Smart Energy Working Group Standpoints & WiGRID PlugFest Appraisal

November 6th, 2013
Ballroom of the Americas C (Hilton Americas), Houston
Eugene Crozier, Chair, WiMAX Forum Smart Energy Working Group
Craig Tedrow, Vice Chair, WiMAX Forum Smart Energy Working Group
Smart Energy Working Group

• The Smart Energy Working Group (SEWG) comprises WiMAX vendors, industrial operators and industry research organizations.
• The focus of the SEWG is to promote the use of WiMAX Technology in industrial networks.
• Based on existing WiMAX technology the SEWG has developed a series of system requirements and system profiles for Smart Grid applications. However these applications have synergy with Oil and Gas communications networks.
• These WiMAX Smart Grid System Profiles (aka WiGRID) are the basis for equipment interoperability, which is beneficial to vendors and industry users.
• We promote WiMAX (WiGRID) Interoperability and Certification based on the Smart Grid Profile using the plugfest events.
Key Smart Energy Requirements

- Layer 2 convergence
- Uplink centric profiles
- Focus on low latency
- No centralized core required (no ASN Gateway)
WiMAX documents

The WiMAX Forum working groups have developed and approve the following documents for Smart Grid and Energy applications:

• **WiMAX Forum® System Profile Requirements for Smart Grid Applications.** This document outlined a series of use cases for Smart Grid applications.

• **WiGrid System Profile.** This document highlighted the additional WiMAX equipment requirements based on the applications.

• The **WiGRID Protocol Implementation Conformance Statement (PICS).** This is used by equipment vendors to verify their equipment against the System Profile document.

• **SEWG PlugFest Guidelines Document** (Test Procedures). This details the equipment tests to verify interoperability.
Smart Grid Use Cases

Smart Grid applications are mainly based on the following use cases that are detailed in the system requirement document:

<table>
<thead>
<tr>
<th>Use Case</th>
<th>Direction</th>
<th>Latency (ms)</th>
<th>Predictability</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 – Situational Awareness (WASA)</td>
<td>Mainly UL</td>
<td>1000</td>
<td>Good</td>
</tr>
<tr>
<td>2 – Monitoring</td>
<td>Highly UL</td>
<td>100</td>
<td>Good</td>
</tr>
<tr>
<td>3 – Control</td>
<td>Mainly UL</td>
<td>100</td>
<td>Random</td>
</tr>
<tr>
<td>4 – Protection</td>
<td>Symmetrical</td>
<td>20</td>
<td>Random</td>
</tr>
<tr>
<td>5 – Metering Regional Collector (DAP)</td>
<td>Mainly UL</td>
<td>1000</td>
<td>Good</td>
</tr>
<tr>
<td>6 – Remote Site Communications</td>
<td>Symmetrical</td>
<td>100</td>
<td>Good</td>
</tr>
<tr>
<td>7 – Direct 4G Smart Metering (AMI)</td>
<td>Mainly UL</td>
<td>5000</td>
<td>Good</td>
</tr>
</tbody>
</table>
WiGRID Certification

Key items for WiGRID Certification are:

• Adherence to the WiGRID System Profile based on the system Requirements.
• Host PlugFest events to support a WiGRID Certification model that is both efficient and cost effective
• Demonstration of interoperability during the PlugFest event against a number of use cases.
• WiMAX Forum will promote WiGRID certification as a clear statement of the benefits of WiMAX technology to industrial users.
Plugfest and Certification Events

• 1st Plugfest event hosted by Powertech Labs in Canada
• 2nd Plugfest and certification hosted by Electric Power Research Institute (EPRI) in Knoxville TN at the end of October 2013.
• Following companies participated in the event;
  • Cisco
  • GE Digital Energy
  • Siemens.
• The plugfest event was successful and the certification results are due in the following week.
• There is planned to be further certification events as the eco-system expands.
Plugfest Results

- All companies involved successfully interoperated.
- Frequency bands were 1.8, 3.65, and 5.8 GHz
Drilling, Completion, Construction - Satellite Communications

- High cost
- Low bandwidth
- High latency
- Difficult remote IT support
- Limited voice & video capability
- Difficult to provide contractors with wireless, Internet, and email access

Production, SCADA, Measurement – Microwave Radio

- Limited bandwidth
- No network access at the well
  - Limited system visibility & reporting
- Inefficient serial communication
  - Single connection per device
  - Long polling cycles – not real-time
  - Limited end device visibility
    - Difficult to Troubleshoot
    - No device level monitoring
Change & Technology Drive Innovation

Drilling & Field Operations
• High per-acre well density
• Shortened drill to complete time
• Increased application use and demand for real-time visibility into drilling and field operations

Network & Telecommunications
• Broadband microwave backbone and WiMAX radio edge
• WiFi
• Voice over IP
• HD video
• Centralized network security

- Justifies infrastructure build
- Encourages a cost-effective rig move process
- Requires higher performing network
- Provides a high bandwidth, low latency network
- Simplifies network access for all users
- Leverages centralized phone system
- Advances monitoring capability
- Improves risk mitigation
Our Mission

Develop a scalable, repeatable, and cost-effective digital oilfield communications solution to meet the current and future needs of EP Energy field operations.
Project Considerations

- Field Connectivity
- Site Mobility
- Field Applications and Reporting
- Voice
- 99% Communication availability
- Frequency of Polling
- Bandwidth utilization
- Total number of devices, users, and protocols
- Integration of current technology (IP telephony, WiFi, CygNet)
- Network and data security
- Device monitoring, management, and support
- Power Efficiency
- Remoteness of field locations
- Scalability
Customer Considerations

**Drilling**
- Video
- Accessibility to shared Documentation (Well CAD Drawings)
- Real time Drilling Monitoring – PVTs

**Construction**
- Accessibility and bandwidth to shared Documentation (Site CAD Drawings)

**Reservoir Engineering**
- Flexibility to add Well Monitoring Communications
  - Build up test
  - Flow Test
  - Down Hole Monitoring

**Production**
- Remote Maintenance
- Field monitoring and event alarming
- Radio
- Asset management

**SCADA/Measurement**
- Remote Maintenance
- EFM (Electronic Field Measurement) Gas and Liquid
- PLCs communications
- Safety and Control System
- Power Grid
- POC (Pump Off Control)
- Gas Lift
- ESP
- Chemical Injection
- Tank
- Well
- Separators
- Compressors
- Pumps
Customer Considerations

Facility Security

- Cameras/DVRs
- Access Control
  - IP Intercom
  - Gate Controls
  - Card Readers
- Integration with existing systems
  - SCADA
  - Cisco CallManager

IT

- Ease of use
- Low administrative overhead
- Remote management, monitoring, diagnostics, and support
- Secure connectivity of users/devices
- Integration with existing systems
  - Network Infrastructure
  - Cisco CallManager
- Enablement of future technologies
  - Cisco Jabber
WiMAX Field

Backbone 5-6 miles

WiMAX 2-3 miles

WiFi 1000 feet
Backbone Tower Location
Drilling Rig Communications Package
SCADA Panel Communications
# Cost Savings Case Study

<table>
<thead>
<tr>
<th>Old Way</th>
<th>New Way</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Satellite</strong> (High Latency, Low Bandwidth)</td>
<td><strong>EPE MAX Connect</strong> (Low Latency, High Bandwidth)</td>
</tr>
</tbody>
</table>

**Case Study #1**

<table>
<thead>
<tr>
<th>Field 1</th>
<th>$910,400</th>
</tr>
</thead>
</table>

**Savings** - $789,600 per year

**Case Study #2**

<table>
<thead>
<tr>
<th>Field 1</th>
<th>$120,800</th>
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</thead>
<tbody>
<tr>
<td>Savings - $1,233,750 per year</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Field 2</th>
<th>$188,750.00</th>
</tr>
</thead>
</table>

| Savings - $1,233,750 per year |
Production Operations

- There could support an average of 70 wells or more per tower location.

- An estimated SCADA radio communications count could be around 5 per well and even more at the CPFs (Central Process Facilities). Partnering with vendors and developing low cost Wi-Fi communications and device solutions could potentially reduce hardware and installation cost as much as 80% and provide almost instant data platform to field devices.

  - An example is that EP Energy can take advantage of off the shelf radio solutions that will cost less than $200.00 verses $1200.00 radio infrastructure or even eliminate cabling.

  - It has proven that Well Head and SCADA Wi-Fi network connectivity reduces travel and reporting time.

  - Reduce risk and improving Safety – Operation’s support personnel can evaluate the real-time data for the need to be deploy and if the environment is safe.

  - Accelerate the deployment and integration of IP field devices and communications.
Intangible Benefits

Drilling, Completion, Construction – IT MAXConnect
- High bandwidth
- Low latency
- Improved remote IT support
- Voice & video capability
- Simplified and secure contractor access to wireless, Internet, and email
- Extension of collaboration tools to the field (web and video conferencing, IM)

Production, SCADA, Measurement – IT MAXConnect
- High bandwidth
- Network access at the well
  - System visibility & reporting
- Efficient IP communication
  - Multiple connections per device if needed
  - Short polling cycles – near real-time
  - Visibility to the end device
    - Simplifies troubleshooting
    - Allows device level monitoring
Customer Feedback

“The WiMax that was installed in the field is working fantastic! It is working so much faster than the satellite system that was here. It is almost like being in the office. We were not doing our reports out here due to the time. I believe that this will save us up to a couple hours/day on computer. Thanks Again.” – Construction Supervisor
Challenges and Concerns

Geographic challenges (Remote areas, proximity to communication towers)
Environmental challenges (Weather, H₂S, Area Classification)
Infrastructure challenges (Land, Power)
Physical security (Theft)
Network security (Unauthorized Access)
Support model (CPF/Well Deployment, Rig/Well Completions moves, Device Additions, Break-Fix)
Feedback needed for continuous process improvement
Will benefits be leveraged throughout the organization?
How do we maximize the potential of the solution?
Emergency/Temporary Communications

- Operations is planning to have a local support staff of 50 to 150 field contract and EP Energy personnel during the Wolfcamp development.

- EP Energy began construction on new office and warehouse in the Big Lake area. Our temporary WiMAX/WiFi communications package was utilized to quickly provide service to the temporary office facility.
Environmental & Infrastructure Challenges

- Use of solar power systems when commercial power is unavailable
- Use of Class I/Div II equipment in hazardous areas
- Weatherproof enclosures protect equipment from the elements
- No climate control necessary
IT Initiatives

Implementation of Cisco Identity Services Engine (ISE) will automate and simplify access control and security compliance for wired and wireless devices.

- **Secure access control** through device and user-specific authentication and authorization methods
- **BYOD** supported through identification, onboarding, and enforcement of secure access for virtually any mobile device
- **Guest wireless network** with Internet and email access will eliminate the need for costly 3rd party satellite services
- **Wireless portal** will allow business sponsors to add guest wireless users, thus removing the need for IT involvement in guest wireless provisioning
Current and Future Development

Low-cost WiFi terminal server
Smart WiFi Wireless Transmitter
Smart WiFi Tank Radar Gauges
WiFi HD Camera and NVR (Network Video Recorder) System
Power Monitoring
IP Intercom
IP Environmental Monitoring
Collaboration
SCADA - Event Alert
Questions
CelPlan Field Experience
Integrated Wireless Network Management

Petrobras
Petrobras

- Petrobras has ten of thousands of wireless deployments countrywide
  - SCADA
  - WiMAX
  - Backhaul
- Designs were done regionally and did not perform uniformly
- CelPlan designed a centralized system that gives access to 250+ professionals
- All the designs are regionally designed, but centrally approved
- The system provides access to the local FCC (ANATEL) and allows for automatic licensing applications and search of available frequencies for backhaul
Reliability Centric Design

Design done for a Mineral Extraction Company in Brazil
Focus on Reliability
Reliability

• Ore extraction project in North East of Brazil required a reliable high throughput communication system

• WiMAX technology was chosen due to its features, like TDD, fading resilience, flexible data size, segmentation and non proprietary fully IP based infrastructure.

• CelPlan did the design and frequency plan complying with all network requirements
  – Network continues to operate even with two simultaneous failures
Iron Ore Extraction

- Ore is extracted, loaded on trains and transported to the port area
Iron Ore Storage

• Ore is stored until ships are available for transportation
Iron Ore Loading

- Ore is loaded on conveyor belts and transported to ships
Iron Ore Loading

- Monstrous machines on rails process and load the ore
- Operator has limited vision inside the machine and relies on several high definition video cameras to operate
- Environment inside the machines is noisy, vibrating and highly susceptible to equipment damage
Remote Machine Command

• The command of each machine was transferred to an operation Center
• The cost of a non operational machine is very high
• A high Reliability network was required
• Four WiMAX Base Stations were assembled in the periphery of the ore deposit field
• Redundant Video Cameras are able to connect to any of the WiMAX systems
• The system was designed to recover from double failure in each machine and triple failure at the WiMAX nodes
Low latency design

Toronto Hydro
Availability Margins

- Wireless Signal Availability
Latency x HARQ

- Latency for WiMAX TDD

  - Function of frame size

EMAC-Data Received

WMAC data Received

HARQ sent

HARQ received

© CelPlan International, Inc.
Latency

- Requirement: 30 ms
- One HARQ cycle: 15 ms
- Two HARQ cycles: 25 ms
- One ARQ cycle: 50 ms

<table>
<thead>
<tr>
<th></th>
<th>Earliest (frames)</th>
<th>Latest (frames)</th>
</tr>
</thead>
<tbody>
<tr>
<td>First HARQ cycle</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Extra HARQ cycle</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>ARQ cycle</td>
<td>4</td>
<td>6</td>
</tr>
</tbody>
</table>
Deploying WiMAX Industrial Networks to Achieve Operational Efficiencies
WiMAX Oil & Gas 2013
Vaibhav J. Parmar
Introduction to Accenture’s Network Consulting Practice

Experienced Team & Extensive Credentials
- Global Organization with 500+ Dedicated Professionals
- Alignment with Industry Groups
- In-Depth Industry Expertise
- Cisco Certified Reseller (Gold Status)

Broad Scope of Services
- Addressing Wired (MPLS, SONET, Ethernet, etc.), Wireless (3G/4G, WiMAX, WiFi, LMR, etc.) and Operations (NOC, OSS/BSS) solutions
- Providing full lifecycle of project services:
  - Plan & Design: strategy, requirements, architecture, vendor selection, deployment planning
  - Build: systems / telecom integration, deployment, testing, PMO
  - Run: infrastructure managed services, NOC

Vendor Alliances and Industry Participation
Wireless Applications in Industrial Environments

Typical Industrial Environments
– Manufacturing facilities
– Oil and gas refineries
– Warehouse and distribution sites
– Mines
– Offshore rigs
– Large construction sites
– And many others…

Typical Wireless Applications in Industrial Environments

- People & Asset Management
- Voice & Data Comms
- Automation
- Safety & Security
## Requirements and Challenges in Industrial Environments

### Safety Concerns
- Access points rated for Class 1/Division 2 hazardous environments like manufacturing plants are now available in the market.
- Wireless access from intrinsically safe PCs, handheld devices and cameras.

### Operational Reliability
- To avoid interference emphasis is put on RF filtering and immunity to electromagnetic interference (EMI) and radio frequency interference (RFI).
- The ability to customize access points with a complete array of antennas ensures the ability to achieve the coverage pattern and range required.

### Multi-path Interference
- Multi-path interference can seriously degrade RF signals in an industrial landscape like refineries.
- Use of diversity antennas is a possible solution to such a problem.

### Compatibility
- Suitability and adoptability of the physical and software interfaces to the industrial applications.
- New products like gateways enable interconnectivity between different systems.

### Power
- Power over Ethernet is a valuable feature used to power remote access points without having to run conduits and electrical wiring.

### Coverage
- Industrial installations cover greater areas than commercial installations.
- There are industrial solutions with high power and high gain antennas that are very effective in extending the distance.
Example Case Study: Italian Coast Guard WiMAX Network

**Project Background**
The Italian Cost Guard wanted to build up its own next generation broadband wireless network in order to be more effective in all patrolling activities at sea and near Italian coast.

**How Accenture Helped**
The project covers 15 main offices and 325 boats of fleet. Accenture provided the client with a tailored radio design for the peculiar context.
The Mobile WiMAX system features include:
- Radio coverage up to 12 nautical miles offshore
- CPE for the fleet boats, including onboard antennas, fixed and mobile devices
- Service data center for audio, video and data services
- First and second level remote operations with field and onboard dispatch

**High Performance Delivered**
Main benefits include:
- Stay competitive in the European environment
- Reduce communications costs
- Adopt modern, efficient and interactive new services
- Innovate technology Infrastructure
- Maximize reuse of existing infrastructure
Questions?

Vaibhav J. Parmar
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Lessons Learned

WiMAX Deployment
City of Houston
60 3.65 GHz WIMAX Sites
PTP Backhaul to Sites
Lessons Learned

- **RNP - Radio Network Plan**
  - Don’t build without - Looking for 85% to 90% Predictability
  - Types of users
    - Bandwidth Requirements, Symmetry (uplink-downlink ratio), QOS, Range
  - Frequency Band, Channel Re-use
    - Sectors, Channels Widths, Azimuth, Down tilt of antennas, Non-Overlapping Channels
  - Path Calculation
    - Obstructions, Calculated RSLs, SNR’s
  - CPE Deployment Options
    - Height, Locations, Flexible Mounting Systems, Multiple Vendors
- **Post-Install Survey & Documentation**
- **Software to push profiles, software upgrades**
Services - Savings

• 36 Water Production Sites
• 400,000 Water Meters (300,000 today)
• 464+ Wastewater Lift Stations
• 1800 Intersections
• 80 Fire Stations
• 40+ Police Stations & Annexes
• 1600+ School Zone Flashers
• Video Surveillance Deployments

• Water Department Savings
  • 4,000 Truck Rolls a month in Water Department
  • Repurpose 200 Meter Readers to Maintenance
  • Early Leak Detection on Water Mains
  • Over 10 Million $ year on leased circuits

• Virtualized Data Center
• Consolidated Staffing 24/7 Centers
The use of WiMAX technology in an industrial network to improve operational efficiency.

Eugene Crozier, Wireless Specialist

November 6th 2013
WiMAX technology is used as a communications conduit to provide a real time fault location, isolation and service restoration (FLISR) system. The System comprises a base station and four remote sites. The system is located in the Gulf Islands, BC. The operation of the system is de-centralized and self reliance.
WiMAX & British Columbia Energy Sector

Electricity Transmission & Distribution

Gas and Oil Pipelines
WiMAX & FLISR
(Fault Location, Isolation, Service Restoration)

Time:
11:00:00

# of Customers without service:
0
WiMAX & FLISR
(Fault Location, Isolation, Service Restoration)

Time:
11:00:30

# of Customers without service:
2972
WiMAX & FLISR
(Fault Location, Isolation, Service Restoration)

Feeder #1

Feeder #2

12834

12998

12839

13012

WiMax
Base Station

Time:
11:00:32

# of Customers without service:
926

Powertech
WiMAX & FLISR
(Fault Location, Isolation, Service Restoration)

Crew Dispatched
(5 Minutes)

Time:
11:05:00

# of Customers
without service:
926
WiMAX & FLISR
(Fault Location, Isolation, Service Restoration)

Feeder #1
Feeder #2

Fault located investigation complete (3 hours)

12834
12998
13012
12839

WiMax Base Station

Time:
02:05:00

# of Customers without service:
926
WiMAX & FLISR
(Fault Location, Isolation, Service Restoration)

Repairs Made
(10 mins)

Time:
02:15:00

# of Customers without service:
926
**WiMAX & FLISR**
(Fault Location, Isolation, Service Restoration)

<table>
<thead>
<tr>
<th>Time Line (Duration)</th>
<th>Activity</th>
<th># Customers without service</th>
<th>Cumulative customer outage (mins)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>With WiMAX &amp; FLISR</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11:00:00 (0 mins)</td>
<td>Fault Occurred</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>11:00:02 (2 sec)</td>
<td>Fault located by line recloser</td>
<td>2972</td>
<td>0</td>
</tr>
<tr>
<td>11:00:30 (30 sec)</td>
<td>Fault isolated downstream</td>
<td>2972</td>
<td>0</td>
</tr>
<tr>
<td>11:00:32 (2 sec)</td>
<td>Service restored downstream</td>
<td>926</td>
<td>0</td>
</tr>
<tr>
<td><strong>FLISR Operation Complete</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11:05:00 (5 mins)</td>
<td>Crew dispatched</td>
<td>926</td>
<td>4,630</td>
</tr>
<tr>
<td>02:05:00 (185 mins)</td>
<td>Crew arrives on scene</td>
<td>926</td>
<td>171,310</td>
</tr>
<tr>
<td>02:15:00 (195 mins)</td>
<td>Fault investigation complete - fault located</td>
<td>926</td>
<td>180,570</td>
</tr>
<tr>
<td>02:25:00 (205 mins)</td>
<td>Repairs made</td>
<td>926</td>
<td>189,830</td>
</tr>
<tr>
<td>02:35:00 (215 mins)</td>
<td>Service restored using remote control</td>
<td>926</td>
<td>199,090</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Time Line (Duration)</th>
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<th># Customers without service</th>
<th>Cumulative customer outage (mins)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Without WiMAX &amp; FLISR</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11:00:00 (0 mins)</td>
<td>Fault Occurred</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>11:00:00+ (0 mins+)</td>
<td>Fault cleared by line recloser</td>
<td>2972</td>
<td>0</td>
</tr>
<tr>
<td>11:00:30 (30 sec)</td>
<td>Customer calls to report lights out</td>
<td>2972</td>
<td>0</td>
</tr>
<tr>
<td>11:05:00 (5 mins)</td>
<td>Crew dispatched</td>
<td>2972</td>
<td>14,860</td>
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<tr>
<td>02:05:00 (185 mins)</td>
<td>Crew arrives on scene</td>
<td>2972</td>
<td>549,820</td>
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<tr>
<td>02:15:00 (195 mins)</td>
<td>Fault investigation complete - fault located</td>
<td>2972</td>
<td>579,540</td>
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<td>02:25:00 (205 mins)</td>
<td>Repairs made</td>
<td>2972</td>
<td>609,260</td>
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<tr>
<td>02:35:00 (215 mins)</td>
<td>Service restored by manual switching</td>
<td>2972</td>
<td>639,980</td>
</tr>
</tbody>
</table>

The overall results are an almost 70% reduction in customer outage minutes. The use of WiMAX technology in similar industrial networks enable the same types of operational benefits.
THANK YOU

Eugene Crozier, Wireless Specialist

November 6th 2013
Deploying WiMAX Industrial Networks to Achieve Operational Efficiency
Lessons Learned & Trends

Oilcomm 2013 - Houston

Louis Lambert
Deploying WiMAX Industrial Networks to Achieve Operational Efficiencies
Lessons Learned

- 3 questions

- Where did we learn these lessons from?

- Lesson Learned & Trends
  - Solution Perspective
  - Organizational Perspective
  - Lessons Learned ....in Pictures
Lessons Learned – From these clients

**OXY:** Digital Oil field in Texas, North Dakota, California, Oman.

**Marathon:** Digital Oil field in North Dakota & Texas

**Shell/PDO:** 45,000 Km² Smart Field Operation - Oman

**Tatweer:** Digital Oil field - Bahrain

**Chevron:** Wafra digital oil field project in Wafra, Kuwait.

**Total Oil:** Offshore platforms at 20 Km.

**Pemex:** Enhanced oil recovery in the Bay of Campiche, Mexico.

**Petrobras:** Portable remote offices and mobile drilling rigs in Peru.
Lessons Learned & Trends

Solution perspective – Architecture

- IP Field Telecom Architecture Standards have to be developed & replicated

- The Field Wireless Network had 3 distinct architecture components
  - The Wireless Backhaul Layer - (PTP between Towers)
  - The Wireless Transport Layer is best when it is simple L2 - (PMP Transport)
  - The Wireless Access Layer needs to be WIFI - (Ground Level Wireless)

- Various BU’s Networks may start with a physical separation... but moving to VLAN Segmentation.

- End-to-end security requirements now stating the need for AES, FIPS 140-2 and 509
Lessons Learned & Trends

Solution perspective - RF Planning

- Start with a Holistic RF coverage and Capacity planning ... Then deploy in phases
- Coverage designed to cover the entire asset
- Prediction maps that are meaningful to IT & the BU’s so they can plan and not react
  - 6’ Pickups
  - 10’ & 20’ Well Sites
  - 35’ Rigs
- Leverage all the spectrum bands available
  - 4.9-5.8 GHz
  - 3.x GHz
  - 2.5 GHz
  - White space
Lessons Learned & Trends

Solution perspective - Solution Design

- RF design start only after proper holistic RF planning
  + Do it right the first time & Need various types of Remote Radio (Fix, Auto Acquiring, Auto Tracking)

- Infrastructure Design and Component Selection have to be Carrier/Industrial Grade
  + The network is mission critical to the business, the safety and efficiency of the asset
  + Design compromise for cost savings purposes can cost lives and excessive downtime

- Redundancy pays for itself with the first failure
  + Ring design between towers
  + Redundant Tower systems
  + Auto acquisition systems
Lessons Learned & Trends

Solution perspective - Deployment & Execution

- Corporate Standards & Best Practices -> applied locally
- Centralized Monitoring with field visibility and capabilities
- Operational model design to be replicated
Lessons Learned & Trends

Solution perspective – Organizational Perspective

- Although Shared Wireless Network Infrastructure will happen, it is taking time.

- IT, Automation, Drilling, Completion, HSSE and others are learning to share Infrastructure

- Cross-Business Collaboration & collaboration enabling technologies are breaking the legacy silos that motivated the various BU’s to build their own infrastructure.

- Shared Field Wireless Infrastructure is not only inevitable, is will become a must!
  + Everyone in the field wants high-capacity, low-latency anywhere & anytime.
Redline Provides the Wireless Transport Layer to Enable Digital Oilfields

- Battery Tank
- RTU - Remote Terminal Unit
- PLC - Programmable Logic Controller
- Emergency Response
- Mobile Drilling Rig
- Field Office
- Video Monitoring
- Work Vehicle
- CWE - Collaborative Work Environment
- Process Domain
- Well Head Automation
- Mobile Field Connectivity
- Operational Video Surveillance
- Micro Seismic Applications
- Asset Tracking via RF-ID
- Energy Management
- Collaborative Working Env.
- Smart Drilling
- SCADA
- Wi-Fi

To HQ
Central Control Room
SCADA Systems

Well Pad

SMART OILFIELD

Work Vehicle
CWE - Collaborative Work Environment
Redline Virtual Fiber™ Technology

- Highest Capacity in Broadband Multipoint Transport
- Unparalleled coverage with multiple solutions/configurations
- Industry’s most robust, reliable, & secure industrial radio
- Self-aligning system saves time, money, repetitive mobilization
- Multiple spectrum – Global spectrum coverage
- Most deployed PMP transport system by Oil Co. in recent years
Build to last  Tower Sites

- **Carrier Grade**
  - RF Planning
  - Tower sites selection
  - Tower /Shelter
  - Set-up
  - Project Management
Built to last Power

- Carrier Grade
  - AC Distribution
  - DC Distribution
  - Grounding
  - Remote management
  - Set-up
  - Documentation
RAS - Self Acquisition systems
Virtual Fiber

Drilling Rigs
Trailers

Long-Range
Nomadic - Mobile
Broadband
Fit for purpose Well Site Cabinet & SCADA

- Carrier Grade
  - Power
  - Battery
  - Set-up
  - Documentation

- SCADA
  - IP only
  - IP + Serial
Redline Provides the Wireless Transport Layer to Enable Digital Oilfields

Mobile Drilling Rig

Battery Tank

RTU - Remote Terminal Unit
PLC - Programmable Logic Controller

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Collaborative Working Env.
Smart Drilling

Work Vehicle
CWE - Collaborative Work Environment

SCADA
Wi-Fi
Standards based solutions for Oil & Gas
Agenda

• Energy Market Trends
• The WiMAX Fit
• Unique Needs of the Energy Market
• Case study
• Contact
Trends

Increasing Safety & Security Using Video Surveillance

Scaling Centralized Resources

Providing Connectivity to Remote Drilling Sites - Portability

Replacing & Upgrading Legacy SCADA Systems

Upgrading Safety Systems

Increasing remote capabilities for monitoring and control results in escalating communications requirements
Core applications available for production and pipeline market segments

Oil & Gas: Major applications

- Wireless connection of mobile applications
- Wellhead monitoring and control
- Gas field control and monitoring
- Rig external communication (radio)
- Rig power management & monitoring - SCADA
- Rig internal communication

Onshore and offshore productions
- Wireless connection of mobile applications
- Wellhead monitoring and control
- Gas field control and monitoring
- Rig external communication (radio)

Pipelines, compressors & pumping stations
- Pipeline SCADA
- Data aggregation in rugged environments
- Process analytics
The risk of leveraging consumer mobile wireless networks

• **Public wireless networks are getting better at delivering “always on” data services...**
  - But, coverage is still centered around populated areas, and not necessarily where energy companies need it.
  - Networks are increasing data coverage overall as 3G spans almost the whole coverage map and LTE networks are still just emerging.
  - $/bit rates are still voice centric...
  - User data traffic is increasing exponentially with no separation of network infrastructure between commercial and industrial subscribers.

• **Network availability is improving with most sites backed up by battery...**
  - But little has been done to ensure minimum throughput and data service up time requirements are met.
  - Cellular traffic and unavailability increases when you need the network throughput the most.
  - SLA’s are difficult to obtain.

**Cellular networks are a great alternative for non time sensitive applications or where very high reliability is not required**
Why WiMAX for Private Network?

WiMAX is the only technology available that meets the needs of the energy market with a standards-based solution:

- **Ecosystem** – A long technology lifecycle is demanded, a standards-based solution required

- **Range / Throughput** - scaling over huge areas of tens - hundreds of square miles with broadband rates

- **Scale** – Reduction of self interference is required

- **Quality of Service** - Multi-service networks

- **Security**- Must meet the needs of Critical Infrastructure Protection
## Managing multiple services/application types

<table>
<thead>
<tr>
<th></th>
<th>CIR</th>
<th>MIR</th>
<th>Jitter</th>
<th>Latency</th>
<th>QoS Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCADA</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Reserve BW and prioritize</td>
</tr>
<tr>
<td>Voice</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Real time capability</td>
</tr>
<tr>
<td>Video</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Real time capability</td>
</tr>
<tr>
<td>Control data</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Nail up low BW</td>
</tr>
<tr>
<td>Field Workers</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Set a max BW to not effect other apps</td>
</tr>
</tbody>
</table>

*Quality of service is much more important in wireless networks*
Special Requirements of the Oil & Gas Market

Remote deployments – not easy to upgrade or replace hardware

Rugged Environment - rain, salt, high temperatures, low temperatures, vibration, etc.

Hazardous locations – depending on deployment model, ATEX / IECEx / Class 1 Div 2 may be required

Security - Infrastructure is a prime target for hackers

Simplified infrastructure - IT / Telecom groups need to be streamlined

The environment and goals of a network for oil and gas is different than that of a mobile operator
What about private LTE networks?

LTE has won the battle for 4G evolution in the mobile operator / carrier space but:

1) Does LTE come in the frequency bands available for private network use?

2) Does LTE really provide an advantage in Oil & Gas specific use cases? Can you use it off the shelf?

3) Is LTE simple to deploy?

4) What is the upfront cost?

5) Is a private LTE hardware solution really a proprietary solution?

Today’s LTE solutions are aimed at mobile network operators and is not optimized for industrial networks.
The role of WIGRID and the SEWG

Purpose - Leverage the ecosystem of WiMax standards-based equipment, but tailor it to the needs of energy customers

Provide - Ethernet based systems with distributed architectures.

Provide - More data going upstream than in a conventional ISP model

Provide - Longer range required for geographically dispersed networks

Provide - Frequency bands which can be used by private companies (5.8, 3.65 GHz)

Drive - interoperability around this “energy profile”

Providing the benefits of 4G network technology optimized for Energy’s needs
The Challenge

Augmenting network services to offshore oil rigs

- Demand for greater bandwidth & lower latency than VSAT
- Multi-service applications like voice, and WIFI consumer access
- Network spread over thousands of square miles of extremely harsh terrain

Extremely harsh environment

- Corrosive salt water
- Hazardous location
- Connection over water, heavy multipath conditions
Solution Architecture

RUGGEDCOM WIN wireless broadband technology

- Standards-based WIMAX system in licensed, lightly licensed and unlicensed bands.
- Provides broadband rates over long distances.
- Provides robust equipment for rugged conditions.
- OFDMA based to provide reliable connections over water.
- Up to 40 Km range.
- Multi-service with guaranteed QoS.
- Low, controllable latency
- Nomadic and mobile services to surrounding vehicles and vessels.
Experience

Stratos Offshore Services

- Provided 100+ base stations covering thousands of square kilometers in Gulf of Mexico.
- Multi service network in licensed 2.5 GHz band
- All offshore connectivity, in place since 2011
Summary

The need for communication technology in the oil field is increasing at a rapid pace.

The remote nature of the communications means implementation of long technology lifecycles.

WIMAX is the standard which is best suited to meet the range, security and throughput needs of the oilfield.

WIGRID is establishing interoperability around frequencies and use cases required for the energy market.
Contact

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www.siemens.com/ruggedcom
WiMAX Profiles for Oil & Gas

Jim C Johnston, RCDD
Oil & Gas Applications

- IP to WellHead
- SCADA
- Real Time Voice, Video, Data
- WiFi Hotspots
- Office in the Truck - Nomadic
- SubContractors & Service Providers
Data

- Forensic
- Real-Time
- Predictive
What’s Important

- Coverage
- Connectivity
- Reliability
- Throughput
- Latency - “Tag” for Priority
Profiles

- 802.16 Allows Many Variables
- Profiles define a subset of parameters for interoperability
- Default profiles optimized for broadband (WISP)
- Type of Application, VOIP, SCADA, Video
- Operating Range
- VLANs for QOS
- CPE Fixed IP or DHCP
Key Parameters for Uplink & Downlink

- Latency
- Traffic Bandwidth (kbit/s)
- Packets per second
- Traffic (Message) Frequency
- Traffic Payload Type (TCP/UDP)
- QoS Type (Real-time, BestEffort, UGS)
- Active / Idle Ratio
- Traffic activity predictability (Random, Regular)
- MIMO antenna on CPE facilitates better uplink
## Application Traffic Profiles

### Communications Requirement Summary

<table>
<thead>
<tr>
<th>Use Case</th>
<th>DL (kbit/s)</th>
<th>UL (kbit/s)</th>
<th>Latency (ms)</th>
<th>Packets per Second</th>
<th>Message Frequency</th>
<th>Payload Type</th>
<th>Active/Idle</th>
<th>Predictability</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-SCADA</td>
<td>~10</td>
<td>200</td>
<td>1000</td>
<td>30</td>
<td>10 sec</td>
<td>TCP</td>
<td>1 sec/5 sec</td>
<td>Good</td>
</tr>
<tr>
<td>2-Video</td>
<td>~10</td>
<td>1000</td>
<td>100</td>
<td>200</td>
<td>20 ms</td>
<td>TCP &amp; UDP</td>
<td>Active</td>
<td>Good</td>
</tr>
<tr>
<td>3-Hotspot</td>
<td>1500</td>
<td>2000</td>
<td>100</td>
<td>200</td>
<td>5 min to 6 hr</td>
<td>TCP</td>
<td>1 sec/5 sec</td>
<td>Random</td>
</tr>
<tr>
<td>4-Controls</td>
<td>150</td>
<td>150</td>
<td>20</td>
<td>100</td>
<td>100 ms</td>
<td>UDP</td>
<td>Active</td>
<td>Random</td>
</tr>
<tr>
<td>5-Keyless Entry</td>
<td>~5</td>
<td>10</td>
<td>1000</td>
<td>10</td>
<td>1 hr to 6 hr</td>
<td>TCP</td>
<td>1 sec/5 sec</td>
<td>Random</td>
</tr>
<tr>
<td>6-Drilling Operations</td>
<td>2000</td>
<td>2000</td>
<td>50</td>
<td>800</td>
<td>20 ms</td>
<td>TCP</td>
<td>Active</td>
<td>Good</td>
</tr>
<tr>
<td>7-VLAN2</td>
<td>xx</td>
<td>xx</td>
<td>xx</td>
<td>xx</td>
<td>xx</td>
<td>TCP/UDP</td>
<td>100 ms/4s</td>
<td>Good</td>
</tr>
</tbody>
</table>
## Channels & Symmetry 3.65 GHz Band

<table>
<thead>
<tr>
<th>Channel Capacity</th>
<th>3 bits/Hz</th>
</tr>
</thead>
<tbody>
<tr>
<td>(varies with distance)</td>
<td></td>
</tr>
<tr>
<td>- 3.5 MHz - 10.5 Mbps</td>
<td></td>
</tr>
<tr>
<td>- 5 MHz - 15 Mbps</td>
<td></td>
</tr>
<tr>
<td>- 7 MHz - 21 Mbps</td>
<td></td>
</tr>
<tr>
<td>- 10 MHz - 30 Mbps</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Symmetry</th>
<th>Downlink/Uplink</th>
</tr>
</thead>
<tbody>
<tr>
<td>(varies with vendor/channel)</td>
<td></td>
</tr>
<tr>
<td>- 75/25</td>
<td></td>
</tr>
<tr>
<td>- 60/40</td>
<td></td>
</tr>
<tr>
<td>- 50/50</td>
<td></td>
</tr>
<tr>
<td>- 30/70</td>
<td></td>
</tr>
</tbody>
</table>
### Key Differences Broadband vs Oil & Gas

<table>
<thead>
<tr>
<th></th>
<th>WiMAX for Broadband</th>
<th>WiMAX for Oil &amp; Gas</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Frequency Bands</strong></td>
<td>• Primarily Licensed</td>
<td>• No bands specifically allocated in the US</td>
</tr>
<tr>
<td></td>
<td>• Dedicated Bands country by country</td>
<td>• Under-utilized bands, share with others</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Some networks will use “lightly” licensed or license-exempt spectrum</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Smaller channel bandwidths - spectrum sharing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Interference management important</td>
</tr>
<tr>
<td><strong>UL &amp; DL Traffic</strong></td>
<td>• Downlink is dominant</td>
<td>• Uplink is dominant</td>
</tr>
<tr>
<td><strong>End-Users</strong></td>
<td>• Mobile</td>
<td>• Primarily fixed</td>
</tr>
<tr>
<td></td>
<td>• Relatively few per base station</td>
<td>• Many users per base station</td>
</tr>
<tr>
<td></td>
<td>• Download files can be large</td>
<td>• Uplink packet sizes tend to be small</td>
</tr>
<tr>
<td><strong>Mobility Requirements</strong></td>
<td>• Important</td>
<td>• High mobility not important</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Nomadic is important for mobile workforce</td>
</tr>
<tr>
<td><strong>Security Requirements</strong></td>
<td>• Privacy concerns</td>
<td>• Very important</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Protection against malicious attack very important</td>
</tr>
<tr>
<td><strong>Network Robustness</strong></td>
<td>• Important</td>
<td>• Very important</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Support for Relaying, Multi-hop and self configuring (no single point-of-failure)</td>
</tr>
<tr>
<td><strong>Latency</strong></td>
<td>• Important for latency-sensitive applications, VOIP, Real Time Gaming</td>
<td>• Varies by payload</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• QOS by Application</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Real-time Video UL</td>
</tr>
<tr>
<td><strong>Coverage</strong></td>
<td>• Ubiquity very desirable</td>
<td>• Strategic locations</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Extended range and multi-hop and/or relay for rural coverage</td>
</tr>
</tbody>
</table>
Conclusions

• Standard, out-of-box profiles are not optimal for Oil & Gas

• Extended Range

• QOS by application

• Higher uplink to downlink ratios are needed

• CPE spends more time transmitting, more power needed at CPE

• CPE with MIMO more efficient, higher uplink modulation with better signal
Thank You

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Design Options for an Effective Data Broadband Network

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WIMAX Forum
Oil & Gas 2013
Presenter

• Leonhard Korowajczuk
  – CEO/CTO CelPlan International
  – 45 years of experience in the telecom field (R&D, manufacturing and services areas)
  – Holds 13 patents
  – Published books
    • “Designing cdma2000 Systems”
    • “LTE, WiMAX and WLAN Network Design, Optimization and Performance Analysis”
  – Books in Preparation:
    • LTE, WiMAX and WLAN Network Design, Optimization and Performance Analysis
      – second edition (2014) LTE-A and WiMAX 2.1 (1,000+ pages)
    • Network Video: Private and Public Safety Applications (2014)
    • Backhaul Network Design (2015)
    • Multi-Technology Networks: from GSM to LTE (2015)
    • Smart Grids Network Design (2016)
CelPlan International

- Employee owned enterprise with international presence
  - Headquarters in USA
  - 450 plus employees
  - Revenues of US$ 40M
  - Twenty (20) years in business
- Subsidiaries in 6 countries with worldwide operation
- Vendor Independent
- Network Design Software (CelPlanner Suite)
- Network Design Services
- Network Optimization Services
- Network Performance Evaluation
- Services are provided to equipment vendors, operators and consultants
- High Level Consulting
  - RFP preparation
  - Vendor interface
  - Technical Audit
  - Business Plan Preparation
  - Specialized (Smart Grids, Aeronautical, Windmill, ...)
- Network Managed Services
- 2G, 3G, 4G, 5G Technologies
- Multi-technology / Multi-band Networks
- Backhaul, Small cells, Indoor, HetNet
Broadband Data
Wireless Architecture
Broadband Data Wireless Architecture
Broadband Data Wireless Architecture

• Remote Units
• Interconnection Network
  – Communications Network
  – Communication Network Technology
Architecture- Remote Units

• Remote Terminal Unit (RTU)
  – Distribution Automation (DA): up to 10,000 RTU
    • Polling and autonomous messaging (RTU: 1kbps)
    • Mission Critical (Latency: < 20 ms, Availability: 99.999%)
    • DH (Design Hour) total traffic: 10 Mbit/s
  – Advanced Metering Infrastructure (AMI)- up to 10,000,000 RTU
    • Polling (RTU: 10 bps)
    • Non mission critical (Latency: non critical, Availability: 99.0%)
    • DH total traffic: 100 Mbit/s
  – Mobile Force (MF): 5,000 RTU
    • Low throughput conversational and text (RTU: 1 kbps)
    • Non mission critical (Latency: conversational , Availability: 99.9%)
    • DH total traffic: 5 Mbit/s
  – Video Network (VN): 1,000 RTU
    • High throughput uplink (2 Mpixel, 1 fps, H.264 ): (RTU: 1 Mbps)
    • Non mission critical (Latency: video, Availability: 99.9%)
    • DH total traffic: 1 Gbit/s
Architecture- Interconnection Network

- Last Mile (LM) Concentration Points (CP)
  - Point to Multipoint (PtM) non LOS (non Line of Sight)
  - Latency: non critical (100 ms)
  - Availability: 99.99%

- Middle Mile (MM) Concentration Points (CP)
  - Point to multipoint mainly LOS (Line of Sight)
  - Latency: 20 ms
  - Availability: 99.999%

- High capacity Backhaul
  - Point to Point (PtP) LOS
  - Latency: 10 ms
  - Availability: 99.999%
Communications Network

- **Commercial**
  - Not recommended for last mile (LM) or middle mile (ML)
  - Throughput can not be guaranteed
  - May be considered as a temporary solution

- **Proprietary**
  - Requires spectrum availability
  - May be expensive
  - Full control

- **Shared**
  - Provisioned by third party
  - Some implementations allow for bandwidth segregation
  - Growth and expansion may be tricky
Communication Network Technologies

- Cable / ADSL
- All-Dielectric Self Supporting (ADSS) fiber
- Optical Ground Wire (OPGW)
  - Fiber to the Home (FTTH)
  - Fiber to the Node (FTTN)
- Wireless over Power Line
- Licensed Point to Multipoint Wireless / Point to Point Wireless
  - Cellular
  - Satellite
  - WiMAX/LTE
  - Proprietary
Wireless Communication Technology Alternatives

- VHF and UHF Narrow Band (SCADA)
  - 12.5 to 50 kHz bandwidth
  - 100 kbps marketing throughput

- Commercial Cellular
  - Cdma2000, EVDO
  - GSM, EDGE, HSPA
  - Wi-Fi
    - Contention based protocol
    - Throughput drops exponentially with number of users, mainly in mesh configurations

- Satellite
  - Limited throughput
  - Emergency situations

- OFDM Based (4G)
  - WiMAX
    - 200 kHz to 20 MHz
    - Up to 8 MBps (10 MHz TDD)
    - Based on commercial IP infrastructure
    - WiGRID specification
  - LTE
    - 200 kHz to 20 MHz
    - Up to 8 MBps (10 + 10 MHz FDD)
    - Based on operator specific infrastructure
Wireless Communication Technology Alternatives

• The overall solution should be a mix of the listed alternatives

• WiMAX is the most adequate technology
  – Higher spectral efficiency
  – Available for licensed and unlicensed bands
  – TDD oriented
  – Powerful interference avoidance and control
  – Possible frequency reuse of 1, through segmentation and zoning
  – Compatible with regular IT infrastructure
  – Best cost to capacity ratio
  – WiGRID specification specially developed for Smart Grids
## Typical System Characteristics

- **Reliability**
  - Hardware dependable (redundancy)

- **Availability**
  - Link dependable (redundancy, repetition)

- **Latency**
  - Delay (confirmation, repetition)

### Typical Values

<table>
<thead>
<tr>
<th></th>
<th>Application</th>
<th>Communication</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Reliability (%)</strong></td>
<td>AMI 99.00</td>
<td>LM 99.99</td>
</tr>
<tr>
<td></td>
<td>SCADA/MF 99.9</td>
<td>MM 99.9999</td>
</tr>
<tr>
<td></td>
<td>DA 99.9999</td>
<td>Backhaul 99.9999</td>
</tr>
<tr>
<td><strong>Availability (%)</strong></td>
<td>AMI 99.00</td>
<td>LM 99.99</td>
</tr>
<tr>
<td></td>
<td>SCADA/MF 99.9</td>
<td>MM 99.9999</td>
</tr>
<tr>
<td></td>
<td>DA 99.9999</td>
<td>Backhaul 99.9999</td>
</tr>
<tr>
<td><strong>Data Throughput (kbps)</strong></td>
<td>AMI 0.01</td>
<td>LM 1,000</td>
</tr>
<tr>
<td></td>
<td>SCADA/MF 1</td>
<td>MM 20,000</td>
</tr>
<tr>
<td></td>
<td>DA 1,000</td>
<td>Backhaul 100,000</td>
</tr>
<tr>
<td><strong>Type</strong></td>
<td>AMI TCP</td>
<td>LM IP</td>
</tr>
<tr>
<td></td>
<td>SCADA/MF TCP</td>
<td>MM IP</td>
</tr>
<tr>
<td></td>
<td>DA TCP</td>
<td>Backhaul IP</td>
</tr>
<tr>
<td><strong>Latency (ms)</strong></td>
<td>AMI 10,000</td>
<td>LM 100</td>
</tr>
<tr>
<td></td>
<td>SCADA/MF 1,000</td>
<td>MM 20</td>
</tr>
<tr>
<td></td>
<td>DA 25</td>
<td>Backhaul 10</td>
</tr>
<tr>
<td><strong>Technology</strong></td>
<td>AMI WiMAX</td>
<td>LM WiMAX</td>
</tr>
<tr>
<td></td>
<td>SCADA/MF PM/WiMAX</td>
<td>MM PM/WiMAX</td>
</tr>
<tr>
<td></td>
<td>DA WiMAX</td>
<td>Backhaul PM/WiMAX</td>
</tr>
<tr>
<td><strong>Band (MHz)</strong></td>
<td>AMI 220, 700, 900</td>
<td>LM 2,500, 3,500</td>
</tr>
<tr>
<td></td>
<td>SCADA/MF 2,500, 3,500</td>
<td>MM 6,000, 12,000, 18,000</td>
</tr>
</tbody>
</table>
Network Design

• A mixed network (Wireline and Wireless) is the best solution

• Broadband Wireless network should be utility owned
  – WiMAX is the best technology

• Robust protocol must be used for Network Automation

• A comprehensive design covering the whole network should be done since the beginning

• A professional design must be done covering all applications
Network Design

- RF propagation model is used to calculate the average signal level
- M2M traffic is simulated as a load to the technology of choice
- Service area and capacity are determined
- Availability and latency are calculated
- A proper design saves significant amounts (CAPEX and OPEX) along the life of the network
WiMAX x LTE
WiMAX x LTE

• WiMAX
  – Conceived as TDD
  – More mature technology
  – Internet compatible technology
  – More economical
  – Better specifications

• LTE
  – Conceived as FDD
  – Better marketing
  – Supported by 2G European vendors
  – 2G compatible technology
  – More expensive
  – Flawed specifications being fixed
  – Should prevail with traditional operators
WiMAX x LTE - Interference Control

• WiMAX
  – Common channels use different locations in each cell
  – Pilots use different locations in each cell
  – Permutation scheme (PUSC) is responsible for interference averaging
  – Many different cyclic prefixes
  – Reduced overhead

• LTE
  – Common channels use same location in all cells
  – Pilots use same locations in all cells
  – No permutation scheme to control interference
    • ICIC (Inter-Channel Interference Control) scheme left to vendors
  – Two cyclic prefixes only
  – Large overhead
Thank You!

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Questions?
THANK YOU!

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