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December 18, 2009

(VIA ELECTRONIC FILING)

Marlene H. Dortch
Secretary
FEDERAL COMMUNICATIONS COMMISSION
445 12th Street, SW
Washington, D.C. 20554

Re: GN Docket Nos. 09-47, 09-51 and 09-137 (Spectrum for Broadband)
Oral and Written *Ex Parte* Communications

Dear Ms. Dortch:

On Thursday, December 17, 2009, Joaquin Silva, President and CEO, Dr. Theodore Myers, Chief Technology Officer, and Don Telage, Chairman of On-Ramp Wireless, Inc. ("On-Ramp") and I met with Commissioner Mignon L. Clyburn and her Acting Legal Advisor, Louis Peraertz.

In a separate meeting that same day, the foregoing group also met with Nick Sinai, Energy and Environmental Director and Charles Worthington, Energy and Environmental Staff of the Commission's National Broadband Taskforce.

Copies of the Attachments "A," "B," and "C" were provided to Commissioner Clyburn; copies of Attachments "B" and "C" were provided to Messrs. Sinai and Worthington. The

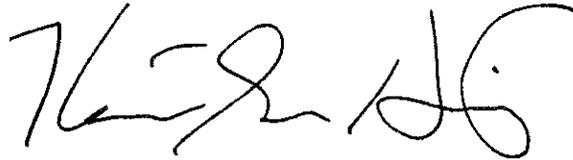
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Ms. Marlene H. Dortch
December 18, 2009
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substance of these attachments was discussed during each meeting.

Respectfully submitted,

A handwritten signature in black ink, appearing to read "K. G. Hurwitz". The signature is fluid and cursive, with the first name "K" being particularly large and stylized.

Kenneth G. Hurwitz
Attorney for On-Ramp Wireless, Inc.

cc: (via e-mail) Commissioner Mignon Clyburn
Louis Peraertz
Nick Sinai
Charles Worthington
Joaquin Silva
Don Telage
Dr. Theodore Myers

Attachment “A”

**Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554**

In the Matters of

Inquiry Concerning the Deployment of Advanced Telecommunications Capability to All Americans in a Reasonable and Timely Fashion, and Possible Steps to Accelerate Such Deployment Pursuant to Section 706 of the Telecommunications Act of 1996, as Amended by the Broadband Data Improvement Act)))))))	GN Docket No. 09-137
A National Broadband Plan for Our Future)	GN Docket No. 09-51
International Comparison and Survey Requirements in the Broadband Data Improvement Act)))	GN Docket No. 09-47

COMMENTS OF ON-RAMP WIRELESS, INC. – NBP PUBLIC NOTICE #2

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October 2, 2009

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COMMENTS OF ON-RAMP WIRELESS, INC. – NBP PUBLIC NOTICE #2

**I.
GENERAL INTRODUCTION**

On-Ramp Wireless, Inc. (“On-Ramp”) hereby submits comments in the above-captioned proceedings in response to the Commission’s September 4, 2009 *Public Notice* seeking tailored comments on how advanced communications infrastructure and services should be used to help achieve implementation of Smart Grid technology.¹ On-Ramp focuses its comments on the first

¹ Public Notice, *Comment Sought on the Implementation of Smart Grid Technology (NBP Public Notice #2)*, GN Docket Nos. 09-47, 09-51, 09-137 (rel. Sept. 4, 2009) (“*Public Notice*”).

three groups of questions delineated in the Commission's *Public Notice*: Suitability of Communications Technologies, Availability of Communications Networks, and Spectrum.²

On-Ramp focuses its comments on these questions in relation to two discrete subsets of Smart Grid functions: (1) the collection of temporal usage data from residential and commercial customer meters, the transmission of those data to the utility, and the communication of price and other electric system information back to customers; and (2) the real-time digital monitoring of the distribution system by use of sensors placed on distribution lines and substations to enable electric utilities to detect, prevent and repair system problems almost instantaneously.³ On-Ramp's comments also address communications needs associated with other Smart Grid functions, such as upstream coordination with generators and the transmission system, and with other Smart Grid functions that will be developed in the future.

II. INTRODUCTION TO ON-RAMP

Located in San Diego and managed by a team of professionals from the wireless, digital, defense and utility automation industries, On-Ramp has developed the first wireless system that is specifically designed to connect millions of hard-to-reach meters and sensors in challenging utility and industrial environments. Today, On-Ramp is working with several utilities and automation companies on a global basis to implement its system, including (1) a public utility and a coalition of energy technology companies in California to implement a Smart Grid demonstration project for distribution automation and energy efficiency applications; (2) a company that is a global leader in utility automation systems with thousands of systems deployed

² See Attachment "A" for a table showing which sections of On-Ramp's comments respond to which questions in the *Public Notice*.

³ Smart Grid also contemplates that customer meter data would be used to identify conditions and contingencies on the distribution system.

for energy efficiency, smart metering and water grid automation across Europe, the Middle East, North America and Asia; and (3) a company that is a global leader in broadband radio development and manufacturing with industry-leading market share. Because On-Ramp's system is purpose-built to connect millions of hard-to-reach meters and sensors in challenging environments, it will work seamlessly with the end-user and distribution system segments of Smart Grid.

On-Ramp's technology employs Central Access Points in a star configuration to transmit and receive low-power signals directly communicating with nodes embedded in the myriad of sensors and customer meters in an urban, suburban, ex-urban or rural environment. The Central Access Points, in turn, communicate bi-directionally with a variety of third-party product platforms, including utility data collection and management systems.⁴ The same Central Access Point-to-node configuration can be used and has been successfully tested for distribution system tasks such as substation monitoring, metering systems and below ground and above ground Fault Circuit Indicators.

The Central Access Points and nodes use Ultra-Link Processing™ technology ("ULP"), a high-receptivity signal processing innovation developed by On-Ramp that is capable of wide-area coverage and is immune from all but high levels of interference, at a significantly lower cost and with far greater capacity, efficiency and system security than existing and proposed wireless mesh systems, and with coverage and reliability far superior to that offered by the commercial cellular network. Equipped with Ultra-Link Processing™ technology, a single Central Access Point can cover an entire industrial site, a 50-story office building or an entire small metropolitan

⁴ The backhaul communications by the Central Access Points can be made via a variety of media, including for example the commercial cellular network, T1 lines and satellite communications.

area. On-Ramp's website, www.onrampwireless.com, sets forth additional background on the company and its announced projects.

III. COMMENTS

On-Ramp believes that the FCC should foster Smart Grid development by allocating spectrum to the electric power industry to enable the provision of robust communications solutions for Smart Grid needs. On-Ramp believes that this position is eminently well-justified (1) in light of the vital importance of Smart Grid to achieving the national energy goals of energy efficiency, reduced greenhouse gas emissions, and greater energy independence; and (2) because the deployment of existing cellular and mesh technology in unlicensed bands is a deeply-flawed model for the growing communications needs of existing and new Smart Grid applications. In this latter regard, On-Ramp explains below that cellular and mesh systems are not sufficiently robust to provide wide-area coverage for all customer meters, and, if deployed on a broad scale, will cause severe interference and operational problems and will be vulnerable from a security point of view.

In these comments, On-Ramp contends that a small portion of the spectrum, 4 MHz, should be set aside for end-user/distribution Smart Grid functions. In addition, for other, higher data rate applications, a separate additional allocation of up to 20 MHz of spectrum will be needed for low latency, high data rate Smart Grid applications, such as transmission congestion management and generation coordination.⁵ On-Ramp further contends that the foregoing allocated portions of the spectrum should be licensed to the Nation's utilities, which in concert with a power frequency coordinator would coordinate entry and set eligibility and performance

⁵ Analysis of the communications system needs of these other applications is beyond the scope of these comments.

standards for wireless entities, who in turn would enter into agreements with individual utilities to address discrete Smart Grid communications requirements. On-Ramp believes that a utility-administered licensing approach could serve as a template for all present and future Smart Grid applications.

A. Smart Grid is a Pivotal Element of National Energy Policy.

The focus of national energy policy as recently declared by Congress and the Obama Administration is to promote energy efficiency, reduce greenhouse gas emissions and encourage energy independence. Smart Grid is a cornerstone of that policy which can contribute greatly to meeting all three of those goals.

Two key pieces of legislation enacted in the last three years confirm that Smart Grid is to play a central role. The Energy Independence and Security Act of 2007⁶ (“EISA”) declared that it is the policy of the United States to support the development of Smart Grid—the modernization of the Nation’s electricity transmission and distribution system to maintain a reliable and secure electricity infrastructure that can meet future demand growth. Earlier this year, the American Recovery and Reinvestment Act of 2009 (“ARRA”)⁷ reaffirmed the importance of Smart Grid and supported development of Smart Grid in several important ways. First, it appropriated substantial funds to the Department of Energy (“DOE”) to implement the Smart Grid program established by EISA.⁸ Second, ARRA made available to companies

⁶ Public Law No. 110-140, 121 Stat. 1492 (2007).

⁷ Public Law No. 111-5, 123 Stat. 115 (2009).

⁸ ARRA, Title IV, at Department of Energy, Energy Programs, Energy Efficiency and Renewable Energy. To date, the DOE has issued Funding Opportunity Announcements (“FOA”) under which it will distribute more than \$4 billion in ARRA grants to support development of Smart Grid. The FOAs and funding amounts issued by the DOE thus far are: Smart Grid Investment Grant Program, \$3.4 billion; Smart Grid Demonstrations, \$615 million; Workforce Training for the Electric Power Sector, \$100 million; and Enhancing State Government Energy Assurance Capabilities and Planning for Smart Grid Resiliency, \$39.5 million.

employing “smart grid technologies” a qualifying advanced energy project tax credit equal to 30 percent of the qualified investment in the smart grid technology.⁹ Third, ARRA directed the Commission to develop a National Broadband Plan, to include “a plan for the use of broadband infrastructure and services in advancing ... energy independence and efficiency.”¹⁰ In the *Public Notice*, the Commission recognizes that Smart Grid technology has been identified as a promising way to meet those goals of the National Broadband Plan.¹¹

A review of how Smart Grid is intended to work makes abundantly clear that Smart Grid is vital to the meeting of the goals of national energy policy. Smart Grid advancements will apply digital technologies to the electric grid, enabling real-time coordination of information from traditional generation supply sources, demand resources and distributed energy resources. Specifically, Smart Grid will possess the following functionalities:

- The ability to develop, store, send and receive digital information concerning electricity use, costs, prices, time of use, nature of use, and storage, to and from the electric utility system.
- The ability to program any end use device such as appliances and HVAC systems to respond to communications automatically.
- The ability to sense and localize disruptions or changes in power flows on the grid and communicate such information instantaneously and automatically for purposes of enabling automatic protective responses to sustain reliability and security of grid operations.
- The ability to detect, prevent, respond to, and recover from system security threats such as cyber-security threats and terrorism, using digital technology.
- The ability to use digital controls to manage and modify electricity demand, enable congestion management, assist in voltage control, provide operating reserves, and provide frequency regulation.¹²

⁹ ARRA § 1302(b), codified at 26 U.S.C. § 48C.

¹⁰ ARRA § 6001(k)(2)(D).

¹¹ *Public Notice* at p. 1.

¹² See also the definitions of “smart grid functions” at EISA § 1306(d).

In addition, over time, Smart Grid will expand beyond the electricity industry, and be used to manage other critical national energy assets such as the natural gas and water utility systems.

Once Smart Grid is fully implemented for the electricity system, consumers, faced with the real-time costs of their electricity consumption and armed with sophisticated methods to adjust their consumption patterns, will consume less electricity both overall and, importantly, at peak times. Intermittent resources such as wind, and distributed generation resources such as residential solar, will be more easily integrated into the grid. Electric vehicles will be able to charge their batteries during off-peak hours and will even be able to act as sources of electricity to help offset fluctuations in the output of intermittent resources. Transmission and distribution systems will become far more reliable. In short, the implementation of Smart Grid will foster the nation's ability to become more energy efficient, reduce emissions of greenhouse gases, and increase our energy independence.

B. It is Axiomatic that Smart Grid Cannot Work Without Robust Communications Capability.

While Smart Grid's capabilities will ultimately reach upstream to coordinate all elements of the utility system, including generation, transmission and distribution functions, it is beyond cavil that one of the very basic components of Smart Grid is Advanced Metering Infrastructure ("AMI"). Under AMI, data will be sent by customer meters to the utility and the utility will convey price information to "smart" commercial and residential controllers or end-use consumer devices such as thermostats, washer/dryers and refrigerators. In order for AMI to work to its full potential, it is essential that robust, secure two-way communications be established between each residence and commercial establishment and the utility. Only with such communications will customers be able to see and respond to price and system conditions, and will the utility to be

able to cost effectively and reliably coordinate its operations to provide its customers far more efficient service at far lower cost.

Another key component of Smart Grid is Distribution Automation, under which sensors will be placed in numerous locations throughout the distribution system—on distribution lines, transformers and in substations—to tell the utility when equipment is about to fail, to sense frequency or voltage fluctuations that suggest a problem is about to occur, and to transmit information to control devices on the distribution system to fix or prevent the problem.¹³ As with AMI, Distribution Automation cannot work properly without robust, secure two-way communications.

As briefly mentioned above, additional elements of Smart Grid will address upstream generation supply and high-voltage transmission systems. Ultimately, Smart Grid will seamlessly integrate all elements of the electric power system, from the power plant to the HVAC system and other appliances located in the customer's home, business or factory. Without a doubt, robust communications capabilities will be necessary in order to fulfill the full promise of Smart Grid in all of its manifestations. And given its importance to the Nation's energy policy and the potential for service disruptions on a wide scale, the Commission would be well-advised to avoid piecemeal or incremental solutions to the communications challenge.

¹³ As suggested above, installation of the same type of wireless sensors to enable automated system monitoring is also coming to the water and natural gas utility sectors. For example, the United States Environmental Protection Agency is funding a project, *Leak Detection and Wireless Telemetry for Water Distribution and Sewerage Systems*, to determine the best methods for developing an underground wireless communication network for the water utility industry. See http://cfpub2.epa.gov/ncer_abstracts/index.cfm/fuseaction/display.abstractDetail/abstract/8952.

C. Today's Cellular and Wireless Mesh Models are Inadequate for Large-Scale Deployment of Residential, Commercial and Distribution Smart Grid Applications.

1. Communications Arrangements for Residential, Commercial and Distribution Smart Grid Functions Must Seamlessly Link Multiple Devices, Must Achieve 100 Percent Coverage of Customer Meters and Other Devices, and Must Operate Without Causing High Levels of Interference and Operational Problems for Existing Devices.

In order for Smart Grid to function at the customer and distribution system levels, a utility must establish secure two-way data connections with its customers and its distribution system. In other words, numerous meters and customer appliances—everything from HVAC and washing machines to electrical motors—as well as distribution system sensors—must be capable of relaying data to and receiving signals from the utility. In addition, communications within the home or business between meters and appliances must be established. All of these communications must be seamless and secure.

Moreover, anything less than 100 percent coverage of end-user meters and devices would be unacceptable. Millions of meters and sensors will be deployed throughout the utility's service territory. Often, the devices will be located in remote areas, or areas that are hard to reach by virtue of topography or man-made structures. Even if 80 percent of such meters are readily accessible for communications purposes, the other 20 percent consisting of "worst cases" must also be kept in the communications fold. In other words, Smart Grid communications systems must be designed on a worst-case basis to enable a data dialogue with *all* customers, even those in the most compromised areas of the electric utility service territory. For a utility to fail in this

respect would severely hamper the effectiveness of Smart Grid, and would invite customer claims of undue discrimination under state law.¹⁴

Finally, for Smart Grid to function, customer and distribution system meters and devices must not *cause* undue interference to, and must not be *susceptible* to interference from other devices. This is true whether the point of reference is unlicensed spectrum, in which mesh and other systems currently operate, or in licensed spectrum, as advocated by On-Ramp in these comments. The problem, and hence the challenge, is especially pronounced for communications protocols that operate in the crowded unlicensed ISM band. This band is heavily populated with devices such as Wi-Fi, baby monitors, garage door openers and other radiators. While under the Commission's Part 15 regulations their power output must be maintained within strict limits to prevent interference with other spectrum users,¹⁵ it is well known that interference in these bands is rife and quickly growing worse.

There are two main technologies commonly proposed as the most advanced solutions by utilities for Smart Grid communications purposes at the end-use customer and distribution levels—the commercial cellular network and mesh networks operating under Part 15 that utilize cellular backhaul. Neither of these systems was specifically designed to handle Smart Grid communications. Moreover, when measured against the three normative standards described above, each has its own unique and stark limitations.

¹⁴ See, e.g., the statement by Pacific Gas and Electric Company (“PG&E”), one of the nation’s largest utilities, that its choice of wireless technology for Smart Grid must ensure that the meter “coverage probability” will be 100 percent. The PG&E statement goes on to note that its “technology choice must be robust in the dense areas and still be flexible enough to cover the rural areas.” *PG&E Smart Grid Discussion* before the IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs) (May 9, 2008), available at <https://mentor.ieee.org/802.15/dcn/08/15-08-0297-00-0000-pg-e-smart-grid-discussion.ppt>.

¹⁵ 47 C.F.R. Part 15.

2. The Commercial Cellular Network is an Inadequate Solution.

Although it is planned to be used by many utility systems to communicate meter and other data, the commercial cellular network cannot effectively and reliably provide adequate communications capability between the millions of customer nodes at issue and utility receipt points. The optimal use of the cellular network is for voice and high-speed data, not the data generated by individual customer meters, which occurs on a low-output basis. Moreover, cellular transmitters and receivers are characterized by short battery life. This phenomenon will exclude a high percentage of the sensors and devices (*e.g.*, gas meters and unpowered monitoring sensors) because they require multi-year battery lives and have no other readily available power sources.

Cellular system dead spots, which plainly cannot be ruled out in many utility service areas, are also a serious concern. While electric utilities, electric cooperatives and municipal systems long ago achieved universal electric service within their service territories, the same cannot be said for the commercial cellular networks of existing carriers. Rather, cellular system dead spots, which occur because of geography (a road between two ridgelines in a rural area), building or infrastructure design (tunnels and shopping malls), or distance from cell towers, are common; on an individual level, every reader of these comments is fully familiar with the phenomena of dropped phone calls and calls that fail to reach their destination. Utilities cannot tolerate such gaps if they are to successfully offer Smart Grid capabilities to their customers on a non-discriminatory basis and integrate customer information into utility operations.

Gaps in system coverage, however, are not the only problem with using the commercial cellular network for Smart Grid applications. Rather, the reliability of the network is also being threatened by the steady penetration of advanced cell phones with high-speed data capabilities that are used for web browsing, music download and video services. The same problem can be

attributed to ubiquitous laptop computers with the same capabilities. The cost of building out the cellular network to eliminate such gaps in coverage and performance would be prohibitive.¹⁶

3. Free ISM Mesh Networks with Cellular Backhaul are Also Inadequate for Large-Scale Smart Grid Application.

a. General Description of Mesh Networks

Many utilities are contemplating the use of free ISM-based mesh networks with cellular system backhaul to collect and transmit data to utility data collection and processing systems. Mesh network and cellular systems combine two sets of technologies, each with its own limitations for Smart Grid applications. Moreover, the *combination* of the two technologies poses serious problems. On-Ramp will explain these limitations below after a brief explanation of how mesh systems are configured.

A mesh network is a wireless network consisting of spatially distributed autonomous devices called radio nodes. Each node is typically equipped with a radio transceiver or other wireless communications device, a microcontroller and often a battery when no power source is available. The nodes in a mesh network “hop” their signals through neighboring nodes in the network via peer-to-peer links. In effect, nodes act as router/repeaters for neighboring nodes, which means that the users themselves constitute the network. The mesh network arranges itself on an *ad hoc* basis, and several nodes may forward data packets to a base station or central collection point. The base station typically relies on cellular backhaul to communicate the collected data to the utility.

Supporters of mesh networks combined with cellular backhaul often claim that the combination offers highly reliable, large capacity communications capabilities. But the reality,

¹⁶ For example, On-Ramp estimates that such a build-out for San Diego area would cost approximately \$150 million and require very substantial bandwidth.

especially in relation to their utility for Smart Grid applications, is otherwise. The reality is that mesh systems both suffer from and cause high levels of interference as to other devices in the crowded ISM bands. Mesh systems are also highly susceptible to intentional and unintentional jamming. Furthermore, the frequent and predictable traffic patterns required for inter-node mesh communications leave these systems vulnerable to security breaches.

b. Mesh Systems do not Work in the Home Area Network (“HAN”).

Under the mesh system methodology, one radio connected to the meter will operate as a node in the mesh network, while a second radio connected to the meter will communicate with devices, such as the thermostat or the dishwasher, in the HAN. The receiver for the second radio currently planned for use is a poor sensitivity receiver (-95dBm) with limited signal processing capability to deter jamming or interference. For a significant portion of homes, meters will be located outside or in the basement, and signals from the radio will not be capable of piercing walls to reach energy consuming appliances located on the first floor and above. In the 900 MHz and 2.4 GHz ISM bands, in particular, where baby monitors, cordless phones, Wi-Fi and Bluetooth are deployed in many homes, the result will be an unreliable networking system incapable of communicating in the home between the customer meter and HVAC systems and thermostats for demand-side management purposes.

c. Mesh Systems are not Scalable Because They Cause Massive Interference.

Mesh systems are not technologically scalable.¹⁷ In other words, they cannot be successfully adapted to serve a typical utility’s entire customer base without causing severe interference to other devices in the already crowded unlicensed ISM band. This interference

¹⁷ Nor are mesh systems scalable from a *cost* perspective. The per-unit infrastructure costs and operations costs for each radio node and repeater in the mesh system are very high, such that the cost for an entire utility customer base would have a significant impact on customer rates.

results from a combination of numerous devices operating at full power, in a narrowband behavior, with numerous hops to communicate data to the central collection points, and concentrated use of meters close to collection points. All this interference likely will be exacerbated by degrading positive feedback loops. It might be useful to break down these phenomena into their constituent parts.

First, it is planned that each home's electric meter will be equipped with a one-watt power amplifier. In order to achieve the necessary range to hop to the next mesh point, eighty such amplifiers per square mile will be required in exurban and five-hundred in urban environments. As noted above, numerous repeaters will have to be installed in addition to the radios on the meters. The network will not be functional unless the radios operate at their maximum power.

Second, the mesh networks will use up to 200 channels, throughout the entire 900 MHz ISM band. Using this many channels increases the likelihood that communications between links will collide with wide-band transmissions by in-home devices such as cordless phones, baby monitors, and garage door openers, which require 1 MHz of bandwidth and do not incorporate interference-avoidance mechanisms.

Third, there will be numerous hops from the central collection point to individual meters, and from meters to the central collection points. Frequently, the mesh network will require a radio-on time of greater than 10 percent for all nodes in the network due to the substantial communications protocol overhead needed to maintain inter-device networking functions. Supporters of mesh systems generally focus on the average number of hops used in a mesh system. But this focus is misleading because it obscures the fact that nodes closer to collection points will transmit far more individual transmissions of data than nodes closer to the periphery

of the network. Correspondingly, devices such as garage door openers, baby monitors, and Wi-Fi networks that are located at or near nodes close to collection points will suffer far more interference than devices near peripheral nodes.

Finally, with reference to positive feedback loops, consider a mesh network subject to a jamming source or high data rates (or worse, a combination of the two). Under such conditions, if the network approaches a point at which it fails to receive data, it will respond by repeating transmissions, thus polluting the system even further. This, in turn, will lead to yet more transmissions, and ultimately cause the system to spiral out of control at the very time the functionality of the system is critical.

The cellular backhaul element of mesh systems presents an additional limitation. The backhaul portion of the data path will originate from hundreds of thousands of radio nodes dispersed throughout the utility service area, as contrasted with star topology systems that will originate the backhaul at a limited number of central locations where redundant connections can cost effectively be added. Simply stated, the probability that a dispersed node in a mesh network will be located in a dead spot in the cellular network is significantly greater than the corresponding probability for a central access point in a star topology. The result is that the risk of transmission failure for the backhaul element is a serious concern and that, given the sheer number of backhaul links, it will be expensive to implement a redundant system to ensure high reliability.

d. Interference Associated with Mesh Systems Would Lead to Complaints.

Under § 15.5(c) of the Commission's regulations, the operator of a radio frequency device is required to cease operating the device upon notification by the Commission that the device is causing harmful interference with licensed operations, and may not resume operation of

the device until it corrects the condition causing the harmful interference.¹⁸ Operation of mesh network systems for Smart Grid applications will cause unprecedented levels of interference in the bands in which they operate. Put plainly, mesh systems will interfere with licensed operations, and the owners of those licensed operations are likely to complain to the FCC.

As stated above, if planned and implemented properly, Smart Grid will bring numerous profound benefits. It would not be wise public policy to invest in a mesh communications technology that will be plagued by such substantial interference that it may be temporarily or permanently required to cease operations.

Moreover, mesh network systems will interfere greatly with unlicensed operations of Part 15 devices. On-Ramp's propagation analysis (available upon request) shows an electric meter AMI mesh solution in a sparse suburban environment will reduce the range of a typical 1 MHz bandwidth, latency-sensitive device by five to ten times. While the owners of such devices will have no legal recourse against the mesh networks, it is equally unwise to allow the widespread implementation of networks that will cause substantial interference with numerous other useful communications devices.

D. A Star Topology Technology Capable of Wide-Area Coverage and Immune from All but High Levels of Interference Offers an Optimal Solution for Customer- and Distribution System-Based Smart Grid Communications.

1. The Major Benefits of a Star Topology System

A star topology system—the topology relied upon by the cellular industry—uses central access points (the center of the “star” in the topology) that communicate directly with operating nodes (sensors, meters and other devices) on the system, in sharp contrast to mesh systems in which individual nodes communicate with each other in order to relay data to central collection

¹⁸ 47 C.F.R. § 15.5(c) (2008).

points. If the receiver deployed in a star topology system uses a sufficiently sensitive, interference-resistant signal processing capability,¹⁹ it will easily outperform mesh systems in receiving communications from dispersed low data rate applications such as customer meters.

A star topology system with this capability can also exert power control of its signals (*i.e.*, the transmitters may be operated at below their maximum allowed power level). Relatively few central access points are needed, which enables the system to take advantage of antenna elevation to increase its ability to reach in-building energy efficiency monitoring devices such that a second radio system would not be required to connect to these devices.²⁰ Because the nodes communicate directly with central access points, they communicate far less frequently. The relative simplicity of the star topology enhances the capacity of the network and does not exact the bandwidth “penalty” associated with mesh networks, which consume a substantial amount of capacity just for the “housekeeping” of the network configuration—in other words, for the reconfiguration of nodes. For all of these reasons, a properly configured star topology system causes far less interference than does a mesh system.

Properly configured, star topology systems can also provide a far more secure operating environment than mesh systems. In sum, a star topology system with sufficiently advanced

¹⁹ The Commission has recognized the importance of receiver sensitivity. In 2003, the Commission issued a Notice of Inquiry to consider incorporating receiver interference immunity performance specifications into its spectrum policy. The Commission noted that incorporation of receiver performance specifications could serve to promote more efficient utilization of the spectrum and create opportunities for new and additional uses of radio communications. *In the Matter of Interference Immunity Performance Specifications for Radio Receivers*, 18 FCC Rcd 6039 (2003). The Commission terminated this proceeding in 2007, because with the passage of time the *Notice* and record in the proceeding had become outdated. However, in terminating the proceeding, the Commission stated that to the extent receiver interference immunity performance specifications are desirable, they may be addressed in proceedings that are frequency band or service specific. 22 FCC Rcd 8941 (2007).

²⁰ The cellular industry likewise relies upon finding favorable locations for its base stations.

receiver technology would be optimal for solving the critical communications requirements of the customer and distribution elements of Smart Grid.²¹

2. The On-Ramp System is a Star Topology System that is Optimal for End-User and Distribution System Smart Grid Functions.

Operating in the free ISM bands (*e.g.*, 900MHz and 2.4Ghz), the On-Ramp system is an example of such a star topology system. Nodes embedded in customer meters and devices and distribution system components communicate data to and from central access points that in turn use T-1 links, cellular, satellite and other forms of communications to link up with the utility data processing system. Both the nodes and the central access points use Ultra-Link Processing™ (“ULP”) technology—a significant innovation in Direct Sequence Spread Spectrum signal processing that results in very high receiver sensitivity. The receive sensitivity of the system results not only far outperforms mesh systems in terms of coverage, but also offers better interference-resistance and inherent link level security with far lower transmitter power levels.

According to On-Ramp estimates, by virtue of the high sensitivity of its receivers, only twenty Central Access Points employing ULP would be necessary to enable the receipt of AMI data from all electricity customers in the entire City of San Diego. This includes “worst-case scenario” receptivity—receptivity from meters in hard-to-reach locations, as well as devices inside buildings—one of the critical requirements of Smart Grid applications. With only twenty Central Access Points necessary to cover such a large area, the On-Ramp System can also take advantage of favorable antenna locations, such as elevated Central Access Points, which further enhances the robustness of the system by a factor of ten, such that in-building energy efficiency

²¹ Unfortunately, cost-effective high-sensitivity receiver and capacity-efficient multiple access point technology was not available to prior architects of utility networks to address the inherent problems with communications systems for end-user and distribution system Smart Grid applications. Indeed, On-Ramp’s system innovation has only recently become commercially available.

monitoring devices can be reached without a second radio system. By comparison, a mesh system working in the free ISM bands would require approximately 56,000 additional repeaters to cover the electric meter backbone. These additional repeaters would require substantial additional infrastructure and backhaul, and would present physical and grid-level security issues. On-Ramp's receiver sensitivity also enables On-Ramp to exert power control of its signals. Taken together, the On-Ramp star topology configuration confers a 600-times coverage advantage over competing mesh systems at equivalent antenna elevations.

ULP technology also offers higher system capacity, which means that the On-Ramp system will be an efficient user of available wireless spectrum and bandwidth and that less infrastructure will be required to serve a higher number of users. Two factors account for ULP's superior capacity. First, ULP uses a new multiple access scheme (called Random Phase Multiple Access) that is specifically designed for wide area high capacity communications, which cannot be said of competing systems designed for relatively few users with high individual node data rate requirements. With this modulation scheme, up to 1,000 transmissions from Smart Grid devices may simultaneously and reliably be received by a Central Access Point.²² Second, for the reasons stated above, the relative simplicity of the star topology enhances the capacity of On-Ramp's network, providing the On-Ramp system a more than twenty-five times advantage in

²² The performance capabilities of this approach are unique to ULP, which is a Direct Sequence Spread Spectrum ("DSSS") system that is capable of 39 dB of processing gain.

The multiple simultaneous concept employed in ULP is also used in cellular Code Division Multiple Access ("CDMA"). Cellular CDMA is also a DSSS system capable of 18 dB of processing gain, enabling such cellular systems to handle approximately ten calls simultaneously in the sector of a base station—two orders of magnitude fewer than the On-Ramp system's capability. Succinctly stated, cellular CDMA is an access scheme ideal for allocating 1 MHz of bandwidth among 10 users at approximately 10 kbps, while ULP is ideal for allocating 1 MHz of bandwidth among 1,000 users at similar spectral efficiency. In addition, cellular CDMA is not optimized for meter and sensor data but voice traffic.

capacity over mesh network systems. Indeed, On-Ramp requires only 1 MHz of spectrum as compared to the 20 MHz of spectrum required by mesh networks.

Turning to power consumption, the On-Ramp technology consumes less power and permits longer battery life than mesh systems. This advantage arises because On-Ramp's technology is purpose-designed for highly duty-cycled, low data rate applications and because of its highly efficient performance capabilities in signal processing. Specifically, the high receive sensitivity enabled by ULP directly translates into lower energy consumption for each connected link.

Our nation's Smart Grid must be secure, as the ability to compromise the grid is a National Security issue. In addition to the data encryption standards that all wireless systems may support, On-Ramp's technology offers unique security advantages. On-Ramp's ULP technology operates at a negative signal-to-noise-ratio ("SNR")—below the thermal noise floor.²³ While other technologies require a positive SNR to operate, allowing signals to be easily detected, the On-Ramp ULP technology offers unique low probability of intercept and detect that is crucial for a secure national Smart Grid.

Overall, what sets the On-Ramp System apart is its extraordinary range and ability to operate in changing RF propagation environments with varying interference levels. This capability is represented quantitatively in the system's allowable path loss of up to 172 dB. Such a large link budget—the total allowable path loss in a radio system—provides the required level of robustness and enables the system to achieve a very large range.

²³ CDMA cellular also operates below the thermal noise floor.

The performance of the On-Ramp system in comparison to mesh systems is summarized in the table below.²⁴

	On-Ramp System	FH Mesh Systems
Required bandwidth	1 MHz	20 MHz
Average power output per meter	0.1 mW	100 mW
Application throughput normalized by bandwidth	20 kbps/MHz	0.05-0.5 kbps/MHz
Interference caused by system	Low	High
Susceptibility to interference	Low	High
Susceptibility to jamming	Low	High
Security	High	Low
Cost	Low	High
Coverage	100%	< 100%
Power consumption	Low	High

E. The Commission Should Allocate 4 MHz of Spectrum Exclusively to End-User and Distribution Smart Grid Applications, Additional Spectrum for Other Smart Grid Applications that Require Low Latency and High Data Rates, Adopt an Expedited Licensing Protocol for Franchised Electric Utilities, and Provide for Utility Supervision of Entry and Imposition of Performance Standards Upon Communications Providers.

On-Ramp believes that 4 MHz of spectrum should be exclusively allocated for end-user and distribution-system monitoring Smart Grid applications, and additional spectrum should be reserved for other Smart Grid applications, such as transmission management and generation coordination that require low latency and high data rates.

Beginning with end-user and distribution Smart Grid applications, we note that star topology, in general, and the On-Ramp system, in particular, would be capable of providing a

²⁴ The primary assumptions used in constructing the table are: the average power in the table is directly correlated with amount of RF interference generated in the ISM bands; On-Ramp's average power output assumes a 2 kilobyte per day payload data per node and a 100 mW power amplifier; and FH Mesh assumes the typical 10 percent on-time required to maintain mesh connectivity and the 1 Watt power amplifier typically used.

high-performing communications solution for the end-user meter and distribution-system monitoring aspects of Smart Grid operations even within unlicensed spectrum. However, even these communications would work far better with licensed than with unlicensed spectrum. The unlicensed ISM bands are crowded today, and are rapidly growing ever more crowded as more and more applications that use such spectrum are developed and deployed.

Moreover, because of the unpredictable, high-interference nature of the ISM bands combined with the in-building signal penetration loss, without licensed spectrum any wireless system, including the one proposed by On-Ramp, cannot communicate directly with home appliances for utility grade reliability with guaranteed 100 percent coverage. For such communications, an allocation of spectrum would be necessary. In particular, in contrast with the mesh system's faulty two-radio version of HAN communications described above, with licensed spectrum the On-Ramp system would establish communications directly between nodes embedded in customer devices and Central Access Points, and customer meters and Central Access Points with utility-grade reliability and 100 percent coverage.²⁵ In light of the deficiencies of the two-radio design, it is clear that the allocation of spectrum is the only reasonable choice for HAN applications. This allocation would ensure a reliable and secure demand response system, eliminate additional interference in the ISM bands and, because reduced in-building interference will provide a highly predictable battery life, will reduce cost.

On-Ramp believes that an allocation of spectrum for the end-user and distribution system aspects of Smart Grid (1) would enable utilities, working hand-in-hand with communications providers, to foster the development of a "purpose-built" communications system tailored to Smart Grid needs; (2) is essential to achievement of the Nation's energy goals, as articulated in

²⁵ It should also be pointed out that even with licensed spectrum, the mesh system will be forced to use the two-radio system and will have poor reliability and coverage.

EISA, which declared that it is the policy of the United States to support the development of Smart Grid; (3) would provide an environment where high-levels of interference do not compromise Smart Grid operations; and (4) would enable entry by different radio technologies to suit particular Smart Grid purposes, such as those requiring high data rates and low latency. Specifically, the Commission should adopt an expedited protocol to license the allocated portion of the spectrum to utilities on a coordinated basis, and provide for utility supervision (in concert with a power frequency coordinator, and with Commission oversight) of entry and imposition of performance standards upon Smart Grid communications providers.

For purposes of setting aside spectrum for Smart Grid purposes, On-Ramp believes that the utility would be the appropriate licensee. For present purposes, electric utilities—a term that should be interpreted to include investor-owned utilities, cooperatives and public power entities that own and operate the transmission and distribution system and have responsibility under state law to serve discrete service territories, as well as Regional Transmission Organizations and Independent Transmission Companies—would be the appropriate vehicle to apply for and receive a license to use a portion of Smart Grid-allocated spectrum.²⁶ Such licenses should be granted on a long-term basis and differentiated in terms of the geographic location of the specific utility’s transmission and distribution system and service territory. Because certain utility service areas are split into two or more geographically distinct pieces, such as those of Virginia

²⁶ A Regional Transmission Organization (“RTO”) is an organization that operates the transmission systems owned by member transmission systems within its geographic area. Two-thirds of electricity consumption in the United States occurs in areas whose transmission systems are operated by RTOs. An Independent Transmission Company (“ITC”) is a company formed to own and operate a transmission-only system, leaving the associated distribution system under the ownership and control of separate entities. An RTO or ITC would require an FCC license to utilize spectrum to perform Smart Grid functions on the transmission system which it operates. RTOs and ITCs and obviously must coordinate their use of Smart Grid spectrum with the use of that spectrum by geographically co-located utilities to perform Smart Grid functions on their distribution systems.

Electric and Power Company in Virginia and Jersey Central Power & Light Company in New Jersey, and because utility service territories are contiguous with one another, some effort on the part of the Commission and frequency coordinators would be necessary in order to prevent overlap between geographically-delineated communications systems.²⁷

As a final element of the recommended framework, On-Ramp envisions that the utility, with appropriate Commission oversight, would supervise entry by various communications providers who would subcontract or sublease spectrum from the utility, and establish eligibility and performance standards for such providers. This is appropriate in light of the fact that it is the utility, more than any other entity, that has end-to-end control over the generation, transmission and distribution and end-use components of the electricity system.²⁸ As such, it is the utility that will oversee the implementation of Smart Grid, and the utility that is in the best position to subcontract or sublease spectrum to individual communications providers, such as On-Ramp, for discrete Smart Grid functions. Such a utility-administered system would allow competition among sub-lessees and subcontractors in the secondary market, and as such, would be eminently consistent with Commission policy.²⁹

²⁷ Further, inasmuch as the right to use spectrum could be licensed to the utility for a discrete geographical area, and could easily coordinate its actions with those of neighboring utilities and, where necessary, RTOs and ITCs, it does not appear that mutually exclusive applications would be filed. *See* 47 U.S.C. § 309(j)(1). Accordingly, it would be inappropriate to issue licenses on the basis of competitive bidding.

²⁸ In some states, competitive service providers compete with utilities to sell energy to retail customers. In such states, the utilities are still monopoly providers of “wires,” or distribution, service. Some competitive service providers will wish to communicate directly with their retail electric customers’ meters, and utilities will need to coordinate Smart Grid spectrum management with those competitive service providers.

²⁹ *See generally* Promoting Efficient Use of Spectrum Through Elimination of Barriers to the Development of Secondary Markets, *Report and Order and Further Notice of Proposed Rulemaking*, 18 FCC Rcd 20604 (2003), *Second Report and Order, Order on Reconsideration, and Second Further Notice of Proposed Rulemaking*, 19 FCC Rcd 17503 (2004).

IV.
CONCLUSION

On-Ramp appreciates the opportunity to submit these Comments. For the reasons stated herein, On-Ramp respectfully submits that the Commission should recognize that deficiencies exist in the present AMI-related Smart Grid communications system, and promptly issue a supplemental notice in this proceeding seeking comment on the remedies that On-Ramp has proposed to ameliorate these deficiencies. Specifically, additional comment should be sought on On-Ramp's proposal to allocate a specific portion of the spectrum exclusively for Smart Grid purposes, to grant rights to use this portion of the spectrum by licensing such rights to electric utilities, and to implement a utility-administered system for supervising entry and imposing performance standards on companies that would sublease spectrum or subcontract with the utility to provide communications capability that is compatible with Smart Grid applications.

Respectfully submitted,

A handwritten signature in black ink, appearing to read "Kenneth G. Hurwitz". The signature is fluid and cursive, with a large, stylized initial "K" and "H".

Kenneth G. Hurwitz
COUNSEL FOR ON-RAMP WIRELESS, INC.

Dated: October 2, 2009

ATTACHMENT "A"

**KEY TO *PUBLIC NOTICE* QUESTIONS
ANSWERED BY ON-RAMP'S COMMENTS**

Question	Section of On-Ramp's Comments
1. Suitability of Communications Technologies. Smart Grid applications are being deployed using a variety of public and private communications networks. We seek to better understand which communications networks and technologies are suitable for various Smart Grid applications.	
b. Which communications technologies and networks meet these requirements? Which are best suited for Smart Grid applications? If this varies by application, why does it vary and in what way? What are the relative costs and performance benefits of different communications technologies for different applications?	III.D
c. What types of network technologies are most commonly used in Smart Grid applications? We welcome detailed analysis of the costs, relative performance and benefits of alternative network technologies currently employed by existing Smart Grid deployments, including both "last mile," backhaul, and control network technologies.	III.C.2, III.C.3, III.D
d. Are current commercial communications networks adequate for deploying Smart Grid applications? If not, what are specific examples of the ways in which current networks are inadequate? How could current networks be improved to make them adequate, and at what cost? If this adequacy varies by application, why does it vary and in what way?	III.C.2, III.C.3
e. How reliable are commercial wireless networks for carrying Smart Grid data (both in last-mile and backhaul applications)? Are commercial wireless networks suitable for critical electricity equipment control communications? How reliably can commercial wireless networks transmit Smart Grid data during and after emergency events? What could be done to make commercial wireless networks more reliable for Smart Grid applications during such events? We welcome detailed comparisons of the reliability of commercial wireless networks and other types of networks for Smart Grid data transport.	III.C.2, III.C.3
2. Availability of Communications Networks. Electric utilities offer near universal service, including in many	

Question	Section of On-Ramp's Comments
geographies where no existing suitable communications networks currently exist (for last-mile, aggregation point data backhaul, and utility control systems). We seek to better understand the availability of existing communications networks, and how this availability may impact Smart Grid deployments.	
b. What percentage of homes have no access to suitable communications networks for Smart Grid applications (either for last-mile, or aggregation point connectivity)?	III.C.1
3. Spectrum. Currently, Smart Grid systems are deployed using a variety of communications technologies, including public and private wireless networks, using licensed and unlicensed spectrum. We seek to better understand how wireless spectrum is or could be used for Smart Grid applications.	
c. Have wireless Smart Grid applications using unlicensed spectrum encountered interference problems? If so, what are the nature, frequency, and potential impact of these problems, and how have they been resolved?	III.C.2, III.C.3
d. What techniques have been successfully used to overcome interference problems, particularly in unlicensed bands?	III.D
f. Is additional spectrum required for Smart Grid applications? If so, why are current wireless solutions inadequate?	
iv. Security: What are the major security challenges, and the relative merits and deficiencies of private utility networks versus alternative solutions provided by commercial network providers, such as VPNs? Do the security requirements and the relative merits of commercial versus private networks depend on the specific Smart Grid application? If so, how?	III.C.2, III.C.3
g. If spectrum were to be allocated for Smart Grid applications, how would this impact current, announced and planned Smart Grid deployments? How many solutions would use allocated spectrum vs. current solutions? Which Smart Grid applications would likely be most impacted?	III.E

Attachment “B”

DISCUSSION PAPER

On-Ramp Wireless, Inc.

December 17, 2009

Presented to Nick Sinai, Energy and Environmental Director and
Charles Worthington, Energy and Environmental Staff of the
FCC's National Broadband Taskforce

1. Introduction

- a. On-Ramp Wireless ("ORW") was asked by Staff whether it would make sense to establish a national machine-to-machine ("M2M") network where carriers would supply wireless services for numerous new service "verticals" of national policy interest such as electric, gas and water utility infrastructure, health care, critical infrastructure, and transportation and asset tracking.
- b. ORW believes that a national M2M network designed to support the billions of currently unconnected device and meter endpoints will enable a broad new set of applications that will lower costs and accelerate innovation in a variety of vertical markets of commercial and national interest.
- c. ORW's will focus on those M2M applications representing the vast majority of endpoints that require high capacity, lower data rate wireless networks with long battery life and low cost infrastructure for wide area metropolitan scale deployments. Examples of these applications include the following service verticals:
 - i. Water leak detection
 - ii. Cargo container monitoring
 - iii. Blood glucose monitoring
 - iv. Infusion pump monitoring
 - v. Streetlight dimming and management
 - vi. Commercial building energy management
 - vii. Water meter demand response
 - viii. Natural gas meters
 - ix. First responder tracking

- x. Electric utility AMI-HAN
- d. The opportunity associated with these service verticals is so large and the challenge of meeting the wireless service needs of these service verticals so daunting that a purpose-built network with a high level of spectral efficiency is an absolute necessity.
 - i. Existing technologies – including cellular, WiMax and mesh – with their high deployment and maintenance costs and poor reliability, are simply inadequate to handle this opportunity because they were built to address fundamentally different applications.
 - ii. The ORW network, on the other hand, uses a wireless technology specifically designed to support the requirements of these opportunities, which require a high-capacity, low-data rate solution that supports long battery life and can be efficiently deployed at a low infrastructure cost.
 - iii. The ORW network is extremely efficient in its use of spectrum, which is a critical characteristic of any network deployed on such a large scale given the already crowded free ISM bands and scarcity of licensed spectrum.
- e. Use of wireless networks that deploy ORW technology will drive tremendous value in the above verticals and will foster the Nation's goals to reduce greenhouse gas emissions, promote energy independence, increase the supply of available water, help protect our borders, increase patient safety and provide numerous other benefits.

2. The Common Wireless Service Requirements of the Foregoing Verticals and the Character of the Network that is Needed to Serve Them

- a. The common wireless service requirements of the foregoing verticals are:
 - i. Small packet sized transactions
 - ii. Low individual node data rates
 - iii. Latency tolerance of seconds to minutes
 - iv. Ability to operate in difficult environments, such as in buildings and below manhole covers where many of the endpoints are located
 - v. Ability to support numerous locations and devices; the number of endpoints requiring service dwarfs cellular; easily reaches billions of endpoints

- vi. Battery life of several months up to 20 years
 - vii. The attached Chart in Appendix A – *Network Requirements by Application* – provides a more detailed description of these service requirements
- b. The corresponding requirements of the network are:
- i. High capacity (network throughput) – Many devices speaking at relatively low individual node data rates represent significant cumulative data flows
 - ii. Low power (battery operation)
 - iii. Efficient scalability
 - iv. Resilience to interference
 - v. Ability to operate in difficult environments
 - vi. Low cost, both initial deployment costs and ongoing operation and maintenance costs
 - vii. High security
 - viii. Spectral efficiency because bandwidth available for allocation is scarce

3. The Inadequacy of Existing Technologies to Meet These Requirements

- a. Existing technologies were originally developed to address fundamentally different applications with substantially different requirements, such as voice and high speed data. They are, thus, unable to adequately meet the requirements of the target service verticals, especially given the tremendous scope of the deployments that will magnify these deficiencies.
- b. Cellular
 - i. Optimized for voice and high-speed data
 - ii. Significant gaps in coverage; cellular technology's small link budget requires substantial additional base stations or repeaters to address all gaps; challenging environments, such as underground, simply cannot be covered.
 - iii. Endpoints characterized by short battery life

- iv. Imposes costly infrastructure requirements per application and per customer
- v. Characterized by low spectral efficiency for small packet transactions
- vi. Challenging and expensive to deploy and operate
- vii. Capacity already burdened by high speed data and smart phones

c. WiMax

- i. Similar performance characteristics to cellular
- ii. High power consumption
- iii. Extremely expensive due to high infrastructure costs resulting from the necessity to deliver high bandwidth with a system with poor receive sensitivity
- iv. Significant gaps in coverage – small link budget requires substantial additional base stations or repeaters to address all gaps; challenging environments, such as underground, simply cannot be covered
- v. Designed for high speed data and downlink centric large file transfers
- vi. Capacity inefficient for small payload transactions

d. Mesh

- i. Mesh system's inability to achieve robust coverage for wide area deployments results in significant coverage gaps
- ii. Characterized by low spectral efficiency; extremely poor data throughput/MHz
- iii. Suffers from and causes interference due to poor spectral efficiency and lack of power control
- iv. Relies heavily on multiple wireless networks such as cellular for backhaul
- v. Requires excessive bandwidth
- vi. Imposes costly infrastructure requirements per application and per customer
- vii. High operational overhead to manage distributed infrastructure

- e. Narrowband License Spectrum Solutions
 - i. Narrowband system that requires a positive signal to noise ratio (performs poorly with any interference in the system including co-channel and self interference)
 - ii. Extremely capacity inefficient, and therefore not a scalable solution to AMI or a viable option for a large scale vertical market M2M network
 - iii. Requires very high power expensive network infrastructure
 - iv. Requires scheduled deterministic data flows to operate
 - v. Link budget similar to cellular
- f. The potential problems of building a nationwide network based on these existing technologies are enormous especially given the magnitude and scale of the opportunity and the importance to applications of national interest. The high deployment and maintenance costs associated with these technologies (that would be necessary to overcome their inefficiencies for the target applications), coupled with their poor reliability for critical applications, will prevent the innovation and application development that the Nation needs.

4. The ORW System Is Ideal for Meeting the Foregoing Network Requirements

- a. Description of ORW's Ultra-Link Processing™ System
 - i. Provides new physical layer purpose built for M2M applications (competing technologies cannot compete since their physical layer – the foundation of every wireless system - was optimized for other requirements)
 - ii. Uses Direct Sequence Spread Spectrum, which is used in CDMA systems (which allows for up to 39 dB of processing gain, which is several magnitudes greater than competing technologies)
 - iii. Uses Random Phase Multiple Access™ (which allows for high levels of spectral efficiency—specifically, for up to 1,000 nodes to be simultaneously received at an access point and superior throughput for a given small spectrum allocation)

- iv. Ten patents filed to date with three already granted through the accelerated filing process.
- b. Capabilities of ORW System
 - i. Huge link margin – provides extensive coverage and robustness to interference (173dB)
 - ii. High capacity
 - iii. Low power
 - iv. Low cost
 - v. Secure
 - vi. Spectrally efficient
 - vii. “Open” platform, supports IP, moving towards standardization
- c. Appendix B – *Sample Application Description* – provides a more detailed description of representative vertical market applications as well as ORW’s suitability to serve them versus competing technologies.

5. Serving Multiple Verticals in a Single Spectrum Band is Economically Efficient Because of Low Infrastructure and Network Operational Cost Per Customer/Device

- a. A very large number of Customers can be served by a single access point
 - i. Ultra-Link Processing enables a single central access point to serve a large number of customers
 - 1. Up to 1,000 transmissions from devices may simultaneously and reliably be received by a single central access point.
 - ii. It is possible to serve such a large number of customers because of two interrelated phenomena associated with the ORW system, high protocol efficiency and low overhead requirements
 - 1. The attached Chart in Appendix C – *Capacity Efficiency Model* – illustrates the high protocol efficiency and low overhead requirements of the Ultra-Link Processing system and compares

these capabilities with frequency hopping spread spectrum (mesh) systems

- b. The fixed costs per customer associated with access points is relatively low given the capability of each access point to serve numerous customers/devices.
 - i. The only other fixed cost is the cost of network service centers which, by definition, does not vary with the number of customers. Total variable costs of serving customers are small relative to total fixed costs.
- c. As customers/devices providing new service verticals are added to each access point, aggregate revenues increase relative to total fixed costs, a phenomenon that enables investment in additional access points to serve an expanding customer base.
- d. *See San Diego deployment example outlined in Appendix D – San Diego Case Study.*

6. The ORW Network System Offers Very High Levels of Spectral Efficiency as Compared to Existing Technologies

- a. For any given allocation of spectrum and specific application, the true measure of spectrum efficiency is how many customer installations/devices could be served.
- b. The ORW system allows superior scalability given the large number of customers/devices that can be served by a single access point and the ability to expand the number of customers by increasing the number of access points within a given allocation of spectrum. (It should be noted that this could also be accomplished by operating in a multi-channel mode by utilizing additional 1 MHz spectrum bands.)
- c. In contrast, mesh systems are characterized by the opposite phenomenon -- adding more infrastructure actually decreases performance unless additional spectrum is used.
- d. This means that a far greater number of customers can be served using the ORW system within a given spectrum band than is the case with competing technologies.
- e. *See Appendix E – Endpoint Support and Scaling.*

7. An ORW Network Deployment Model and Case Study Example for San Diego County Show Substantially Lower Infrastructure Cost and Spectrum to Service Endpoints Across Vertical Applications

- a. ORW has already deployed a network covering 600 square miles and conducted a detailed network propagation model proving that 28 central access points can reach 97% of the endpoints outlined in Appendix B distributed over 2,100 square miles
- b. The cost to deploy and operate the network is several orders of magnitude less than existing technologies**
- c. Sufficient spectrum to service 4million endpoints in target vertical of national interest in 2Mhz of allocated bandwidth

8. Deficiencies of Free Spectrum for Multiple Verticals and Benefits of and Need for Licensed Spectrum

- a. Many individual applications, taken one at a time, can be adequately addressed using free spectrum available in ISM bands.
 - i. However, the free ISM bands are becoming too crowded to reliably operate a commercial service with high availability requirements especially once the Smart Grid and critical verticals of interest deploy *en mass*.
 - ii. The high interference environment that is characteristic of the free ISM bands is not suitable for many M2M service applications individually because it threatens the viability of these high-value applications.
 - iii. Customer perception of the risks of deploying mission-critical, security or medical applications in free spectrum with escalating interference will slow adoption
- b. The sheer number of applications, their demanding reliability and security requirements and the need to make these applications available to a myriad of end-users can best be addressed in the low interference environment of allocated spectrum.
- c. An allocation of spectrum is also necessary to accommodate the arrival of new applications over time.

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- d. Moreover, the allocation of a small amount of licensed spectrum to these high value applications would dramatically improve the public health and welfare and foster the implementation of national policy goals.

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Appendix A: Network Requirements by Application

	Electric AMI	Gas Meter	Water Meter	Distribution FCI	Building/HVAC Monitoring
Daily Uplink Payload Data	5kb plus alarms	500 bytes plus alarms	500 bytes plus alarms	150 bytes plus alarms	600 bytes every 5 minutes per building; control messages 100 bytes once per hour
Daily Downlink Payload Data	Network acknowledgment, shut off, rate tables	Network acknowledgment, shut off	Network acknowledgment, shut off	Network acknowledgment, reset	Control messages, rate information tables
Latency Tolerance	Seconds for alarms; Minutes for payload	Seconds for alarms; Minutes for payload	Seconds for alarms; Minutes for payload	Seconds for alarms; Minutes for payload	Seconds to minutes
Battery Requirements	n/a for meter; months to years for HAN devices	15-20 years	15-20 years	10 years	Months to years for in-room monitors without AC power

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	Blood Glucose Meters	Streetlights	Cargo Container Security	First Responder Tracking	Water Leak Detection
Daily Uplink Payload Data	500 bytes 4-10 times per day	300 bytes 2 times per day; plus alarms and control messages	250 byte status every hour; plus location changes and alarms as needed (100 bytes)	10 bytes every 2 minutes; plus alarms	150 bytes 2 times per day
Daily Downlink Payload Data	Alarms, acknowledgements	Control messages	Status, alarms	Status, alarms	Network acknowledgment, shut off
Latency Tolerance	Minutes	Seconds	Seconds to minutes	Seconds for alarms; Minutes for payload	Seconds for alarms; Minutes for payload
Battery Requirements	Weeks to months	n/a	Months	Months to years	15-20 years

Appendix B: Sample Application Descriptions

BUILDING HVAC AND LIGHTING MONITORING AND CONTROL

- Commercial buildings use approximately 20% of the total energy consumed in the United States each year with over 50% of the average building's energy use going towards lighting and indoor climate control. Both of these uses are often totally unmanaged, resulting in extreme inefficiencies with offices fully lit and cooled with no occupants. It is estimated that the average commercial building could reduce its energy use by 20% by allowing more precise control over lighting and HVAC systems, both of which are ideally managed with wireless controls due to the expense of wired solutions. These wireless controls enable HVAC and lighting systems to be precisely controlled with time of day information or paired with a motion sensor to operate only when needed. Furthermore, remotely monitoring of the HVAC units can optimize maintenance, ensuring each unit is operating efficiently and not simply working harder to overcome a mechanical issue.
- A managed service using On-Ramp's Ultra-Link Processing™ (ULP) technology has several advantages over the emerging cellular and mesh network solutions:
 - Ultra-Link Processing™ has the necessary range in order to allow the wireless signal penetrate into commercial buildings from an access point several miles away, rather than require a access point in each building that mesh approaches require. Additionally, many cellular networks have poor coverage inside of buildings and hence can be unsuitable for many in-room applications with the addition of a repeater.
 - Although a network powered by Ultra-Link Processing™ technology can operate using free spectrum, the use of licensed spectrum dramatically increases the range of the wireless signal, which reduces the infrastructure needed to support the network (hence further increasing the cost advantage) and allows the signal to penetrate further into a building (e.g., monitoring underground devices).

BLOOD GLUCOSE MONITORING

- There are approximately 18 million people struggling with diabetes in the United States today. For these people, it is extremely important that blood glucose levels be carefully monitored in order to determine the appropriate dosage of insulin to maintain healthy levels. However, between 40-60% of these people are considered non-compliant, meaning that they do not regularly check blood glucose levels or administer the proper amount of insulin. The cost of non-compliance is significant, costing several thousand dollars per person each year more than the compliant population due to complications that can arise. One way to reduce this significant expense and increase patient health is to monitor compliance through wireless blood glucose monitors that enable readings and trends to be shared with a health care professional, and to help ensure the patient understands the proper drug levels to be administered. The overall cost savings from monitoring can easily reach the billions of

dollars while helping individuals with diabetes better manage the disease to enjoy longer and healthier lives.

- A managed service using Ultra-Link Processing™ technology has several advantages over the emerging cellular solutions:
 - A blood glucose meter with an integrated ULP node does not require the user to “pair” the meter with a cell phone. This pairing can be a very difficult and unreliable process with a cellular approach that is made even more problematic if the user is unfamiliar with the pairing process (using Bluetooth or other pairing technologies).
 - The coverage advantage provided by Ultra-Link Processing™ (which is extended when using licensed spectrum) minimizes dead zones and other connection issues that plague cellular networks.
 - Ultra-Link Processing™ can easily support robust security protocols that may be required in order to protect patient data, which may be difficult for cellular networks to deploy on such a large shared network.
 - Ultra-Link Processing™ is extremely power efficient and can enable a blood glucose meter to operate for several weeks or months without the need to recharge the battery, as opposed to a cellular modem that requires charging every 1-2 days.

INTELLIGENT STREETLIGHT DIMMING & MANAGEMENT

- The cost to power and maintain tens of thousands of streetlights is an enormous direct expense for many municipalities and businesses. However, by adding wireless control units to each lamp, operators can reduce energy costs by up to 35% through a combination of optimizing hours of operation, improving maintenance and dimming during off-peak traffic times. Furthermore, repair and maintenance costs can be reduced by 10-25% through burn-hour optimization and automatic notification of problematic units. The overall energy savings and cost reduction potential is enormous considering the estimated 35 million streetlights installed throughout the United States. Monitoring even a fraction of these streetlights could significantly reduce national CO2 emissions help promote energy independence across the nation.
- A managed service using Ultra-Link Processing™ technology has several advantages over emerging cellular and mesh network solutions:
 - Ultra-Link Processing™ can easily support this application with substantially less infrastructure than mesh based systems since ULP can easily connect each streetlight given its superior link budget. Mesh, on the other hand, breaks down in many instances where the distance between clusters of streetlights results in numerous “islands” that each requires additional equipment in order to properly transmit the application data.
 - A managed network powered by Ultra-Link Processing™ can enable municipalities and other customers of this service to avoid the high recurring fees imposed by cellular operators that can dramatically increase the cost of the application.

- Although a network powered by Ultra-Link Processing™ technology can operate in free spectrum, the ability to use licensed spectrum would dramatically increase the effective range and therefore can reduce the network service cost to the end customer. This is especially relevant for streetlights in residential areas with significant 900MHz and 2.4GHz traffic that can reduce the link margin of the system, which has the effect of reducing range of the wireless signal.

CARGO CONTAINER MONITORING

- Given the recent elevated threat of terrorist attacks, it is more important than ever to monitor the estimated 11 million cargo containers that enter U.S. ports each year. However, due to the sheer volume of cargo, it is impossible to manually inspect each container. Therefore, U.S. authorities need a better way to determine whether a container has been opened or otherwise compromised during transit. Wireless cargo container monitoring is a reliable and extremely cost effective method to accomplish this goal by adding a security device to each container to transmit critical security data miles before the container has reached the port. This can help identify containers that require manual inspection and therefore significantly reduce the threat of an attack with minimal disruption in the flow of goods into the country. On the commercial side, these cargo container monitors can also transmit temperature, humidity and other data about the conditions inside the container, which may be valuable in ensuring the quality of the contents.
- A managed service using Ultra-Link Processing™ has several advantages over emerging cellular, RFID and mesh network solutions:
 - Ultra-Link Processing™ allows the monitoring devices to be battery operated for months and even years, as opposed to cellular and mesh network approaches that require access to AC power for this application.
 - The range advantage of Ultra-Link Processing™ enables containers to be monitored by the receiving port while a cargo ship is still several miles away. This provides additional time to verify the status of each container prior to its arrival to minimize any delay once the ship arrives at the port, and does not require “choke points” required by RFID solutions that can create transport delays.
 - Although the system can operate in unlicensed spectrum, the availability of licensed spectrum will increase the ability of the system to reliably deliver this critical data and reduce the opportunity for intentional or unintentional jamming of the signal.

WATER LEAK DETECTION AND LOCATION

- Water is becoming an increasingly precious commodity as demand continues to grow due to increasing consumption per capita along with a growing population while supply is decreasing due to prolonged droughts impacting many areas of the United States. Unfortunately this situation is compounded by the fact that much of the water piped through the aging water delivery infrastructure is lost due to leakage before reaching its destination. It has been estimated that as much as 7 billion gallons of drinking water are lost each day in the United States and as much as 15% of all municipal water and 17% of water delivered by public systems that serve more than 1 million people. Reducing this avoidable loss through

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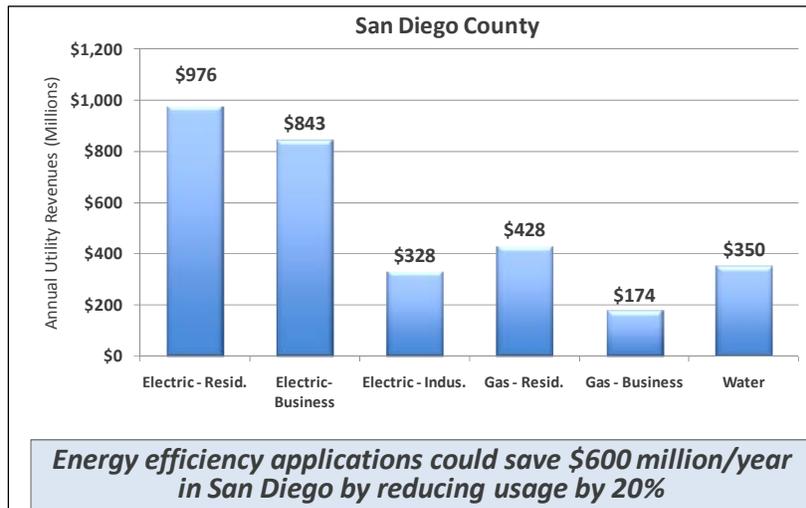
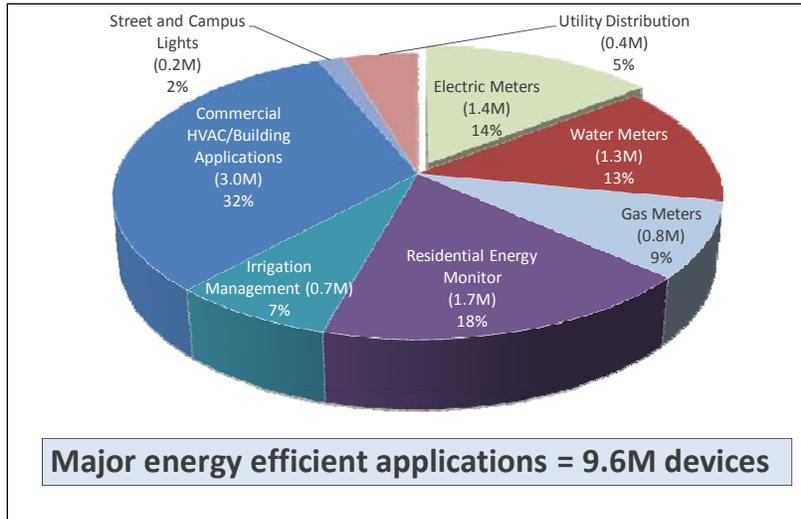
the use of existing water leak detection technology, which use an acoustic sensor or other monitoring device to determine the occurrence and location of a leak, can significantly increase the supply of usable water and enable us to more efficiently use our current supplies.

- A managed service using Ultra-Link Processing™ technology in licensed spectrum is the only reliable option for wireless leak detection due to the inability of other radios to penetrate manhole covers to monitor underground pipes (where most pipes are located). The system can operate using unlicensed spectrum, but the added range enabled by licensed spectrum ensures that a greater portion of the water distribution infrastructure can be monitored with substantially less infrastructure. This lowers the cost to deploy wireless leak detection systems, increases their effectiveness, and will help to ensure rapid adoption of this technology in order to quickly impact the amount of water available to businesses and consumers.

Appendix C: Capacity Efficiency Model (ULP vs. Mesh)

Uplink Data Rate	Ultra-Link Processing – 1Mhz	FHSS – 20Mhz, 100Khz bandwidth
Uplink Aggregate Data Rate	66 Kbps	100 Kbps
Half-duplex	33 Kbps	Payload dependent (10% - 70% overhead)
Aloha Protocol Max Efficiency	N/A, 33Kbps	18kbps
Engineering Margin/Protocol Efficiency	22Kbps	7 Kbps
After Mesh Inter-device Networking Overhead	N/A, 22 Kbps	1Kbps
1000 meter capacity/1Mhz	22bps/meter/1Mhz	0.05bps/meter/1Mhz

Appendix D: San Diego Case Study



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Appendix E: Endpoint Support and Scaling

	Endpoints Supported by Single ULP Access Point (using 1 MHz of spectrum @ 2.4 GHz)
Electric Meters (AMI)	17,280
Gas Meters	172,800
Water Meters	172,800
Streetlights	144,000
Water Leak Detection	288,000
HVAC	500 commercial buildings (Avg. 30K sq. ft. building with 60 sensors)
Blood Glucose Meters	17,280
Cargo Containers	28,800
First Responder Tracking	4,300

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**Ultra-Link Processing™ Scalability
- Electric AMI Example -**

4	69,120 meters	138,240 meters	207,360 meters	276,480 meters
3	51,840 meters	103,680 meters	155,520 meters	207,360 meters
2	34,560 meters	69,120 meters	103,680 meters	138,240 meters
1	17,280 meters	34,560 meters	51,840 meters	69,120 meters
	1	2	3	4

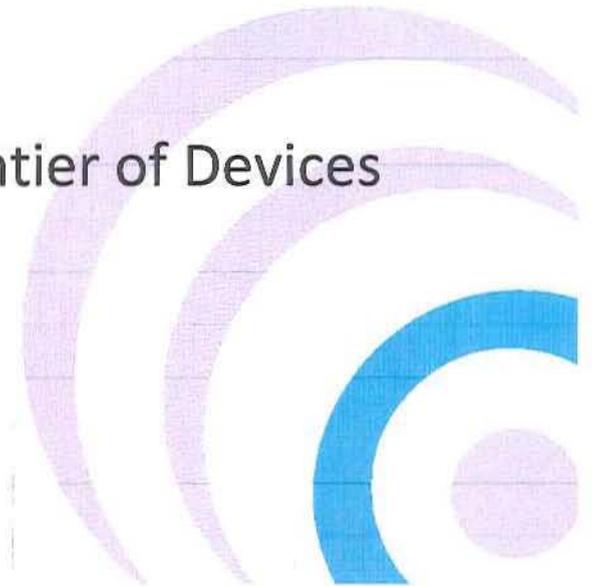
*Note: Given one application requiring 5KB of uplink data each day; plus downlink control and alarm data with less than 12 second latency for alarms

Attachment “C”



Bringing Wireless Connectivity to The Last Frontier of Devices

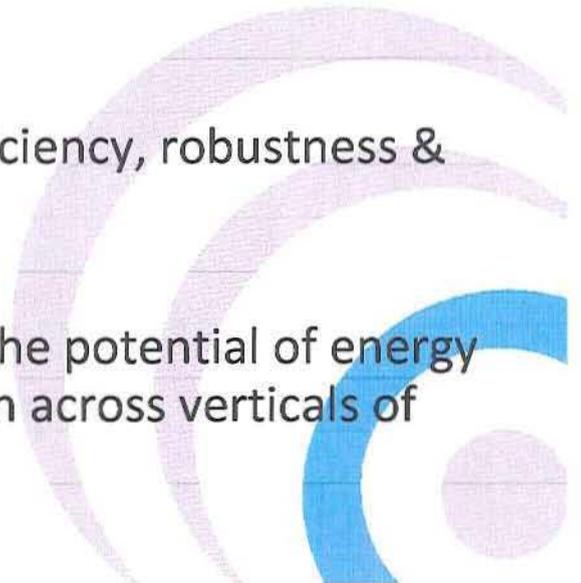
FCC Smart Grid Inquiry



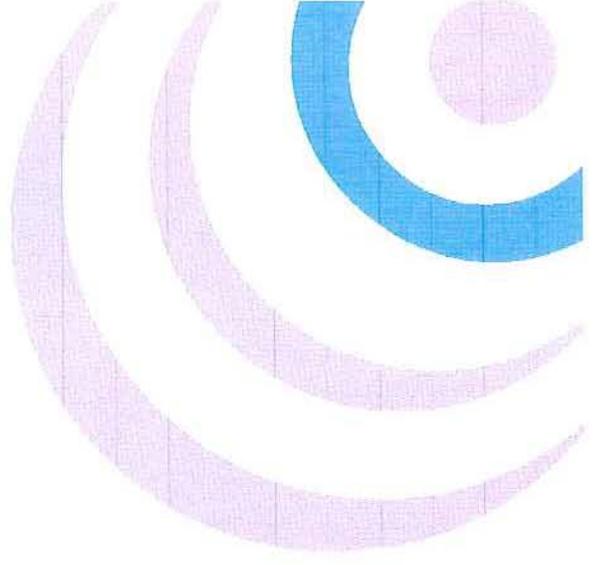
Review of Last Discussion



- \$60 billion per year for the national economy is at stake for connecting the Smart Grid and increasing Energy Efficiency
- Robust communications are critical and the requirements are drastically different than what Broadband and Cellular were designed to achieve
- Demand side management (e.g., AMI) and distribution automation wireless solutions proposed are inadequate
 - Are not cost effective, are spectrally inefficient and do not scale
 - Cause undue interference in ISM bands and are prone to security breaches and failures
 - Can not scale across other applications of national interest
- On-Ramp's solution provides network cost, spectral efficiency, robustness & scalability that is many order of magnitudes superior
- Lack of licensed spectrum over the long term will limit the potential of energy efficiency applications and stall adoption and innovation across verticals of national interest (security, health care)



Introduction



The On-Ramp Advantage



Ultra-Link Processing™

- -145 dBm Receive Sensitivity
- Random Phase Multiple Access

600x Coverage Advantage

25-100x Capacity Advantage

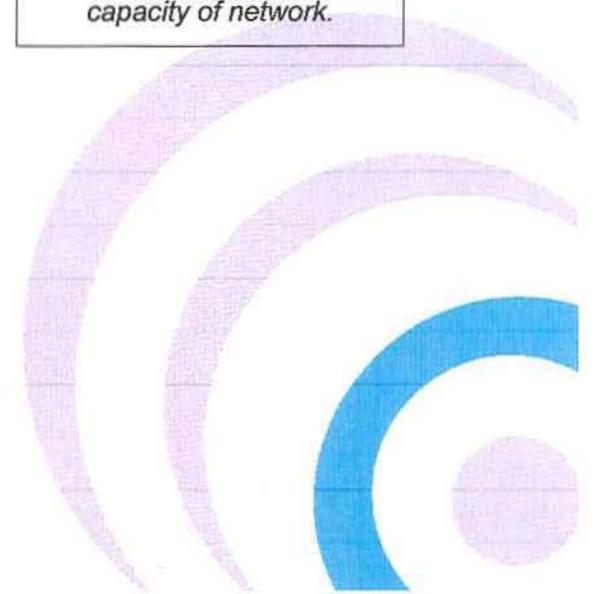
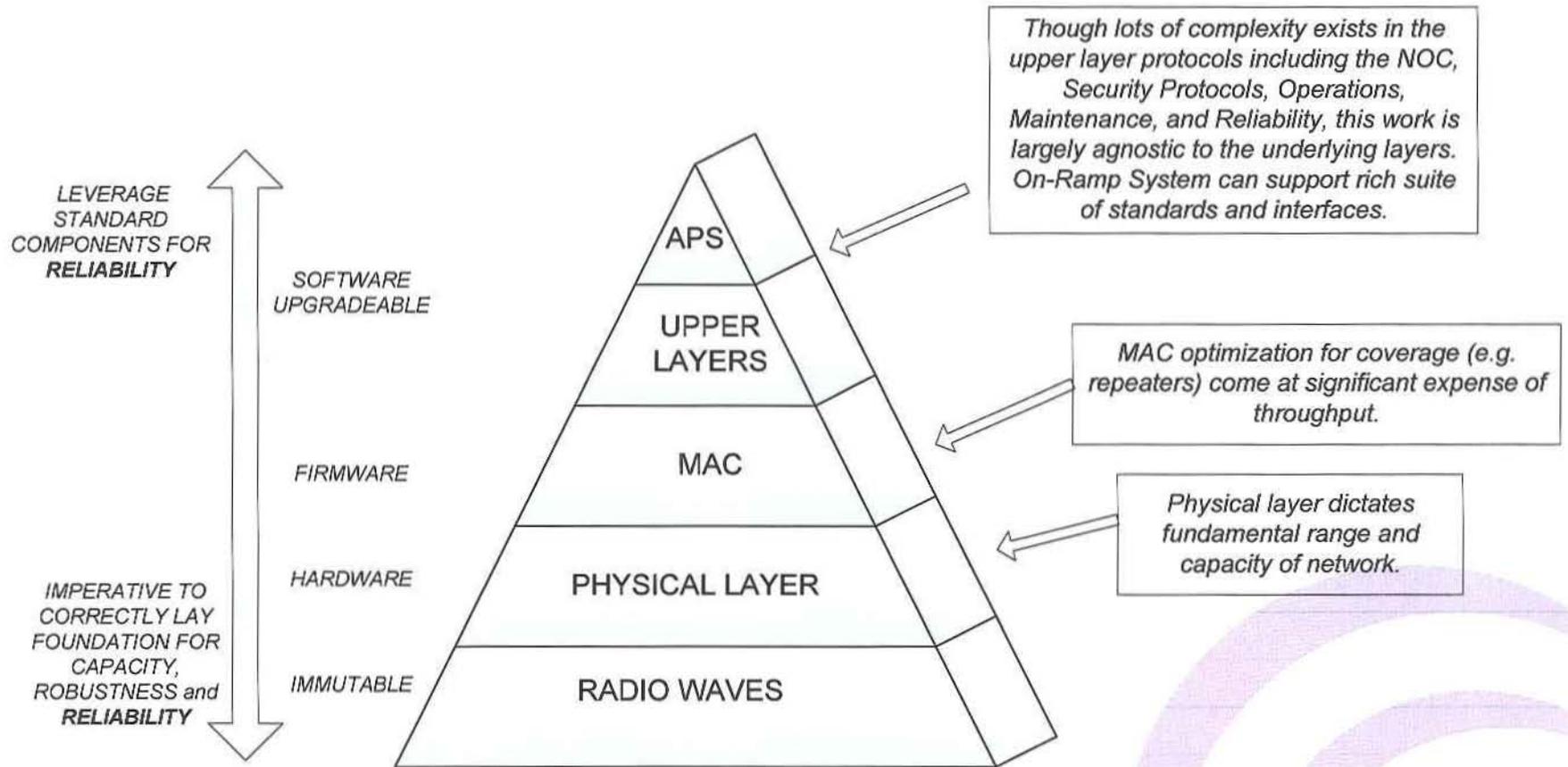
Scalable & Robust

Low Power

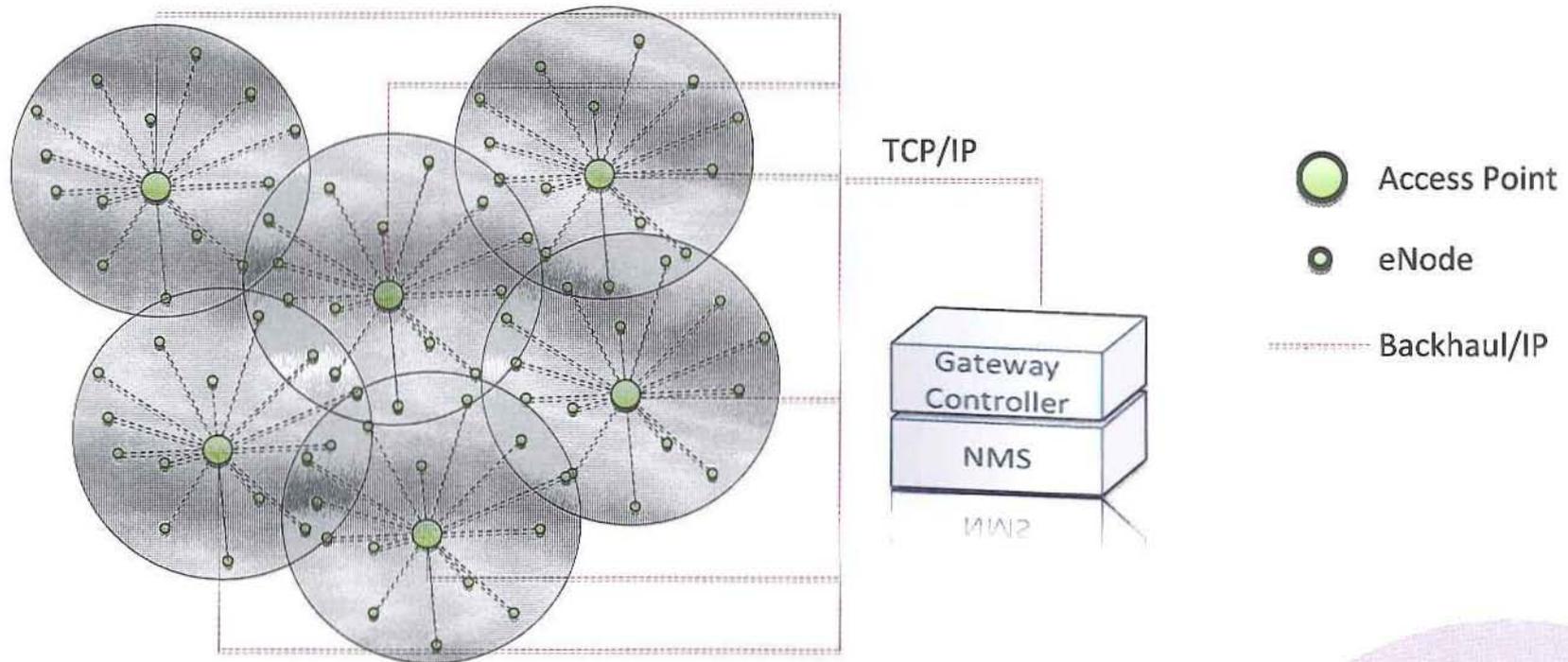
Low System & Ops. Cost



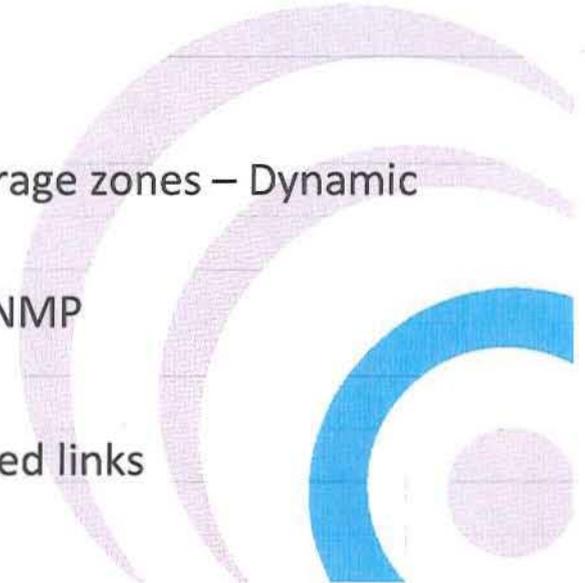
The Physical Layer - Foundation for Application Performance



On-Ramp Packet Data Network

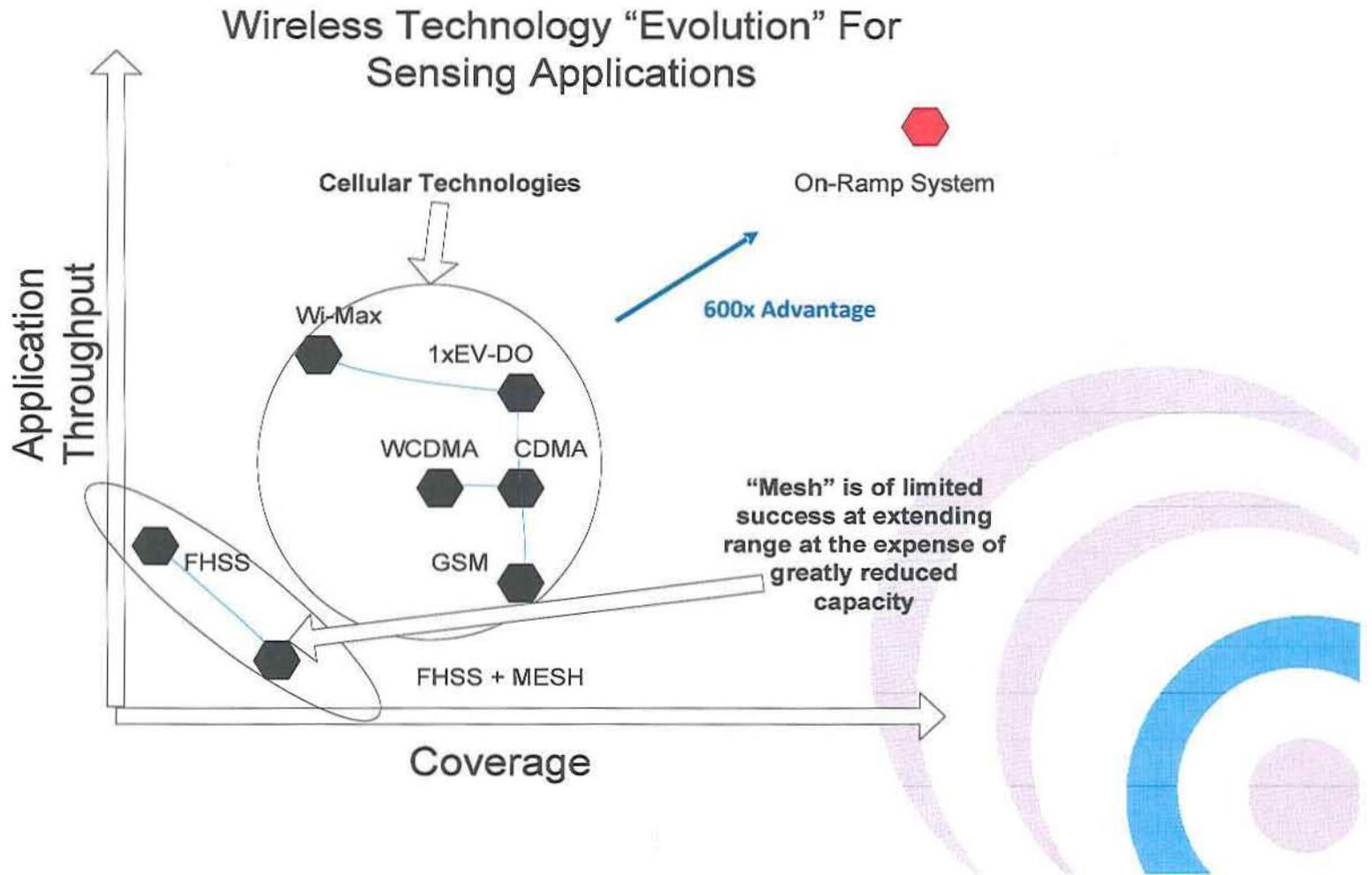


- “Cellular style” network with star topology overlapping coverage zones – Dynamic node acquisition
 - Seamless IP addressing support using ROHC, IPv4 and SNMP
- QoS support to optimize application traffic flows
- Same network infrastructure can support battery and powered links



Coverage and Application Throughput

On-Ramp's system is optimized for coverage and application throughput for many devices communicating relatively small amounts of data



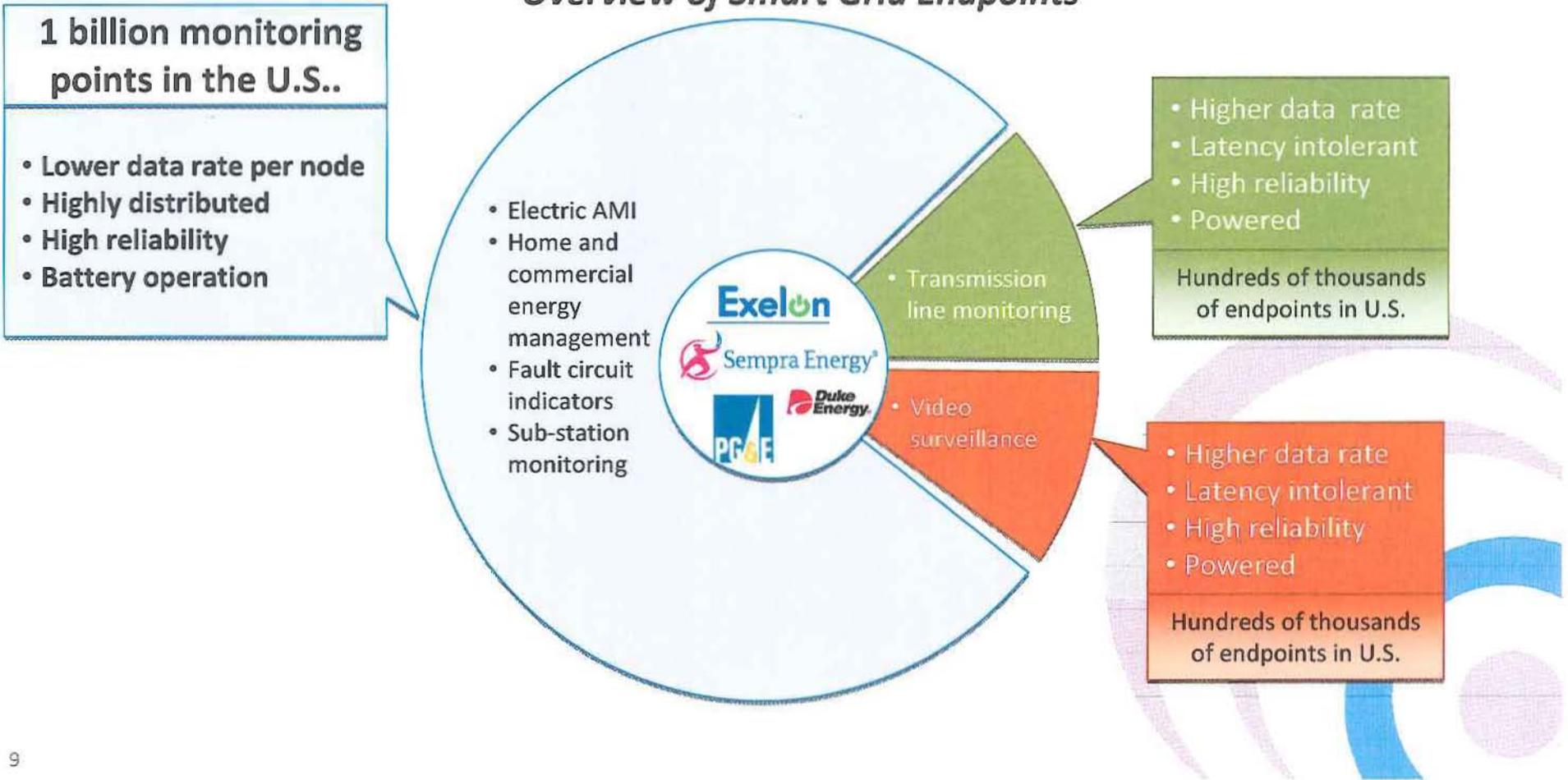
Application Network Requirement Analysis



Smart Grid Network Requirements Segmentation

The vast majority of Smart Grid endpoints require a secure, highly reliable wireless network for lower data rate applications

Overview of Smart Grid Endpoints



A National Critical Infrastructure Network

Additional markets of national interest – representing 1 billion additional endpoints – share similar network requirements

Infrastructure Monitoring	Transportation and Asset tracking	Healthcare	Security & Life Safety
<ul style="list-style-type: none">• Water leak detection• Sewer monitors• Bridge/structural monitors• Traffic light control systems• Soil moisture/temp monitors	<ul style="list-style-type: none">• Municipal vehicle tracking• Public transport tracking• Traffic monitors• Parolee tracking	<ul style="list-style-type: none">• Blood glucose monitors• Heart rate/blood pressure monitors• Elderly/at risk personal tracking• Ventilators• Home medical alarms	<ul style="list-style-type: none">• First responder tracking• Gas/hazardous material detection• Perimeter security• Border surveillance• Cargo container monitoring

Small data packet, widely dispersed, high capacity, battery operated applications requiring a secure, reliable and cost effective wireless network

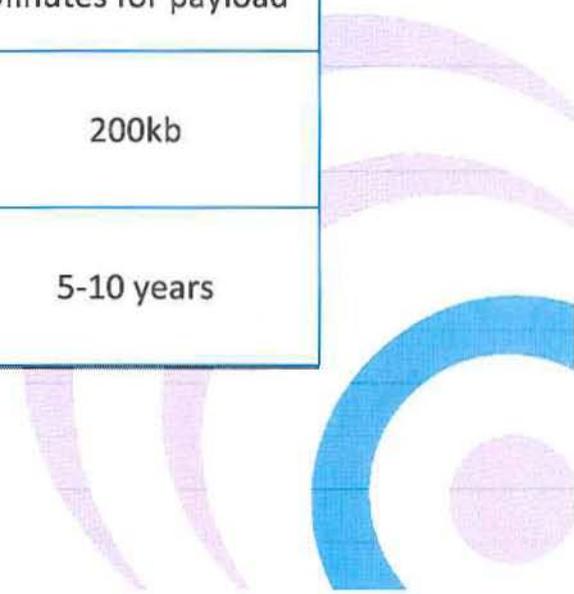
Utility Network Requirements



	Electric AMI	Gas Meter	Water Meter	Distribution FCI
Daily Uplink Payload Data	5kb +Alarms	500bytes + Alarms	500bytes +Alarms	150 bytes +Alarms
Daily Downlink Payload Data	Network acknowledgement, shut off, rate tables	Network acknowledgment, shut off	Network acknowledgment, shut off	Network acknowledgment, reset
Latency Tolerance	Seconds for alarms; Minutes for payload	Seconds for alarms; Minutes for payload	Seconds for alarms; Minutes for payload	Seconds for alarms; Minutes for payload
Firmware Upgrade	600kb	200kb	200kb	N/A
Battery Requirements	n/a for meter; months to years for HAN devices	15-20 years	15-20 years	10 years

Energy Efficiency

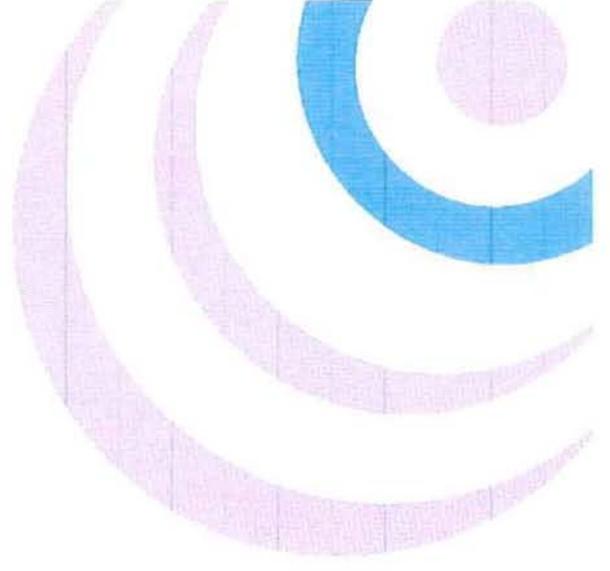
	Building/HVAC Monitoring	Streetlights	Water Leak Detection
Daily Uplink Payload Data	600 bytes every 5 minutes per building (10 bytes per node); Control messages 100 bytes once per hour	300 bytes 2 times per day; plus alarms and control messages	150 bytes 2 times per day
Daily Downlink Payload Data	Control messages, rate information tables	Control messages	Network acknowledgment, shut off
Latency Tolerance	Seconds to minutes	Seconds	Seconds for alarms; Minutes for payload
Firmware Upgrade	n/a	Yes	200kb
Battery Requirements	Months to years for in-room monitors without AC power	n/a	5-10 years



Security & Healthcare

	First Responder Tracking	Cargo Container Security	Blood Glucose Meters
Daily Uplink Payload Data	10 bytes every 2 minutes; plus alarms	250 byte status every hour; plus location changes and alarms as needed (100 bytes)	500 bytes 4-10 times per day
Daily Downlink Payload Data	Status, alarms	Status, alarms	Alarms, acknowledgements
Latency Tolerance	Seconds for alarms; Minutes for payload	Seconds to minutes	Minutes
Firmware Upgrade	n/a	n/a	No
Battery Requirements	Months to years	Months	Weeks to months

San Diego Case Study Analysis



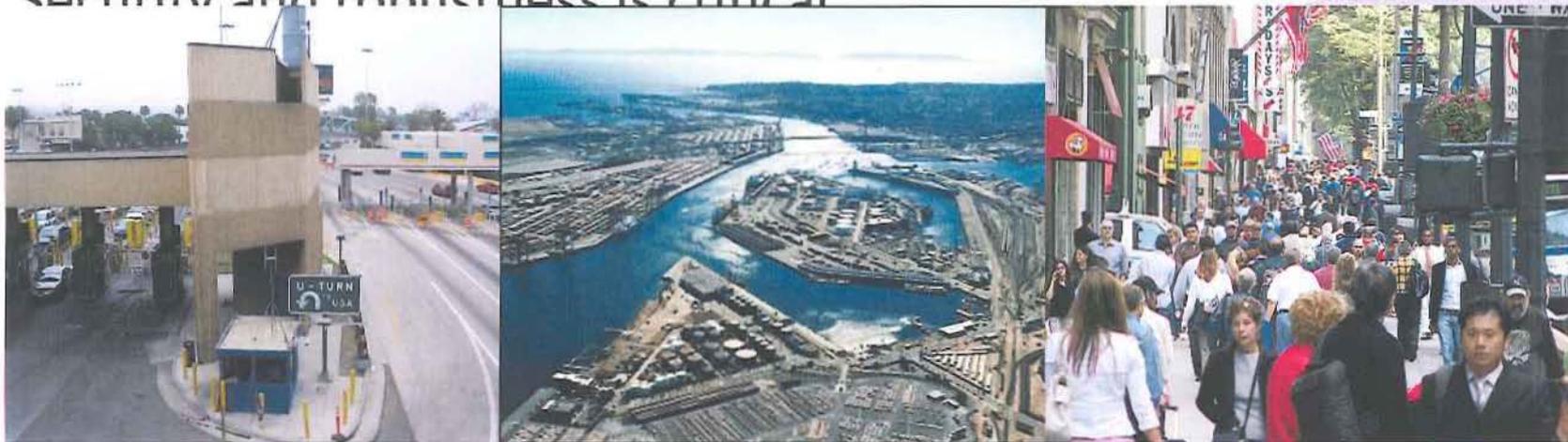
Achieving Energy Efficiency is Challenging

- Data trapped in billions of devices
- Devices often in hard-to-reach locations
- Interference increasing
- Security and reliability is critical
- No wireless communications solutions designed for the problem

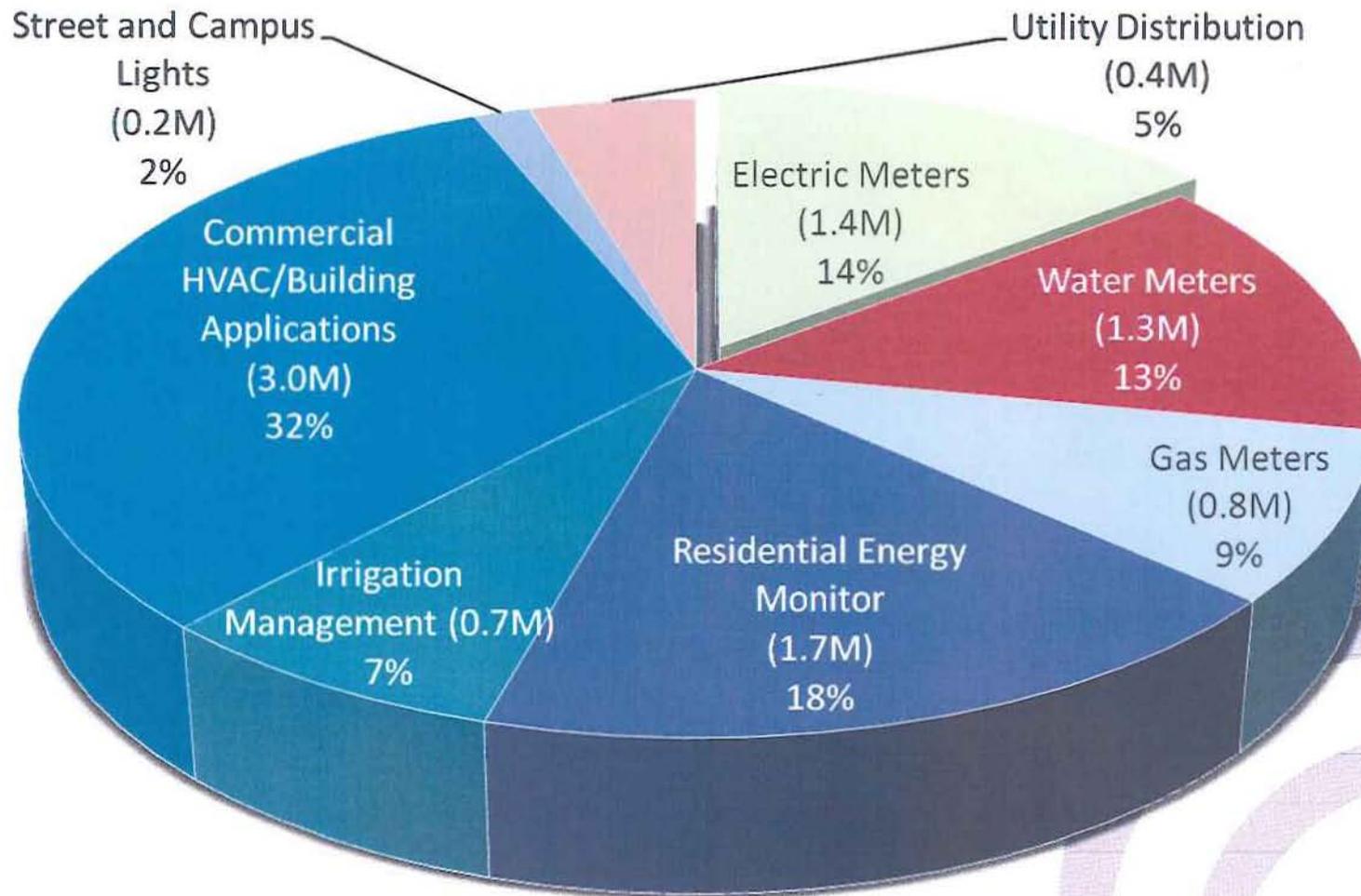


Why is Metro and Regional Security Challenging?

- No network infrastructure to reliably communicate with distributed sensors covering broad spectrum of potential threats
- Potentially millions of sensors often in hard-to-reach locations
- One incident could cause major infrastructure or loss of life – it must work every time!
- Security and robustness is critical



San Diego Case Study – Energy/Resource Efficiency

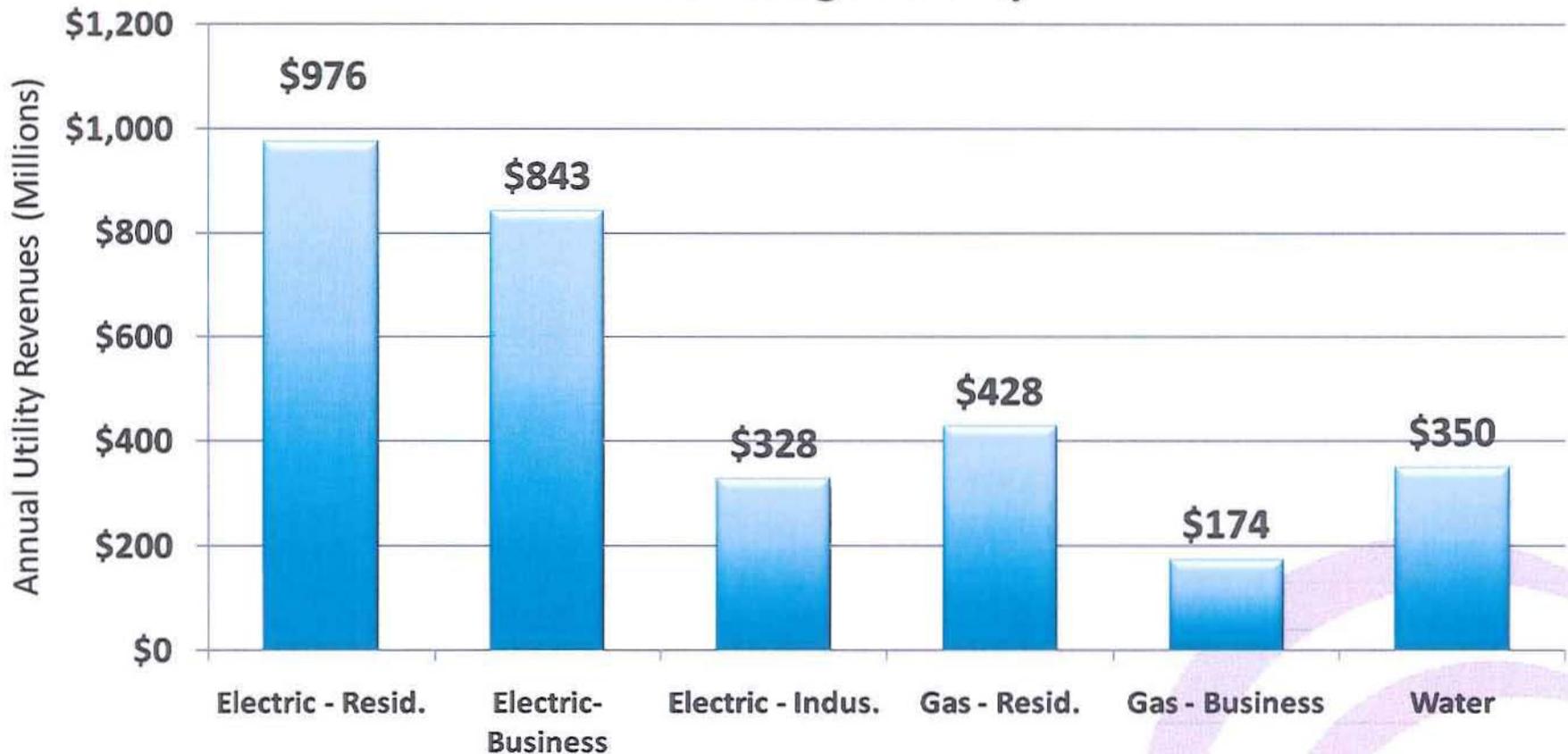


Major energy efficient applications = 9.6M devices

San Diego Case Study – Energy/Resource Efficiency



San Diego County

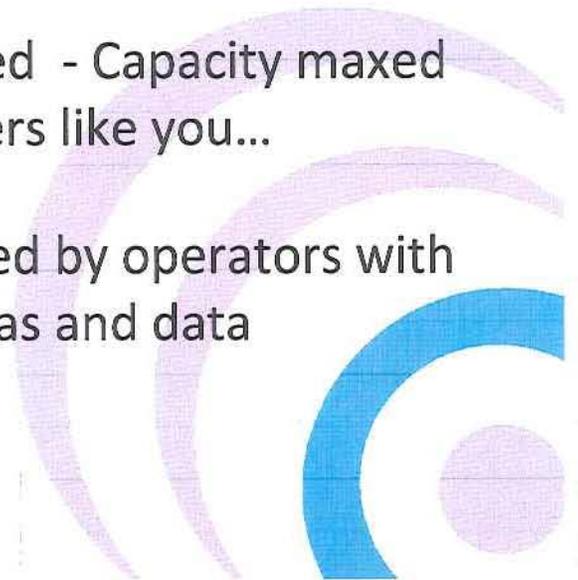


Energy efficiency applications could save \$600 million/year in San Diego by reducing usage by 20%

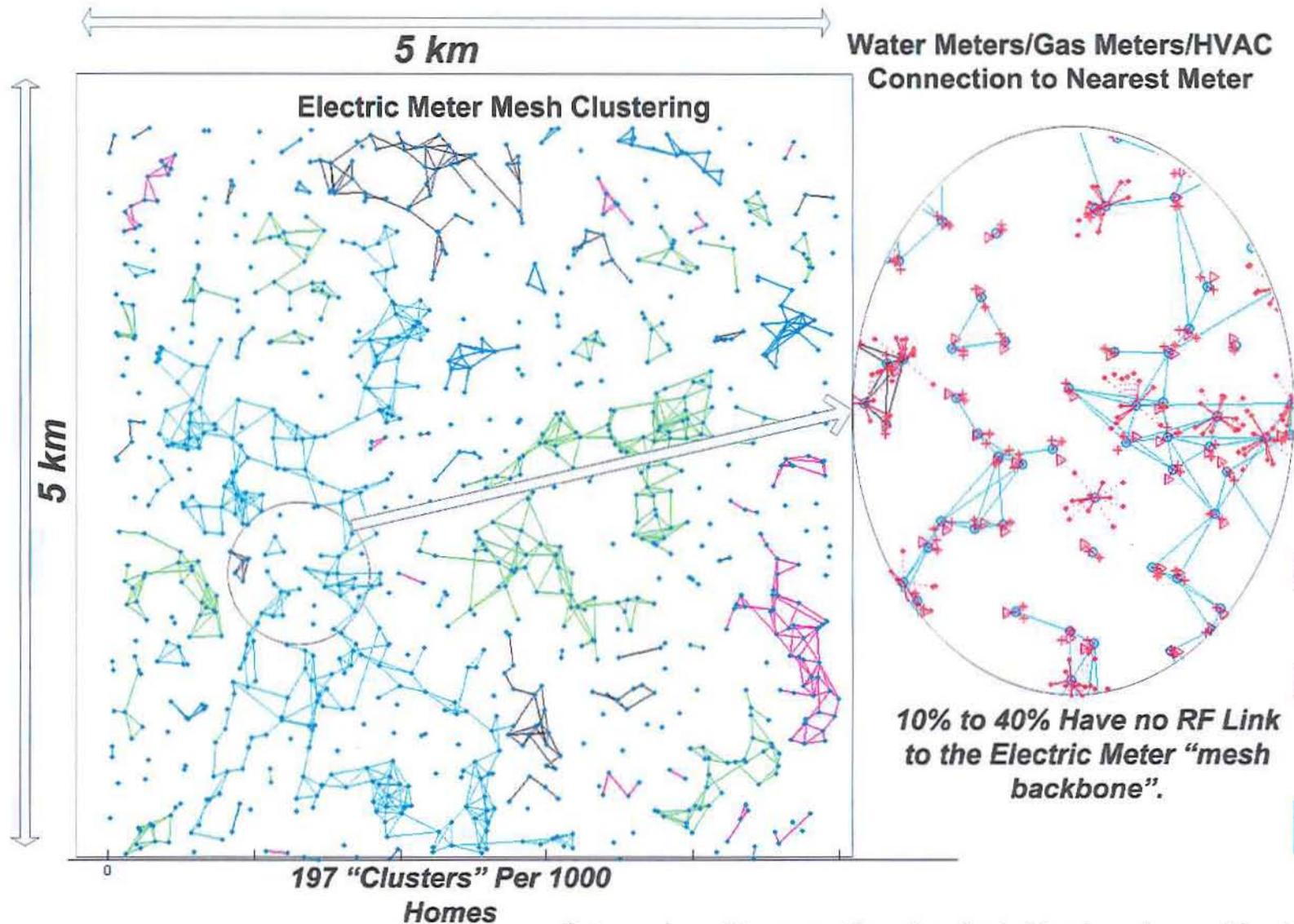
Can Cellular or WiMax Solve The Problem?



- Optimized for voice & high speed data
- Short battery life
- Sparse coverage in *hard-to-reach* locations
- Expanding network infrastructure in San Diego costs \$150 million
- Spectrum is limited - Capacity maxed out by iPhone users like you...
- Network controlled by operators with competing agendas and data requirements



Mesh Networking plus Cellular Backhaul?



* Based on Propagation Analysis Tool endorsed by NIST

Mesh Does Not Scale Efficiently

Residential Applications

	Electric Meters	Gas Meters	Water Meters	Home Energy	Total
Total Meters	1,400,000	1,300,000	830,000	1,700,000	5,230,000
Required Mesh Repeaters	57,600		205,600		263,200
System Cost Impact	\$115M		\$113M		\$218M
Spectrum	20MHz		5MHz		25Mhz

Plus additional 4.4 million commercial end point devices are not connected

Capacity Efficiency Model



Application throughput for uplink available for meter data

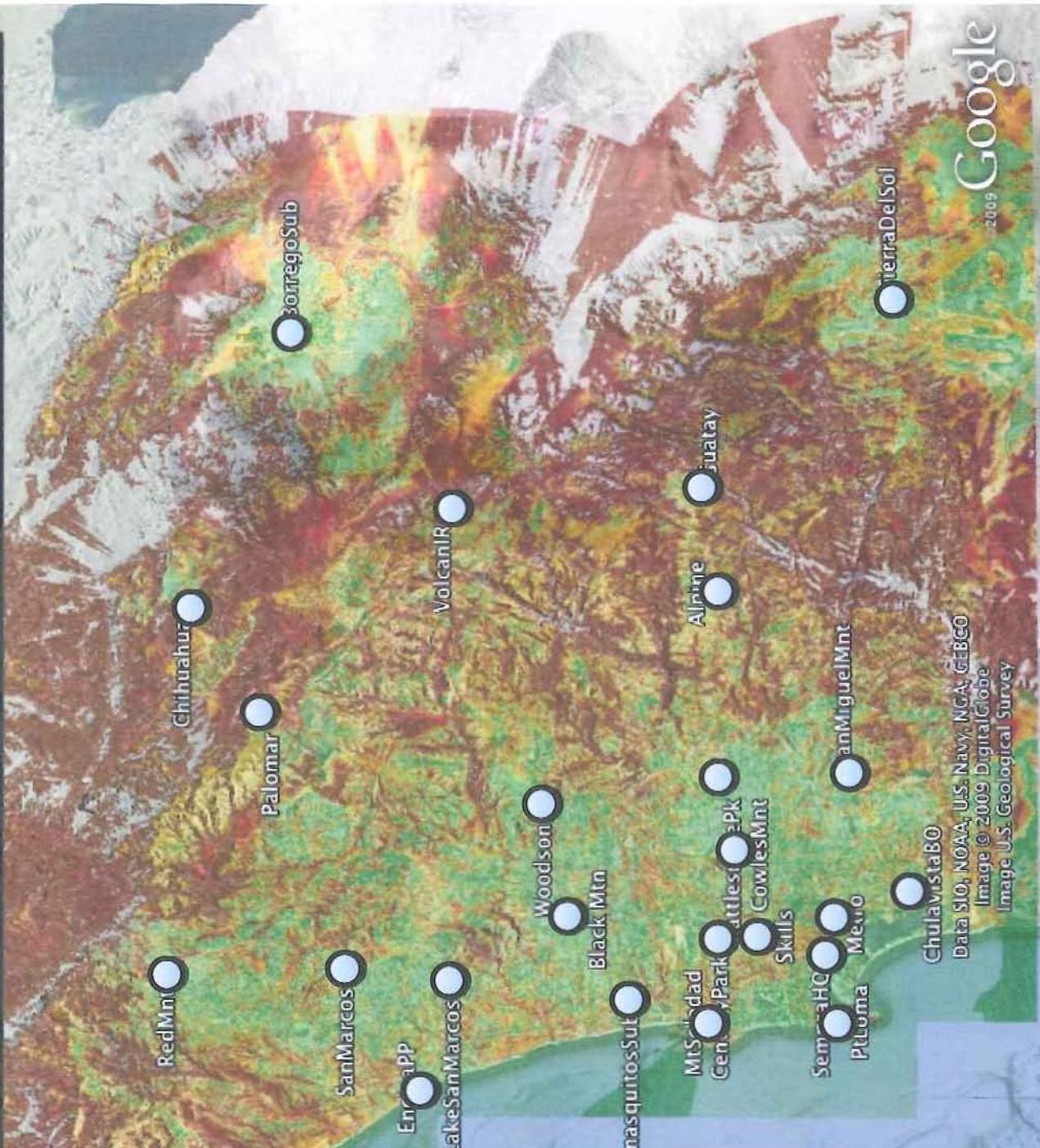
Uplink Data Rate	Ultra-Link Processing – 1Mhz	FHSS – 20Mhz, 100Khz bandwidth
Uplink Aggregate Data Rate	66 Kbps	100 Kbps
Half-duplex	33 Kbps	Payload dependent (10% - 70% overhead)
Aloha Protocol Max Efficiency	N/A, 33Kbps	18kbps
Engineering Margin/Protocol Efficiency	22Kbps	7 Kbps
After Mesh Inter-device Networking Overhead	N/A, 22 Kbps	1Kbps
1000 meter capacity/1Mhz	22bps/meter/1Mhz	.05bps/meter/1Mhz



On-Ramp Network Deployment Model

ULP Coverage Model	
Network Coverage Receive Sensitivity	>= 136 dBm
Coverage Area	≈ 4000 mi ²
Number of Access Points Required	28
Utility End-Point Coverage	97%
Capacity	Up to 4M endpoints in 2Mhz
Infrastructure Cost	< \$1M
Legend	
	>= 100 dBm
	>= 106 dBm
	>= 112 dBm
	>= 118 dBm
	>= 124 dBm
	>= 130 dBm
	>= 136 dBm
	>= 172 dBm
	On-Ramp Access Point

Moult...Niguel
Laguna Niguel
Hill 127



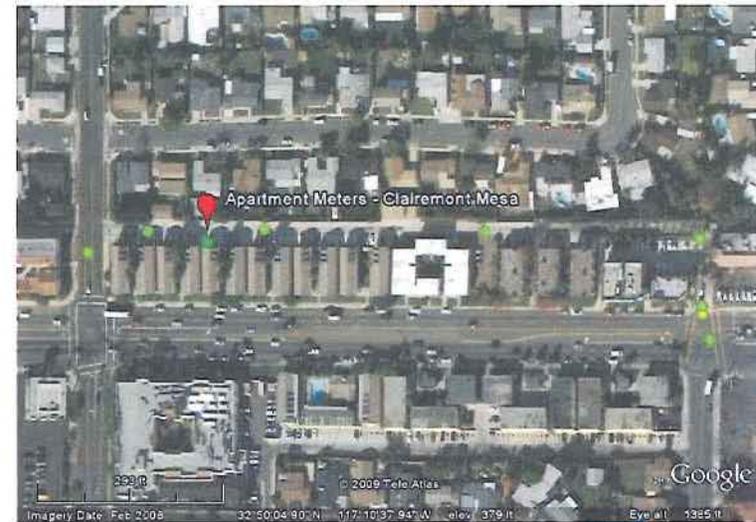
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image © 2009 DigitalGlobe
Image U.S. Geological Survey

2009 Google

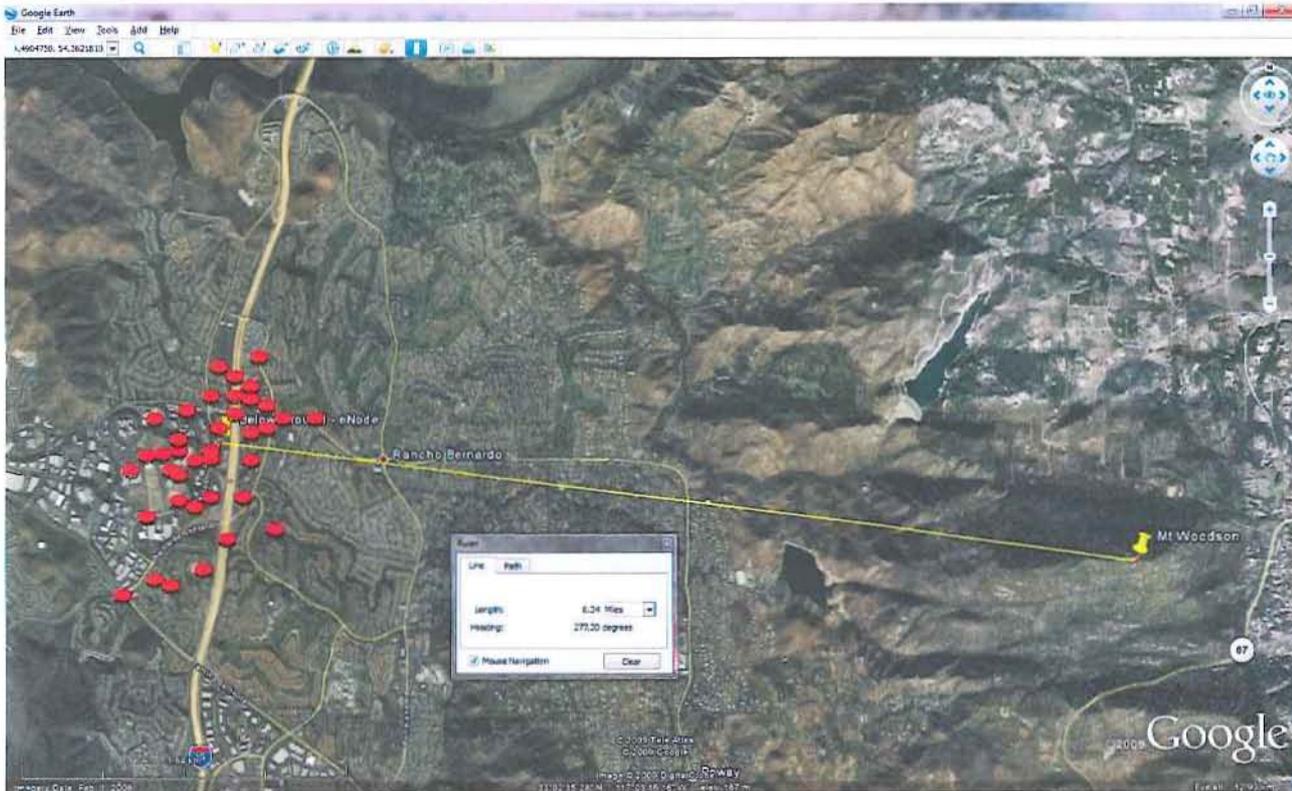
Metro Scale Test



- 1 Access Point covers 300 square miles
- Green, red and yellow represent successful node test points
- 2.4 GHz frequency, 100mW PA
- Link closed up to 15 miles
- High noise floor with significant residential 2.4GHz traffic
- Non line of sight meters, substations, fault circuit indicators fully covered



Mt. Woodson Above and Below Ground Test

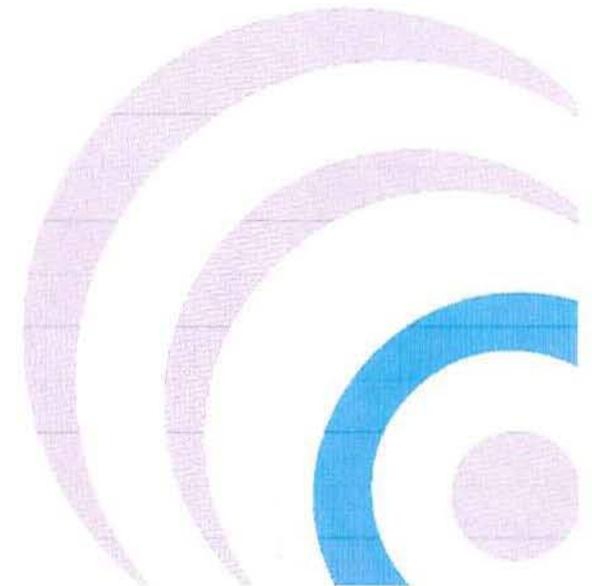


- 40 eNodes placed at and below ground level
- Spread out in Rancho Bernardo area commercial and residential
- 7 miles from Mt. Woodson Access Point – a high interference environment
- Below ground eNode was in concrete utility access vault approximately 12" below the sidewalk level

Network Costs – San Diego Example



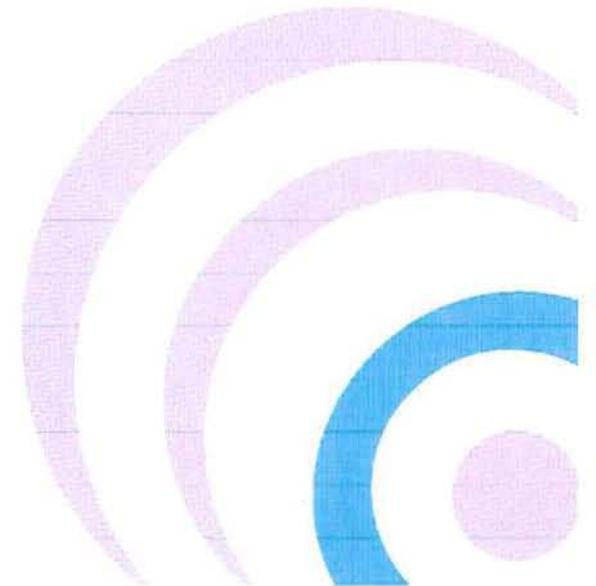
	ULP Deployment Scenario (2.4 GHz)
Metro	San Diego
Land Area	2,100 square miles effective 4,200 total square miles
Access Points	28
Area Coverage	97%
Planning & Deployment Costs	\$600,000
Annual Maintenance	\$370,000
Total 5 Year Cost of Network	\$2,450,000

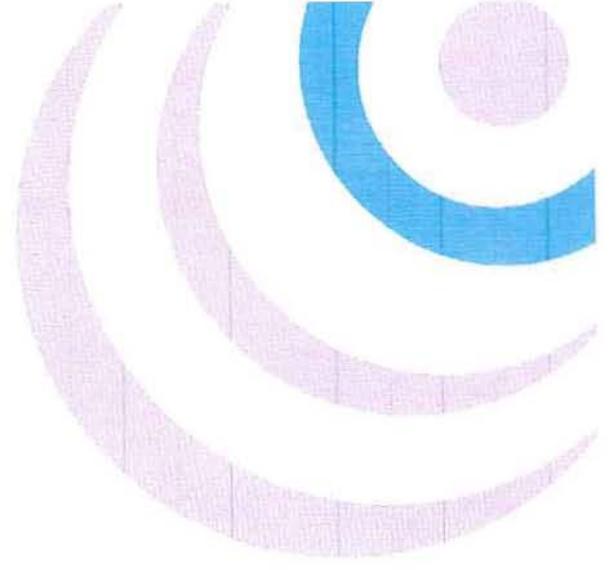


Endpoint Support Analysis



	Endpoints Supported by Single ULP Access Point (using 1 MHz of spectrum @ 2.4 GHz)
Electric Meters (AMI)	17,280
Gas Meters	172,800
Water Meters	172,800
Streetlights	144,000
Water Leak Detection	288,000
HVAC	500 commercial buildings (Avg. 30K sq. ft. building with 60 sensors)
Blood Glucose Meters	17,280
Cargo Containers	28,800
First Responder Tracking	4,300





Summary

Summary Recommendations

- A National M2M network is justified for verticals of national interest : Billions per year of impact per vertical
 - Common requirements among key applications that are not well serviced by existing technologies
 - Better spectral efficiency and lower cost to deploy and operate will speed adoption and innovation
 - Reduce interference and improve overall reliability of applications
- Respectfully recommend commission issue supplemental notice that deficiencies exist in the Smart Grid communications system
- Advise DOE, NIST and Utility commissions of these concerns and recommendations
- Recommend national M2M model optimized for sensing and control application across verticals be promoted
- Initial thoughts on required spectrum
 - 1MHz for mission critical low data rate applications for utilities
 - 1MHz for security & life safety
 - 3-4Mhz for shared M2M network across verticals

