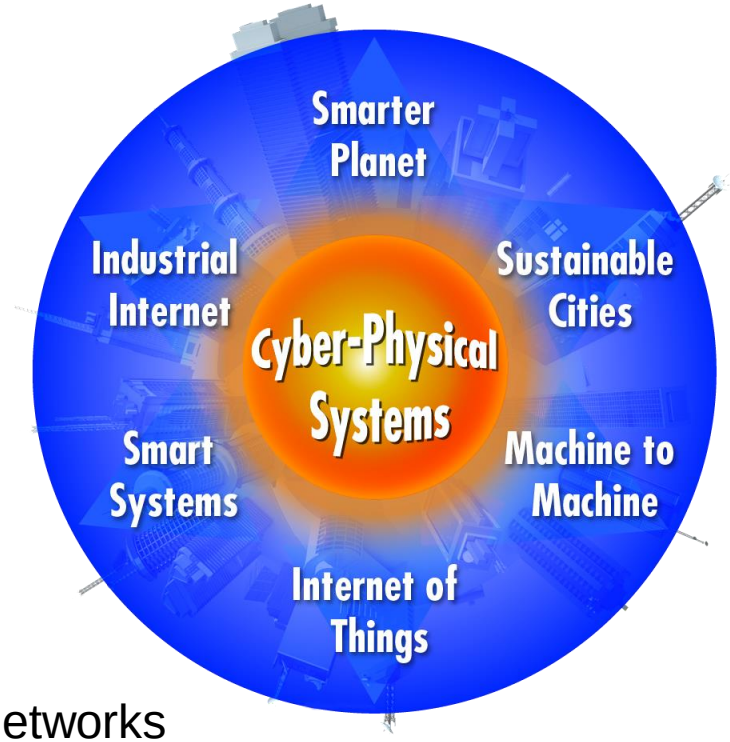
IOT AND SMART CITIES

Sokwoo Rhee
Associate Director of Cyber-Physical Systems Program
National Institute of Standards and Technology (NIST)
US Department of Commerce

Cyber-Physical Systems (CPS)

- Integrated, hybrid networks of cyber and engineered physical elements
- Co-designed and co-engineered to create adaptive and predictive systems
- Respond in real time to enhance performance



Examples:

- Internet of Things (IoT)
- Emergency Response Networks
- Smart Robots/UAVs
- Autonomous Vehicles & Traffic Management Networks
- Smart Grid
- Network-enabled Healthcare Solutions
- Advanced Manufacturing Plants

A Systems Context

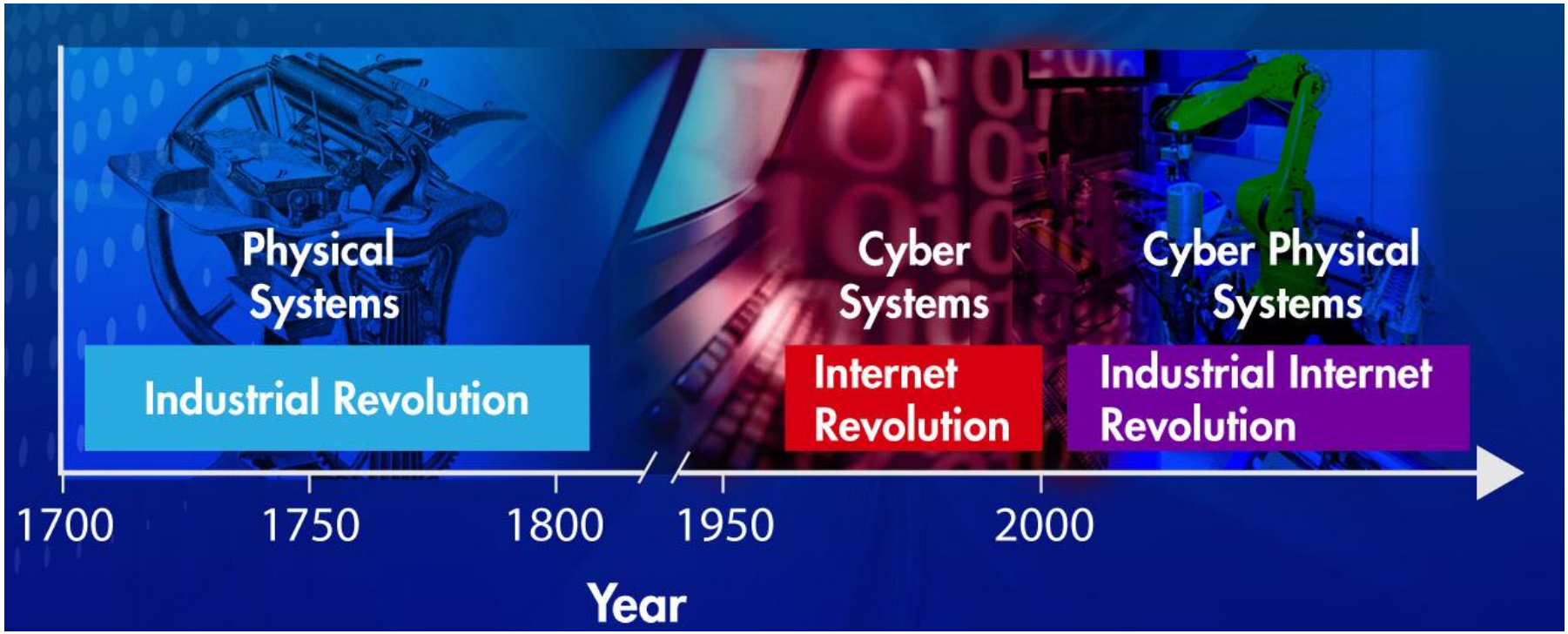
- Machines Facilities
- Infrastructure Fleets
- People

- Data/information
- Communications
- Sensing
- Monitoring
- Wireless
- Analysis

Life-Cycle* Performance Optimization

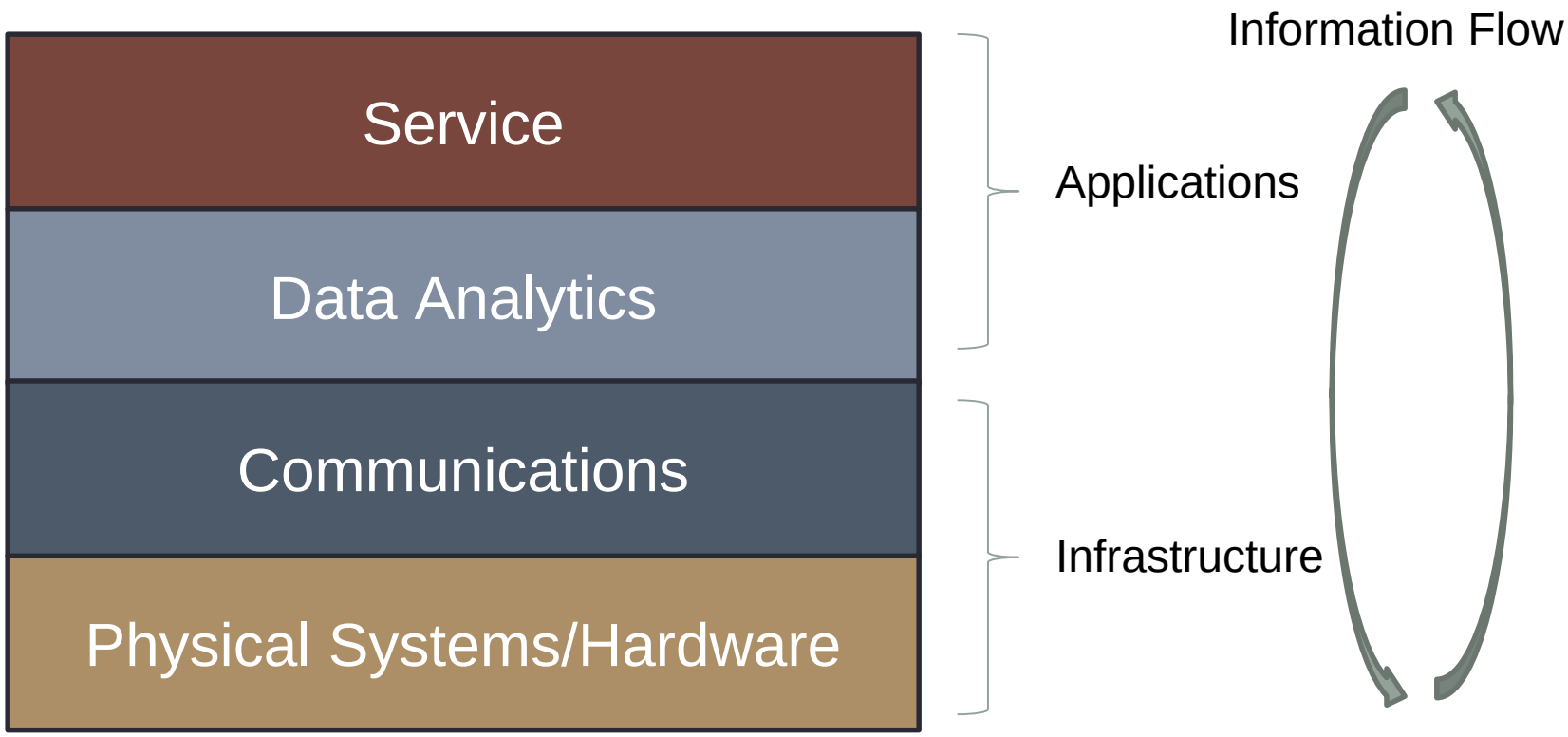
- Efficiency & Sustainability
- Agility & Flexibility
- Reliability & Resilience
- Safety & Security

A Time Context



CPS are an innovation-based growth engine for the U.S. economy and society

Internet of Things (IoT) and Smart Communities/Cities



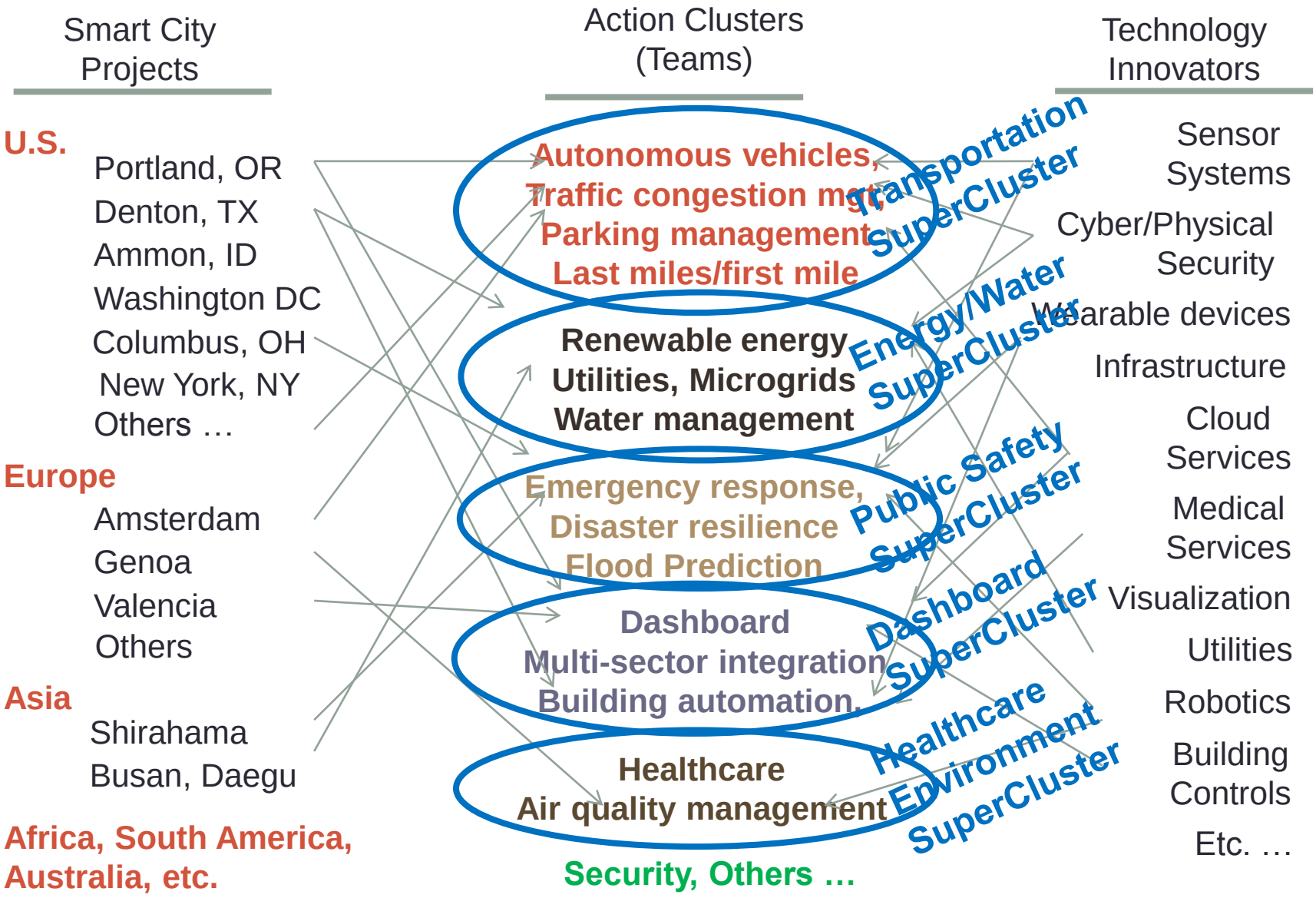
Public Sector IoT: Smart Cities and Communities

- Smart City/Community: Use smart technologies such as IoT and CPS to improve the quality of life in cities and communities
- Many smart community efforts are one-off projects with heavy emphasis on customization and inadequate consideration for future upgradability and extensibility
- As a result, many Smart Cities/Communities deployments are isolated and do not enjoy the economy of scale.

Global City Teams Challenge

- Establish and demonstrate replicable, scalable and sustainable models for collaborative incubation and deployment of interoperable, standard-based solutions and demonstrate their *measurable* benefits in communities and cities
- Enable the measurement science for real-world IoT deployments in scale

GCTC Approach "SuperClusters"

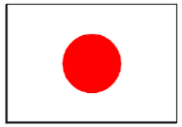


Over 160 Cities Communities in GCTC 2015-2017 (Partial list shown):

- Portland, OR
- Newport News, VA
- Greenville, SC
- Raleigh, NC
- Montgomery County, MD
- Winooski, VT
- San Mateo County, CA
- New York, NY
- Washington, DC
- Columbus, OH
- Kansas City, MO
- Nashville, TN
- Austin, TX
- Amsterdam (Netherlands)
- Genova, Perugia (Italy)
- Coruna, Valencia (Spain)
- Saint-Quentin (France)
- Abuja City, Obia-Akpor City (Nigeria)
- La Marsa (Tunisia)
- Busan, Seoul, Daegu (Korea)
- Saitama (Japan)
- Visit www.globalcitychallenge.org for the full list of participation cities in 2016-2017

And, over 400 companies, universities, non-profits, government agencies

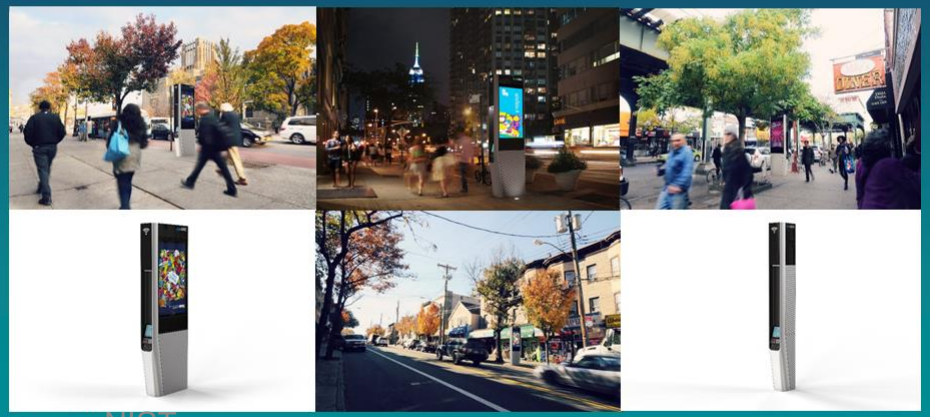
GCTC 2017 Partners



Action Cluster Examples

LinkNYC by City Bridge

First-of-its-kind communications network that will bring the fastest available municipal Wi-Fi to millions of New Yorkers and visitors



Source: www.NIST

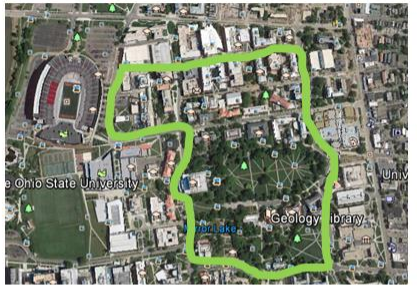
New York City, Qualcomm Incorporated, Titan360, Control Group, COMARK Corporation, Antenna Design

SMART MOBILE OPERATION: OSU TRANSPORTATION HUB (SMOOTH)

The Ohio State University
Center for Automotive Research

First Mile/Last Mile Solutions

- On demand automated vehicles will move passengers the first mile to the bus stop and the last mile from the bus stop (bottom picture).
- Scheduled or on demand vehicles will move passengers through a closed loop within OSU campus (through roads and pedestrian areas, top picture).
- The vehicles will:
  - use automated driving technology;
  - use V2V communication for convoy driving;
  - be equipped with vulnerable road user protection technology enabling them to function in pedestrian zones.
- SMOOTH will keep track of vehicles and guide them.
- Smartphone applications will be developed to schedule and track the on-demand automated vehicles.



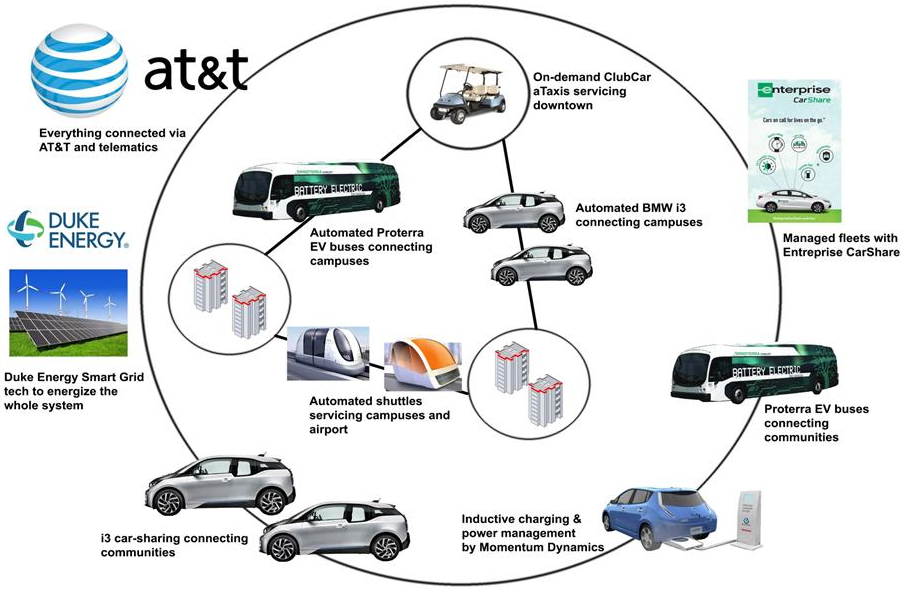
PARTNERS

Ohio State University - Center for Automotive Research
City of Columbus
Mid-Ohio Regional Planning Commission (MORPC)
Team ARIBO

Location: Columbus, Ohio

Automating the First and Last Miles

Greenville Smart City Vision



ARIBO Robotic Vehicle CPS Test-Beds in 2014

Stanford and West Point are piloting the Induct Navia as an automated on-demand shuttle. This 100% electric shuttle is the **FIRST** COTS automated vehicle and it also has remote monitoring, fleet management and inductive charging.

These automated shuttle fleet are transportation's 1st examples of "Internet of Things". The CPS test-beds will be able to test networked and integrated systems from smart grids to V2X networks.

What is the Induct Navia?

navia
The 100% Driveless & 100% Electric Shuttle System

Mobile CPS Test-Bed

Who is Collaborating?

Team ARIBO

- US Army
- TARDEC
- Induct
- NASA
- Stanford
- SLAC
- DOE
- DOT
- West Point
- Comet
- UMTRI
- UTARI
- TTI

How is it Manufactured?

unicor

Navia is being manufactured by DOJ company, Unicor. Inmates are gaining high-tech job skills building the future of transportation for more successful transition and reduced recidivism.

ARIBO CPS Test-Beds Impact

High-Growth Industries	New Jobs	New Markets	Manufacturing
Automated Vehicles Electric Vehicles (diverse) Wireless Charging Next-Gen Battery (Li-S) Connected Vehicle Mobile Wireless Network	Engineers Roboticists Programmers Technicians Operations Cyber Security	Robotics Automated Vehicles V2X Wireless Networks Wireless Charging	Platform (Vehicles) Accessories Batteries

ARIBO CPS Test-Beds 2014 Timeline

Stanford SLAC Start — APR 2014 · West Point Start — JUN · Fort Bragg Opti. Test — JUL · West Point Phase 2 — AUG/SEP · Fort Bragg Operational — OCT · Military Installations — 2015

Smart America Challenge Event

Demo

- Navia Ride – 12 mph of automated awesome will shuttle VIPs at the Smart America Event: Routes TBD
- Viewing station to remotely monitor vehicle location, speed, and diagnostics
- ARIBO Overview and Impact Discussion – Delivered by one of the ARIBO team members
- Team Member Testimonials – live or recorded. Options:
  - DOJ leadership and/or inmate – what will building robotic vehicles do for his/her future
  - SLAC operations team – Why did they choose an automated system
  - West Point Leaders and/or Cadets, Induct Leadership,
  - NASA
  - RDEC – How and Why did they come up with ARIBO

How is it being Tested?

Stanford leading modeling and simulation to test dynamic vehicle routing algorithms for automated on-demand systems. The simulation models and data will be shared with West Point.

Stanford SLAC Campus

West Point

Capabilities being Tested

V2I · Cyber Security · Remote Supervision · V2P · Cloud Connection · Hospital Transit · Wireless Charging · Advanced Batteries

Corey Clothier / coreyclothier@gmail.com

Vehicle-to-Pedestrian CPS Safety Concept

14% of U.S. traffic fatalities were incurred by pedestrians in 2011

Honda & Qualcomm collaborated to extend existing V2V development to the new area of vehicle-to-pedestrian (V2P) safety

HONDA

Vehicle-To-Pedestrian
Cooperative Safety Application

QUALCOMM

Enhanced Water Distribution Infrastructure Enabled by Cellular-Based CPS

Conservation * Security * Environmental Benefits * Lower Cost

CH2MHILL

QUALCOMM

EVENTS


Water Contamination


Drought Management

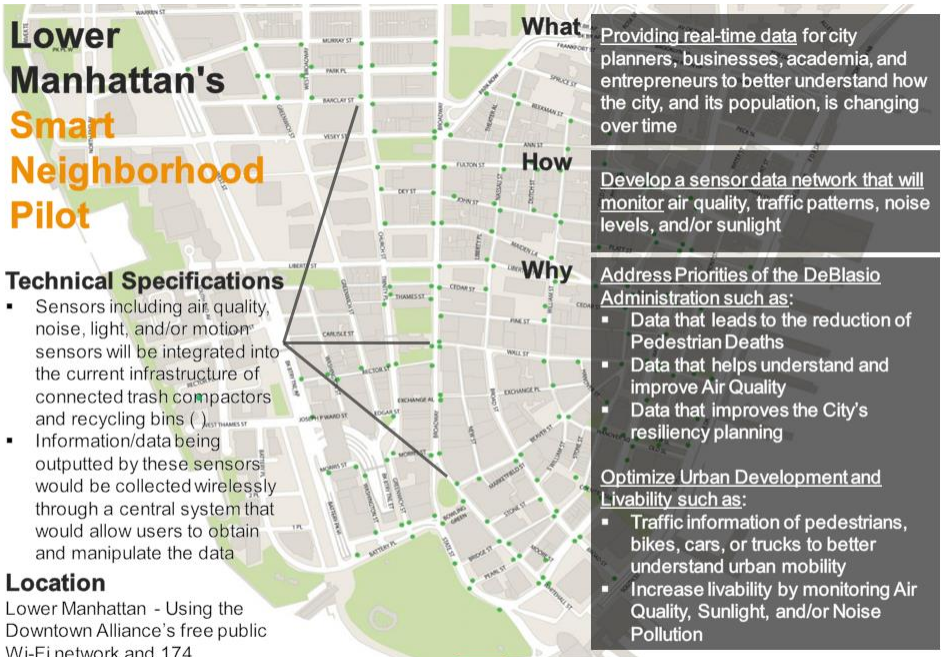

Leak Detection


Water Quality

USING Cyber Physical Systems (CPS) / M2M to manage our water system means...

Real-time monitoring and control, addition of fewer chemicals, accident prevention, faster response to contamination or other events, better leak detection to minimize losses, safer and more secure water that costs less

Lower Manhattan's Smart Neighborhood Pilot



What

Providing real-time data for city planners, businesses, academia, and entrepreneurs to better understand how the city, and its population, is changing over time

How

Develop a sensor data network that will monitor air quality, traffic patterns, noise levels, and/or sunlight

Why

Address Priorities of the DeBlasio Administration such as:

- Data that leads to the reduction of Pedestrian Deaths
- Data that helps understand and improve Air Quality
- Data that improves the City's resiliency planning

Optimize Urban Development and Livability such as:

- Traffic information of pedestrians, bikes, cars, or trucks to better understand urban mobility
- Increase livability by monitoring Air Quality, Sunlight, and/or Noise Pollution

Technical Specifications

- Sensors including air quality, noise, light, and/or motion sensors will be integrated into the current infrastructure of connected trash compactors and recycling bins ( )
- Information/data being outputted by these sensors would be collected wirelessly through a central system that would allow users to obtain and manipulate the data

Location

Lower Manhattan - Using the Downtown Alliance's free public Wi-Fi network and 174 connected trash compactors and recycling bins

Downtown Alliance

EVERYTHING HAPPENING IN LOWER MANHATTAN

NYCEDC
New York City Economic Development Corporation

- The City of San Francisco expects to incur an estimated $62 billion in climate-related infrastructure damage by the middle of the 21st century.
- Buildings are responsible for 52% of the city's carbon emissions, a major cause of climate change.
- 75% of the city's largest 2,000 commercial buildings fall within the boundaries of the San Francisco 2030 District.
- Despite progressive green building codes, capital markets, real estate investors, property managers, commercial tenants, and even utilities lack comprehensive, granular data about the specific energy efficiency opportunities and solutions.
- 5D Smart San Francisco 2030 District will serve as a hub making necessary data and solutions easily available to building owners in the city in order to accelerate and expand investment in energy efficiency retrofits.

5D SMART SAN FRANCISCO 2030 DISTRICT

CITYZENITH
DATA VISUALIZATION PLATFORM

SF Environment
MUNICIPAL GOVERNMENT DEPARTMENT

C40 CITIES
GHG STANDARDS NETWORK

verizon
SMART CITY PLATFORM PROVIDER

HELIOS Building Efficiency
BUILDING ENERGY RETROFIT FINANCE

STREETLIGHTDATA
TRANSPORTATION EMISSIONS ANALYSIS

BERKELEY LAB
BUILDING ENERGY RETROFIT ANALYSIS

echoMESH
BUILDING ENERGY CHANGE MANAGEMENT

A 3D data visualization platform project mapping building energy usage and GHG emissions data to a 3D model of downtown San Francisco that will empower building owners with the information and tools they need to make their buildings more energy efficient.

(((SCALE: Safe Community Alert Network)))

Extending the Internet of Things to Everyone: Residents of an affordable housing complex who cannot otherwise afford broadband are given smart community sensors. A resident, possibly elderly, is in distress and the sensor sends a signal to the nearest base station.

MHP
MONTGOMERY HOUSING PARTNERSHIP

County Facility Equipped with Antenna

Cloud-based public safety awareness and alert system

Dispatch Center

Emergency validated via mobile device; alert is sent to the dispatch center and a first response unit is sent to the resident in distress.

Within minutes first responders arrive without any need for manual action by the person in distress

IBM · SigFox Wireless · Schneider Electric · Anomaly Systems · UCIrvine University of California, Irvine · twilio · senseware

SERS 2 (Smart Emergency Response System)

GLOBAL CITY TEAMS CHALLENGE

Drone Wi-Fi

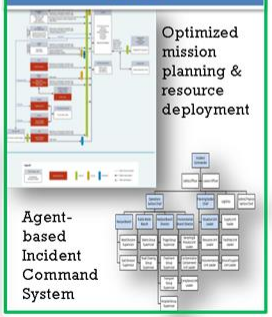
On-Demand Communication Infrastructure

To connect cyber-physical technologies with humans in the loop to save lives, rescue people, and attend to their critical needs when disaster strikes.

- Seamless integration with existing emergency response system
- Mature on-demand drone-carried communication infrastructure
- Support of missions for first responders, rescue robots, and mission command and control centers
- Real-world deployment and testing

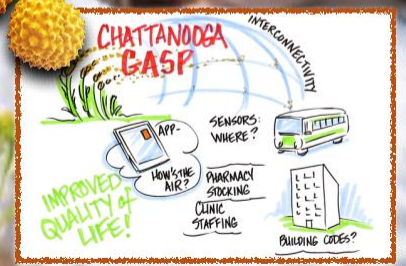
First Responders, Survivors, and Rescue Robots

Mission Command and Control



GEOLOCATED ALLERGEN SENSING PLATFORM

GASP



Four objectives:

1. Develop and deploy an array of Internet of Things remote airborne particle sensors within Chattanooga to be used to provide real-time streamed data on hourly particulate levels, both pollen- sized (10-40 micron) and smaller (<2.5 micron) particles.
2. Deploy an in-situ pollen air sampler in Chattanooga to identify specific pollen types.
3. Merge locally streamed data with already-collected, satellite-based NASA data to complement and enhance the newly-collected particulate data and generate Chattanooga-focused particulate maps.
4. Develop web-based visual tools to provide real-time pollen and smaller particle alerts to end users such as asthma patients, health institutions, and businesses and other institutions affected by elevated pollen levels.

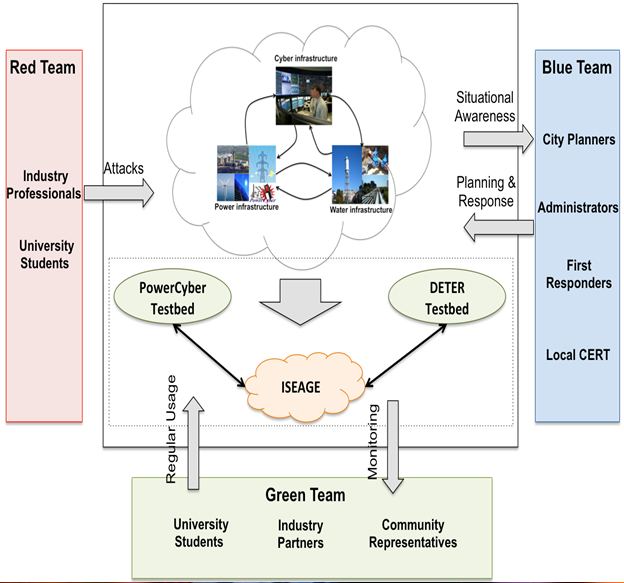
UT Dallas · The University of Tulsa · The Public Library · epb Fiber Optics · The Enterprise Center

University of North Texas | Mathworks | HumanoidWay | Worcester Polytechnic Institute | Wright State University | Myth Innovations | Emergency Preparedness Department of the North Central Texas Council of Governments
Contacts: yan.wan@unt.edu; shengli.fu@unt.edu; dr.justyna.zander@ieee.org

CyDECS: Cyber Defense Exercise for Critical Infrastructure Security

Team: Iowa State University, USC/ISI, …

Cyber Security Preparedness & Resiliency Training



Autonomous Notification and Data Collection System

Law Enforcement Safety Alert Network

HOW DOES IT WORK?

Designed as a pre-wired READY TO INSTALL pole data package, the Autonomous Notification & Data Collection System is truly the most cutting edge, innovate answer to increasing security where we live, work and play.

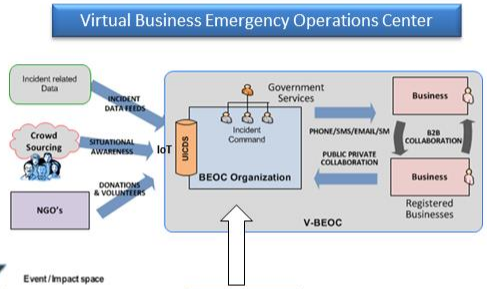
Used in conjunction with the LED lantern and surveillance camera, the complete Data Collection System is engineered to deliver discreet security surveillance and state of the art real time sensors and data collection to meet municipal risk management requirements.

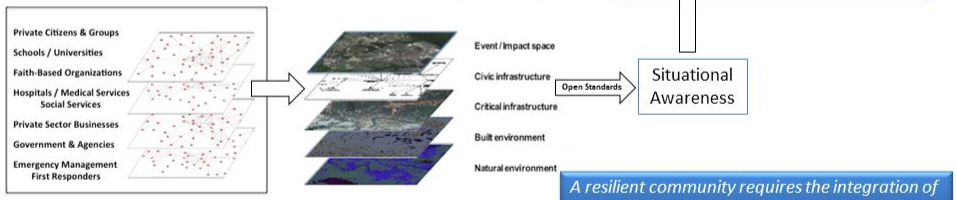
Global Cities Team Challenge

Human Geography Mapping for Enhanced Community Resilience

Annapolis, Maryland

2003 – Hurricane Isabel caused $400M in damage to the Annapolis, Maryland community





A resilient community requires the integration of human capital into resources and infrastructure.

LINKING PEOPLE, DEVICES AND ACTIONS

NIST Berkman · OGC · The City of Annapolis Maryland · AΣthena Analytics · TCecure · University of Louisiana

George Mason University · verizon (in communication) · INOVA · Fairfax County Fire & Rescue (in communication) · Yet

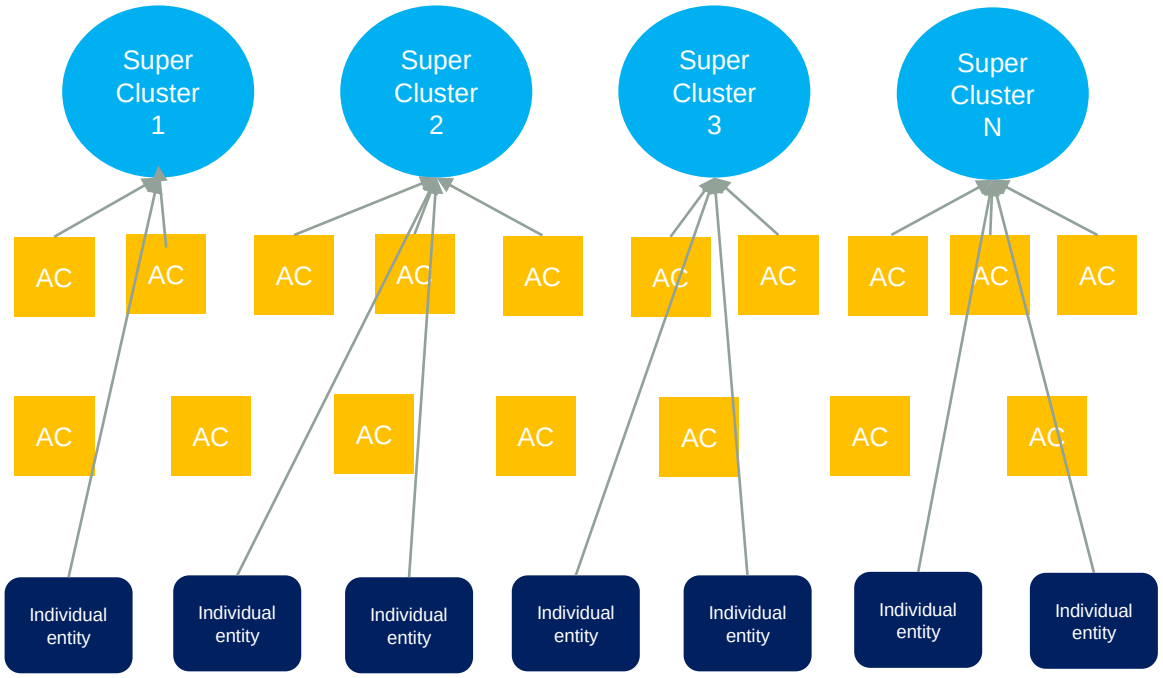
GCTC 2015 and 2016 Expo

GCTC 2016 EXPO
90+ Teams
120+ Cities/Local Governments
300+ Companies, Universities, Non-profits
14 Countries
2000 attendees

Photo Credits: NIST / US-Ignite

GCTC Structure

- Action Cluster is the basic unit of participation. It is a team of technology providers and one or more municipal partners. Action Cluster may choose to be affiliated with a SuperCluster.
- SuperCluster is a collaboration of Action Clusters with participation from additional individual entities.



Expo Exhibit/Presentation Opportunities
- Layer 1-3: Eligible for an independent exhibit space and a presentation slot, assuming municipal participation
- Layer 4: Can be part of a SuperCluster exhibit/presentation, but no independent space/presentation slot

What is a SuperCluster

- A Cluster of Action Clusters
  - Multi-city, multi-stakeholder clusters organized around common project objectives and shared solutions.
  - Committed cities/communities and partners to jointly tackle shared issues – develop and deploy shares solutions to create economies of scale
  - Minimum requirement: 2 cities/communities and 2 technology innovators (companies, universities, non-profits, etc.)
- How to define a Successful SuperCluster?
  - A SuperCluster with a shared blueprint that a larger number of cities and partners work together to implement.
  - Size matters – The more cities and partners, the better. Global collaboration is also important.
  - Scope matters – the broader and more inclusive the scope of the blueprint, the better.
  - Result matters – A SuperCluster showing tangible, measurable and quantifiable impacts on a larger number of cities and communities.
- GCTC will feature the results and process of successful SuperClusters and their members throughout the year, and highly recognize them at the 2017 GCTC Expo.

Key Products of a SuperCluster

- Develop **blueprint/playbook/source book** for each SuperCluster, starting at the GCTC 2016 SuperCluster Kickoff on Oct 2016 -
  - Create the inventory of volunteering action clusters and related technologies
  - Identify relationships among the solutions
  - Produce the strategy to maximize synergy among solutions
  - Discuss the collaboration plan
- Convene in-person, sector-specific **GCTC SuperCluster Workshops** of interested GCTC Action Clusters and stakeholders
- Conduct **multi-city, collaborative deployments** consistent with the SuperCluster blueprint, and measure the impacts
- Report initial results at the **GCTC Expo** in August 2017

Smart City SuperCluster Blueprint / Playbook

- The Main Goal

“Help the cities and communities to jumpstart planning and deployment of replicable and successful best practices without going through the painful and complicated process that other cities may have already gone through.”

- The blueprint/playbook will be the foundation for the next rounds of GCTC.

List of SuperClusters

- General Information: https://pages.nist.gov/GCTC/super-clusters/
- Transportation SuperCluster (TSC)
  - Leading city: Portland, OR, Columbus OH
  - Join the group: https://groups.google.com/a/urban.systems/forum/#!forum/global-city-teams-challenge-super-action-cluster/join
- Public Safety SuperCluster (PSSC)
  - Leading City: Washington DC
  - Join the group: https://groups.google.com/forum/#!forum/gctc-public-safety-supercluster/join
- Energy, Water, Waste Management SuperCluster (EWSC)
  - Leading City: Atlanta, GA, San Leandro, CA
  - Join the group: https://groups.google.com/forum/#!forum/gctc-energy-water-waste-management-supercluster/join
- Public WiFi SuperCluster (PWSC)
  - Leading City: San Mateo County, CA, San Leandro, CA, Schenectady, NY
  - Join the group: https://groups.google.com/forum/#!forum/gctc-wifi-supercluster/join
- City Data Platform SuperCluster (CPSC)
  - Leading City: Kansas City, MO

Cybersecurity and Trustworthiness in Smart Cities and Communities

- Cities and communities across the globe are striving to adopt advanced technologies to improve the quality of life of the residents.
- Many cities and communities are aware of the cybersecurity and trustworthiness risks in their deployments, but not many of them have a clear vision and expertise to address them.
- Industry stakeholders are eager to address cybersecurity and trustworthiness issues in smart cities/communities as well, but struggling to find a clear business model for cybersecurity and trustworthiness of IoT/smart city solutions.

Cybersecurity and Trustworthiness in Smart Cities and Communities

- Partnership approaches are necessary to accelerate the identification and replication of secure and trustworthy solutions in community environments
- It is critical to identify scalable business models to improve cybersecurity and trustworthiness in smart cities and communities.

GCTC Expo 2017

"The Largest Smart City/Community Event hosted by the US Federal Government"

- **August 28-29, 2017, Walter E. Washington DC Convention Center**
  - Monday (8/28) & Tuesday (8/29)
  - Federal government keynotes
  - Mayor and County Executive keynotes panel
  - 5 SuperClusters, 90+ Action Clusters presentations and exhibits
  - 100+ Cities and communities from around the world
  - 400+ Companies, universities, and non-profits
  - 1500+ Attendees
  - No registration fee.
- Visit www.globalcityexpo.org for more info or contact Sokwoo.rhee@nist.gov.
- To become an Action Cluster and exhibit/speak, visit https://pages.nist.gov/GCTC/about/participation-guide/

For More Information

- Contact
  - Sokwoo Rhee (sokwoo.rhee@nist.gov)
- GCTC web site:
  - https://pages.nist.gov/GCTC/
  - https://www.nist.gov/el/cyber-physical-systems/smart-americaglobal-cities
- GCTC 2017 Expo Registration:
  - https://pages.nist.gov/GCTC/event/gctc-expo-2017/