State of North Dakota

Broadband Solutions Review

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1 Executive Summary

The State of North Dakota retained Elert & Associates to conduct a review of proposals by any organizations that submit possible solutions to provide broadband (internet) services to North Dakota citizens, state and municipal employees, and public safety operations.

Elert & Associates has reviewed all of the material provided by the State of North Dakota and by Flow Mobile, both public information and trade secret material that is not for public release. In addition, a meeting was held with both the State CIO and a separate series of meetings and a full demonstration of the technology with Flow Mobile.

From a recent 2008 study by CostQuest Associates as commissioned by the Cellular Technology Industry Association and provided by Flow Mobile, it would require an investment of more than $500 Million to upgrade the cellular infrastructure in North Dakota to the 3G standard with today's geographic coverage (66% of roads and 71% of the total geographic area are not served today.) 3G offers speed to 500 kbps downstream and 100 kbps upstream. The FCC currently expects 4G to deliver 4 Mbps both up and down.

The Flow Mobile design is today delivering at least 3 Mbps within three cities both in an out of North Dakota and this company expects to deliver this service both as commercial broadband and public safety broadband to 90% of the state. The technology Flow Mobile is offering to the rural areas of the State of North Dakota is based on the industry standard IEEE 802.11, however using licensed frequencies. Flow Mobile has co-developed a solution that would make use of commercially available 700 MHz spectrum to serve Internet to residential and business clients in the under-served and unserved areas of the state plus all of public safety as a mobile platform. The service to commercial clients would be using leasable 700 MHz bandwidth, while the proposed public safety mobile data network would make use of the 700 MHz D-Block combined with the 700 MHz A-Block to provide sufficient bandwidth to meet the required 4 Mbps 4G expectations.

It is the opinion of Elert & Associates that the plan by Flow Mobile represents a unique and very viable solution for North Dakota, however, the following concerns need to be resolved:

1) Use of the 700 MHz narrowband frequencies
2) Site design for base stations
3) End to end performance in a fully mobile environment
4) Design for system reliability
5) Complete understanding of overall design
6) Review the Cass County build-out

2 Findings

2.1 Background

Today the State of North Dakota makes use of a low speed UHF Motorola Premier public safety mobile data system that covers about 80% of the state, supported by NetMotion V8.5 with about 600 users.

Various other state and municipal departments across the state have other private mobile data solutions and also some make use of Verizon and Alltel wireless air-cards with a cost of ~$55-$60/month per user.

The State of North Dakota has a fiber optic wide area network called StageNet that provides a wired high speed network connectivity supporting public safety and other government interconnection needs.

2.2 Expectations of State Users

A telephone interview of six State departments was conducted the week of September 21, 2009 in which leaders expressed a number of needs for a state-wide broadband system. The following is a list of the needs that were stated and thus will be used in the comparison:

- Access to Computer Aided Dispatch
- Access to Web EOC
- Automatic Vehicle Location
- Use of Covert IP Cameras
- On-demand Access to Fixed IP Cameras
- On-demand Access to Public Safety IP Cameras
- Connectivity to Dynamic Highway Message Boards
- Connectivity to Weigh-in-Motion and other Traffic Monitors
- Remote State Park Voice and Data Access (ad-hoc and fixed)
- Public Access in State Parks

North Dakota expects that whatever system it invests in would cover >90% of the state's geographic territory when used by in-motion mobile units on state and county highways.

2.3 Questions Asked by State User Focus Group

1. What kind of Quality of Service will be provided by the solution?
2. Is the proposed technology viable? Short term? Long Term?

3. What Rights-of-Way are expected by the proposers?
4. Who will own the technology once installed?
5. What is the real cost to the State's users?
6. When will an upgrade be required and at what cost?

2.4 Question Asked by Consultant

7. How does the proposed technology measure up to what 4G is defined as today?
8. How will the various state and municipalities gain access to their own databases via this system?
9. How will the proposed technology offer public safety priority service?
10. Will/how will the proposer insure the backbone infrastructure is upgraded to support user needs?
11. What will the proposed solution offer in terms of reliability and redundancy?
12. How will the network be protected from denial of service attacks if non-public safety users are allowed on the same network?
13. What is the public safety available throughput/bandwidth per base station?
14. How will priority service for public safety be provided on the 700 MHz D-block as per your agreement with the North Dakota Department of Emergency Services??
15. What authentication method is being used?
16. What are the choke points in the network? Describe.
17. What happens to the 700 MHz guard bands if Flow Mobile is allowed to use the narrowband areas, especially near the boundary states?
18. Is there a plan to move to a 4G standard solution when one is established?
19. What is the ability to manage base stations as network nodes?
20. How does the design account for temperature and other environmental extremes?

3 Related Information

3.1 Definition of Broadband

The Federal Communications Commission (FCC) defines broadband as data throughputs greater than 200 Kbps, though it does not define whether this is for

fixed or mobile access. In the latest release of RUS[1] and NTIA[2] funding these organizations define broadband as two way transmissions with speeds of at least 768 Kbps minimum downstream and 200 Kbps upstream from end users. The Institute of Electrical and Electronic Engineers (IEEE) has recommended that no federal dollars be spent unless a project provides a minimum of 20 Mbps bidirectional speed with 90 percent availability throughout the nation[3].

America does lag behind in the broadband world as it ranks 14th in household penetration, 22nd in average price for a connection and 24th in average advertised download speed. In Japan the typical offering is 8-50 Mbps at a cost of $30-$60.

The BTOP and RUS grant/loan requirements for broadband focus on rural and unserved areas. "Underserved" areas, as defined in the Notice of Funds Availability, are also eligible. The emphasis on these types of areas is advantageous to a mostly rural state like North Dakota.

3.2 National Broadband Plan

By February 17, 2010 the FCC is to present to Congress a National Broadband Plan that must detail the most effective and efficient ways to ensure affordable broadband access for all. In addition, the plan must also address: "How to use broadband to advance consumer welfare, civic participation, public safety and homeland security, community development, health care delivery, energy independence and efficiency, education, worker training, private sector investment, entrepreneurial activity, and other national purposes."

Congress directed the FCC to answer the following four questions:

1. What is the current state of broadband deployment, affordability, and other factors?
2. What is the near-term solution if there were no dramatic change in government policy?
3. What are the areas in which there are demonstrable harms to the public interest?
4. What are the ways of lessening the public-interest harms?

[1] RUS: Rural Utilities Service. A division of the US Department of Agriculture. The RUS is administering a competitive program known as the Broadband Investment Program (BIP) to provide loans and grants to develop broadband networks and services in rural areas.

[2] BTOP: Broadband Technology Opportunities Program, administered by the National Telecommunication and Information Administration (NTIA), which is an agency of the federal Department of Commerce. The BTOP program awards competitive grants to help eligible entities expand broadband services to underserved areas and to improve public safety agencies' access to broadband.

[3] IEEE Response to FCC GN Docket No. 09-51, Dated 5 June 2009, Page 2.

The completed Broadband Plan may have significant implications for the State of North Dakota. For example, the plan might recommend establishment of something akin to the Rural Electrification Administration to bring broadband to all residents. Some recommendations may be directed at existing federal agencies (e.g., the FCC, RUS and/or NTIA), and others may focus on activities that states and municipalities could undertake. There is still time to provide input into the plan, and it may behoove the state to do so.

Ultimately, parts of the plan may need to be made into legislation, thus the State of North Dakota may also want ask its federal legislators to act on the state's behalf.

4 Use of 700 MHz Spectrum

4.1 The 700 MHz Public Safety Spectrum National Plan

The frequency band from 763-775 MHz and 793-805 MHz, spectrum recovered from UHF television, is being reassigned for use by broadband and narrowband public safety applications. Each state was requested to develop a plan for the use of the narrowband portion (769-775 MHz and 793-799 MHz). The single biggest issue for the use of the narrowband spectrum in a state like North Dakota is the cost of implementation due to the number of base stations required to service such a system. As such, the spectrum remains basically unused.

4.2 Public Safety/Private Partnership for the Upper D-Block

The following is taken directly from the FCC website[1]:

In the 700 MHz Second Report and Order, the Commission established a single nationwide Public Safety Broadband License (PSBL) for the 700 MHz public safety broadband spectrum. On November 19, 2007, the Commission assigned this license to the Public Safety Spectrum Trust Corporation (PSSTC). The PSBL and the Upper D-Block commercial licensee will form a Public Safety/Private Partnership to develop a shared, nationwide interoperable network for both commercial and public safety users. This network will provide public safety entities access to new broadband technologies across the country.

The Commission will award a nationwide 10 megahertz commercial license in the Upper 700 MHz Band "D" Block to the winning bidder once it has entered into a Commission-approved Network Sharing Agreement (NSA) with the PSBL. The NSA is subject to FCC approval, and must contain certain provisions such as service fees and a detailed build-out schedule for the network. The public safety broadband network will facilitate effective communications among first responders not just in emergencies, but as part of cooperative communications

[1] http://www.fcc.gov/pshs/public-safety-spectrum/700-MHz/partnership.html

plans that will enable first responders from different disciplines, such as police and fire departments, and jurisdictions to work together in emergency preparedness and response.

Under the Partnership, the PSBL will have priority access to the commercial spectrum in times of emergency, and the commercial licensee will have preemptible, secondary access to the public safety broadband spectrum. Providing for shared infrastructure will help achieve significant cost efficiencies while maximizing public safety's access to interoperable broadband spectrum.

4.3 The FCC's Plan for D-Block (700 MHz Spectrum)

The D-Block is immediately adjacent to the public safety band (758-763 MHz and 788-793 MHz). FCC Chairman Julius Genachowski told Congress September 17, 2009 that a new plan for auctioning off a key piece of the 700 MHz spectrum in support of public safety will occur by February 2010. Genachowski said that plans for the "D-Block" are part of the FCC's emerging national broadband plan due to be delivered to Congress next year. The intent for this spectrum was and is to develop a shared commercial and public safety band with public safety being given priority for its use during emergency situations, though the investment would be by a selected national carrier for a nationwide service.

4.4 The other 700 MHz Spectrum

The other blocks of 700 MHz spectrum have been auctioned by the FCC and are owned by numerous entities which are awaiting the right technology solution to offer broadband. Some of these holders of 700 MHz spectrum are willing to sell or lease. They include spectrum from 698-758 MHz, 775-787 MHz.

5 Broadband Wireless Options and Reference Information

5.1 Broadband Wireless Network Attributes

What makes a wireless network mobile? Mobility includes allowing a subscriber to connect to a base station and move about without disconnection or considerable reduction in connectivity, and to roam from one base station to another. There are two basic forms of roaming, in the first the subscriber device chooses which base to connect to and in the second this decision is made by a central controlling device. Commercial services use the central control system, while Wi-Fi technology allows the subscriber device to control the connection based on the best received signal strength following the IEEE 802.11r specification.

Much of the work going on today is to enhance and improve roaming capability. So what are the challenges?

- Seamlessly moving from one base station to the next without loss of the connection.
- Control and management of the handoff, connectivity and authentication.
- Maintaining security over varying backhaul methods.
- Maintaining Quality of Service over varying backhaul methods

5.2 Wi-Fi

Unlicensed Wi-Fi has been around now since the early 90's and was initially developed as an unlicensed fixed in-building standard, the IEEE 802.11. The next IEEE standard evolution was the 802.11b and has since evolved to include 802.11a, 801.11g and 802.11n. The IEEE 802.11 wireless standard uses 2.4 and/or 5 GHz unlicensed frequencies.

In general, Wi-Fi 802.11b/g has a range of up to 300 feet outdoors (600 feet for 802.11n) under ideal conditions and with acceptable interference.

Wi-Fi 802.11g has a theoretical throughput of 54 Mbps, but 25-30 Mbps is typically truly achievable. This capacity is shared among all devices (and therefore users) associated to any one wireless access point. At longer distances throughput is typically much lower due primarily to a lower signal to noise signal RF air interface.

Wi-Fi continues to be primarily an in-building nomadic[1] standard through some manufactures and vendors have created modifications whereby the technology can be used as point to point fixed, neighborhood and campus outdoor uses and to create a mesh environment. Care must be taken to reduce interference as Wi-Fi makes use of unlicensed frequency bands and low power with many users.

The IEEE 802.11r fast roaming / fast base station selection standard was developed and approved July 2008 to allow subscriber units to roam from one Wi-Fi access point to another. This standard defines how to maintain persistence of a connection as based on the RSSI[2] levels of the subscriber.

Two recent modifications of Wi-Fi include the use of MIMO[3] adaptive antenna systems and access points under the control of a server. Both of these methods can further improve throughput and range between the subscriber devices and the access point especially when used with IEEE 802.11n.

Wi-Fi like technology is also deployed in other bands by multiple manufacturers, although the fact it does not operate within the above listed IEEE standard frequency ranges means it cannot truly be defined as Wi-Fi.

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[1] Nomadic means that a user moves from one location to another though is generally not in motion.

[2] RSSI – Received Signal Strength Indication

[3] MIMO – Multiple In Multiple Out is a scheme of using multiple antennas to focus RF energy

5.3 Commercial Third Generation Wireless

Third generation (3G) services via cellular phone companies make use of various forms of RF air interfaces including IS-2000, UMTS, HSXPA, 1xEVDO, TD-CDMA and TD-SCDMA. Constant improvements are being made and through the use of multimode phones the carrier can even offer roaming on other carriers' networks. Average speeds of 3G are in the range of 500+ Kbps downstream and 100+ Kbps upstream while in motion. As of today, 3G has not been fully deployed throughout the US and in some areas to a very low percentage.

An early 2009 study by PC World on the throughput of typical 3G services offered by commercial carriers reported that the average 3G carrier (AT&T, Sprint and Verizon) provided 600-700 Kbps download speed. Roaming between wired and wireless networks is not a part of the specification or of the roll out of the technology. Quality of Service and Priority Services are only possible through some proprietary service offerings.

Some manufacturers are defining new offerings such as 3GPP LTE (Release 8) while another is WiMax (IEEE 802.16m). Even with these enhancements today's technology is still 3G; there are still significant technological hurdles to overcome before the first true 4G standard is in place.

5.4 Fourth Generation Wireless Broadband Technology

Fourth Generation technologies are now under development but none are available in the market today though there are many promises. With 4G services, the goal is to have 100 Mbps download and 50 Mbps upload while in motion while also offering Quality of Service to the user. When the user is nomadic and not in motion, the expectation is upwards of 1 Gbps throughput. Expectations of 4G services include seamless roaming and handoff between wireless and wired networks using IP. As the standard is still evolving, it is hard to determine exactly what the initial 4G rollout bandwidth will be.

Early technologies include: Flash-OFDM, the 802.16e mobile version of WiMax, and HC-SDMA 3GPP. Long Term Evolution (LTE Advanced) is expected to reach the market 1–2 years after Mobile WiMax released. An even higher speed version of WiMax is the IEEE 802.16m specification is under development for Clearwire to not only provide throughput enhancements but also mobility.

A number of manufacturers are now building base stations and subscriber equipment to the existing WiMax developmental standard with enhancements ongoing to offer a mobile version. The same can be said for Long Term Evolution (LTE Release 10) though few private systems are yet in place. Some of the features that make a technology meet the definitions as described in the preceding paragraph. Features such as roaming, are yet to be fully developed.

5.5 Comparing Wi-Fi with other Wireless Broadband Technologies

Two new 4G technologies on the near term horizon include the previously defined WiMax and LTE, both of which are generally considered licensed commercial services. WiMax was initially developed as an IEEE standard, 802.16e though work has stopped by the committees while manufacturers have developed an infrastructure product. LTE (Long Term Evolution) is still under development and is supported by numerous carriers. Both WiMax and LTE are expected to deliver 10-20 Mbps at distances up to 5-6 miles in mobile applications as commercial carrier services. This means 10-12 miles would be the maximum separation between base stations if the terrain allows.

Wi-Fi can suffer from subscriber overload; the larger the numbers of users utilizing a single access point, the higher the level of contention for bandwidth as there is no way to control which users connect to which access point. Other technologies such as WiMax and LTE are expected to send a subscriber to a different base station when the current base station is overloaded with traffic and coverage allows a subscriber to connect to multiple access points.

One similarity between Wi-Fi and commercial mobile cellular technology is security. An early form of security, WEP, for Wi-Fi has been broken and WPA is rumored to have been broken. However, the current security standard for Wi-Fi, WPA2, like WiMax and LTE, is designed to support AES encryption. This is extremely important to government and public safety users.

Wi-Fi is considered an in-building standard and requires about twice the bandwidth for the same throughput as WiMax, anticipated to make the latter a much more efficient standard though until WiMax is fully developed and compared this is a theoretical performance concern. Wi-Fi is a contention based Media Access Control protocol created using half duplex, while WiMax makes use of a Request/Grant protocol in which full duplex is supported, thus allowing WiMax to offer Quality of Service. Wi-Fi can make use of a new IEEE 802.11e standard that now offers some degree of QoS though it is only half duplex. The actual comparison must take into account total bandwidth required for the uplink and downlink.

Wi-Fi is built into the PC as a standard offering as a, b and/or g and now n. Today, gaining access to WiMax or LTE requires an outboard air interface device (dongle or PC card) but that too may change as these technologies are standardized and rolled out by the carriers.

One option to increase the range with Wi-Fi is to make use of better antenna systems for the PC and access point to increase the quality of connection.

The only way Wi-Fi can be used in a wide area network is to cobble together a solution using proprietary solutions. One such cobbled together technology introduced in 2007 is known as Max-Fi, a technology promising up to 2 km range from the access point in a point to multipoint solution. Another proprietary

solution is mesh that a number of manufacturers have created in support of Wi-Fi subscriber devices without any change.

5.6 Carriers' Plans for 4G Broadband

Sprint has indicated its plans to roll out WiMax as its standard for broadband via its subsidiary Clearwire (or Xohm) while the other major carriers, AT&T and Verizon, have decided to go with Long Term Evolution (LTE).

Sprint is presently in talks with T-Mobile to support WiMax. It should be noted that Clearwire has a consortium consisting of Time Warner, Comcast, Google, Intel and BrightHouse Networks who are all financially supporting WiMax and some roll out taking place.

From a timing perspective, Sprint/Clearwire has implemented WiMax in Atlanta, Baltimore, Las Vegas, and Portland, OR. Verizon launched LTE service in Boston and Seattle in August. Clearwire plans to launch WiMax service later in 2009 in Charlotte, Chicago, Dallas/Ft. Worth, Honolulu, Philadelphia, and Seattle; meanwhile Boston, Houston, San Francisco, and Washington D.C. are in line for a 2010 startup. Verizon has announced it will roll out LTE in 20 to 30 US cities/market areas in 2010 and complete its nationwide upgrade program by early 2014. AT&T says it will well be 2011 before it starts the rollout.

5.7 The Subscriber End Terminal Issue

For the potential user of any of the present mobile data solutions key questions are: what is the end terminal device, where can it be obtained, and from whom? For 4G, the answer is not easy since the standard is not yet complete, and thus nearly all of the mobile end terminal devices are typically custom modifications of existing 3G devices or they are for fixed locations.

With Wi-Fi there are numerous equipment manufacturers of end terminal devices and nearly every laptop produced today has it built in. However, because Wi-Fi (802.11a, b, g and n) operate in the 2.4, 5.2 and 5.8 GHz spectrum of unlicensed frequencies, those end devices have been designed specifically to use those frequencies. End user devices using 802.11 in other frequency ranges are non-standard and rare.

Some cell phone companies who produce 3G terminals have also included Wi-Fi in their device as another mode of operation thus allowing Internet access and even voice calls to happen over Wi-Fi channels. By their admission in various IEEE journals this cost adds about $5 to the terminal.

True 4G terminals are not expected to become routinely available until a standard is finalized and 4G infrastructure is widely deployed.

6 Technology Review – Flow Mobile Proposal

Flow Mobile, a wireless technology company, has created a plan for North Dakota to provide wireless Internet access throughout the entire state, and through a BIP/BTOP grant request, has asked for financial assistance to cover the most rural areas of the state.

The stimulus grant is only part of Flow Mobile's request; the other major part of the request is for the State of North Dakota to support the use of the new, yet to be assigned, D Block as well as the upper portion of the 700 MHz public safety narrowband for Flow Mobile's use in providing services to public safety. Using the public safety narrowband portion for broadband would be a departure from current FCC policy. Flow mobile has already acquired other 700 MHz broadband spectrum for its commercial offerings.

The technology Flow Mobile is offering is expected to provide a minimum of 3 Mbps of download and upload speed to at least 90% of the State of North Dakota using licensed 700 MHz frequencies with a backbone of fiber, together with licensed and unlicensed microwave technology in support of public safety.

6.1 Demonstration Project at Dickenson, ND

Flow Mobile has created a proof of concept of their planned technology by installing the system in Dickenson, a city of about 9 square miles. The present system as installed makes use of unlicensed 2.4 GHz spectrum using a unique base station to provide coverage far beyond the normal coverage range of Wi-Fi access points. This system makes use of multiple access points throughout the city and offers Internet to the public. In addition Flow mobile has a demonstration project using licensed 700 MHz spectrum. From reports by State officials, the demonstration system does not offer roaming between the two bands and because the 700 MHz system is a single site system, roaming between two such systems was not possible to be demonstrated.

Elert & Associates also took part in a demonstration that was generally successful although included some hiccups. Handoff (transition between access points) on the 2.4 GHz network was demonstrated, although one of 4-5 transitions resulted in a dropped connection.

During the demonstration of the 700 MHz there was only one access point due to the temporary FCC spectrum use authorization. This limitation meant we could not conduct a review of the 700 MHz system handoff capabilities.

6.1.1 Infrastructure

The infrastructure as designed by Flow Mobile makes use of a Wi-Fi technology for its 700 MHz solution. What this means is the technology is

based on the present IEEE 802.11 standard though it operates in the licensed 700 MHz band. The actual equipment manufacturer is not being disclosed at this time. During the demonstration connectivity to the base station clearly met the 3 Mbps throughput requirements while in motion with much higher throughput when stopped (in a nomadic mode.)

The hardware used for the demonstration project at the base station was a self-contained system of electronics and associated antenna system mounted at more than 40 feet in the air.

6.1.2 Subscriber Terminals

The subscriber terminal being used by Flow Mobile was a device manufactured by Ubiquiti. A Flow Mobile representative stated that modifying the standard Wi-Fi electronics to support 700 MHz was not a difficult task, and numerous manufacturers should easily be able to make this conversion as 802.11 is an open standard.

For the demonstration the device used to connect to the laptop in the vehicle consisted of a small PC board mounted in an enclosure connected to the laptop via a Cat 5 patch cord, power from the vehicle and an exterior antenna.

6.2 Cass County Project

During the visit to the Dickenson project it was announced that Flow Mobile has acquired the necessary block of 700 MHz frequencies in the Cass County, ND area to develop a complete county-wide 700 MHz system. According to Flow Mobile the installation is to begin shortly and the system will be completely operational by the end of 2009. This system will have numerous base stations and thus will have the ability to show base station transitions (hand-offs) plus system coverage/throughput. Cass County includes the City of Fargo.

6.3 Provided Information for Review

Note: Due to the non-disclosure of technical information provided to E&A, a detailed review is not being presented though a comparison to anticipated 4G technology will be attempted because Flow Mobile has stated the technology it is offering is a “4G-like technology” and will allow for interoperability with future 4G technology.

1. For their commercial customers, Flow Mobile is offering a Wi-Fi type of technology modified to use the licensed 700 MHz Band. Due to frequency re-use, the desire is to have three 5 MHz channels for reliable call hand off between base station sites. Flow Mobile has completed a lease for 700 MHz commercial spectrum in the eastern part of the state and is working

to lease commercial 700 MHz spectrum in the western part of the state for its residential and commercial services.

2. For its public safety customers, Flow Mobile also desires 15 MHz of bandwidth and thus has requested the bandwidth of 763-775 MHz and 793-798 MHz in support of three channels.
3. Flow Mobile states that interoperability and migration to 4G technology will be possible as the subscriber equipment can be equipped with multiple bands/modulation to support both their technology and that of whatever 4G technology is adopted in the future.
4. It is stated there will be priority service as required by the Department of Emergency Services, though there is no mention of how this service will be instituted. However in interviews it was stated the expectation is to build parallel commercial and public safety networks thus providing full separation of the services.
5. Access to the network for public safety is stated as being offered, however there are no publically released details as to how, beyond the fact there will be two separate networks
6. As usage of the network increases the backbone infrastructure will also grow though there is no detail of how or what triggers the upgrade. Assuming a dual network of commercial and public safety is created then the natural priority is that one network is only for public safety users. If not a separate network, IEEE 802.1p and 802.1Q are expected to be utilized.
7. It is indicated that a non-proprietary technology design (centered around Wi-Fi standards) will be utilized for the offered system to be used by the subscriber (end user). It should be noted there is no true 4G technology available today as even the present WiMax and LTE do not reach the broadband bandwidth requirements to meet the 4G definition. If Wi-Fi based technology is used at 700 MHz, this makes the technology proprietary to some degree and thus possibly manufacturer dependent.
8. There does not seem to be any discussion of the offering as being able to support Quality of Service though if it is truly following Wi-Fi standards then the IEEE 802.11e will probably be followed as they are using off the shelf, though modified, Wi-Fi technology.
9. The application calls out the support for advanced video, data and voice services in a mobile environment though no data supporting this claim can be found in the technical data provided beyond the features of IEEE 802.11 standards.
10. How adjacent states' use of the 700 MHz band will be protected is not exactly clear though it is assumed normal interference mitigation techniques will be utilized. Such as filters, frequency assignments and base station spacing.

6.4 Noted Issues

1. The described system of using 80' poles and batteries would not generally be considered acceptable reliability for public safety communications. However, after asking about this it was discovered Flow Mobile has a more sophisticated plan to provide the necessary coverage and method of building base station sites.
2. The written materials do not well describe the initial capability or long term viability backhaul network, but Elert & Associates was later provided further detail of the plan and was assured the plan is quite adequate to provide a non-blocking architecture. This concern however still remains if there is heavy loading in one area such that the bandwidth coming into an individual base station exceeds the available backhaul capacity.
3. The redundancy of the network is neither defined nor described in the presented materials, though during the interview it was clear a plan is in place for loss of a base station though not for the loss of core node.
4. Anticipated equipment environmental concerns such as operating temperature range, power, and battery failure/maintenance were voiced. Flow Mobile's current plan could stand some improvement in these areas, though the basic plan is quite sound.
5. Is there any remote monitoring of base station (access point) equipment? Yes, through the use of SNMP tools.
6. Is the state subject to the Flow Mobile's Acceptable Use Policy? The question remains unanswered though the public safety network is completely separate from the commercial network.
7. Does the state understand the loss of narrowband spectrum and D-Block to obtaining a mobile data solution state-wide vs. the option of narrowband voice communications?

6.5 FCC Request for Comments on Early Deployment of 700 MHz

The FCC has requested formal comments on the various plans submitted for RUS and NTIA stimulus[1] grants relative to the use of the 700 MHz D-Block spectrum.

The National Public Safety Telecommunications Council (NPSTC) has submitted the following concerns relative to the Flow Mobile grant request:

- If waivers were granted how can the FCC be sure the system would migrate to a common future solution? *Flow Mobile's response[2]: Once a*

[1] The American Recovery and Reinvestment Act (ARRA or Stimulus) allocated $7.2 billion in funding for these two programs for 2009-2010.
[2] FM Response is per verbal response to these questions as posed by Elert & Associates.

standard is adopted, the solution would be to integrate a dual mode capability in the subscriber equipment.

- How will geographic coordination of the band be accomplished? *FM response: The same as it is today relative to frequency sharing.*
- Will the Petitioner be eligible to operate on the network under the 700 MHz Public Safety eligibility rules? *FM response: It is believed their methodology will serve the needs at an affordable price in the stated area, which would be last to be built out by the carriers due to low population density.*
- Are the "commercial and residential services" mentioned in the Flow Mobile's waiver eligible to use the spectrum? *FM response: It is the intent to occupy commercially available spectrum for commercial and residential services, not the pubic safety D-Block.*
- How would deploying broadband on the narrowband general use spectrum impact adjacent states/regions deployment of narrowband systems? *FM response: Normal interference mitigation and frequency sharing of the band would be used.*
- Is a proposed "4G-Like" network consistent with the FCC's interoperability and integration goals? *FM response: It is the belief of Flow Mobile that throughout North Dakota the coverage is expected to exceed 90% and that within the coverage area complete integration and interoperability will be maintained.*

The Association of Public-Safety Communications Officers (APCO) has submitted the following comments:

- The Public Safety System Trust (PSST) holds the present licenses to the 700 MHz D-block spectrum and should be allowed to secondary license the frequencies under the FCC rules as it would not be appropriate to issue new licenses when the license has already been issued to local, state or regional uses in the same spectrum. *FM response: Acceptable, as Flow Mobile would expect to lease the bandwidth from the PSST.*
- Due to the fact non-urban areas where commercial 700 MHz technology may be a number of years before being deployed, alternative solutions should be allowed under a lease agreement to the PSST. *FM response: Acceptable*
- Some of the submittals do not have enough technical information for a waiver or similar relief from the FCC. *FM response: Technical detail can be provided under non-disclosure.*

- Other than the requirements for normal waivers, routine reports should be required from the entities given the authorization to insure progress. *FM response: Acceptable*
- Interoperability with the selected technology (potentially LTE) should be a requirement. *FM response: Acceptable*
- The use must be consistent with Section 337(f) of the Communications Act. *FM response: Acceptable*
- There is a concern for interference to 700 MHz narrowband users in adjacent states. *FM response: Normal interference mitigation techniques will be utilized.*

The comments provided to the FCC as October 6th and 7th in testimony in Washington by Flow Mobile suggested their proposed use and method of using the available 700 MHz spectrum was in concert with the intent and that in a number of western states this may be the only way the 700 MHz spectrum is viable as the cost of the other technologies is too great to deploy. These remarks were made to the consultant during interviews on October 7th and 8th, 2009 by the Flow Mobile representative who had just returned from the FCC meetings.

6.6 Financial Concerns

The cost of providing necessary electrical power is not really covered in any of the material provided, nor was an adequate response provided during the interview. The response was that this will have to be negotiated on a site by site basis, though some estimates were included in the provided spreadsheets.

6.7 Questions by State and Consultant

Question	Response
What kind of Quality of Service will be provided by the solution?	IEEE 802.11e is planned as the method of delivering Quality of Service.
Is the proposed technology viable? Short term? Long Term?	Flow Mobile is adopting the use of Wi-Fi standards-based technology as they use today for their 802.11 commercial network, though modified for use in the 700 MHz band. The demonstration of a single site system shown the technology works, but until the Cass County system is operational, the consultant reserves judgment as to full viability.
What Rights-of-Way are expected by the proposers?	Flow Mobile desires the use of State and local jurisdictions' Rights-of-Way to place mounting poles and trench fiber.

	Flow Mobile also desires permission to use State-owned towers for some of the microwave backhaul links.
Who will own the technology once installed?	Flow Mobile (New EA, Inc.)
When will an upgrade be required and at what cost?	Flow Mobile (NEW EA, Inc.) has indicated they will be responsible in the future for all infrastructure costs after the initial build-out which is expected to take about 24 months for the state.
What is the real cost to the State's users?	The cost to North Dakota will be giving up the 700 MHz narrowband frequencies now under their control to be used to support the mobile data service. The grant, if awarded, will pay for all of the initial subscriber equipment and installation, however Flow Mobile does expect an ongoing revenue stream of roughly the cost of a commercial air card service today (~$55-60/month/card). **Further discussion on this issue is highly recommended**.
How does the proposed technology measure up to what 4G is defined as today?	The FCC expects 4G to provide 4 Mbps up and down link throughput. Today, the present WiMax is being defined at 3.5 Mbps and the 3GPP2 is 3.9 Mbps, thus both under the mark for this definition of 4G. Wi-Fi, as it is being implemented by Flow Mobile, is believed to equal or greater than the 4G requirements as defined by the FCC at this time.
How will the various state and municipalities gain access to their own databases via this system?	In North Dakota, StageNet already allows various jurisdictions to access each other's RMS databases. Providing a connection via a secure mobility server is expected to provide access. It is also anticipated that local connectivity could be provided for local databases.
How will the proposed technology offer public safety priority service?	With the plan as proposed the public safety network frequency block would be separate from the commercial network frequency block. In addition, as the network is based on Wi-Fi, the 802.1p and 802.1Q standards would be implemented to provide additional levels of priority. During emergency conditions, the commercial bandwidth would also be made available to public safety on a priority basis.
How will the proposer insure the backbone	Through conversations (only) with Flow Mobile, we understand the plan is to use a combination of

infrastructure is upgraded to support user needs?	licenses and unlicensed microwave and fiber interconnections. Upgrades will be completed as needed.
What will the proposed solution offer in terms of reliability and redundancy?	The overall reliability as compared to what is termed "normal" public safety sites is still being engineered, with considerable attention given to the ways and means. **Further discussion on this issue is highly recommended**.
How will the network be protected from denial of service attacks if non-public safety users are allowed on the same network?	Normal protection as provided by the nearest router (of more than 200 to be deployed throughout the state.)
What is the available throughput/bandwidth per base station?	The same capability of a Wi-Fi access point, since the system is built on Wi-Fi standards. The bigger issue may be that the backhaul may not be sufficient to handle the two access point's total bandwidth.
How will priority service for public safety be provided on the 700 MHz D-block?	As the network is based on Wi-Fi, the 802.1p and 802.1Q standards would be implemented to provide priority, though there are no intended non-public safety users on the D-Block unless the State were to authorize this.
What authentication method is being used?	Flow Mobile intends to make use of a RADIUS server for authentication and if authorized, to allow any public safety user from anywhere to be registered on the system.
What happens to the 700 MHz guard bands if the narrowband areas are allowed to be used by Flow Mobile, especially near the boundary states?	As the proposed system is RF based as would any other 4G solution, normal interference mitigation techniques are proposed. Flow Mobile has disclosed a unique method to add to the normal tool box of solutions, however. This solution's ways and means is being held as a trade secret at this time.
What are the choke points in the network? Describe.	Just as in any IP network, routine monitoring will be used to determine if traffic is being held back or dropped. The initial build-out plan does not appear to have any "choke points."

Is there a plan to move to a 4G standard solution when it becomes available?	If a standard 4G solution is developed and is financially viable for North Dakota, Flow Mobile would review as a possible future upgrade.
What is the ability to manage base stations as network nodes?	All of the base stations are accessible via SNMP and thus their condition, even to the antenna, can be monitored and various elements adjusted remotely, as needed.
How does the design account for temperature and other environmental extremes?	The overall reliability as compared to what is termed "normal" public safety sites is still being engineered with considerable attention given to the ways and means. **Further discussion on this issue is highly recommended**.

7 General Observations by Consultant

The Flow Mobile base station design implementation using 700 MHz has enabled the system coverage range of Wi-Fi standards-based technology to be expanded from a few hundred yards to a few miles outdoors. Since the frequency is no longer the unlicensed spectrum of 2.4 GHz and 5.2/5.8 GHz but rather 700 MHz, the physical characteristics of the band exceed the coverage of the higher Wi-Fi frequencies in much the same way as the 850 MHz cellular band offers a higher level of coverage than the 1900 MHz PCS band. It is the understanding of the consultant that the equipment being used for the access point and the base station is from a single manufacturer though this is typically the situation with almost any of these new technologies. The manufacturer has assured Flow Mobile it will be able to meet its quantity and timing requirements for deployment.

The solution offered by Flow Mobile seems to offer the State of North Dakota the means of obtaining nearly 4G-like mobile data with a cost of implementation far below that being estimated using other commercial platforms such as WiMax or LTE. The solution may not be appropriate where there are huge geographic feature changes (e.g, mountains) or highly populated areas though neither of these are issues in North Dakota.

Assuming the present plan by the FCC and the PSST for the use of the recovered 700 MHz frequencies doesn't really seem to offer a solution to North Dakota public safety, then the Flow Mobile solution may just be the best method of providing an affordable broadband. The narrowband allocation (799-805 MHz) would still be available for its intended use thus offering non-repeated voice radio. Due to the limited use of the 800 MHz public safety band in North Dakota, this band could also be used for emergency interoperable voice communications.

8 Recommendations

Elert & Associates believes that based on our brief review of the proposed implementation, this is a viable solution to provide broadband public safety mobile services to North Dakota assuming 700 MHz narrowband repeaters will not be expected to be used in the state.

The following are Elert & Associates recommendations to address the outstanding concerns after the review and interviews:

8.1 Use of 700 MHz Narrowband Frequencies

The Flow Mobile solution would make use of the 768-775 MHz narrowband allocation which thus removes the potential of operating on these frequencies under the nationwide plan. E&A recommends the state fully understand the consequences of this decision.

8.2 Site Design for Base Stations

The discussion of planned design for the base station did not leave E&A with a good feeling that it would meet generally accepted ways and means for public safety systems. E&A was informed by Flow Mobile that their outside plant made it through the recent tornado pretty much unscathed, though for the rural areas the plan for these sites still remains a concern. E&A recommends this information be given as feedback to Flow Mobile and that a careful review of the final design detail be performed.

8.3 End to end Performance in a Fully Mobile Environment

The end-to-end performance of the network could not be completely tested with the tools available, with the presented material or within the time for the report. E&A recommends a full review of the system take place once the Cass County system is built out, by measuring throughput, latency, packet loss and other key metrics to insure the network meets the State's requirements.

8.4 Design for System Reliability

If an RFP is developed for the system or if the design takes a different authorization path, it would be highly desirable to establish performance criteria that focused on end to end system reliability for Flow Mobile or whatever company is selected to develop the system. The criteria should include not only the network elements but also the physical poles, towers, shelters, cabinets, power plant, environmental concerns and security.

8.5 Complete Understanding of Overall Design

It is clear the complete design as proposed by Flow Mobile is not entirely known or understood by the state IT staff serving the public safety personnel. At some point this staff will have to gain a complete understanding of the proposed system, verify its operation as meeting the needs of the state and be enabled to understand the entire network. Assuming the Flow Mobile network is accepted, E&A recommends the State IT Department will need to form a partnership with the Flow Mobile design team for the public safety mobile data network.

8.6 Review the Cass County Build-out

Flow Mobile has announced its intention to build out an entire county in North Dakota (Cass County) utilizing leased 700 MHz commercial spectrum and to offer mobile data services to commercial, residential and government users. The E&A recommendation is for the state to take this opportunity to understand in detail the intricacies of the offering.