Center for Global Public Safety
September 17, 2018
Agenda

• Mission & Vision
• Five Year Strategy
• Phase I: Initiate
• Phase II: Growth
• Phase III: Scale & Sustain
Mission: Making the World a Safer Place......

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

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

- 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)

- 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)

- 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)

- 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)

- Scaling of research and innovation opportunities at Tsinghua, Khalifa, UAE Civil Defense and AUS
- Annual CGPS Symposioms 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

- 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

- 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?

Biology, Engineering and Informatics → DNA → Proteins → Cells → High Value Applications

- Human Therapeutics
- Industrial Products
- Agriculture
- Animal Sciences/Aquaculture
- Protein Production

Synthetic Biology Applies Engineering Design Principles to Living Systems

Data Sources

- **Scientific literature:** Molecular structure and function studies
- **Bioinformatics databases:** Genomics, proteomics and transcriptomics
- **In silico design tools:** BioCAD software, RBS and promoter calculators

Biopart registries: DNA sequences, characterization data and experimental metadata

Design-Build-Test

- **Biological systems design and modeling**
- **In vitro rapid assembly and prototyping**
- **In vivo high-throughput characterization**
- **Final design testing**

Iterative learning

http://www.msf.bio.ic.ac.uk/synth.php
BioBricks: The Building Blocks of Synthetic Biology

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

Assembly of BioBricks into functional, predictable circuits
Biosensors

Bhalia et al., 2016
Building a Better Biosensor for Lead
Flint, Michigan

**Detroit Water**
Flint's former and current water supplier:

- **2.3 parts per billion**

**EPA: Cause for Concern**
Levels this high are considered concerning by the EPA, especially for children:

- **5 parts per billion**

**Flint River Water**
Readings from 271 Flint homes tested last summer:

- **27 parts per billion**

**Flint River Water**
Highest level recorded by Virginia Tech study in Flint's 8th Ward:

- **158 parts per billion**

**Flint River Water**
Highest level recorded by a wider Virginia Tech study. The EPA considers water reading 5,000ppb to be "toxic waste."

- **13,000 parts per billion**

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.

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
• 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)?
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

CGPS Industry Stakeholders’ Forum
Ideas for Generating Novel Biosensors

Facilitated Evolution

Lead-binding Nucleic Acids

Chen et al., 2018

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
- 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

- 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

- 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

- 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).
Approach

- Fire Safety
- Disaster Response
- Food Safety
- Water & others

Global Safety Index
Seed Grant Activities

CGPS

Pilot
- USA
- China

Fund

Grow
- Int’l partners
Summary and Conclusion

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?
Questions

THANK YOU!

THANK YOU!