Appalachia and the Emerging Internet of Things (IoT)

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Three Internet Waves

Internet 1.0: desktops and laptops

Internet 2.0: smartphones and tablets

Internet 3.0: infrastructure, vehicles, and industrial equipment

Internet 1.0

- Fixed Internet
- Connected desktops and laptops to the Internet
- 1 billion users connected

Internet 2.0

- Mobile Internet
- Connected smartphones and tablets to the Internet
- 2 billion users connected

Internet 3.0

- Internet of Things (IoT)
- Connecting infrastructure and equipment to the Internet
- 30-60 billion “things” connected

Source: Goldman Sachs IoT Report, September 2014

Source: Connected Magazine (www.connectedremag.com), August 2017

Promising IoT Sectors in Appalachia

Drones intersect with all IoT sectors

Infrastructure IoT and consumer IoT intersect for utilities

Infrastructure IoT and mobility IoT intersect for smart roads and vehicles

Infrastructure IoT

- Smart meters
- Inspection drones and robots

Consumer IoT

- Smart home devices
- Personal assistant drones and robots

Mobility IoT

- Connected and autonomous (CAV) vehicles
- Delivery drones and robots

Infrastructure IoT Defined

Physical Infrastructure + Data Infrastructure

Physical infrastructure transports & stores vital physical goods

Data infrastructure transmits & stores data about physical infrastructure

Infrastructure IoT

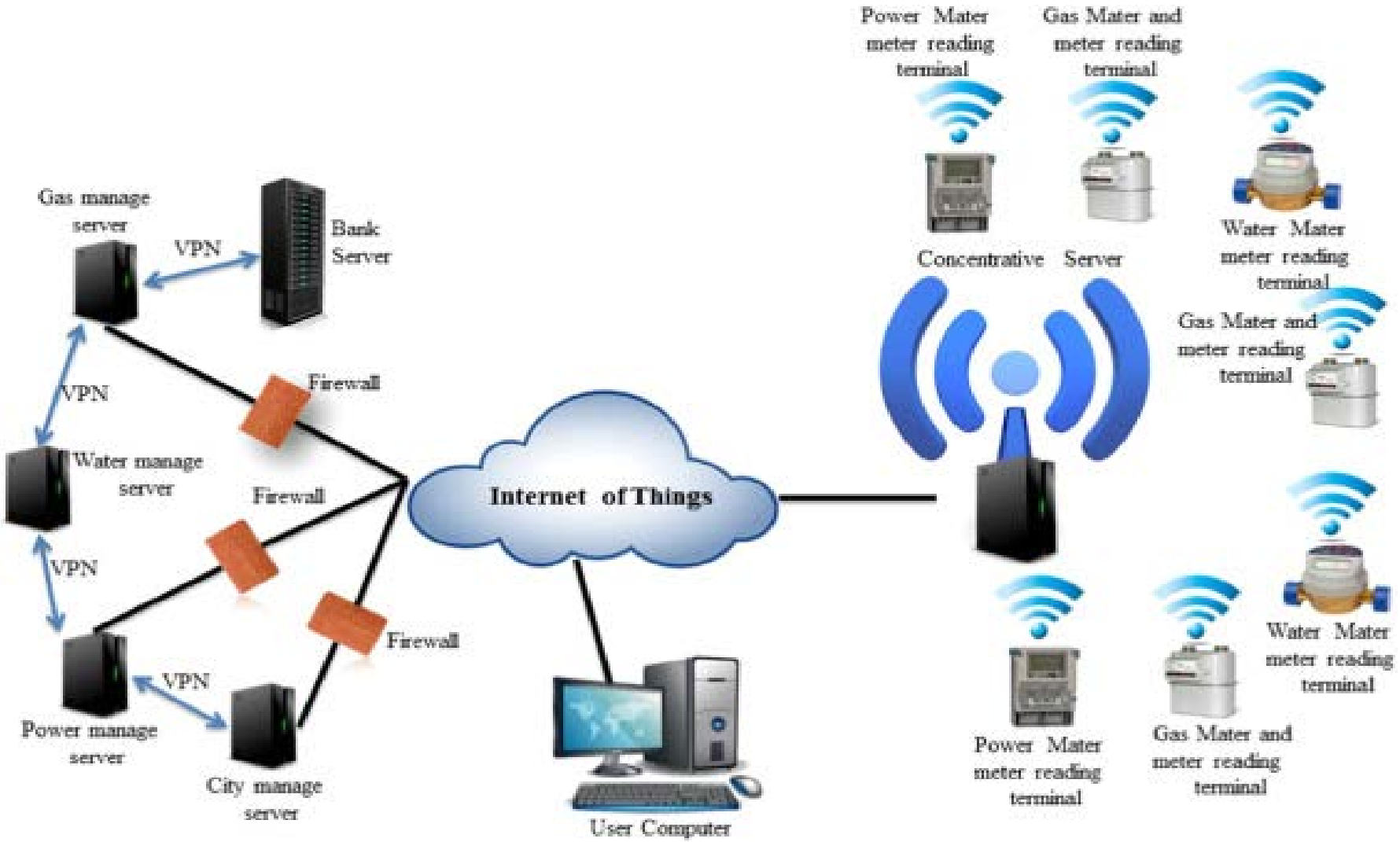
- Infrastructure IoT = Physical Infrastructure + Data Infrastructure

Physical Infrastructure

- Electric grids
- Water/sewer pipelines
- Natural gas pipelines
- Roads, highways, and bridges

Data Infrastructure

- Fixed sensors (smart meters)
- Mobile sensors (drones and robots)
- Fiber/wireless connection
- Data storage and analytics



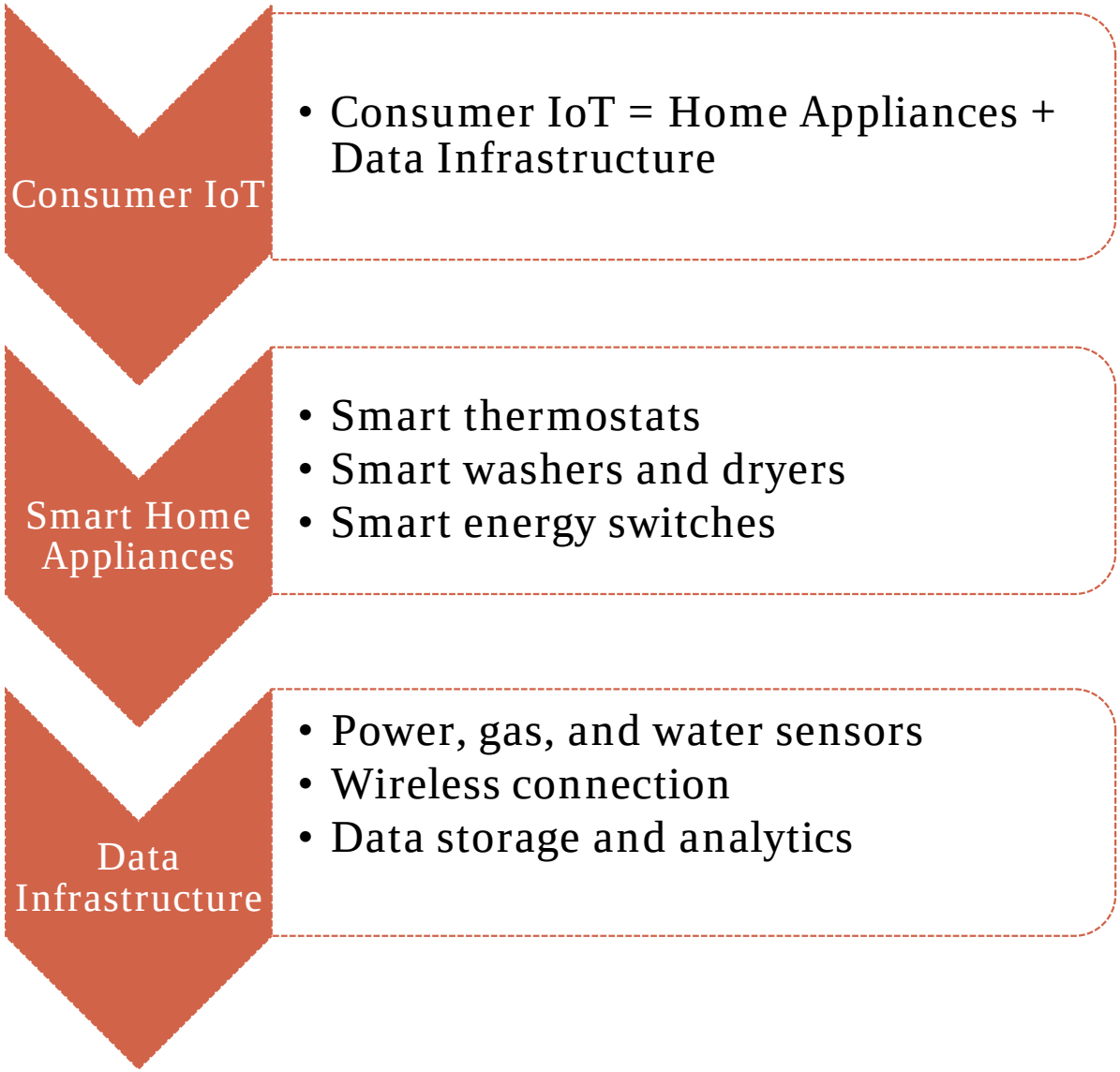
Source: ScienceDirect, December 2016

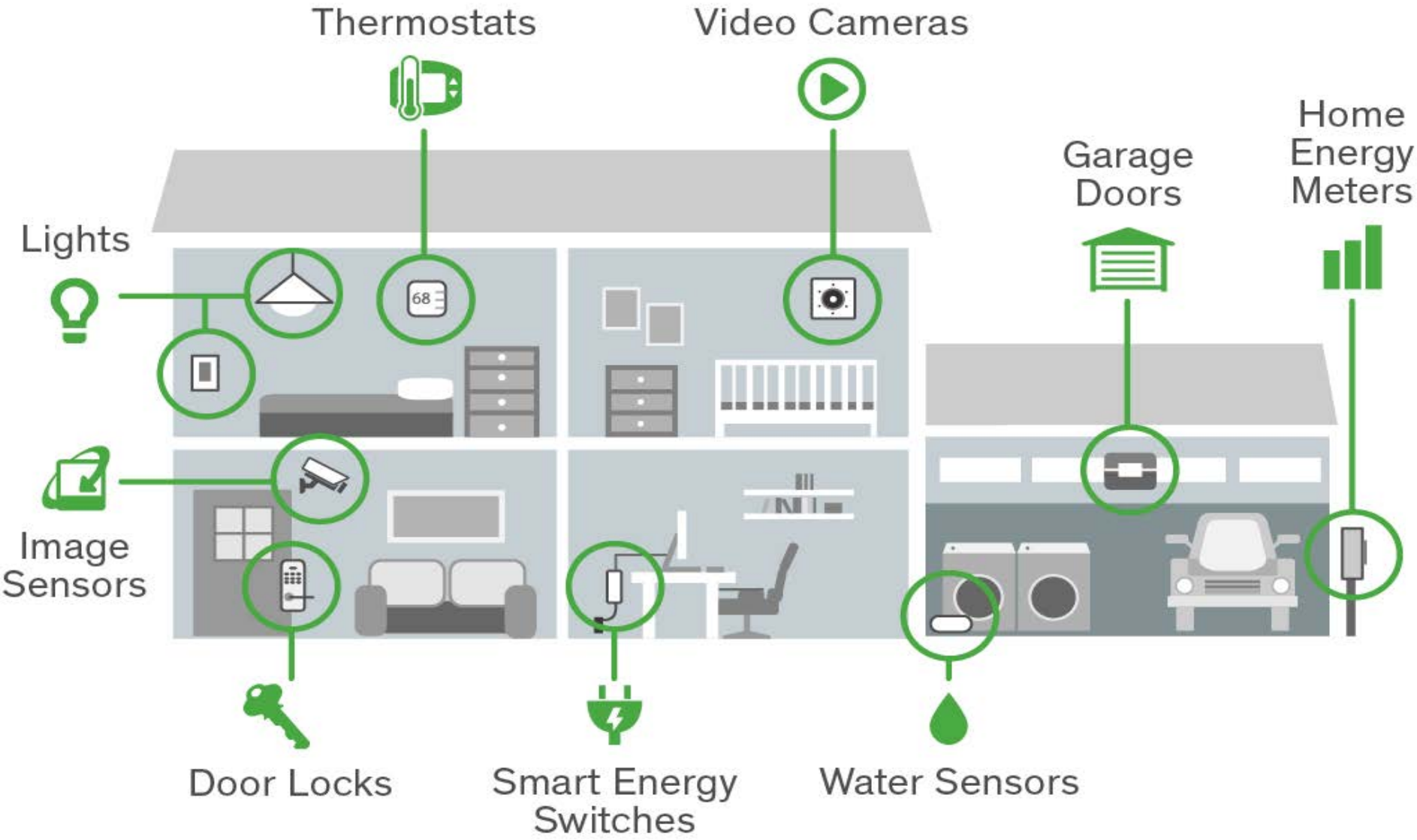
Consumer IoT Defined

Physical Infrastructure + Data Infrastructure

Home appliances might consume water, gas, or power

Data infrastructure transmits & stores data about physical infrastructure





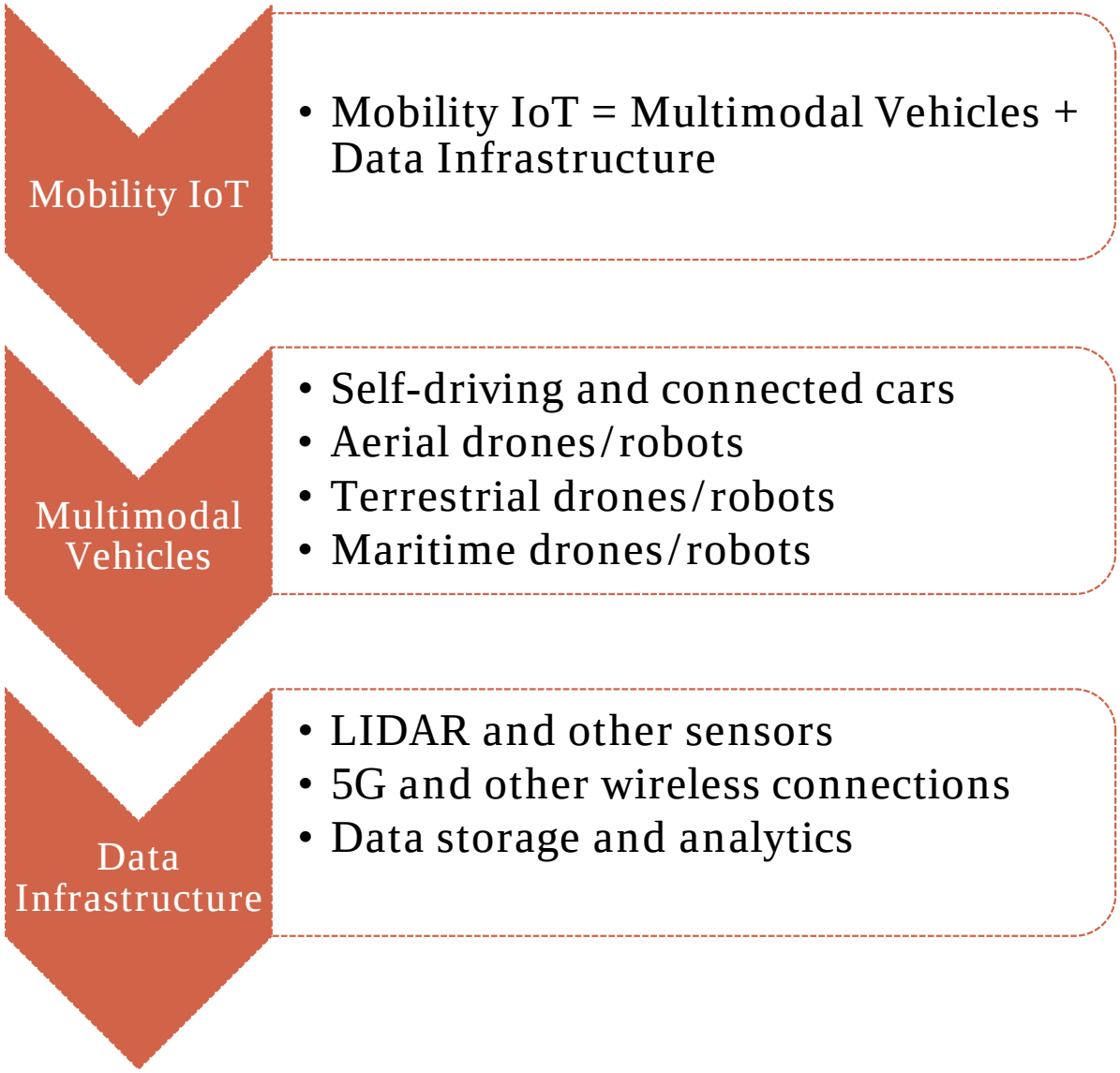
Source: Petro Home Services Automation

Mobility IoT Defined

Multimodal Vehicles+ Data Infrastructure

Includes vehicles across land, air, and water domains

Data infrastructure transmits & stores data about multimodal vehicles



Smart cars and smart roads working together

Autonomous vehicles can achieve maximum functionality if integrated with smart roads containing enabled sensors and communication technology

Source: TM&E Magazine, 2013

What Is Data Infrastructure?

Putting the "I" in "IoT"

Data generation (sensors)

Data transmission (signals, broadband)

Data storage (servers)

Sensors

- Fixed sensors (smart meters, smart devices, etc.)
- Mobile sensors (drones and other mobile robots)

Signals

- Fiber transmission of data
- High-speed wireless transmission of data (e.g., microwave, Wi-Fi, etc.)

Servers

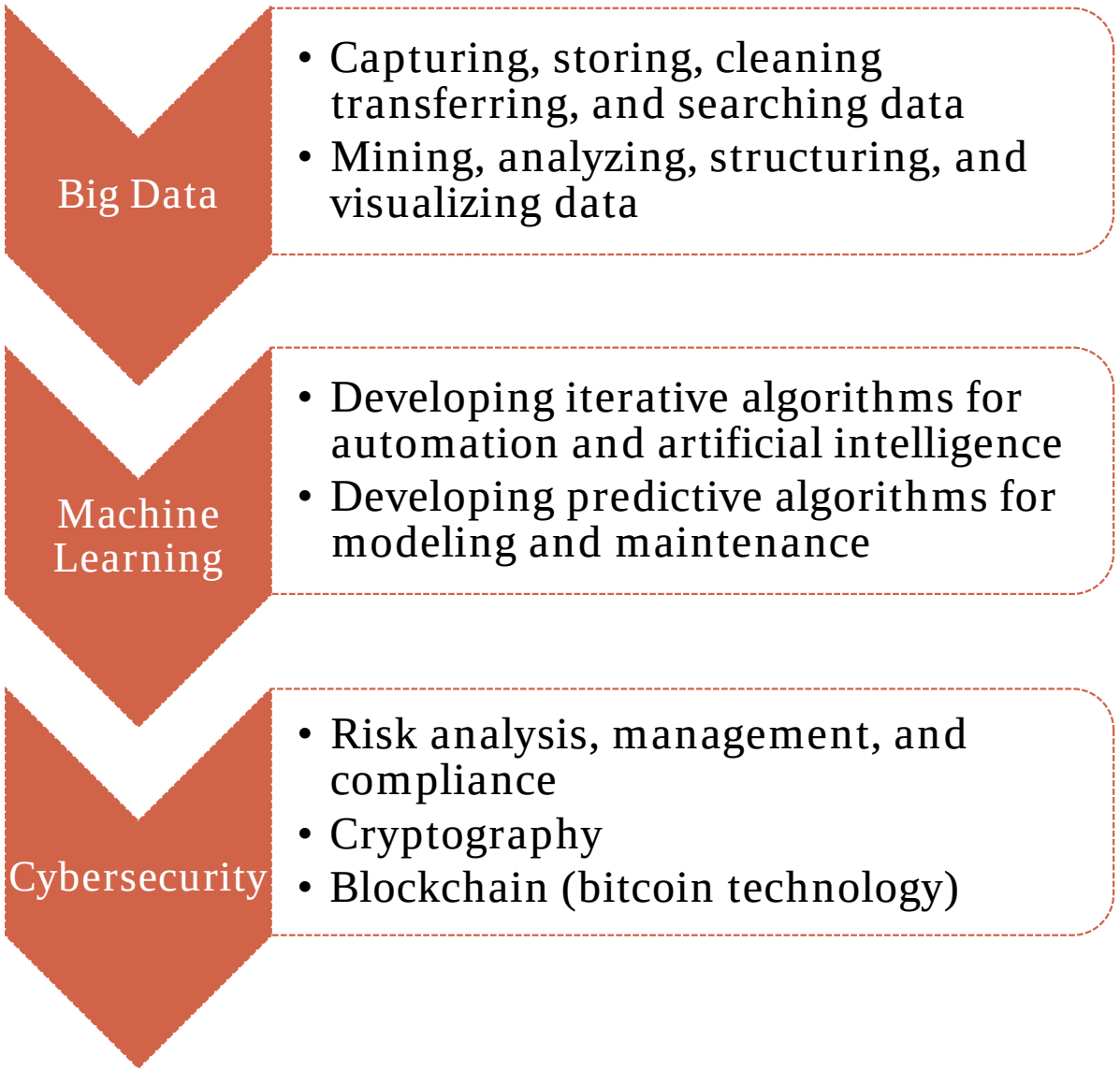
- Network operations center (NOC)
- Supervisory control and data acquisition (SCADA) system
- Data center (local or cloud)

Creating a Data Economy

Data infrastructure will generate Big Data applications

Machine learning applications can aid automation of data infrastructure

Data infrastructure generates sensitive data that needs to be secured

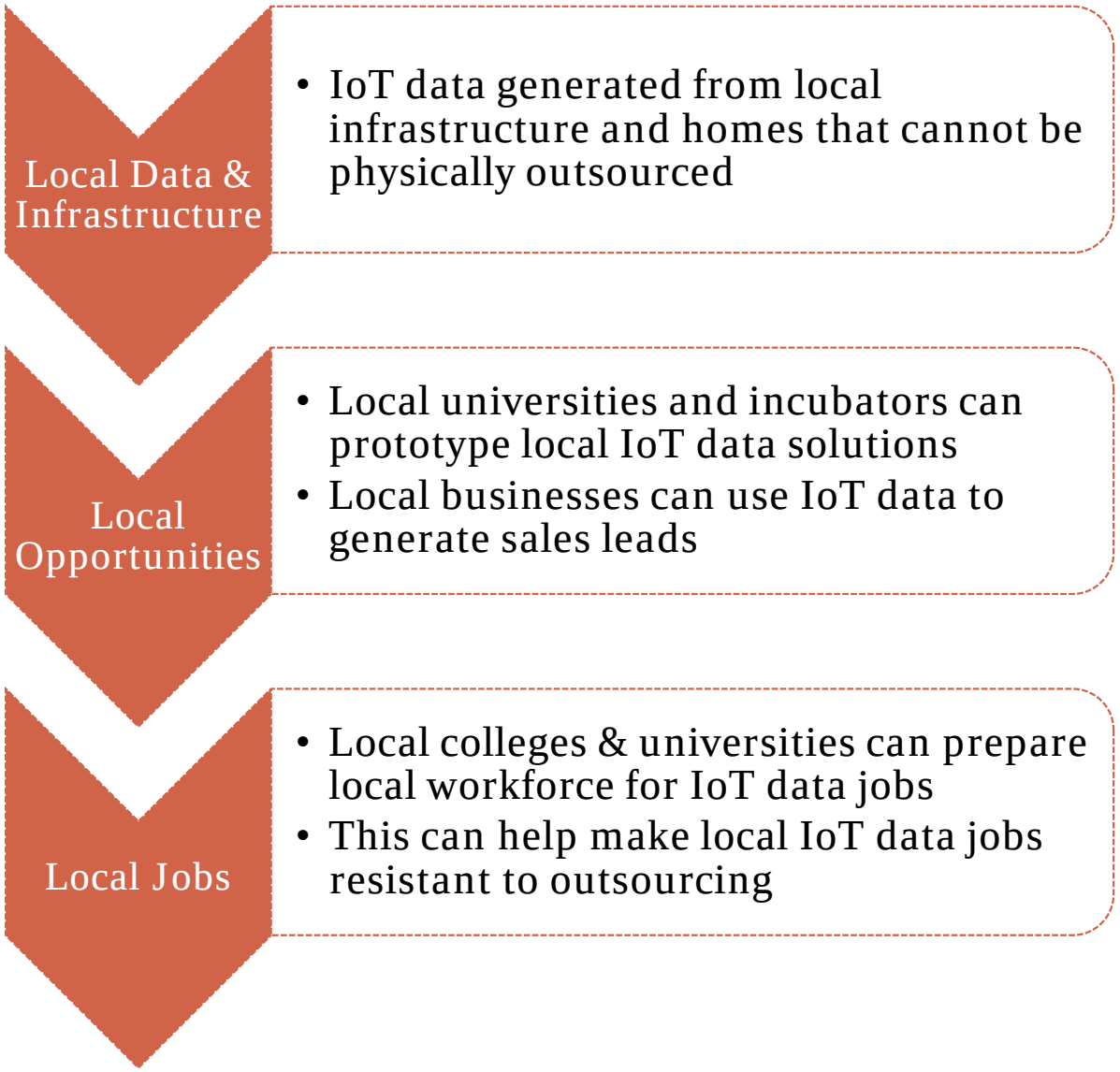


Jobs Rooted in the Local Community

Local infrastructure and homes cannot be outsourced

Local universities and businesses can benefit from IoT data

Local residents can be trained for infrastructure IoT jobs that are resistant to outsourcing



The Rural Advantage in IoT Innovation

Smart grid use cases help drive innovation

Ideal drone testing environment

Ideal conditions for data centers

Use Cases for Smart Grids

- Rural utilities have a greater strategic need for remote monitoring technologies

Ideal Drone Testbed

- Low population density of rural areas makes testing safer

Data Center Friendly

- Cheap plentiful land
- Cheap utilities, especially power
- Distant from population centers

Adverse Economics of Rural Utilities

High economies of scale mean high fixed capital costs

Higher monitoring costs for wide rural utility networks

Low population density and low "revenue density"

Lost revenues from system losses

High Costs

- High fixed capital costs
- High variable operating costs

Low Density

- Relatively small customer base
- Customers spread over large area

Limited Revenues

- Small customer base limits revenue potential
- Aging, leaking infrastructure further reduces revenues

IoT and the New Economics of Rural Utilities

Delayed capital expenditures lower fixed capital costs and boost cash flow

Remote monitoring lowers variable operating costs

Shifting peak demand lowers congestion costs

Recovered revenues from leak detection

New revenues from broadband services

Reduce Fixed Costs

- Real-time monitoring catches problems early and extends the life of the system
- This saves money by allowing major system repairs to be delayed

Reduce Variable Costs

- Remote monitoring reduces costs and allows repair crews to focus their efforts
- Shifting peak demand lowers the variable costs associated with network congestion

Increase Revenues

- Real-time monitoring helps detect system leaks and recover lost revenue
- The fiber that supports the smart grid can be leveraged to provide the utility with a new broadband revenue stream

Infrastructure IoT Paybacks: Chattanooga EPB Example

$4.8M in lower costs

$5M in recovered revenues

$14.4M in new broadband revenues

$23.6M in net annual paybacks

12-year payback period on investment

Lower Costs

- $2.3M in peak power purchase savings
- $2.5M in reduced monitoring costs

Higher Revenues

- $5M in recovered revenues from leak and theft detection
- $14.4M in new broadband service revenues

Solid Returns

- $111.6M in ARRA funding in 2009
- $280M cost of fiber and smart grid
- $23.6M net annual paybacks
- 12-year payback period for smart metering and broadband

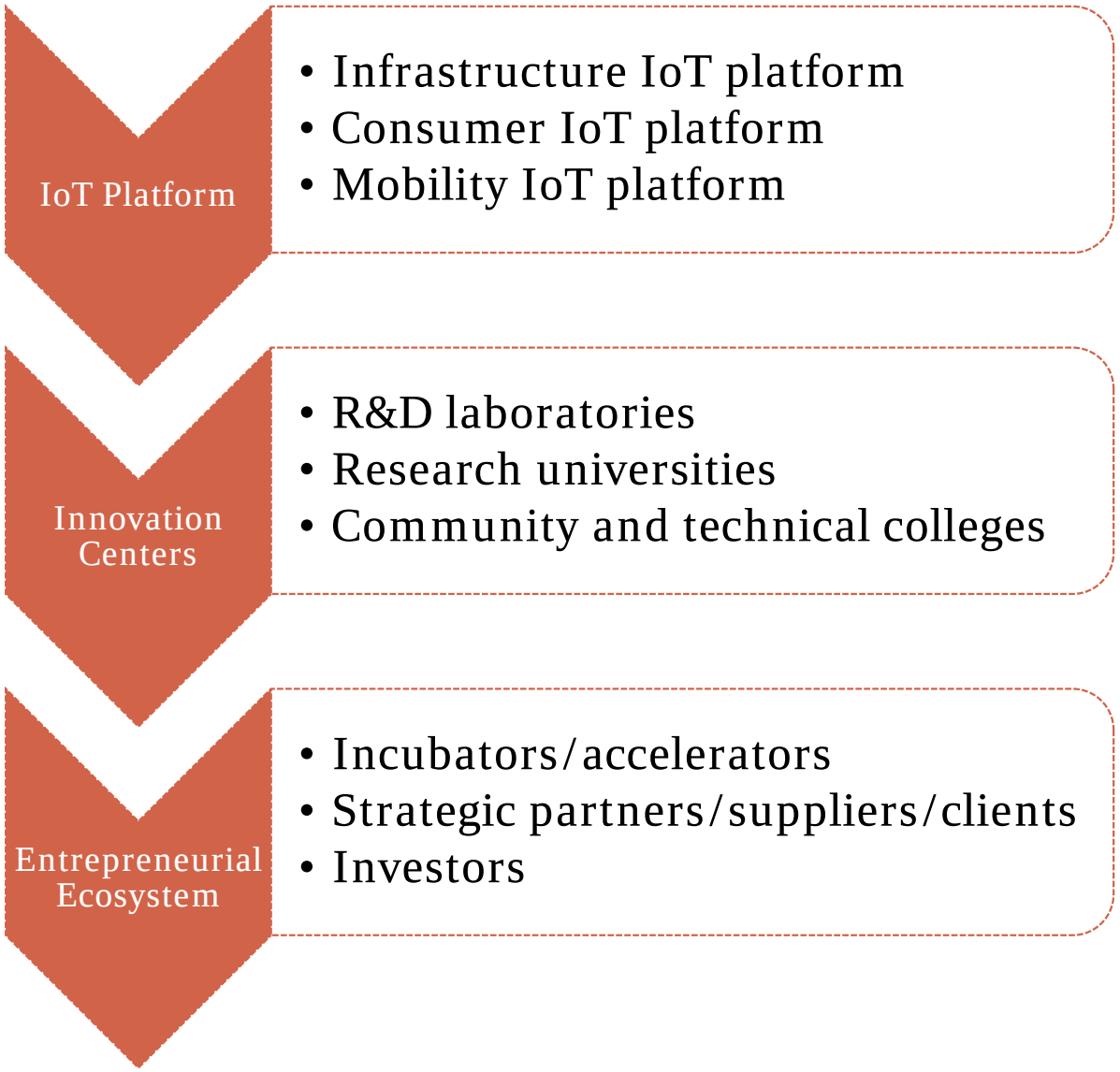
Source: The Municipal Fiber Project, Harvard University, February 2017; Oak Ridge National Laboratory Report, 2015

Building an IoT Innovation Ecosystem

Generate data from IoT platforms

Prototype IoT applications with innovation partners

Commercialize and accelerate viable IoT solutions through an entrepreneurial ecosystem



IoT Innovation Ecosystem: Volunteer Energy Cooperative

Rural Electric Cooperative

National Laboratory and Local University

Regional Entrepreneur Center & Accelerator

POWER Applicant, Round 1, 2018

Volunteer Energy Cooperative

- VEC to deploy gigabit-speed fiber service and smart meters that enable load management of smart home devices

MIT-LL & Tennessee Tech

- MIT Lincoln Lab to build a local copy of its testbed system at Tennessee Tech
- Tennessee Tech to create "digital twin" of VEC grid and prototype grid solutions

Biz Foundry

- Biz Foundry assists entrepreneurs in Cookeville region of Tennessee
- Client entrepreneurs would develop IoT software applications

IoT Innovation Ecosystem: Potomac Highlands Airport Authority

- Rural Airport Authority
- National Laboratory and Research Universities
- Technology Incubator
- POWER Applicant, Round 2, 2018?

Potomac Highlands Airport Authority (PHAA)

- PHAA plans support sensor technology innovation at the Cumberland Regional Airport in West Virginia

MIT-LL, UMD, FSU, & WVU

- MIT-LL, MTI at UMD, Frostburg State University, and WVU would partner to prototype mobility IoT solutions

Autonomous Technology Center (ATC)

- PHAA developing ATC to seed and commercialize unmanned vehicle (UMV) system innovation

IoT Innovation Ecosystem: Wise County Public Service Authority

Rural Water Authority

National Laboratory and Local University

Regional Technology Accelerator

POWER Applicant, 2019?

Wise County Public Service Authority

- Wise County PSA to invest in system-wide water leak detection technology
- MIT researchers field tested a water leak detection robot at Wise in January 2018

MIT-LL, MECC, & UVA-Wise

- MIT-LL to conduct a review of various leak detection technologies
- Big Data from this project will be integrated into local cybersecurity training program

MACH37

- MACH37 is a cybersecurity accelerator that works with entrepreneurs to develop new cyber applications

Possible ARC Infrastructure IoT Grantees

200 muni and co-0p electric utilities

149 muni & co-op gas utilities

4,050 water/sewer utilities

Electric Utilities

- 307 total electric utilities in ARC region
- 95 municipal electric utilities in ARC region
- 105 co-op electric utilities in ARC region

Natural Gas Utilities

- 217 total gas utilities in ARC region
- 144 municipal gas utilities in ARC region
- 5 co-op gas utilities in ARC region

Water/Sewer Utilities

- 4,417 total water/sewer utilities in ARC region
- 4,050 municipal water/sewer utilities in ARC region

Source: Energy Information Administration (EIA), DOT Pipeline and Hazardous Materials Safety Administration (PHMSA), and EPA Pollution Data

Appalachian Infrastructure IoT Potential Investment

$2B in potential smart meter investments

$24.4B in potential aerial deployments of fiber along electric lines

523,000 new jobs created from electric infrastructure IoT investments

Smart Meters

- 2.9M uninstalled smart meters from muni and co-op electric utilities in ARC region
- $2B in potential smart meter investments by these utilities

Broadband

- 641,000 miles of distribution lines from ARC muni and co-op electric utilities
- $24.4B in potential aerial deployments of fiber along electric lines

Job Creation

- 35,000 new jobs created from smart meter investments
- 488,000 new jobs created from aerial broadband investments

Source: DOE Economic Impact of ARRA Investments in the Smart Grid (2012) and NTIA Economic Impact of Broadband Stimulus (2009)

Infrastructure IoT Possible C0-Funders

Electric infrastructure funders

Water/sewer infrastructure funders

Natural gas infrastructure funders

RUS Electric Program

- Made $3.2B of loans in FY16; $2.1B or 65% in ARC states
- Manages $46B portfolio; $23B+ in ARC states
- Major funder of smart grids and related fiber

State Revolving Funds

- SRF programs (e.g., GEFA) fund EPA-based water/sewer projects
- SRF programs in ARC states have a combined $35B in assets

Economic Development Agencies

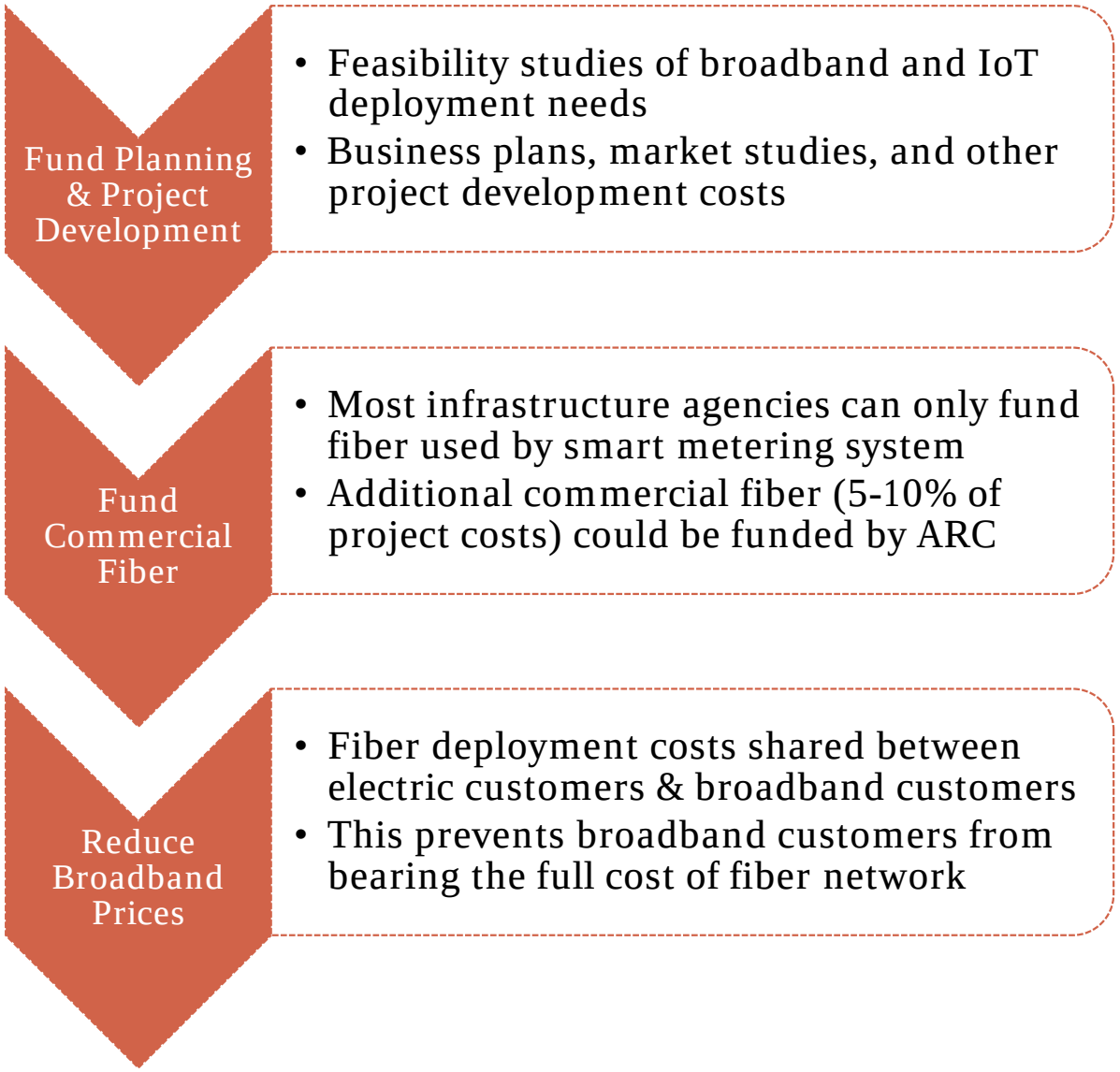
- Commonwealth Financing Authority (CFA) is funding natural gas infrastructure in PA
- Empire State Development (ESD) can fund natural gas infrastructure in New York

ARC's Strategic Value Added

Fund development costs of IoT projects

Fund commercial fiber component of infrastructure IoT projects

Fund commercial fiber component of infrastructure IoT projects



Tennessee as Focal Point for IoT Innovation Ecosystems

TVA encouraging adoption of infrastructure IoT

TN has ORNL and great universities and colleges

TN has an extensive entrepreneurial ecosystem

IoT Platform

- TVA is encouraging its electric distribution utilities to adopt smart metering and set aside spare fiber for that purpose
- Tennessee state law now allows rural electric co-ops to provide broadband

Innovation Centers

- TN has a world renowned research lab in Oak Ridge National Laboratory
- TN has a high concentration of great universities and community colleges

Entrepreneurial Ecosystem

- TN has invested extensively in the creation and development of Launch Tennessee, a statewide network of entrepreneur centers

Next Steps for ARC & Partners

Embed IoT technology in infrastructure investments

Leverage research labs and institutions to drive innovation in ARC region

Develop more entrepreneurial ecosystems in other states

Support IoT Embed in Infrastructure

- Encourage embedding of IoT technology in ARC infrastructure investments
- Includes adaptive signal control (ASC) technology in local access road projects

Support IoT Innovation

- Enable technology transfer into the region from outside innovation partners
- Promote IoT innovation clusters across the ARC region

Support Entrepreneurial Ecosystems

- Develop entrepreneurial ecosystems in other states possibly using Launch Tennessee model

Contact

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