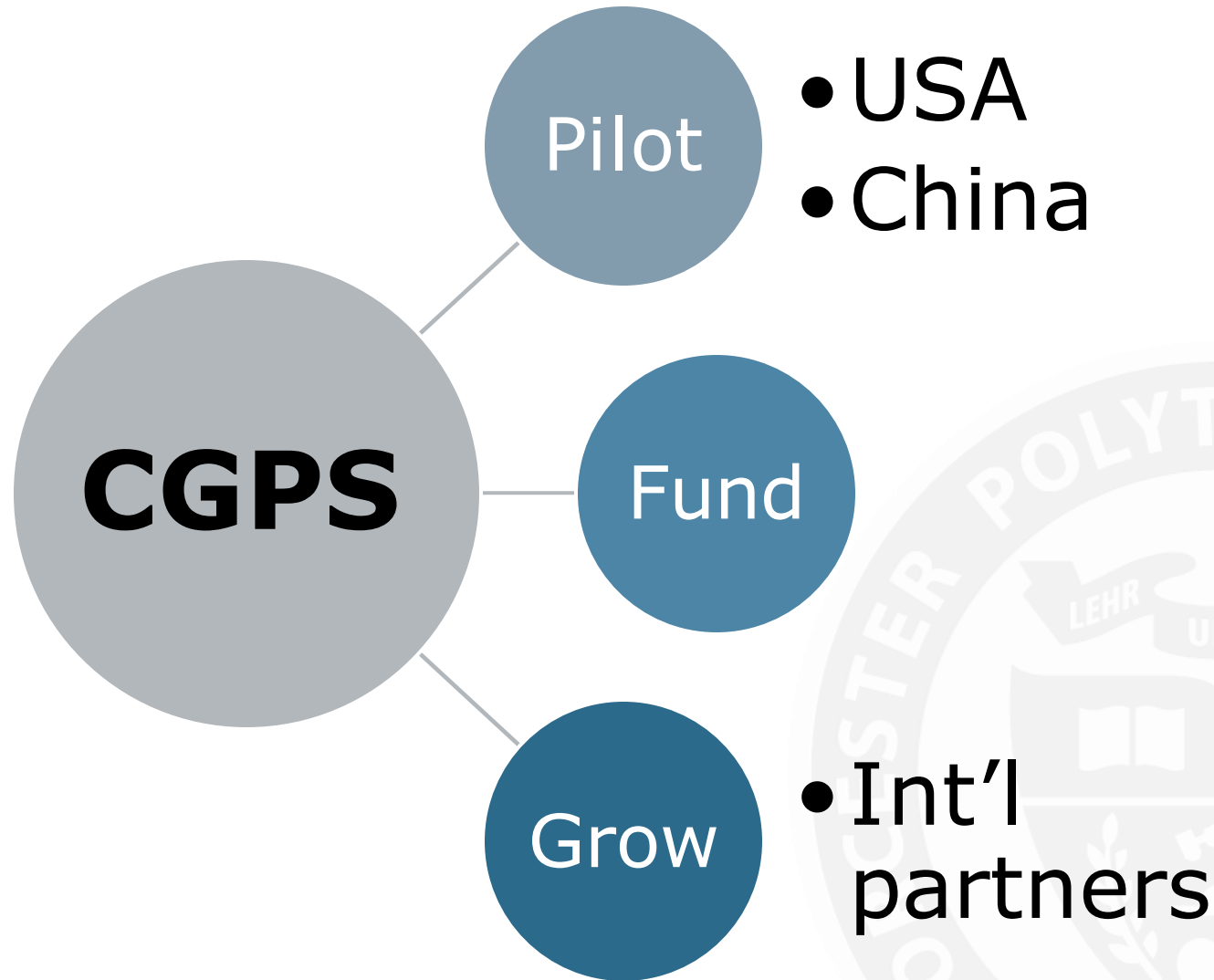




# Approach



# Seed Grant Activities



# Summary and Conclusion

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Our goal:

Within 5 years, to have established a global network that is delivering impactful results in public safety to communities across the world in demand-driven areas such as fire, water, food, energy, transportation and emergency services.



# Questions?

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# Questions

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