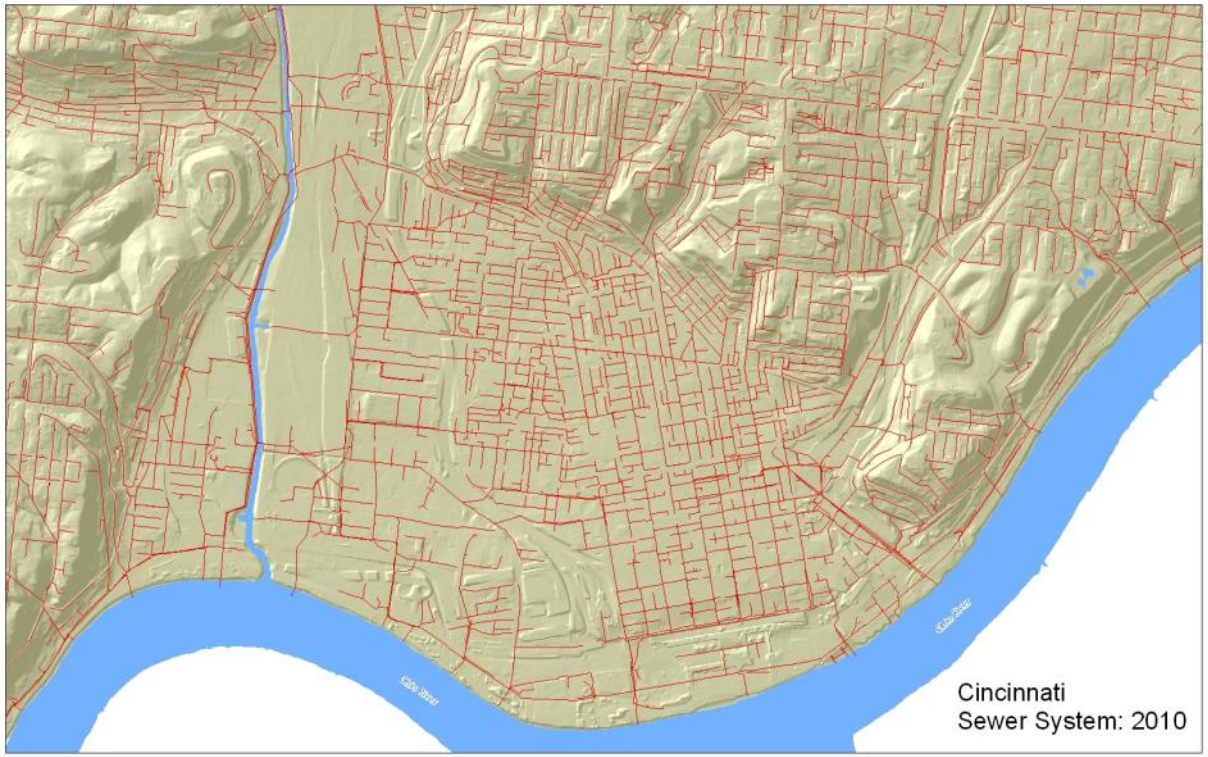
Smart Technology
Assessing System-Wide Deployment

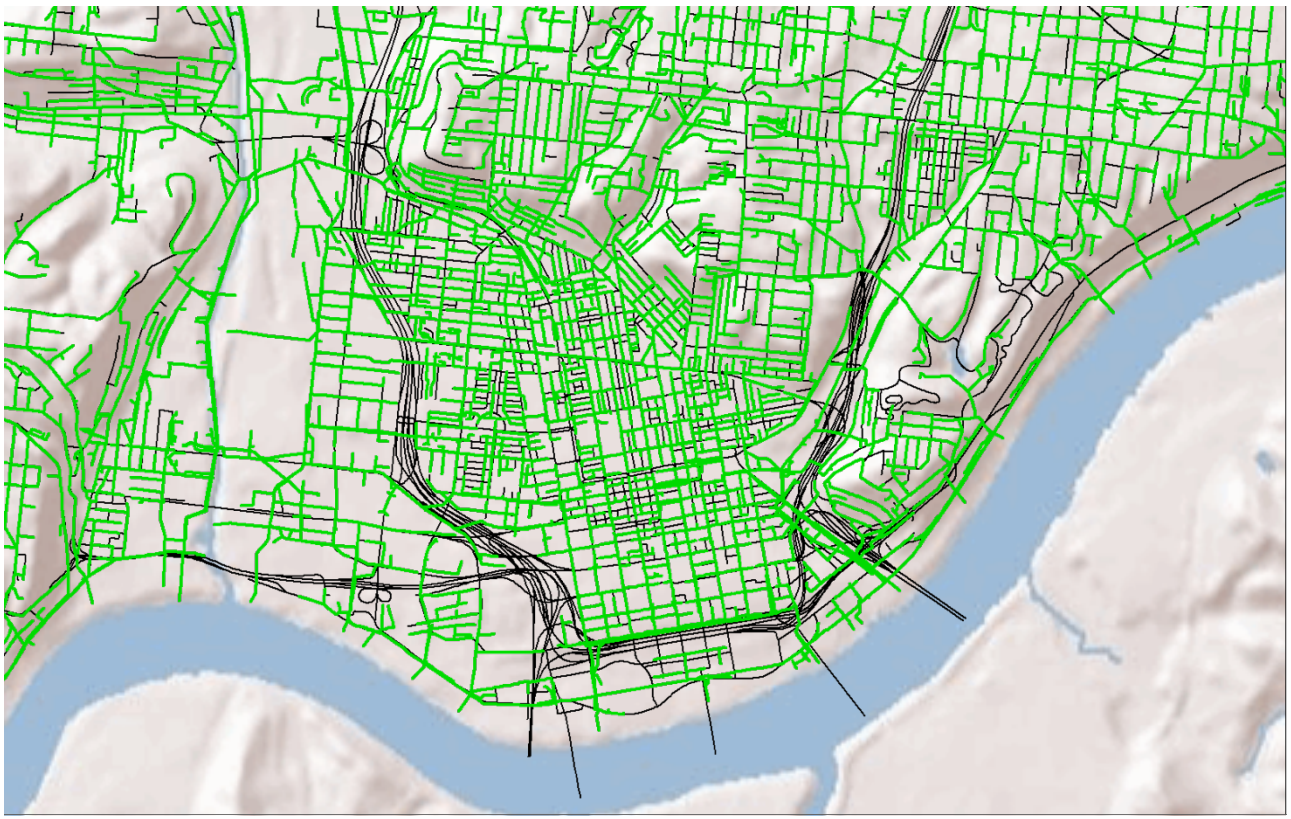
Biju George, Greater Cincinnati Water Works
Michal Koenig, Qualcomm Technologies

Reinventing Decision Making to Maximize All your Utility Assets

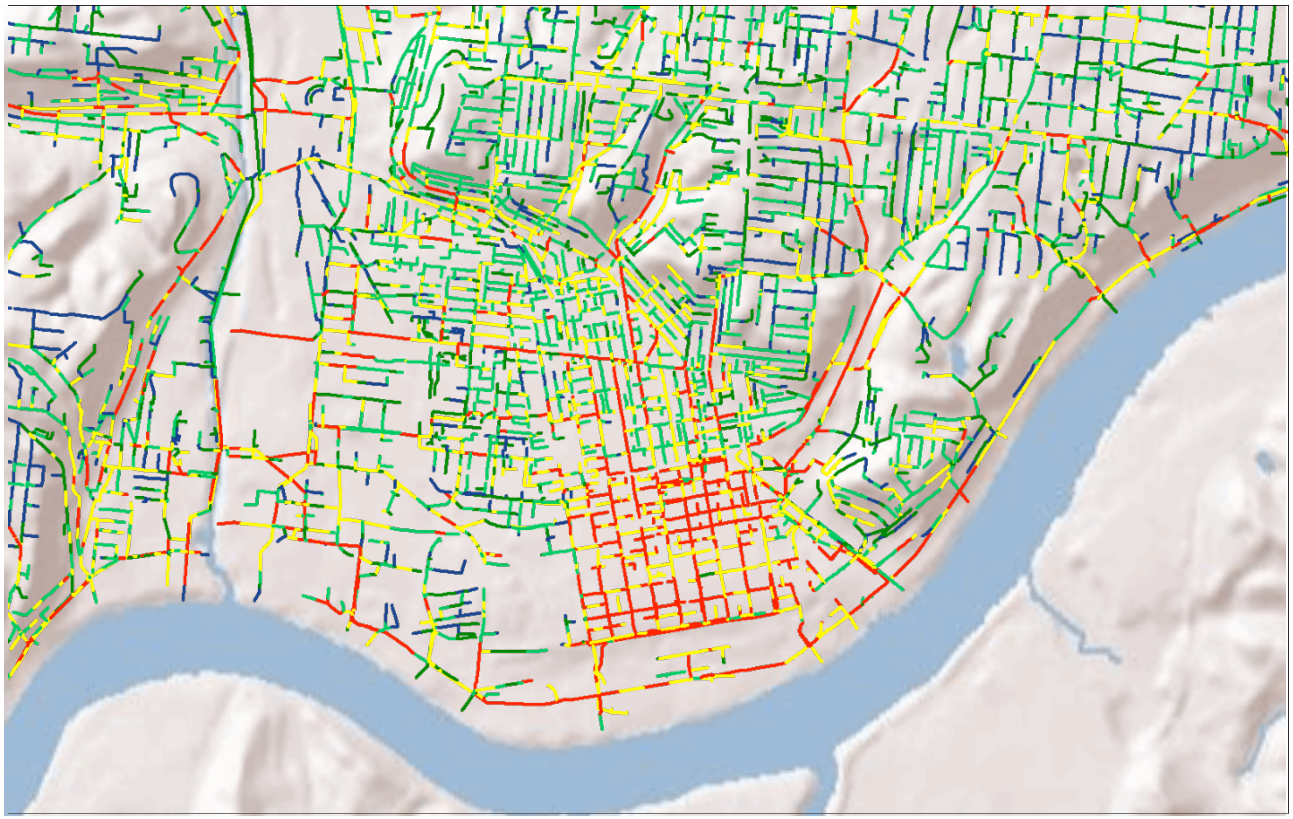
Defining Grid and Smart Infrastructure



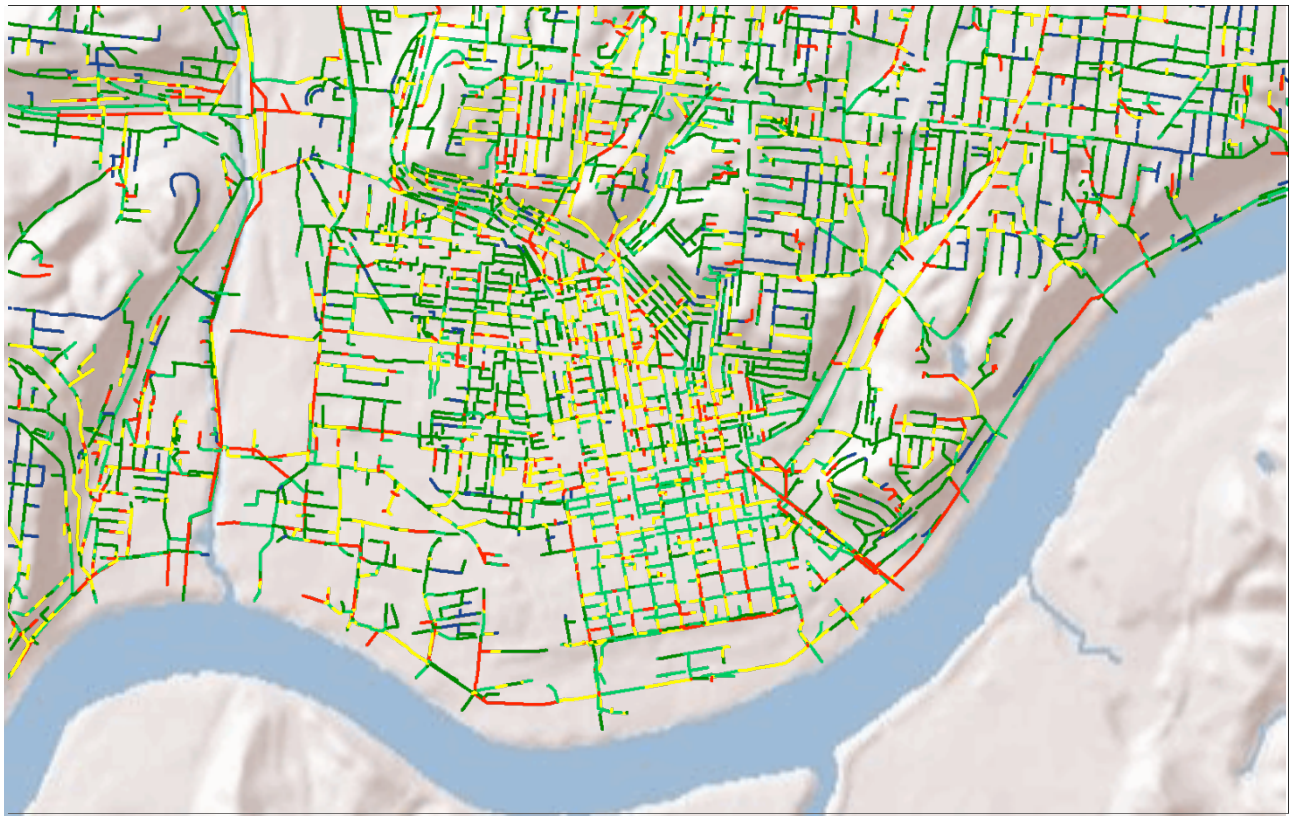
City of Cincinnati – Sewers 2013



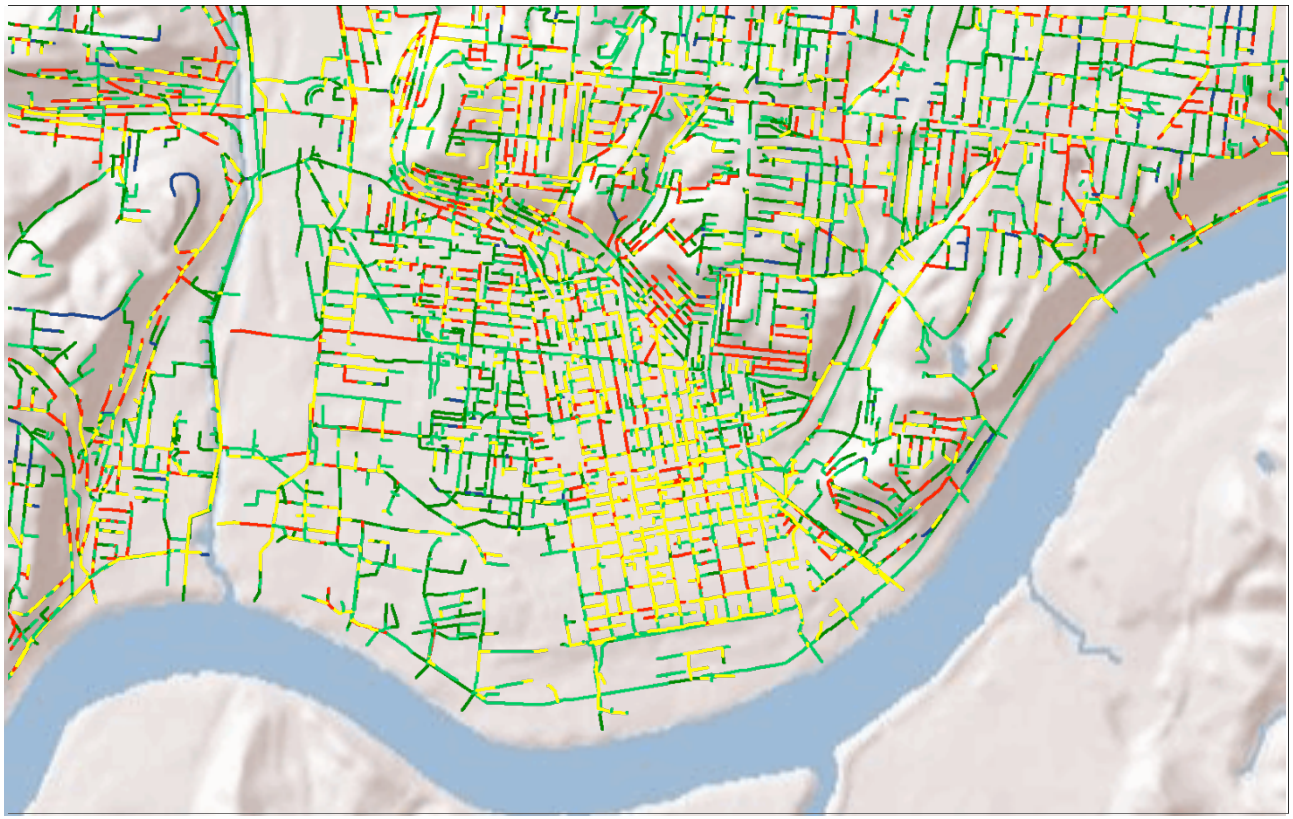
Sewer Criticality



Sewer Maintenance Risk

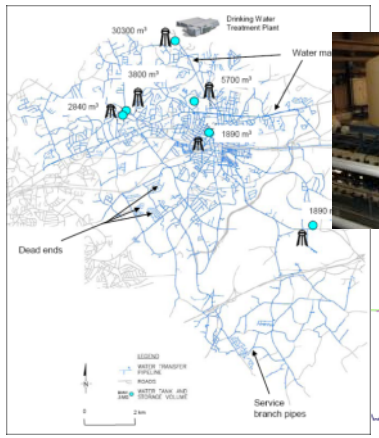


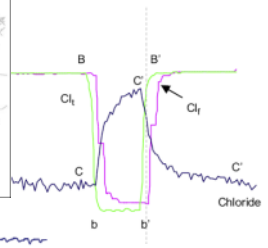
Sewer Structural Risk

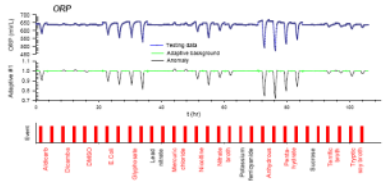


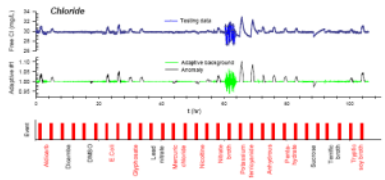
Infrastructure Data Use Evolution

- 1990s and before – Measure, Monitor, Analyze
  - Manual sampling and lab analysis
  - Compliance assessment
- 1990s – early 2000s – Model
  - Model-assisted operations
  - Online monitoring
  - System operational stability for water quality compliances
- Late 2000s - Early 2010 – Forecast
  - Real-time online monitoring, data communication
  - System diagnosis and process control
  - Real-time operation assistance
- Future - Optimize
  - System optimization on both water quality and energy/cost for sustainability
  - Simulation (Monte-Carlo) engines for climate change uncertainties in water inputs
  - Process evaluation and treatment process adaptive engineering
  - Probability curve for future regulation violations and adaptation cost









Utility Value Proposition

- Asset Optimization
  - Predictive Analytics – Transparency of the Invisible
- Operation Optimization
  - Operation Analytics – Prioritization and Optimization
- New Revenue Opportunities
  - Content Analytics – Meaning and Value
- Risk Mitigation
  - Augmented Reality Analytics – Building Resiliency

Infrastructure Data Use Matrix – Identify Opportunity

Optimize				
Model/ Forecast				
Analyze				
Measure Monitor				
	Individual Asset	Unit Process	Facility	Multiple Facilities

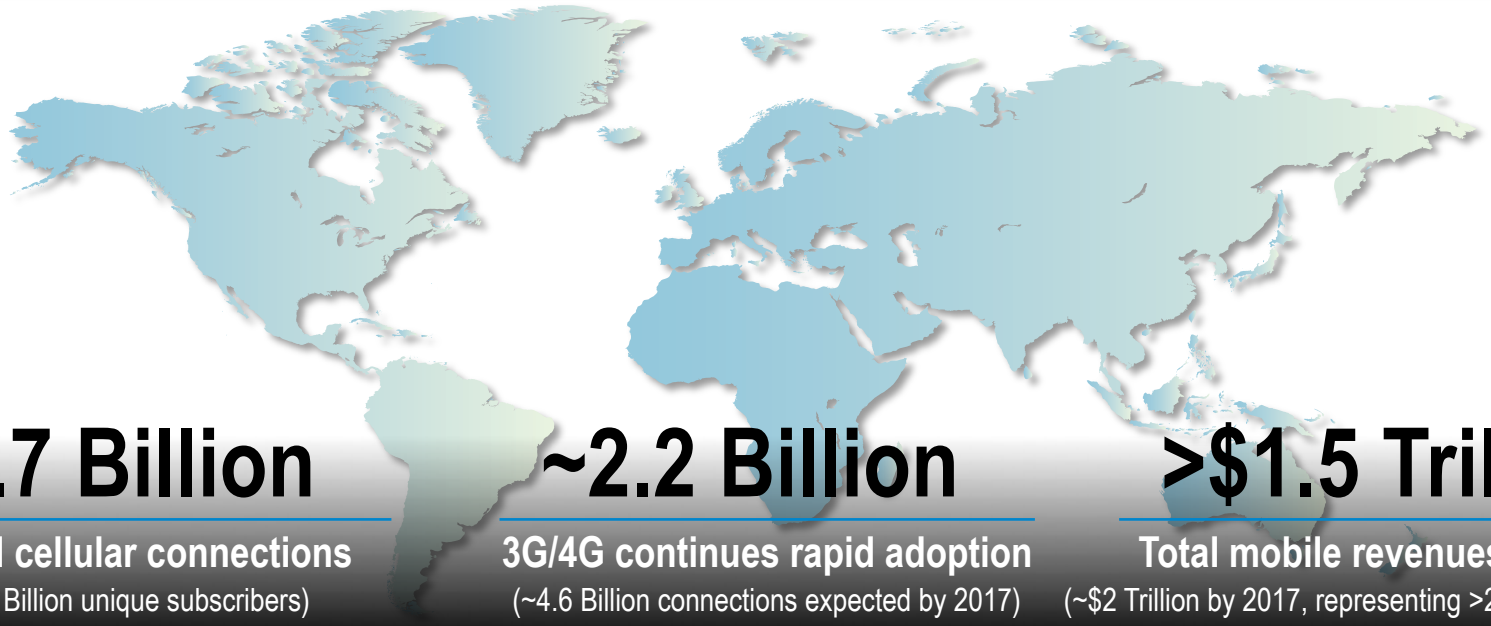
Building Smart Infrastructure

- Defining the Need
  - Data Sufficiency
  - Data Density
- Selecting Enabling Technologies
  - Low Cost Sensors
  - Wireless Communication
  - Cloud Computing

Qualcomm IoE Update for M2M in the Utility Industry

Scale of wireless continues to grow

Cellular is the largest technology platform in history



~6.7 Billion

Global cellular connections

(~3.3 Billion unique subscribers)

~2.2 Billion

3G/4G continues rapid adoption

(~4.6 Billion connections expected by 2017)

>$1.5 Trillion

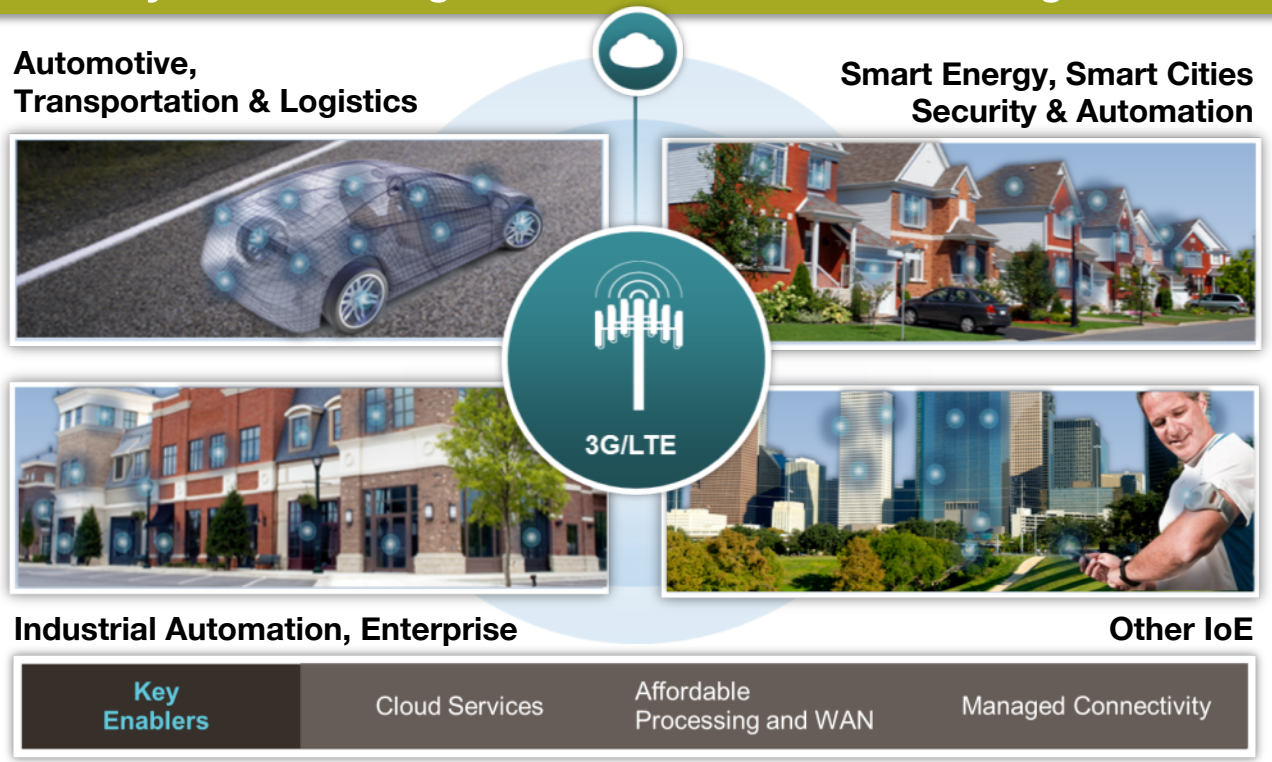
Total mobile revenues in 2012

(~$2 Trillion by 2017, representing >2% of Global GDP)

(GSMA Intelligence, Jul. '13; UN, Dec. '12)
(A.T. Kearney Analysis, Feb. '13)

Internet of everything: key segments

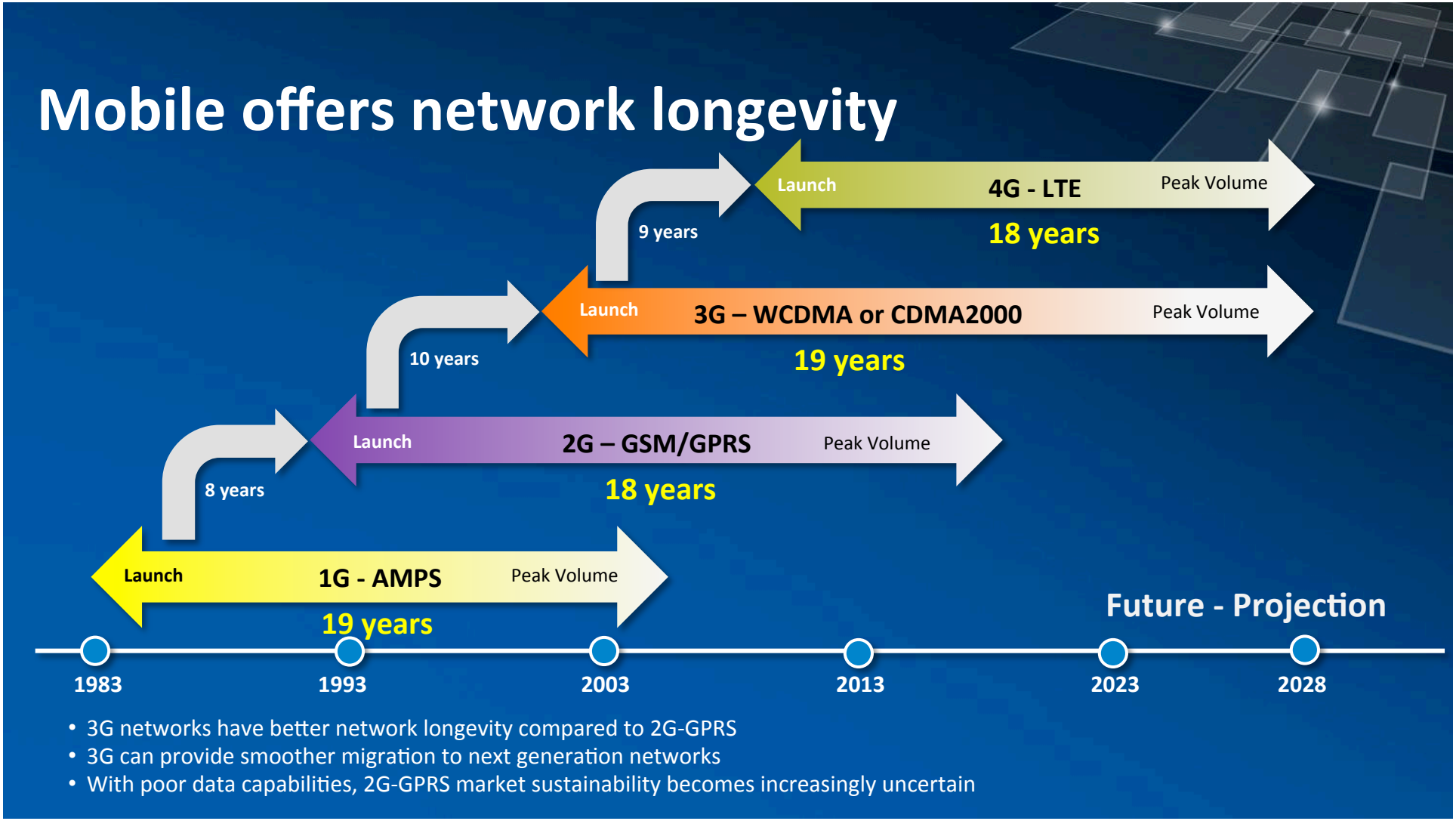
Cellular industry is embracing business models to deliver growth of IoE / M2M



The world is moving to 3G and 4G

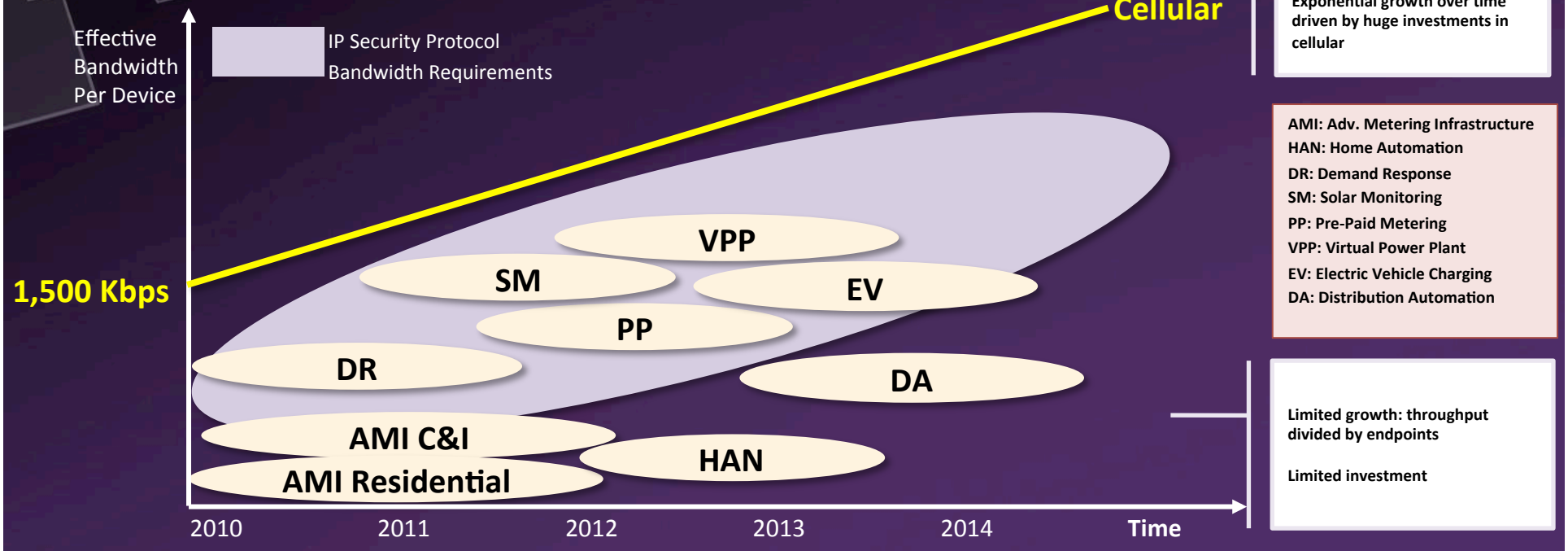
Globally, 3G and 4G-LTE continue to displace 2G-GSM and WiMAX

Mobile offers network longevity



- 3G networks have better network longevity compared to 2G-GPRS
- 3G can provide smoother migration to next generation networks
- With poor data capabilities, 2G-GPRS market sustainability becomes increasingly uncertain

Throughput is increasingly important



Exponential growth over time driven by huge investments in cellular

AMI: Adv. Metering Infrastructure
HAN: Home Automation
DR: Demand Response
SM: Solar Monitoring
PP: Pre-Paid Metering
VPP: Virtual Power Plant
EV: Electric Vehicle Charging
DA: Distribution Automation

Limited growth: throughput divided by endpoints

Limited investment

Source: Itron

- Cellular has enough throughput to accommodate all new grid applications
- Security requirements will increase bandwidth needs
- More data = more value; emerging apps require increasing throughput

Why 3G cellular for Smart Utilities

Smart Grid benefits from cellular' s pervasiveness and sustained investment

Ubiquitous coverage
- Serving 98% UK population[1], **fast time to market on existing infrastructure**

High reliability
- Redundant network design with >99% availability[2]

Robust security
- Built-in security features; used in government & finance sectors

Low cost of ownership
- Large established ecosystem provides economy-of-scale

High performance
- High throughput with average latency of milliseconds[4]

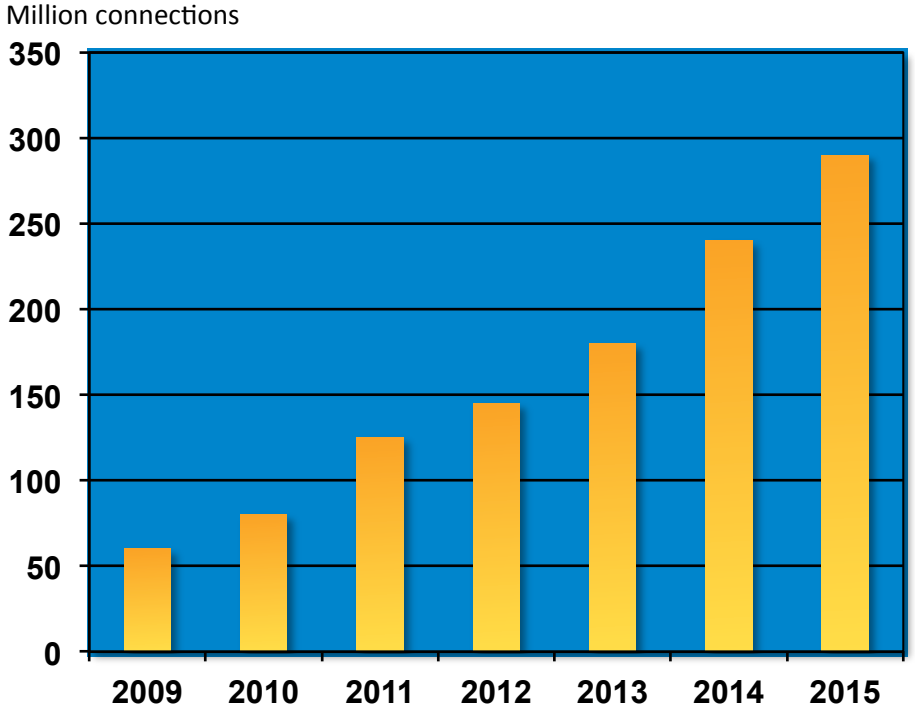
High scalability
- Approx. 6.6 billion total connections worldwide[3]

Standard-based
- Seamless interoperability; backed by global standards

[1] http://ukmobilecoverage.co.uk/best April 2013
[2] NIST, "Consolidated NIST Wireless Characteristics Matrix V5", 10/25/2010
[3] Wireless Intelligence, Apr. '13; CIA, Jul. '13
[4] C; "Mobile Broadband Comparison"; March 2008

M2M growth drives value

- Global growth drives down chipset costs
- Carrier M2M focus spans multiple industries: Utilities, Defense, Transportation, Healthcare, etc.
- Carrier networks are leading in reliability, coverage, security, throughput

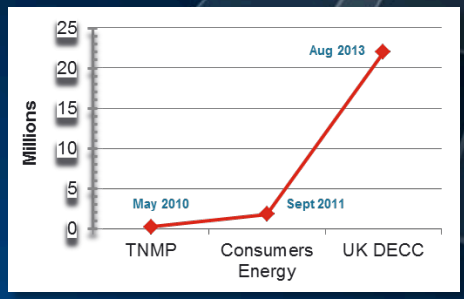


Cellular M2M network connections (World 2009-2015)

Source: Berg Insight

Cellular Momentum Builds in Energy

- Cellular has served the all important C&I needs for over a decade
- Since 2010, cellular has won in residential smart grid, energy mngt, renewables and EVSE
- In August 2013, cellular won one of the largest smart grid deals ever



1998
- SmartSynch funded
- Manage C&I assets

2004
- More cellular entrants formed to manage C&I endpoints

May 10'
- TNMP selects SmartSynch for 231k cellular residential smart meters

Jan 11'
- Sprint connects ECOtality EV charging network

Aug 11'
3G cellular load mngt. to CPS Energy

Sept 11'
- Consumers Energy announces 3G award for 1.8M smart meters

May 12'
- Entergy awards Itron with 3G cellular project
- Itron completes $100M acquisition of SmartSynch

July 12'
- Duke Energy merger benefits Ambient's 3G cellular smart grid
- Locus Energy launches cellular hardware for monitoring Solar PV

Jan 13'
- Itron announced global collaboration with Qualcomm

May 13'
- AT&T wins Duck River project for 3G cellular smart metering
- SP AusNet announces 3G cellular program on Telstra network

Feb 13'
- Landis+Gyr and Aclara each acquire cellular smart grid companies

July 13'
- Deck Monitoring leverages 3G cellular smart meters for photovoltaic monitoring

Aug 13'
- UK DECC awards Telefónica for ~22M cellular smart meter service
- GCEC selects Itron 3G cellular for advanced metering deployment

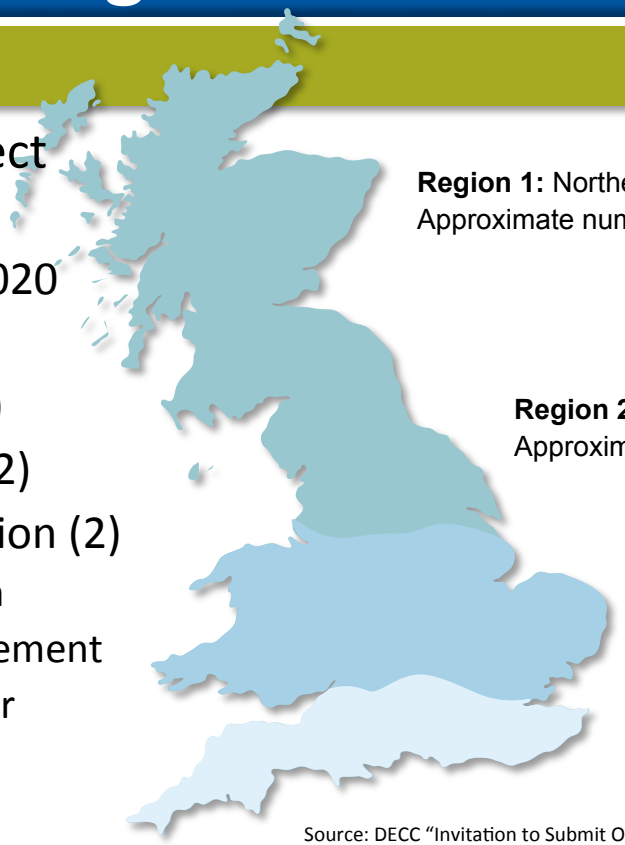
AMR Evolves to AMI | Cellular M2M Targets Smart Energy | Future

UK Smart Metering Programme

World's largest M2M contract

- Largest Smart Metering Project
  - Covering all of GB
  - Mass roll-out period: 2015-2020
  - 61M meters (1)
  - 34M communication hubs (1)
  - 20 year cost of £12.1 billion (2)
  - Net benefits totaling £6.7 billion (2)
    - Reduced energy consumption
    - More efficient energy management
    - 2B tons reduction of CO2/year

(1) Telefonica Digital
(2) DECC "Smart meter roll-out for the domestic and small and medium non-domestic sectors (GB)", Jan 2013



Region 1: Northern GB including Scotland
Approximate number of premises:9M

Region 2: Central GB including Wales
Approximate number of premises:10M

Region 3: Southern GB
Approximate number of premises:11M

Source: DECC "Invitation to Submit Outline Solutions", March 2012

Key Verticals in support of M2M and the IoE

- Healthcare
- Education
- Transportation
- Vehicle
- Home Automation
- Security
- Utility
  - Electric
  - Water

Qualcomm approach: Enabling the key technology blocks

Technology Enablers

Air Interface and Peer to Peer Technologies:

- 3G/4G, WiFi, Alljoyn (peer to peer), Bluetooth and BT LE, LTE Direct, Broadcast, Mobile Broadcast

Recognition/input Technologies

- Gesture recognition, Facial recognition, Voice/audio recognition, Augmented reality (target recognition and tracking), NFC (Near Field Communications), External sensors, Accelerometer, Touch screen

Output Technologies:

- Audio, Video/3D, Video projection, Vibration

Location/Motion Technologies

- GPS, Triangulation, Compass, Accelerometer

Enhanced Application Development

- Snapdragon SDK

Common Misconceptions

M2M is now a significant focus for the cellular ecosystem, Resulting in aggressive competition for smart energy wins

Statement	True / False
Cellular is too expensive for smart grid and carriers are inflexible to utility needs.	**FALSE**: Smart meter OEMs are optimizing hardware designs to lower cellular CapEx. Operators now offer very compelling, utility-oriented business models, tariffs, longevity and SLA terms for competitive OpEx.
Private RF Mesh networks have negligible operating expenses.	**FALSE**: Managing and operating a communications network requires ongoing CapEx and dedicated personnel (OpEx), which has sometimes been understated. Utilities who leverage cellular networks benefit from billions invested annually in network maintenance, expansion, and security.
Cellular networks don't have adequate disaster recovery methods.	**FALSE**: Cellular operators globally continue to invest in back-up power (generators/batteries), and portable satellite base-stations ensuring minimal outage. When an outage occurs, carriers answer to regulators. Cellular recovery during Hurricanes Sandy/Katrina and the Great East Japan Earthquake and Tsunami demonstrate rapid restorations, leveraging readily available standards-based technology and vast employee resources.
RF Mesh technology is proven technology with minimal risk to interference.	**FALSE**: RF Mesh deployments have largely been proprietary, and have cumulative deployments in the 10s of millions, as compared to billions of cellular devices shipping globally. Use of any unlicensed spectrum runs the risk of harmful interference from a variety of sources, vs. licensed cellular.
Cellular networks don't have the reliability needed to support the utility industry	**FALSE**: Cellular networks are built to extremely high standards. Back bones are built to standards that meet or exceed typical utility standards for reliability. Network data is typically provided by multiple sites so single points of failure are significantly reduced.

Smart Water

Water Industry Needs

Improved sensor technologies

- Real time information valuable (very limited)
- Chemical, biological, physical parameters
- Reliable in harsh conditions (sub-surface)

Low power use devices

- Remote areas
- Solar, hydraulic

Improved Communication

- To and from remote areas
- With buried infrastructure (100K miles of mains)
- To and from O&M personnel
- With customers

Areas of Focus

- Enhanced Customer Communications
- Distribution Systems (Valves and Water Main Assessment)
- Remote Facility O&M
- Enabling new services and revenue opportunities

- **Asset Management**
- **Smart metering for water use**
- **Water Quality, Safety and Security**
- **Storm Drain and Sewage Water Systems**

Key M2M Water Use Case

Asset Management

- Collaborating with CH2M HILL, asset companies, sensor companies, Digi and other device OEMs
- Trial solutions available early 2014

Water Metering

- Collaborating with CH2M HILL, Neptune, intelliH2O, Digi and other device OEMs
- Trial solutions available early 2014

Safety and Security

- Finalizing Requirements
- Beginning solutions developments
- Collaborating with CH2M HILL, Digi, sensor companies and other device OEMs

Storm Drains and Sewer Water Systems

- Collaborating with CH2M HILL, Digi, sensor companies and other device OEMs
- Trial solutions available in early 2014

IoE platforms

Modules - hardware value chain in Internet of Everything

Base of
"Indirect QMC customers"

Mature ecosystem of QTI module OEMs

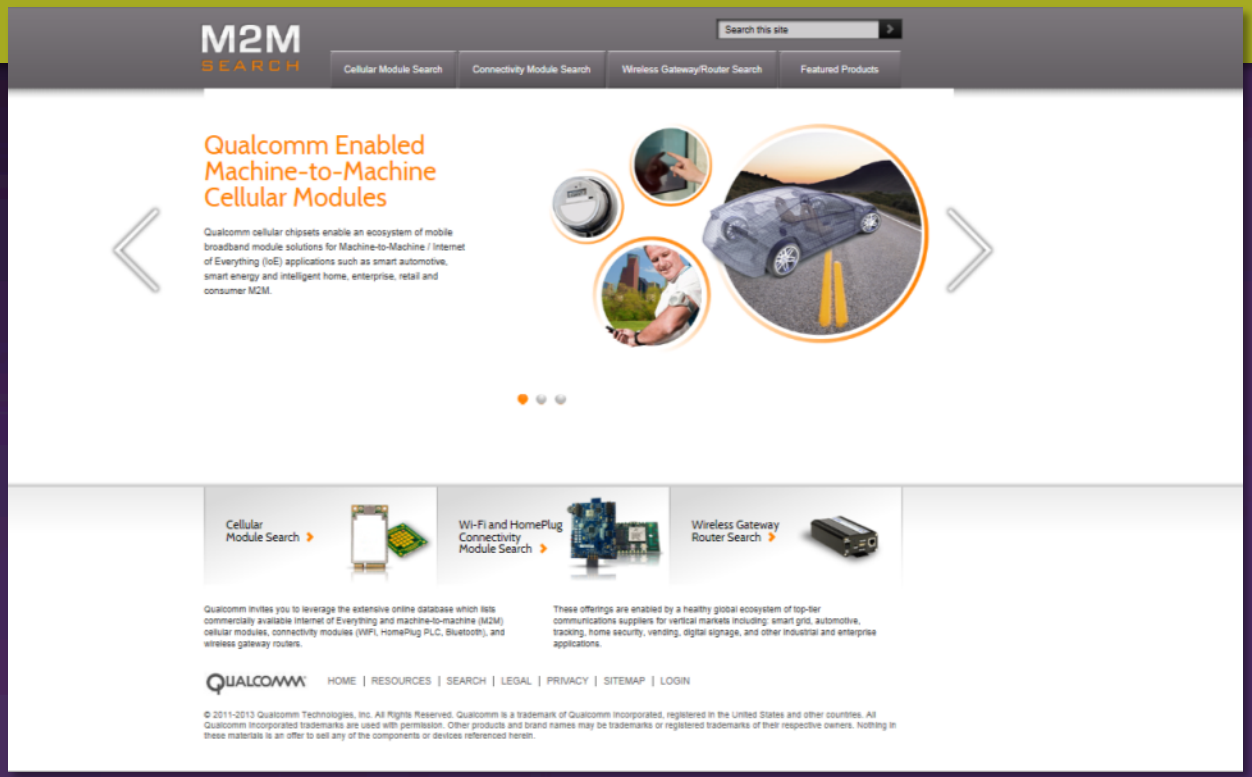
www.m2msearch.com

More than 175 WAN and Wi-Fi / HPGP modules and solutions from leading OEMs

[1] A partial list of cellular modules from various vendors is available at www.m2msearch.com

On-Line Access to M2M Modules

M2MSearch.com



The future: Smart cities

Smart Cities – sensors and Big Data

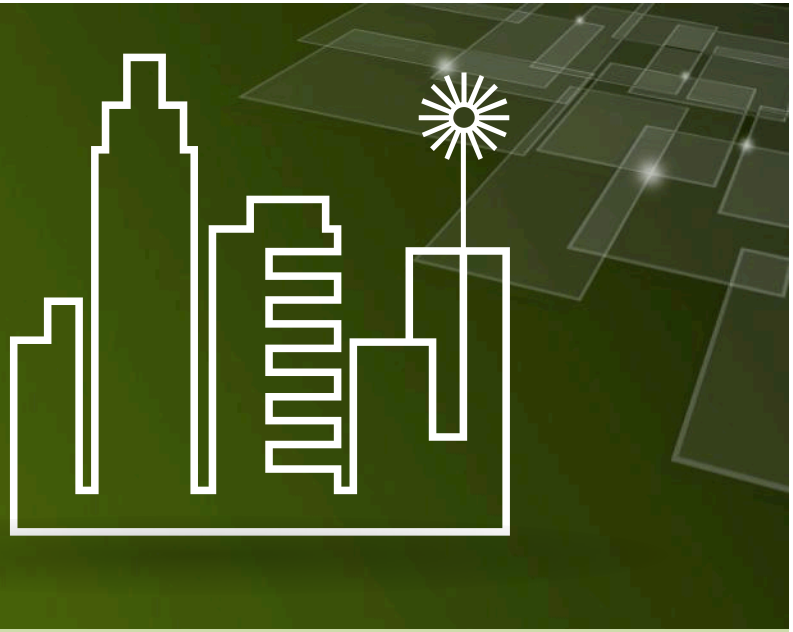
- Sensors
  - Low power, long lived, purpose built
  - Evolved network architecture
  - LTE MTC and 802.11ah
- Small Cell Networks
  - Solves capacity and coverage
  - Relays and Gateways

Why Smart Cities

By 2050
cities will be home to

70%

of world's people



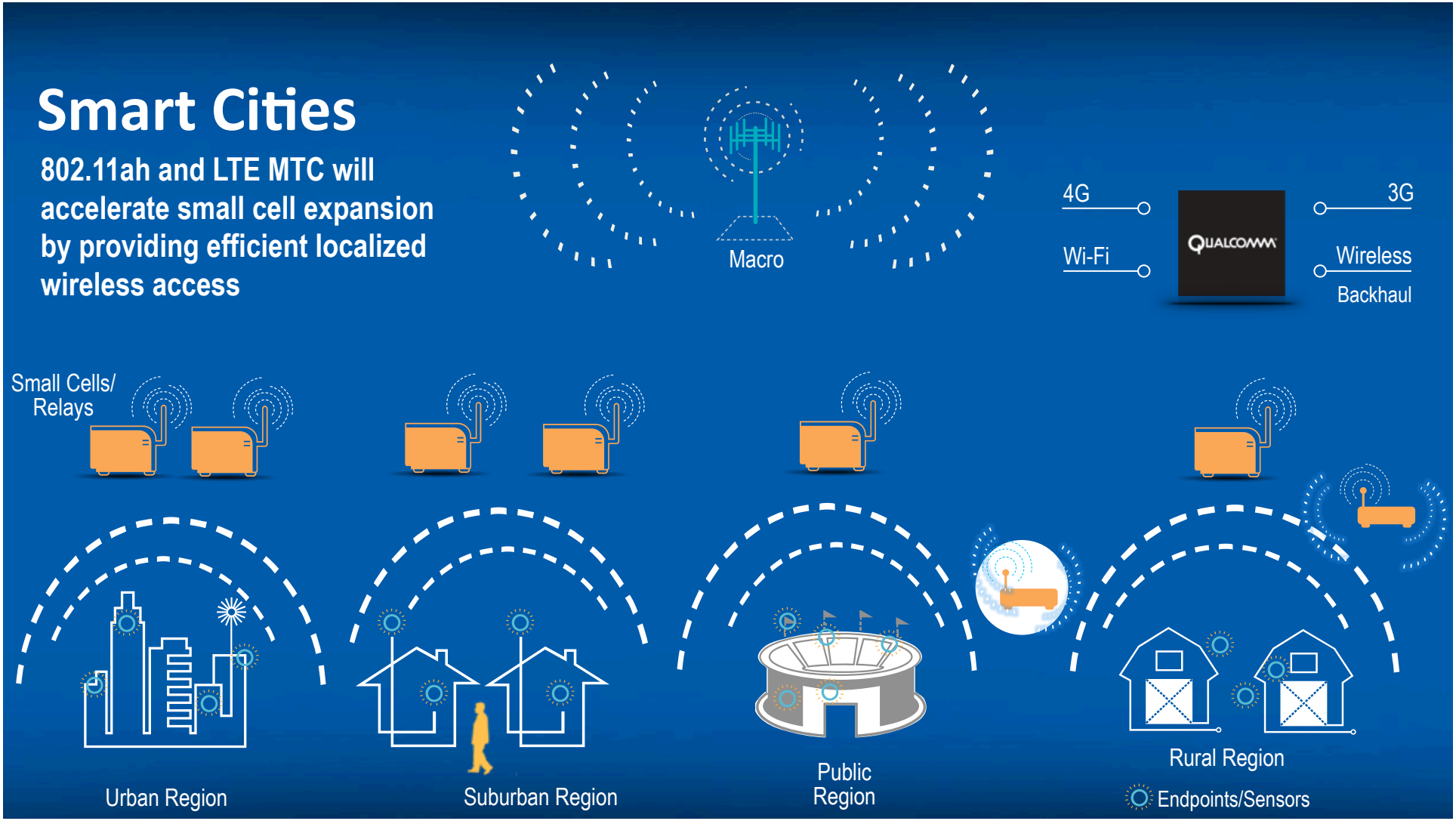
- Over 1M people move to cities every day
- 1B people call slums home today
- There are over 21 megacities with over 10M people
- China alone will create 81 new major cities by 2025

Advanced information and communication technologies can help address these trends and make our cities more livable and sustainable

Source: Smart Cities Council

Smart Cities

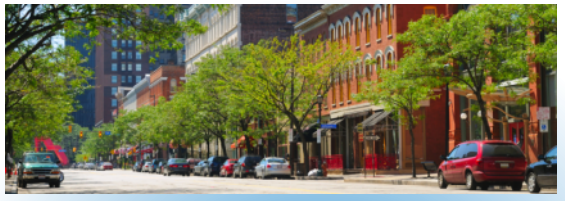
802.11ah and LTE MTC will accelerate small cell expansion by providing efficient localized wireless access

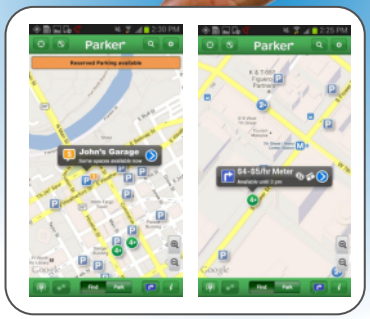


Smart parking meters, sensors and data management system use case

STREETLINE
CONNECTING THE REAL WORLD

- Smart parking meters
  - Pre-integrated with wireless vehicle detection systems, smart phone apps, smart collection system, web-based data management system
  - More than 100,000 meters deployed in the USA/Canada*
  - 100 million for-pay parking spots in US**
- Vehicle detection sensors
  - Detects for the presence and absence of a vehicle in a parking space. The sensor uniquely directs all sensing information via the parking meter cellular and short-range communications
- Data management system (DMS)
  - A real-time, web-based application that allows parking professionals to remotely monitor their parking network from anywhere, at any time.



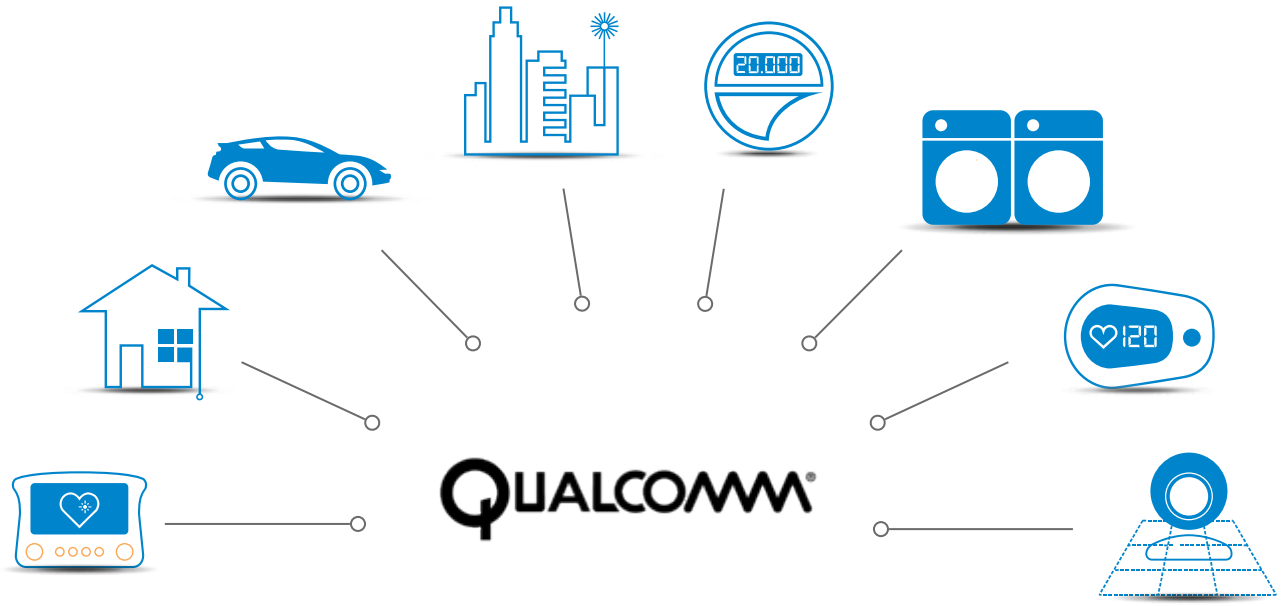


Source: *IPS Group; **Microprocessor Report/Linley Group, March 18, 2013

Qualcomm Leading IoE Growth

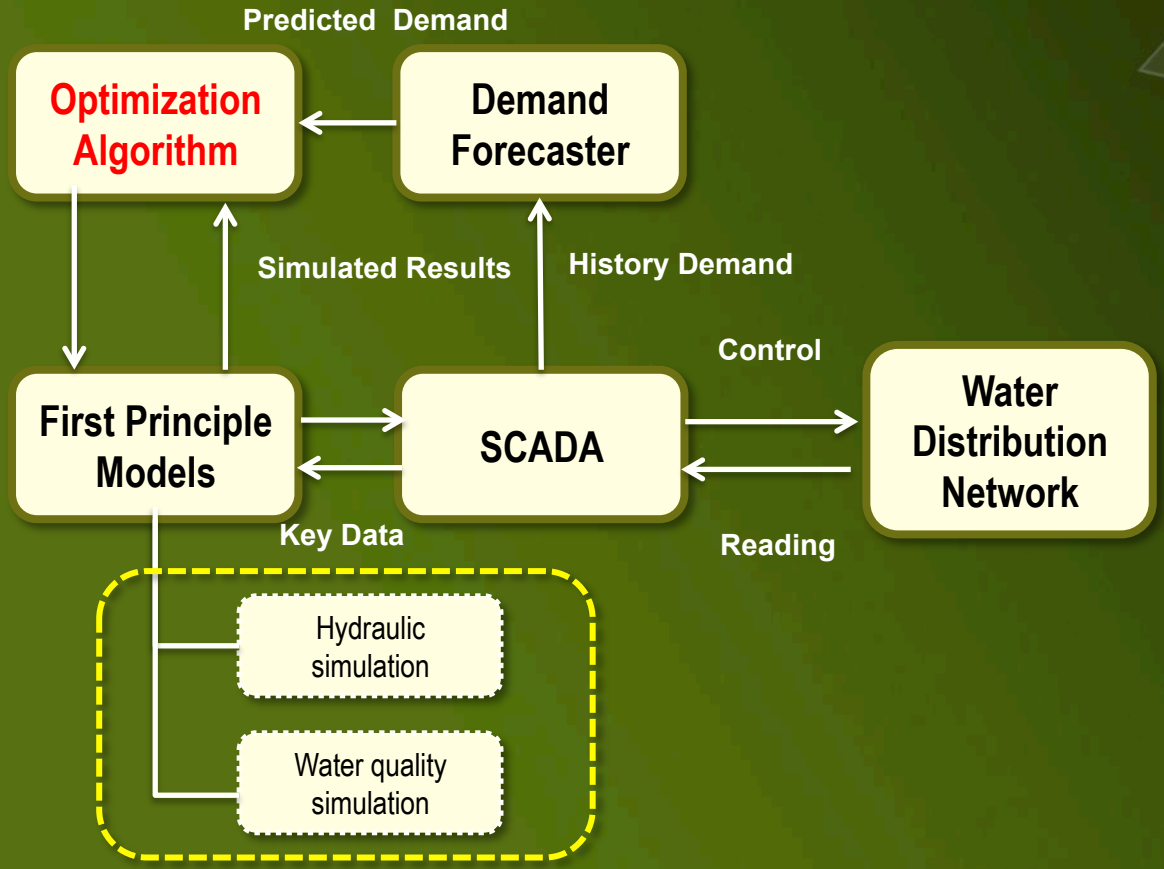
Alignment across IoE portfolios

- Core businesses align with IOE growth drivers
  - Superior modem technology
  - Wireless CPU leader
  - Low-power WiFi expert
  - Lead edge HPGP technology
  - Horizontal interoperable communications framework
- Deep relationships with key customers
  - Automakers
  - Networking
  - Energy
  - Security
  - Consumer Appliances
  - Consumer Electronics
  - Carriers

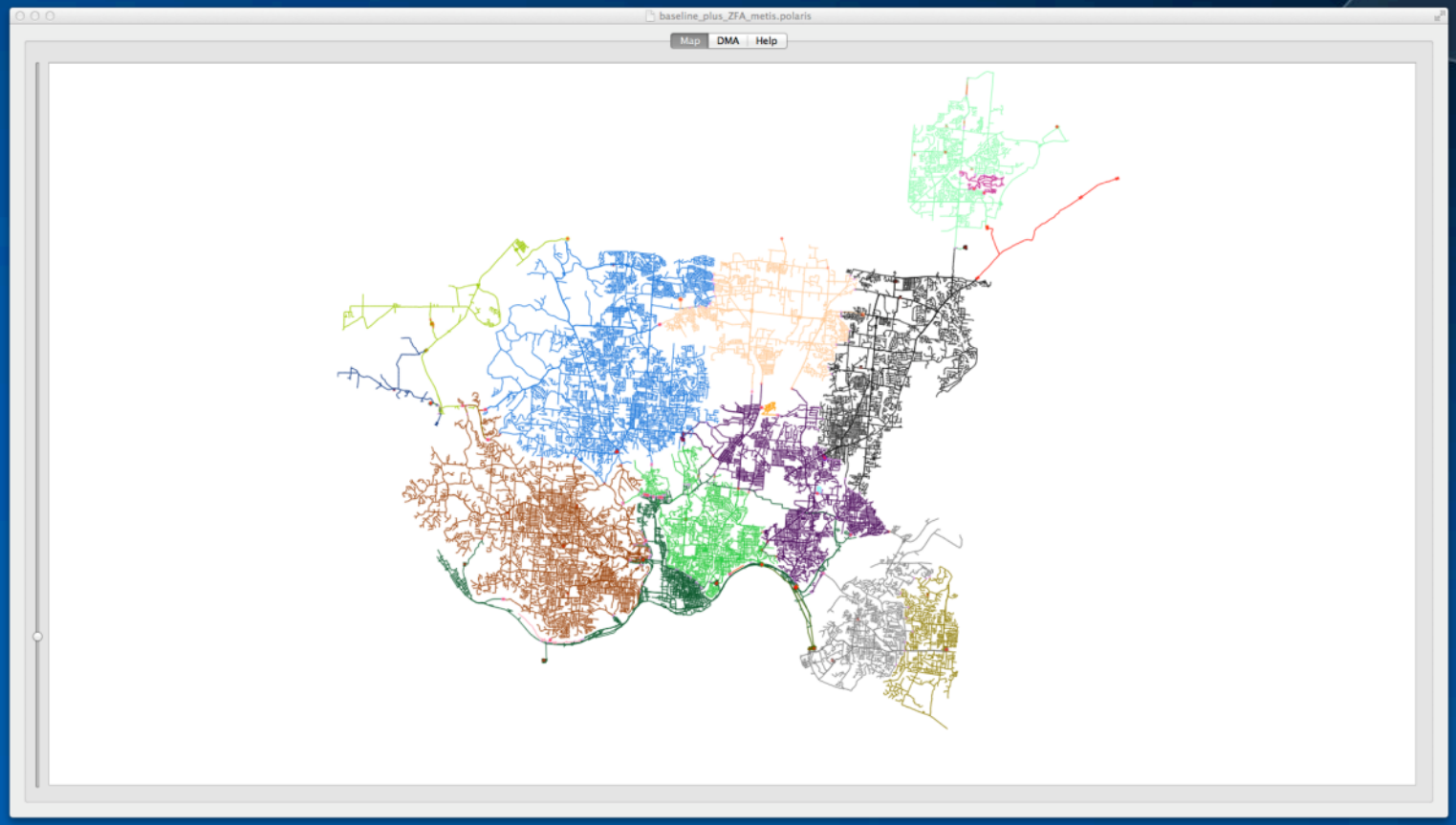


Current Applications/Approach

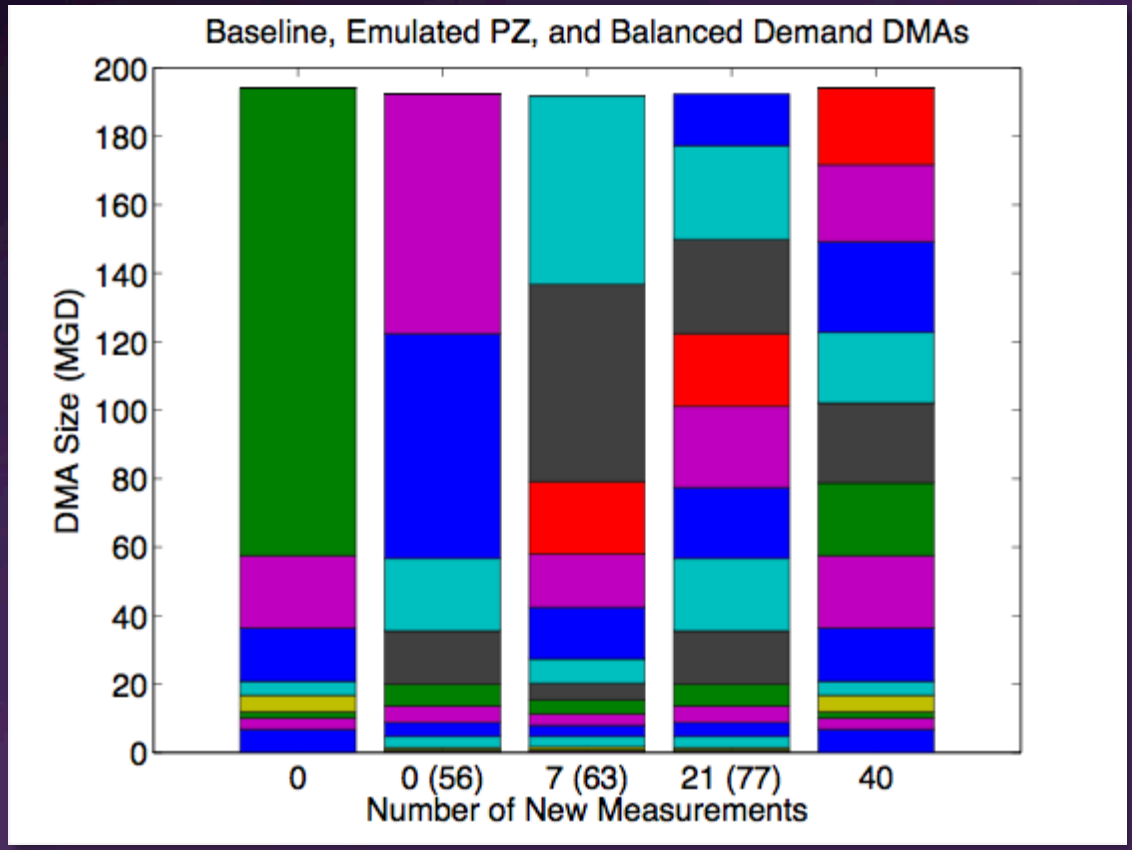
Drinking Water Real Time Process Control



Future District Metered Areas With Additional Optimal Measurement Locations

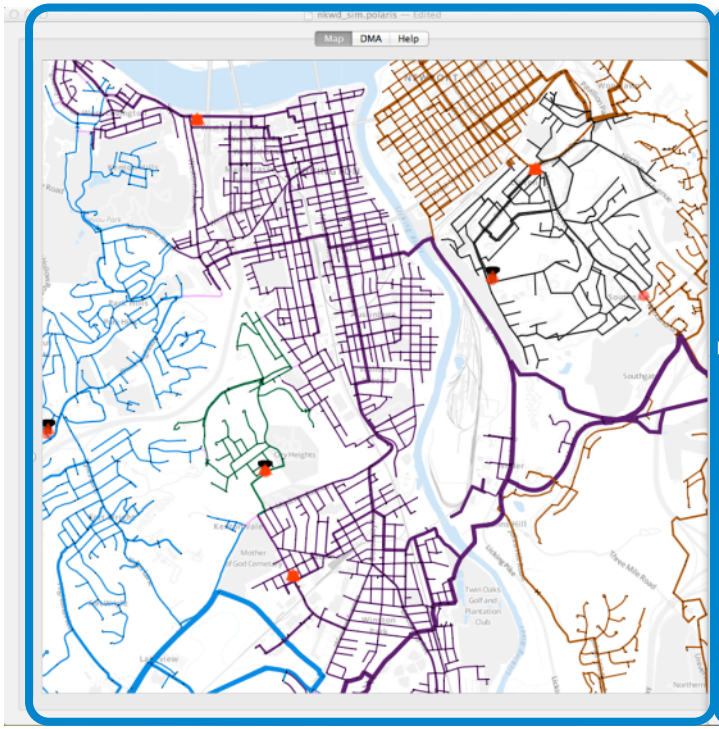


Optimization of Flow Measurement Locations

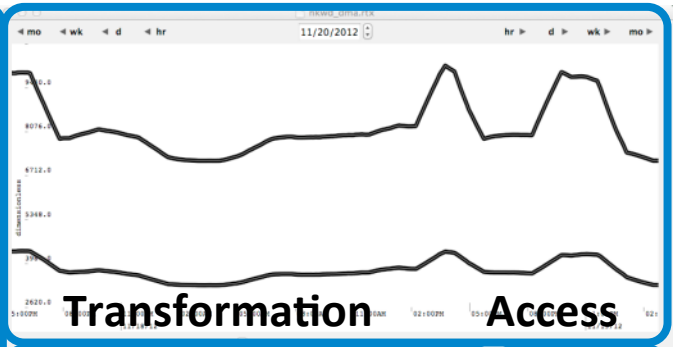


Integrated Real-time Modeling Environment - Key to efficiency and reliability

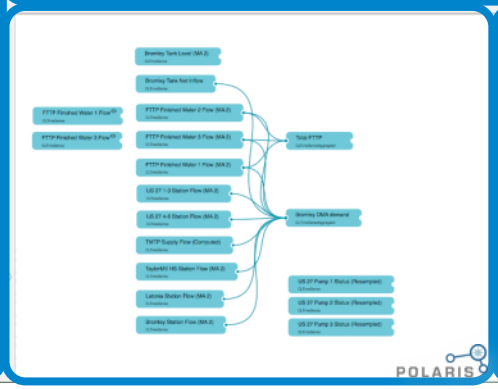
Infrastructure



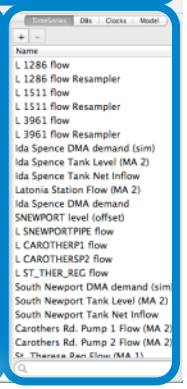
Visualization



Transformation

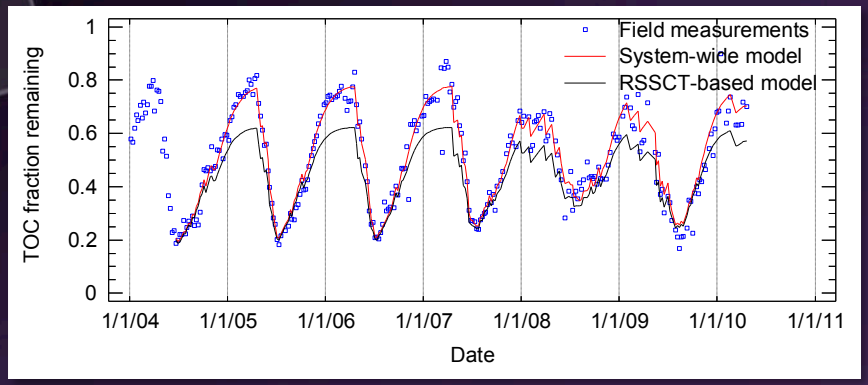


Access

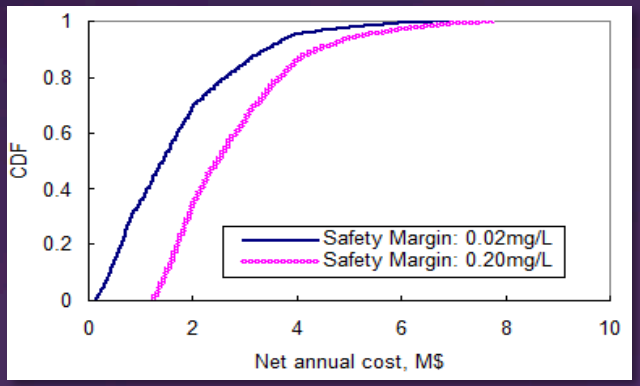


Operation Optimization – GAC Regeneration

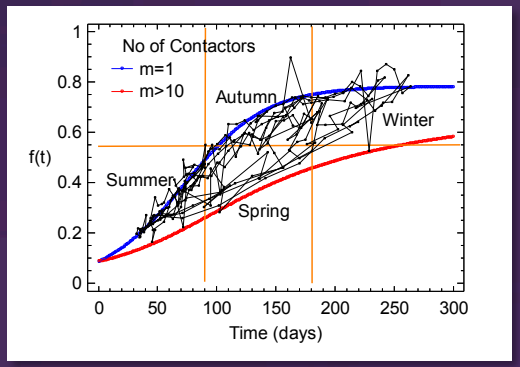
GAC process model performance

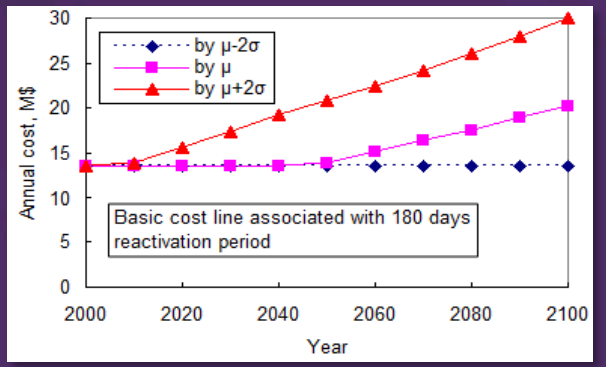


Adaptation cost in O&M

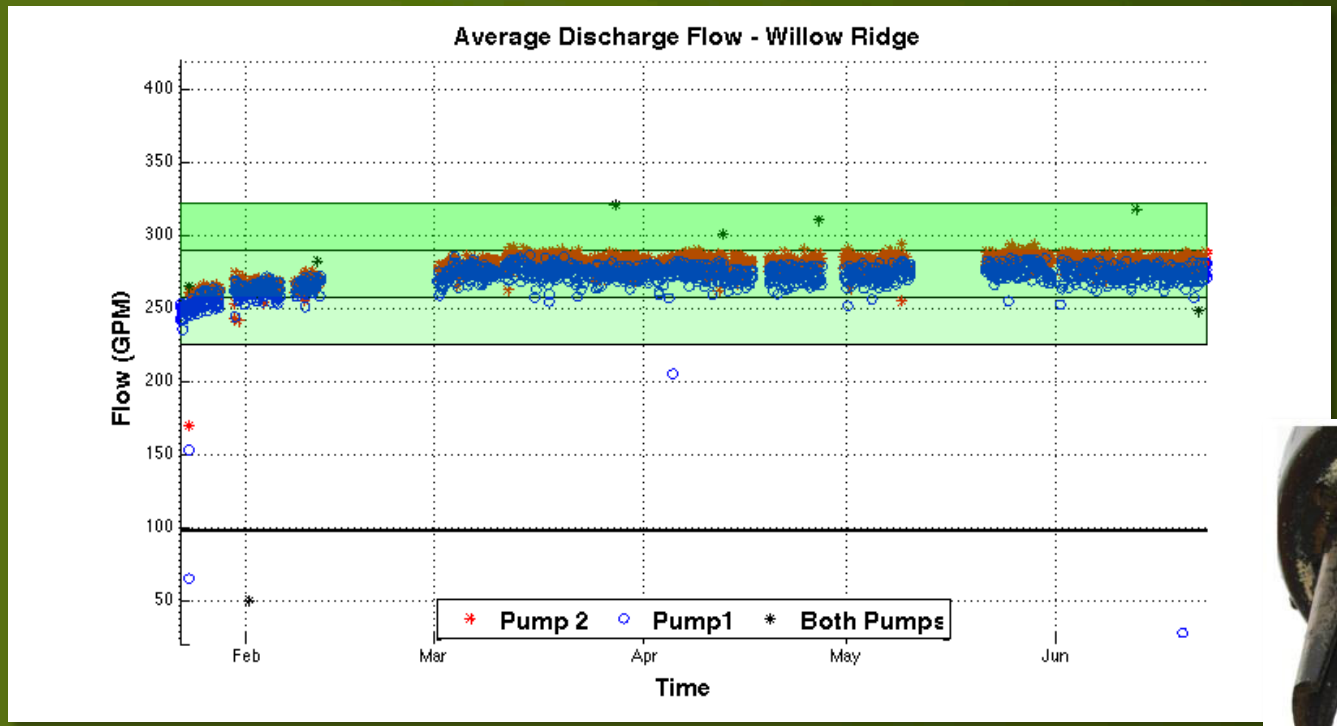


GAC Contactor Optimization

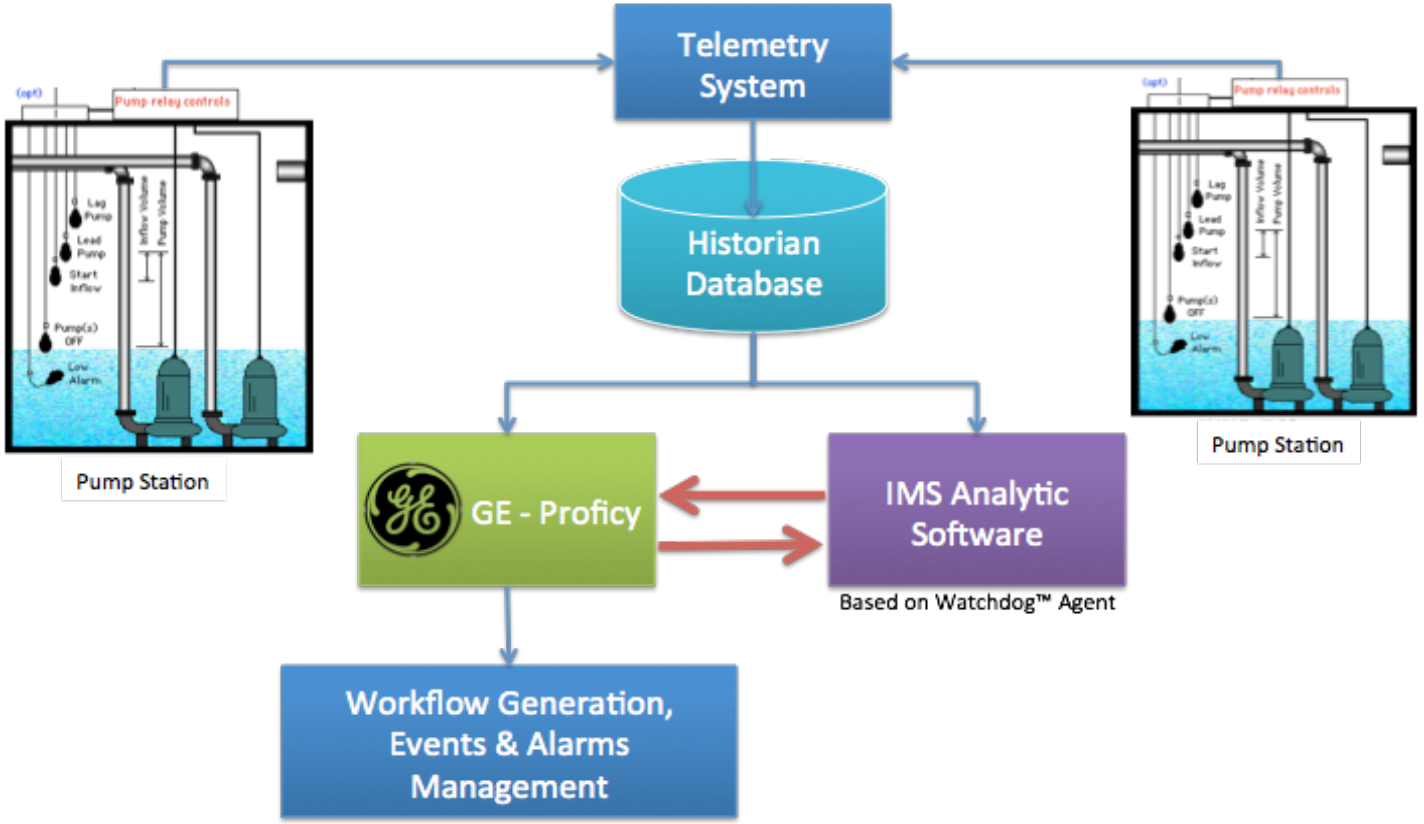




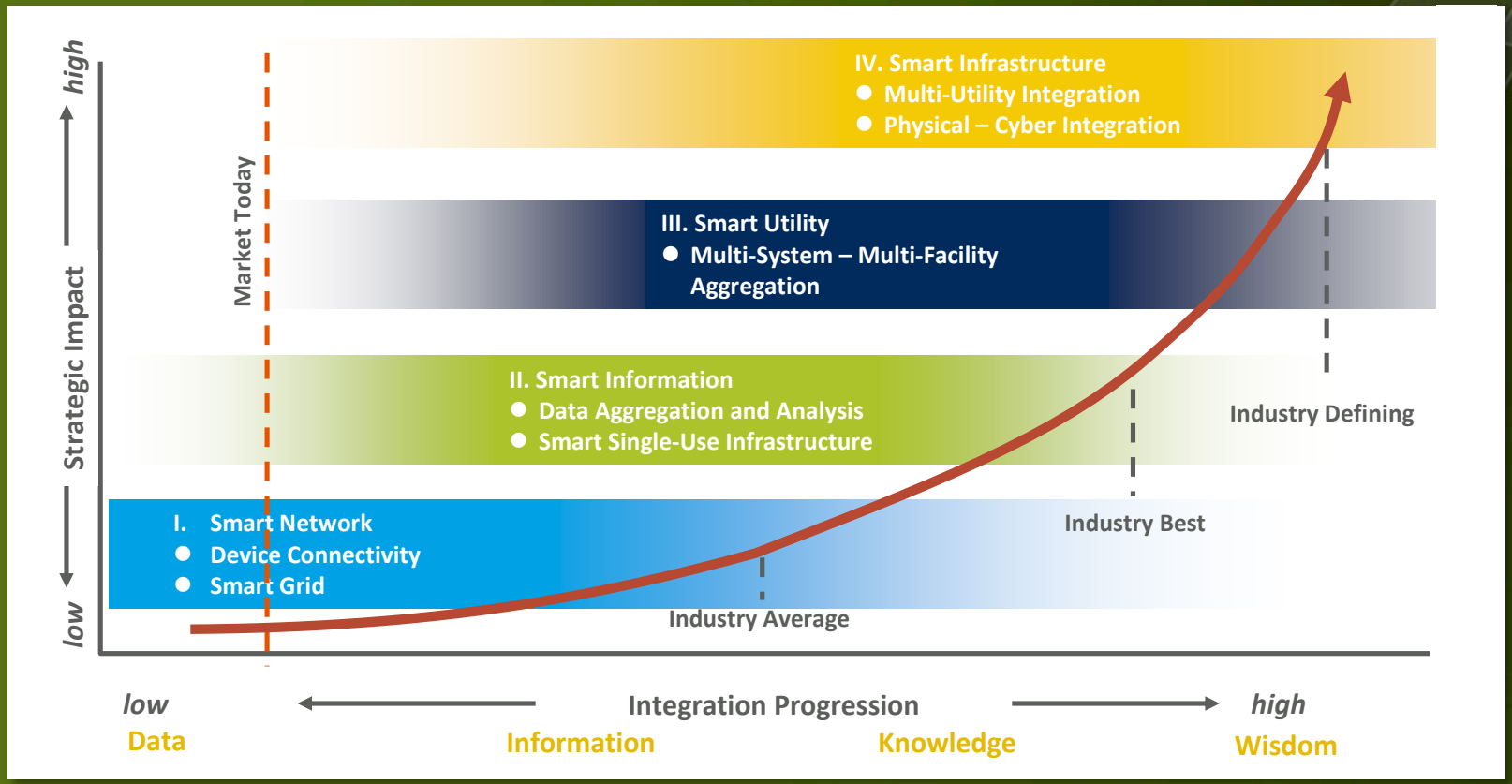
Asset Optimization – Sewer Lift Stations



Prognostic Asset Health Management Model



Smart Infrastructure – It is a Journey




CINCINNATI WATER WORKS
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Smart Technology
Assessing System-Wide Deployment

Biju George, Greater Cincinnati Water Works
Michal Koenig, Qualcomm Technologies