ATTACHMENT 1:
Flow Mobile Responds to
Public Safety Spectrum Trust (PSST)

TABLE OF CONTENTS

1. FM: TDD-based technology not interoperable with nationwide FDD-LTE 2
2. FM: TDD system likely to interfere with neighboring FDD based LTE Systems 3
3. FM: Proposed solution confound implementation of a nationwide public safety network 3
4. FM: Seeks to usurp Public Safety narrowband channels 5
5. WiFi Technology will be widely used US on 700 MHz Spectrum 5
6. WiFi was designed for WLAN. 6
7. LTE also incorporates MIMO 8
8. LTE incorporates highly developed algorithms and inter-base station and core network processes for handing-off traffic from base station to base station 9
9. FM: Equipment apparently is software defined 9
10. Interoperability is highly unlikely if not impossible: 10
11. Locally-built 700 MHz public safety networks 11
12. FM: Needs to provide technical explanation 12
13. Interoperability only if all devices and systems support a common technology 12
14. WiFi on 700 MHz very likely will be used nowhere else in the world 12
15. LTE devices in use everywhere else in the country will not function on FM's network 13
16. FM: One-of-a-kind 700 MHz WiFi devices will not function 14
17. FM: Stated that the FDD & TDD incompatibility and interoperability will be solved... 14
18. Market force to drive device manufacturers to make a specialized 700 MHz TDD WiFi and FDD LTE device. 14
19. WiFi is TDD (Time Division Duplex) 16
20. The Upper 700 MHz channel plan in the US is intended for FDD operations. 17
21. FM: Technology likely to cause harmful interference 18
22. LTE defines both AAS & MIMO (Multiple Input, Multiple Output) as acceptable spatial diversity techniques for multiplying channel capacity. 19
23. MIMO and AAS are prescribed by the standards bodies 19

In this document, please find Flow Mobile's responses to criticisms bought to the Public Safety Spectrum Trust (PSST) regarding the waiver Flow Mobile requested to deploy a public safety network in North Dakota. The criticisms from the PSST are in **BLUE FONT** and the Flow Mobile responses are in **BLACK FONT. Please note that the original questions/comments were written in 3 sections. We have identified the 2nd and the 3rd section with Roman Numerals to avoid confusion since we numbered the first set of questions.**

1. Flow Mobile's TDD-based technology will not be interoperable with nationwide FDD-LTE.

Flow Mobile Answer: This statement confuses **"interoperability"** with **"exchangeable use".** To explain the invalidity of this statement, we will being with the definition of interoperability as defined on the FCC website: Public Safety and Homeland Security Bureau ~ www.fcc.gov/pshs/techtopics/tech-interop.html

International Standards Organization. This worldwide federation suggests in its draft technical report(ISO/IEC 2382-01, Information Technology Vocabulary, Fundamental Terms) that interoperability be defined as **"the capability to communicate, execute programs, or transfer data among various functional units in a manner that requires the user to have little or no knowledge of the unique characteristics of those units."**

IEEE Standard Computer Dictionary. The Institute of Electrical and Electronic Engineers (IEEE) provides the generally accepted definition of interoperability, at least from a technical perspective. It defines the term as **"the ability of two or more systems or components to exchange information and to use the information that has been exchanged."** See IEEE Standard Computer Dictionary: A Compilation of IEEE Standard Computer Glossaries (New York, NY: 1990).

The Federal Communications Commission (FCC) has adopted the following definition of interoperability. Interoperability is defined in Section 90.7 of the Commission's rules as **"[a]n essential communications link within public safety and public service wireless communications systems which permits units from two or more different entities to interact with one another and to exchange information according to a prescribed method in order to achieve predictable results."**

The interoperability previously defined can be achieved by using simple methods which are currently in place. Presently there is information exchange between multiple devices. An I Phone has GSM, 3G and Waif all on the same device. As early as 2003, phones with both Wi-Fi and GSM were developed and currently most enterprises are using Wi-Fi in their offices for voice and data communications. SIP devices have been in the market for several years and are available abundantly in the market today. Sip Hardware (www.siphardware.com) shows such devices. As early as July of 2004, Motorola launched a phone that hands-off from a Wi-Fi network to a cellular network in order to support Wi-Fi in enterprises. This clearly meets the interoperability requirements as described by the ISO, IEEE and the FCC.

The network that Flow Mobile is building is standard Wi-Fi down converted and implemented in 700 MHz. Hence the hand-off mechanism described above from Wi-Fi to GSM and CDMA will be implemented. Wi-Fi/CDMA and Wi-Fi/GSM phones have been available for over 5 years now. In the future, when LTE phones become available, the same mechanism will enable the handoff from Wi-Fi to LTE. The development of LTE does not change the basic principle of interoperability. Interoperability between a Wi-Fi standard system and devices will work the same proven way with LTE or any other future standard. Flow Mobile's system will be interoperable. The development of LTE does not change the basic principal of interoperability that is already successful.

2. Flow Mobile's TDD system is likely to interfere with neighboring FDD based LTE Systems

Flow Mobile Answer: The TDD and FDD interference discussion was completed years ago. In 2001, the TDD coalition presented this document, published on the FCC website: www.fcc.gov/realaudio/mt120301.pdf.

It is a known fact that TDD systems use spectrum more efficiently than FDD systems. TDD systems have been adopted by Europe, Japan, and Canada. WiMax, which is currently based on TDD, is accepted widely as a 4G standard for deployment. Interference mitigation is discussed extensively in the document previously referenced. It specifically discusses Wi-Fi implementations. Slide 48 of the presentation discusses how even co-location of TDD and FDD systems on the same tower can operate without interference. It should be noted that Flow Mobile's approach, in the states we are planning to serve, is to build our own deployment locations. We will not need to co-locate with other LTE oriented systems.

FCC has already approved the use of TDD in several frequencies. The methods of interference mitigation have been discussed. Flow Mobile plans on deploying a system that is based on beam-forming and SDMA technology which mitigates interference even further. Apart from increasing throughput by focusing energy to and from the clients, beam-forming significantly reduces the interference since the energy is transmitted in all directions but is focused on the client on a per-packet basis. Flow Mobile understands FCC standards on interference and will adhere to them.

3. Flow Mobile's proposed solution will confound implementation of a nationwide public safety network.

We believe that our approach enhances the chances of building a nation-wide public safety network. It is a well established fact that historically, networks are first built in densely populated areas and then move towards more sparsely populated areas. This pattern has been dictated by financial models for understandable reasons. We believe that implementation of a nationwide public safety network will not be possible without a solution such as provided by Flow Mobile because a "one-size-fits-all" approach will

mean that the most rural states will not be able to afford the costs of deployment of a single proprietary technology such as LTE. Thus, an insistence on one high-cost technology standard will prevent the possibility of a nationwide network. Therefore, the only way to ensure a true nationwide network is to allow for multiple technology standards to emerge and make possible deployment in rural and sparsely populated areas.

Flow Mobile's business model and technology make it possible for us to deploy networks in the thinly populated states that have been underserved for years. If the construction of a nationwide public safety network takes a "one-size-fits-all" approach and public safety service is confined to only one proprietary technology, such as LTE which has a similar cost structure to the current 2G and 3G systems, large rural areas of the country will never have a mobile broadband network constructed. It will not be financially feasible to invest hundreds of millions of dollars to cover very sparsely populated areas. A true **national network** is going to require **flexibility and allowance of multiple networks** that are designed to best meet the **geographic circumstances**, while adhering to **national operational standards and requirements for interoperability.**

Public Safety organizations in the states we plan to serve have already pressed for a network such as the one proposed by Flow Mobile. A high throughput, broadband network that covers the entire state has been a requirement for these states for years. As explained earlier, interoperability can be achieved between the Flow Mobile network and others in a way that has been used in the industry for many years.

Flow Mobile is focused on providing public safety organizations a mobile broadband network in the thinly populated, mid-western states. Our low-cost, high quality technology makes this possible because our cost structure differs radically from the traditional 2G and 3G systems. We believe our network provides a superior cost model and greater performance than potential LTE systems. It is clear from information available in general press, that the currently endorsed LTE standard will be implemented only at some time in the far future. Flow Mobile's proposal of using Wi-Fi, technology that has been tried and tested for years, means that the network **can be built now**. If the FCC implements the interoperability standards, it will be effortless for any device to have 700 MHz Wi-Fi capability.

An LTE-only plan, for a national public safety network, has a serious gapping void: How will rural areas afford to construct mobile broadband networks suitable for public safety use at the anticipated costs of LTE? Nobody has been able to answer that riddle yet. A recent House Commerce Committee hearing gave considerable focus to this problem, yet nobody at the hearing could identify a viable pathway to address the problem. Without Flow Mobile's solution, there cannot be a true national network. A true national network is going to require the emergence of a radically different cost structure such as the solution Flow Mobile offers.

4. Flow Mobile seeks to usurp Public Safety narrowband channels that should only be used for interoperable voice operations.

If there was a predictable pathway to know when and how the PSBL spectrum and the D Block would be licensed and available in these rural states, there will be no need to consider the narrowband channels. Flow Mobile seeks to serve the public safety community in rural states. In some of the states, the 700 MHz spectrum currently assigned for narrowband service is fallow and will likely remain fallow for an extended period of time, if not indefinitely. Many of these rural states already have narrowband services in other spectrum bands and it is unlikely that some, if not many, will ever have the means to invest in another narrowband system, including in the 700 MHz narrowband spectrum. Thus, some public safety entities in these rural states do not believe that the narrowband 700 MHz spectrum will ever be built out with a narrowband system. This is why the 700 MHz narrowband spectrum is under consideration in some states for other use as uncertainty over the Public Safety Broadband License (PSBL) and the D Block remain. States that want to move forward while debates on the Hill continue are looking for options.

Flow Mobile's system is very spectrally efficient. We only need 10 MHz to provide high quality service to public safety. Long term, we believe that attracting private investment to help finance and construct public safety networks, and additional spectrum to include some commercial service will be necessary. However, public safety use in the states Flow Mobile seeks to serve will really only require 10 MHz Access to the PSBL or D Block will eliminate any need for a discussion on the narrowband spectrum.

The fundamental problem for many rural states is that fallow spectrum is tied up in either indecision or requirements that are unattainable. There is no shortage of spectrum available for public safety use. The problem is that the FCC needs to allow this spectrum to be put into use and needs to work with the public safety agencies on the ground to meet their needs.

5. It is not reasonable to expect that Wi-Fi technology will be widely or ever used at all anywhere in the US on 700 MHz or that any vendor except perhaps Flow Mobile will ever develop any Wi-Fi devices for 700 MHz

Wi-Fi technology is the most prolific wireless technology on the planet. It is proven. All Flow Mobile is doing is applying that same technology and standard into a new frequency. The conversion is simple and can be done immediately – well in advance of any LTE devices entering the market. Flow Mobile has presented an approach to building a mobile broadband network that provides high data speeds in a mobile environment for 1/10th the cost of the current networks. It is estimated that building a 3G network to cover ND will cost upwards of $700 million. The Flow Mobile approach has been reviewed by both state and independent entities to ascertain the feasibility.

Device Plan: The Flow Mobile approach starts with a new way of building networks at a low cost for infrastructure. Wi-Fi is the only standard that is ubiquitous in the entire world therefore devices using Wi-Fi on 2.4GHz are abundant. We believe our 12 state plan proposed is just a start. Any state that has issues with infrastructure cost, could adopt this approach. We are building a dual use network in the states we will serve that will serve the public safety and the general population. This approach has vast world-wide appeal. The United States can be a trend-setter again; just like we did when we pushed for the ubiquitous presence of Wi-Fi covering every public location. Our initial conversations with device vendors have been productive, the device we are talking about is a simple down-conversion of 2.4GHz baseband to 700 MHz, and it is a very simple process for vendors. Flow Mobile believes that ultimately, the chipset will be developed to be dual mode 2.4GHz and 700 MHz Wi-Fi. The beauty of our approach is that all of the electronics that go into manufacturing devices are the same; they are the 2.4GHz Wi-Fi electronics, and the only change is the addition of the frequency down-converter. This means that the change required is minimal and the benefits of the low-cost electronics that have been available because of the ubiquity of Wi-Fi will be readily available for 700 MHz Wi-Fi devices.

All the advances and enhancements made in Wi-Fi, such as the implementation of MIMO etc, will also be available in our system because the entire system is standard Wi-Fi. Hence the vision we present is one of an open standard that is already global and has huge appeal to the general population to be implemented in 700 MHz using existing electronics and components. There is nothing more reasonable than our approach in creating uptake of devices in the market. We are implementing all of the standards that Wi-Fi has already included for years.

6. **Wi-Fi was designed for WLAN (Wireless Local Area Network – fixed and nomadic, short range (100 meter) network), and was never intended for fully mobile WMAN/WRAN use (Wireless Metropolitan/Regional Area Network – the scale of cellular networks). Wi-Fi's OFDM (Orthogonal Frequency Division Multiplex) was designed for stationary or pedestrian (nomadic) speeds, and will struggle to avoid the dynamic channel impairments that occur with full speeds, and will struggle to avoid the dynamic channel impairments that occur with full mobility. Wi-Fi's OFDM divides a 20 MHz-wide radio channel into 52 closely spaced sub-carriers, and the data for each user is distributed across them all, sharing them in time among users. When the radio channel becomes impaired, the modulation rate (which determines the amount of data throughput possible per subcarrier) for all subcarriers across the entire channel for that user is reduced to compensate. Performance is thus affected for all subcarriers for the user when only some of them may have**

been affected. Wi-Fi is thus ill-equipped to deal with Doppler effect and the fast fading multipath cancellations that take place and change rapidly at vehicular speeds at various narrow frequency segments within a radio channel. The cannel will be treated as just poor overall, and will force lower modulations rates for long periods, rather than for instants they appear on any given subcarrier.

LTE's OFDMA (Orthogonal Frequency Division Multiple Access) on the other hand, while dividing the radio channel (each base station can dynamically choose 72 of an available 2048 subcarriers in a 20 MHz-wide channel), is able to assign different groups of adjacent or even non-adjacent subcarriers (12 at a time) to each user depending upon the channel quality and whichever method is optimum for the user's speed. It also can re-assign them differently every few hundredth's of a second depending upon the channel quality reported back from the mobile, and, can change the modulation rate as needed on a subcarrier group by subcarrier group basis. It thus can avoid partial channel impairments as rapidly as they occur and are therefore highly adaptive to mobility.

Flow Mobile Comment: The statement above combines several different concepts into one objection. It is important to address each one of them separately in order to explain why Wi-Fi works in mobile environments. We have not claimed that Wi-Fi has all the bells and whistles built-in day one that a new standard which is still being worked on has. Wi-Fi in 700 MHz today can provide a high-speed mobile broadband network. If we were to hypothesize how Wi-Fi in 700 MHz would look through enhancements 3 years from now, it would be a wasted discussion. We are building this network now and are ready to have networks up and operational 12 months from the time we start building.

First, we will address the claim that Wi-Fi is not suitable for use in long distances since it was designed as a short-range (100m) network. To address this point, the **"link budget"** needs to be considered since the uplink is weaker than downlink, we need to consider the uplink budget. In our system the uplink budget is 154 dB, which is comparable to that of the LTE standard, and can safely support a range of 5 miles. It should be pointed out that this link budget is made possible by our unique and powerful beam forming technology. In fact, the ability of our system to cover such large areas was demonstrated in our proof-of-concept 700 MHz system that we deployed in Dickinson, ND. If there is any doubt in this, the critics are welcome to come to Dickinson, ND to see how this works. It is operational and functioning today.

Next the comment that Wi-Fi is not suitable for mobile **WMAN/WRAN use** can be addressed in several ways. The Wi-Fi standard originally compiled for Local Area

Networks (LANs) had handoff between BTSs already built-in (original Wi-Fi standard allows for 6 mph handoff). Later enhancements and additions, specifically the 802.11r standard, which has been in development since 2004 and was conceived and implemented by several of the IEEE members (including Atheros) allows for fast handoff between BTSs. The goal for fast handoff was set at under 50 milliseconds, which is a very acceptable number for voice application.

Several **WMAN/WRAN** mobile networks have been built and working suitably using Wi-Fi. Flow Mobile has deployed a mobile network with handoff between BTSs in the City of Dickinson, ND. We have demonstrated vehicular speed handoff in the city and our network is currently being used by public safety organizations. Several police departments have been using Wi-Fi networks in 2.4GHz for public safety on a metro scale. Oklahoma City's police have been using the city's Wi-Fi network for an extended period of time now.

Implementation of Wi-Fi in the 700 MHz frequency adds to the range factor and implementation of fast handoff adds to the mobility factor.

Addressing the claim that Wi-Fi's OFDM was designed for stationary or pedestrian (nomadic) speeds and cannot cope with the dynamic channel impairments that occur with full speeds; we would like to point out that OFDM, as a modulation scheme can cope with mobility by its inherent nature. Moreover, when porting the Wi-Fi to 700 MHz band and 5 MHz channels, these inherent capabilities of OFDM are enhanced. More importantly, our unique and powerful beam forming technology, which is done per-packet and per sub-carrier bin in both the uplink and the downlink, takes the mobility capabilities to a different level and enables high throughput and stable connectivity at speeds of 100 mph.

7. LTE also incorporates MIMO (Multiple Input, Multiple Output antennas described further below) which takes advantage of multipath – even the rapidly changing multipath is mobile systems, to actually improve communications, rather that it being an impairment. LTE is intrinsically designed and intended to support speeds to 75 mph with high performance, and to continue to function well even at over 200 mph, continuing to operate even to 300+mph. Thus LTE was purpose-built for mobile applications perfectly suited to Public Safety's high vehicle and even aircraft speeds, whereas Wi-Fi is an inferior adaptation at best.

Our Beam forming capability takes advantage of multipath, in the same way as MIMO, and as result can cope with 100mph speeds. Moreover, unlike LTE MIMO that will have 2-4 antennas at some time in the future, our beam forming technology is using 6 antennas and six radio transceivers; hence its exploitation of the multipath is superior.

Please note that MIMO is an RF phenomenon. Irrespective of the protocol used for communication, MIMO will provide the same benefits to LTE networks as well as Wi-Fi networks. There is no difference in the benefits.

8. **LTE also incorporates highly developed algorithms and inter-base station and core network processes for handing-off traffic from base station to base station in light of the above radio channel challenges in a fully mobile environment. Flow Mobile would need to explain how handoffs would be handled, of if they would even be possible at fast vehicular speeds, with their Wi-Fi WLAN technology.**

As explained in the previous sections, the perceived challenges as described in this paper have been addressed. Flow Mobile will provide full mobility and handoff using 802.11r fast handoff standard that was developed into the Wi-Fi standards since 2004 and ratified by IEEE in 2008. Fast handoff enables the voice handoff capabilities in Wi-Fi. 802.11r being built into the standard over a year ago, makes it widely available but not fully implemented since Wi-Fi in high-speeds has not been implemented before. Flow Mobile's innovative approach to solving the problem at hand brings out the best of the Wi-Fi standards.

9. **Flow Mobile's equipment apparently is software defined (meaning that the RF signal is created by a microprocessor and software in the radio), presumably this basis of their unsupported claim to have the ability to migrate to LTE. However, assuming its RF amplifiers and filters are of sufficiently high fidelity to support LTE, which is doubtful, and even if new FCC certification of its equipment for LTE is somehow ultimately obtained (Flow Mobile is demonstrating its current technology under an experimental STA, thus it is highly unlikely that Flow Mobile has obtained FCC certification for its currently proposed equipment), Flow Mobile has not discussed the inevitably high cost of R&D to develop LTE software that all infrastructure vendors have endured, as is normal for any new technology development, nor have they addressed the resulting future costs to the state(s) that must result to support this. LTE technology has been developed by the entire, global mobile radio industry out of mutually recognized technical necessities to support true, fully mobile broadband. Ignoring these unavoidable technical requirements for the sake of cheap equipment will result in performance to match and will require another spend in the future to**

finally achieve it, which could have been avoided. Even if one ignores these hurdles and the experimental nature of the technology to which Flow Mobile seeks to commit state Public Safety, larger issues exist:

We thought it would be wise to deflate this theory of **"software defined radio and LTE standards on the same BTS"** right at the outset. Flow Mobile has not said, in any forum, that our system is "software defined". We also have not made any claims that we will transform our existing Wi-Fi based system into an LTE system. This entire statement is false and a figment of the author's imagination. The very aspect of the expensive R&D required to build LTE and the fact that states like North Dakota can only see a mobile broadband network in their distant future due to the costs of building such a network using LTE, is the reason we devised a system using Wi-Fi. The statement "cheap equipment will result in performance to match" reeks of big business conspiracy and sounds condescending at best.

A $30 router provides Wi-Fi broadband access to every user at home. This service is better than what anyone could have hoped for 10 years ago. Innovation and a global standard is a result of this development. A cellular phone in North Dakota goes dead for miles at a time if you are away from the main MSAs. Even when there is a full signal, the coverage is spotty and can drop at any given moment Cellular phones and the plans purchased by individuals are as expensive as they are anywhere else in the country, but in the middle states (the big square states) these cell phones go silent. Public Safety in North Dakota depends solely on a radio system that requires enhancements. There is really no mobile broadband available to them even in the form of slow 3G.

Authors should keep in mind that solutions that are cost effective win. **"Expensive" does not necessarily mean "better"!** We are building a network that can provide upwards of 16 mbps to the user in a mobile environment. We have DEMONSTRATED this on a 16 MHz channel. We are achieving throughputs of upwards of 25 mbps in a fully multi-path, urban environment.

10. Interoperability is highly unlikely if not impossible.

There is no basis for such a statement and such a statement should be dismissed as ridiculous. We can only assume that the assumption behind such a statement is that only interoperability presumes only one technology standard. This is obviously not true – note the fact that so many commercial handsets operate using multiple standards today and are interoperable. Simply because Flow Mobile proposes to use a <u>proven, existing</u> standard in 700 MHz and other carriers may use a new standard still in development (e.g., LTE) does not suggest lack of interoperability.

We would like to state up front that we do not believe that LTE is a bad standard or that it is a standard that does not have great capabilities and potential. We are not wedded to a particular standard. Flow Mobile is solving an age-old problem in which states that are thinly populated are being neglected because they don't have enough population to support the business models of existing carriers. We have devised a way to reduce the CAPEX and hence make it economically feasible to make the system deployable. We are however in no way against the use of LTE or any other standard to build networks if they are economically viable for our target demographics. We strongly believe that the economic model we have developed revolutionizes the way networks can be built.

11. Locally-built 700 MHz public safety networks should be designed to allow local users to roam nationally on the SWBN when outside the local network. In addition, systems should be designed to allow other (i.e., non-local) users of the SWBN to roam onto their system when in the local network area.

In the current docket there are 13 waiver requests. If one excludes the waiver requests from North Dakota and Flow Mobile, there are 11 other requests. Some of these requests are centered on the use of 3G based technologies to build out their areas. They will face the same dilemma if and when the rest of the nation is built using a single technology. The arguments in this document make the assumption that the network of choice is LTE; thus, these 3G networks need to interoperate with the LTE networks as well. Roaming is critically important and can be achieved through adherence to national requirements.

The Flow Mobile network, which is going to be built now, faces the same interoperability requirement that a nation-wide LTE network will face whenever it gets built in a majority of the areas. We are building the network now, which means that we will have a network with users by the time an LTE network is built. Our approach for the use of devices interchangeable as follows:

1. It is our responsibility, in the states we build out, to provide devices to the public safety entities that will work on the network operated outside of the states we serve.

2. We will also provide a reference design for an add-on module that will enable operators building LTE to include access to our Wi-Fi-based networks. The add-on component is as simple as adding Wi-Fi to an I-phone or a Blackberry device that is being done today. Our technology is completely standards based and hence an addition of a down-converted Wi-Fi chip will allow the LTE device to operate on our network.

12. Flow Mobile needs to provide technical explanation of how their technology possibly could be in-and-out interoperable with LTE, and a technical explanation of what would be required to cutover to LTE.

As in general cellular technologies, handoff is affected by the handset. The handset makes the decision on when to handoff to another BTS or another device. In general, technology today is capable of carrying multiple protocols operating on the same device.

We will use the scenario of a device that is connected to Flow Mobile network inside a state and needs to handoff when it goes across the borders to a state that is operating LTE: Since the handoff is affected and executed by the handset, as soon as a device enters the area of LTE coverage, moving over from an area that is covered by Flow Mobile's solution, the LTE side of the handset associates with its BTS and continues to operate. The requirement for the handoff technique is similar to those in cellular environments where a HLR (Home Location Register) and VLR (Visitor Location Register) mechanism is utilized. These registers are available on the LTE network side as well as on the Flow Mobile network side. Together they provide the authentication for the device, similar to today's roaming/handoff mechanism. The whole system will work exactly the way the current cellular system works.

13. Interoperability can only take place if all devices and systems support a common technology

This is a completely illogical statement. CDMA and GSM systems do communicate with each other today. 2G based phones can call and exchange information with 3G based and WiMax based systems. The definition of interoperability, as provided by 3 major entities, shows that this statement is baseless and false.

14. Wi-Fi on 700 MHz very likely will be used nowhere else in the world, let alone in the US unless Flow Mobile's single vendor platform somehow prevails as SWBN technology nationwide – highly unlikely, especially given the endorsement of LTE by APCO, NENA, NPSTC and the PSST.

This is another false statement and baseless speculation. Flow Mobile's system **is not** a **"single vendor"** technology. LTE is a single vendor platform. The Flow Mobile solution is open standards and will enable any vendor to develop equipment to operate on the open access network. The insistence of a an LTE only solution is the death nail to innovation, whereas the Flow Mobile solution allows for open access and innovation that will best respond to the diverse needs of public safety. Flow Mobile's technology is based on standard Wi-Fi and it is down-converted to 700 MHz so it can operate at a

lower frequency with the benefits of wall penetration and longer distance while keeping the completely developed standard of Wi-Fi intact in that frequency. As soon as the United States paves the way for a 700 MHz Wi-Fi platform, the rest of the world will follow. Indeed, in many parts of the world there is a debate regarding what to do with the 700 MHz spectrum that is being opened; it is very likely that they will follow the US in our progression. Predicting that Wi-Fi, a proven technology, will not be adopted in the rest of the world - while assuming LTE, a technology still in development, will be on a single standard base is a ridiculous speculation and certainly not grounds to draw a conclusion regarding Flow Mobile.

Innovative, low-cost, high-performance and ubiquitous technology that is readily available will always catch fire. The fact that there are no royalties to be paid to start a company to manufacture devices, no licenses to be obtained and it is a simple process to build devices that are available publicly will change the way we look at cellular solutions.

False statements like “single vendor technology” are meant to create unnecessary confusion in the market. Flow Mobile’s innovation is the idea that Wi-Fi could work just as well in 700 MHz as it would in 2.4 GHz and that Wi-Fi is capable of fully mobile broadband communications. Carriers have for years deployed CDMA and GSM in multiple bands without any claims that they will not operate well in other bands. The reason for the push back against Wi-Fi is simply because it is not a proprietary technology.

A more plausible speculation is that the FCC will not regulate a single proprietary standard, including LTE. While the major carriers and some national public safety organizations may prefer this standard, the FCC has traditionally regulated in a technology neutral manner and the major carriers and national organization supporting a particular standard should not assume that they can dictate their standard in the market place. Flow Mobile will continue to urge the FCC not to dictate one particular standard but to take the approach of requiring interoperability and managing interference through performance requirements.

15. LTE devices in use everywhere else in the country will not function on Flow Mobile’s network, unless it somehow simultaneously supports LTE, and in the configuration to be deployed in the US (meaning FDD not TDD, and MIMO not AAS, discussed further below)

This statement, again, as explained earlier, is false. A GSM phone with 3G capabilities (two completely different systems) has a Wi-Fi chip on it and functions perfectly well. The user has the ability to toggle between GSM, 3G and Wi-Fi. How is this different from having LTE and 700 MHz Wi-Fi operating on the same device? We are not talking future development; it is current development and in use in the field now. The same principal will also apply in 700 MHz. LTE is future technology and 700 Wi-Fi can be easily incorporated in the reference design of a handset. 700 MHz antennas supporting

MIMO are the same whether it is LTE or Wi-Fi. An RF antenna does not know the difference in the protocol. This means, a handset that has 700 MHz antennas configured for MIMO will work just as well with an 802.11n chip that is operating in 700 MHz range when connected according to design.

16. Similarly, Flow Mobile's one-of-a-kind 700 MHz Wi-Fi devices will not function on visited LTE networks unless equipped with dual technology – and this would be the only way interoperability could take place. This also would be highly unlikely and more expensive even if achievable.

As explained above 700 MHz Wi-Fi on an LTE handset is as simple as putting Wi-Fi on any GSM/CDMA/3G handset in the market today. It has already been done. Skype calls on an iPhone or iPod Touch today can be made today. Why would this addition on an LTE device be that expensive? 700 MHz Wi-Fi is not a totally new standard or technology, it is Wi-Fi converted to 700 MHz.

17. Flow Mobile has stated that the FDD & TDD incompatibility and interoperability will be solved by the manufacturers of the handsets and consumer devices. Their claim is that it would require the addition of a $5 chip.

The fundamental argument that handsets will solve TDD & FDD incompatibility is false. Where is the reason to solve the problem? 700 MHz Wi-Fi networks, as deployed by Flow Mobile, will be in one frequency and the side of the handset that deals with Wi-Fi will associate to those BTSs. This is similar to a Wi-Fi chip on a GSM/3G phone. GSM is on quad band and operates in TDMA. 3G is usually in the 2.1GHz band and depending on the version, uses the particular brand of CDMA or other technology, and Wi-Fi directly associates with APs in 2.4GHz band. All of them can operate on the same device; the user simply toggles between them. The Flow Mobile explanation of the $5 chip is associated with the addition of the chipset to the handset that is operating on 700 MHz LTE. We don't believe that LTE and Wi-Fi can be deployed in the same frequency block. The thought of deploying two networks in the same frequency block is not a possibility and is absurd.

18. In practice there would be little market force to drive device manufacturers to make a specialized 700 MHz TDD Wi-Fi and FDD LTE device. Volume commitments and scale are required to drive device manufacturers to develop devices. To commence service, Flow Mobile would only have a PC card that is proprietary to their network, developed for a small scale and thus with potentially high

R&D costs per unit, and manufactured by and as yet undisclosed vendor, with no real hope of this scale ever improving with time. These will later need to be replaced either with LTE-only devices – likely all that will be available for several years or perhaps with specialized LTE/700 MHZ-Wi-Fi devices, again potentially expensive due to the small market scale. This will significantly increase the cost for the state. Frankly, device vendors are in the process of committing their resources to produce LTE devices for the Public Safety market nationwide, since public safety community has embraced this technology. It is exceedingly doubtful that any manufacturer would produce a specialized, dual technology LTE/Wi-Fi 700MHz device with just the small scale of even a 12 state rural market let alone North Dakota.

The argument on the TDD and FDD has been addressed several times in this document. This particular point brings forth the thought that somehow the R&D associated with developing a Wi-Fi based device will be much higher than that of an LTE device. This is ridiculous.

There is a false statement made regarding the LTE devices for public safety that are currently being built. At the recently concluded standards board meeting of NPSTC, it was clearly stated that LTE devices currently being built do not include devices for band class 14 which covers 5 MHz channels to cover the PSST spectrum and the D-Block. There is no investment being made to address this particular requirement for Public Safety. Hence a statement that says "**Frankly, device vendors are in the process of committing their resources to produce LTE devices for the Public Safety market nationwide, since public safety community has embraced this technology"** is completely false and a misrepresentation of the actual picture on the ground. There is no design available for these channels owing to the delay in the auction of the D-block and the use of the PSST spectrum and therefore there is no question of resources being committed to produce handsets. This fact is in the discussions at NPSTC and the meeting minutes reflect this fact.

www.rrmediagroup.com/newsArticle.cfm?news_id=4517 shows a press release which documents the discussions between vendors and Public Safety on the Band Class 14. In one quote, ***"There are a lot of unknowns around band 14, so until it's resolved, we don't know for sure," said an Ericsson official.*** This was in response to a question of adding Band Class 14 to the currently planned LTE devices so Public Safety can get economies of scale.

We would also like to address the "proprietary" part of the discussion. Wi-Fi devices, as stated above, have been produced abundantly. A down-converted Wi-Fi device is produced by adding one component on the board. This does not make the entire process proprietary. In reality we are an open standard where any manufacturer

without requirement of special licenses can manufacture handsets. It fosters open competition without limits being imposed on the money the company needs to accumulate to pay the license holders of a technology to manufacture devices that operate on it. Our approach has the potential of revolutionizing the whole telecommunications industry into moving towards a more open approach. This triggers innovation as has been seen in the Wi-Fi market. Consumers benefit from this type of innovation.

Our approach has been to build a dual-use network. There are 130,000+ public safety professionals in the underserved states we will serve. There are a total of approximately 34 million people that live in these areas. This is the market we intend to cover. As simple concept like we are proposing, will catch on in the rest of the world once it is built.

The final statement surmises the attitude of some of these critics whose criticisms are being addressed in this document. Rural state concerns often get neglected at the national level. We fear the same course will occur should the discussions on 700 MHz public safety focus on only one technology and other approaches are rejected even before the preferred technology can even be introduced into the market. The very reason for our mission in developing this approach is to make sure these states are not neglected anymore. States like North Dakota have been made islands where communications infrastructure is abysmal compared to the rest of the country. Our approach is to change the situation.

II. Simultaneous support of or smooth migration <u>to LTE is highly unlikely if not impossible:</u> (the Roman Numeral II is from the original document we received)

19. Wi-Fi is TDD (Time Division Duplex, where one channel is used to support both the uplink and downlink by using the channel part of the time for one and rest of the time for the other). LTE as deployed in the US and most of the rest of the world will be FDD (Frequency Division Duplex, where downlink occurs on one channel simultaneously with the uplink on another). The two do not interoperate well in any simultaneous deployment and require separate spectrum; even then it requires difficult frequency planning and isolation:

This statement has been discussed at length and the requirements on the guard band usage, filters, beam-forming smart antenna systems, all of which could help mitigate the interference, have been addressed. It has also been clear that TDD is the most efficient way to use spectrum and with the latest techniques it is possible to create isolation necessary to mitigate any interference. The document that discusses this was

presented to the FCC with respect to WiMax and Wi-Fi back in 2001. It is currently available on the FCC website for review: www.fcc.gov/pshs/techtopics/tech-interop.html

We believe the FCC has considerable experience in the matter and since it addressed this very effectively in the past it would do so going forward. We believe that interference mitigation is a subject that has advanced considerably and our solution addresses all the needs for this deployment. We occupy 4 MHz channel as opposed to the entire 5 MHz, thus, in any band, we have the ability to allow for 1 MHZ guard band on either side. This, combined with a beam-forming system, is enough to mitigate adjacent channel interference.

With respect to the last statement that "it requires difficult frequency planning and isolation", difficulty in building something cannot be the reason for giving up on building it, especially in the case of a network for a state like North Dakota or any of their neighboring states. Our approach is one of finding engineering solutions. In cases where we will see potential interference problems, we are willing to work with the operators of adjacent channels to mitigate such interference. This has also been specified by the FCC.

20. The Upper 700 MHz channel plan in the US is intended for FDD operations and FCC prescribed signal limits at the market borders were intended for neighboring FDD operations. Neighboring FCC and TDD systems are very likely to interfere. This is because, even if signal levels are kept to the FCC-prescribed limits at the market borders, during the period of the time that TDD transmitters on a prescribed FDD uplink channel are transmitting their downlinks, these powerful base station transmitters mounted high up on towers will swamp neighboring, highly sensitive base station receivers on the same frequency, also mounted high up on towers, intended to hear tiny signals from low-power mobiles at the surface full time on that channel. While the signals arriving at the border from the TDD transmitters may be of marginal level for useful communications with their mobiles, they will be plenty powerful by a large margin, even when travelling well into neighboring market, to interfere with the FCC receiver's ability to hear. Flow Mobile is thus likely to cause harmful interference to neighboring FDD LTE networks.

According to the critics whose opinions are documented here, TDD and FDD cannot coexist on borders is a false statement. Power restrictions and creating micro and pico cells can easily mitigate the issues brought up in the previous argument. Interference always works both ways. There is no benefit to our BTS interfering with other's BTS on the border since we will experience the same. Our BTS will be at an average height of

80 feet and not several hundred feet as expressed in the previous point. Hence this argument goes back to whether we have confidence in the FCC to implement and require certification of products using standards they set to operate in these frequencies or not even try because one side has decided to go with a standard that is not complete and does not even have a plan to support the 700 MHz band class 14 that is critical to public safety. We believe that we should listen to the issues facing the middle of the country, the underserved and unserved, which does not typically get the latest technology, service or gadgets. It is shameful that these places in the United States are behind many developing countries on the type of technology they have access to. The interference caused as discussed here is along the borders when two companies are using the same spectrum. Interference is caused, in those cases, if two different companies have license to use the spectrum. The effort and the spirit to mitigate is the important factor to prevent harmful interference, not that TDD and FDD are incompatible next to each other.

The other aspect that seems to be ignored is that if we go by these arguments, we have to deploy FDD systems only in the entire 700 MHz block! This makes innovation on a TDD system which is widely accepted as better use of spectrum almost impossible. Accepting a TDD system and placing the onus on the company deploying the system to find ways to mitigate interference created is a better approach than just ruling things out right completely. There can be no development if all of us use the one single system and say there is no reason to have choices. Technology innovation creates choices for people and increases a choice for consumers. This is fundamentally why we have several search engines. If we were to decide that Google has done an excellent job in searching the web and other search engines cataloging pages in the web could increase the traffic on the web and hence we should stop such cataloging, there would be no competition! It leads to monopolies.

21. For similar reasons, Flow Mobile's technology is likely to cause harmful interference with attempted LTE deployments in the neighboring D Block, by a future D Block auction winner in partnership with PSST. If the D Block ultimately goes to auction, the likelihood of harmful interference and interoperability issues with the existing system will chill private interest in the ND D Block for anyone having done proper due diligence on it prior to the auction.

This statement can be classified as fear mongering. No engineer or business will stop buying spectrum if it is lucrative for their business because of fears like interference. FCC has mitigated interference between adjacent channels before and will have standards to mitigate interference now as well. This thought that the FCC will not be able to solve this issue and that it will somehow impact North Dakota is unfounded.

22. **LTE defines both AAS (mentioned earlier) & MIMO (Multiple Input, Multiple Output) as acceptable spatial diversity techniques for multiplying channel capacity. AAS uses an array of several antennas in close proximity and pattern-correlated in such a way as to be able to create narrow beams and nulls dynamically with the signal from a single transmitter that is phased differently for each antenna by a processor. This permits it to be able to focus on a user's direction and reject interference as long as it is coming from a different direction. "2x2" MIMO on the other hand uses two transmitters on the same channel at the same time, each with its own antenna and transmitting separate, uniquely coded data stream representing half of a user's data. The antennas are arranged in such a way as to create identifiable differences in their transmit energy patterns, and are said to be "anti-correlated". The receiver also uses two anti-correlated antennas and two receivers, and through processing is able to sort out the two arriving streams and to add them back together to nearly double the otherwise single path throughput capacity of the channel. By also being able to adapt the MIMO signals quickly to change in multipath, as described earlier fro subcarrier assignment, LTE is thus properly suited for a high speed mobile environment.**

23. **While both MIMO and AAS are prescribed by the standards bodies, 2X2 MIMO will be deployed in US not AAS. Besides a controller software changeover to support MIMO, Flow Mobile's proprietary AAS will require at the minimum another horizontally separated antenna (by ten wavelengths or approximately 13 feet) or otherwise anti correlated antenna (such as a dual-polarity antenna) at each site, and another radio for it, to provide MIMO to LTE devices – Thus doubling the electronics and antenna system costs at that time, besides the LTE development costs discussed above.**

The statements above are confusing and baseless. Although we have not completely released specification of our product to the market, such conclusions as articulated in the above have no basis. Our current beam forming system has six antennas spaced on a circle of 60 centimeters. This system will also enable, via a SW upgrade, to double the downlink capacity by using our SDMA technology, which is built into our system. That is, the base station will be able to transmit two different data streams to two

different users simultaneously in the same frequency. Flow Mobile never claimed and does not plan to provide MIMO to LTE devices. It is absurd.

- **Wi-Fi's OFDM requires subdivision of the available spectrum into narrower traditional radio channels (into which groups of OFDM subcarriers are deployed) along with sufficient (unused) guard bands in a channel frequency re-use pattern, or else in time (neither of which is efficient). Even with all of PSST's spectrum plus the Narrowband allocation, there is no room for even one traditional 20 MHz-wide Wi-Fi channel. There would scarcely be enough spectrum to accommodate even two non-standard 10 MHz wide Wi-Fi channels for any sort of a re-use pattern. (For example if you've ever set up a Wi-Fi wireless router, you've noticed that you must make a separate channel selection from any other nearby wireless router.) Flow Mobile is demonstrating their technology to ND with an FCC special Temporary Authority (STA) for a contiguous 22 MHz of spectrum spanning part of the D Block, PSST's downlink allocation, the NB downlink allocation, two guard bands and part of Verizon's C Block. In practice, if their waiver request was granted they would have far less then this – two 12 MHz segments at the most (assuming permitted use of the guard bands separating the PSST and Narrowband allocations), which likely will have to be further divided and re-used among base stations. More likely four 5 MHz channels would have to be used, and thus much lower possible throughputs would result – less than fourth of that of a traditional 20 MHz Wi-Fi carrier that they could demonstrate under STA with contiguous 22 MHz of temporary spectrum. 5 MHz of traditional Wi-Fi would deliver only around 6 mbps maximum of net (actual pay load) aggregate (uplink plus downlink) throughput, to be shared among users on each channel.**

There are several false statements above. We will address them separately below:

1. The first statement that is false is that 10-MHz Wi-Fi channel is non-standard. "**There would scarcely be enough spectrum to accommodate even two non-standard 10 MHz wide Wi-Fi channels for any sort of a re-use pattern."** As you can see from the IEEE 802.11 standard allows for 5 and 10 MHz operating channel size as a part of the standard.
2. The STA from the FCC was for 16 MHz 760-776 and not the other bands as described in the statements above
3. The 5 MHz of Wi-Fi as tested by Flow Mobile is capable of delivering upwards of 8 mbps and 16 mbps with SDMA.

Hence, Flow Mobile does not require several of the Wi-Fi channels as described with the example of a home router. Wi-Fi implemented in 700 MHz is an open standard capable of operating in 5 MHz channels.

- **With LTE OFDMA's ability to manipulate individual subcarriers within a channel however, all base stations can transmit on the entire spectrum**

allocation (channel) at the same time, requiring no re-use pattern. Throughput efficiency (in bits per MHz of channel width) increases with wider channel widths. For comparison, given the same amount of spectrum (a pair of 10 MHz wide channels, one for uplink and other for downlink), LTE could routinely achieve 25 Mbps of full-time (not aggregate) downlink net throughput, with peaks approaching double that.

As stated earlier, we are not disputing that LTE could, at a future time, provide high throughputs when implemented (whenever that may be). We would like to compare apples to apples for throughput comparison. As explained above our SDMA capability enables us to double the downlink throughput so that we can provide 16 Mbps on a 5 MHz channel. In the future, with the MIMO capabilities of the Wi-Fi standard, we plan to double this throughput and reach 32 Mbps.

- **More importantly, OFDM and OFDMA will not co-exist; each would require its own spectrum or a coordinated sharing of the spectrum in time between two technologies, which is highly inefficient.**

We never suggested that we implement LTE and 700 MHz Wi-Fi in the same spectrum block. That would not work for any technology. Licensed spectrum is purchased by an entity so they can implement a technology of their choice while adhering to the FCC guidelines. We have picked 700 MHz Wi-Fi because of its cost-effective nature and ability to deliver what is required in these states. Coordinated sharing of the spectrum, interference mitigation etc. are the rules that FCC implements based on the industry guidelines.

- **Wi-Fi OFDM technology is very similar to that of 802.16-2004, OFDM based Fixed-WiMax technology. The fact that no mobile devices for Fixed-WiMax have been developed since its release in 2004 is telling, as is the fact that the WiMax-Forum chose to endorse a new and incompatible OFDMA-based technology for Mobile-WiMAX – 802.16e-2005, very similar to LTE. Even with both being TDD, Fixed and Mobile WiMax still are not interoperable for the same reasons that Flow's Wi-Fi technology and LTE's OFDMA-based technology are not interoperable.**

The fact is that OFDM is the best way to deliver high data rates and to allow for multipath. OFDMA is a form of OFDM that has its trade-offs with OFDM. The interoperability between two networks is not the interoperability between two BTSs.

- A phone call made from a user connected to a 700 MHz Wi-Fi BTS will reach the user that is connected to a 700 MHz LTE BTS.
- A text message, MMS, etc. sent by the same user will reach the destination.

This is the Interoperability defined by FCC. The misleading requirement that two modulation schemes be compatible has nothing to do with user interoperability; both can coexist and interoperate as explained above.

- **LTE devices worldwide will use removable Subscriber Identity Module (SIM) in the device and a SIM server for user authentication. This is important for authentication of visiting Public Safety users, and the ability to be authenticated on other Public Safety LTE networks when roaming. A Wi-Fi network would require special adaptation to user devices and its network authentication system to support this.**

Flow Mobile has said that we will equip our users with a device that will be authenticated on an LTE network. We will give our users LTE/Wi-Fi devices when LTE devices become available with Band Class 14 support. Hence, these devices will also have SIM cards that will be authenticated on the LTE networks when our users roam. When a LTE user comes to our territory, we will have our authentication system recognize the user on our system through reading their Wi-Fi connection as a registered device. There is no need for an LTE vendor to add Wi-Fi MAC and other authentication methods since there will be SIMs in all devices.

- **Unless Flow Mobile's infrastructure and devices support dual technology, to migrate to LTE, a hot cutover and replacement of all devices is required.**

This statement is making the assumption that an LTE/700 MHz Wi-Fi device is not possible. Once we have an LTE/700 MHz Wi-Fi device, there is no need for any change in device. As explained through this document, we will work towards the development of such device.

- **If hot cutover is required, there are far better interim, time-proven and widely available solutions, such as 3G on a major carrier network (such as the interim EVDO approach that the City of Boston has proposed).**

We would not be having this debate if states like North Dakota could afford to spend $700M for a public safety or even a dual use network. No carrier is ever going to spend that money to cover the entire state. The current coverage is spotty at best and pathetic at worst. A 3G based technology, for coverage alone, would cost over $700M for the State of North Dakota according to a study that was submitted to the CTIA. This approach is not a practical one. However, the objections rose so far about the strength of Wi-Fi will multiply multi-fold on 3G. First, it is a CDMA based technology. If OFDM based technologies are so much better, why go back to a CDMA based technology (if that is what the author is proposing)? If $700M is easy to find to build a network in North Dakota, why is it that no one has received funding to build such a network?

- **If it requires hot-cutover and/or separate equipment and spectrum, it is not interoperable, nor is it smooth migration**

Already addressed.

III. Flow Mobile proposes use of Public Safety narrowband spectrum.

- **This defeats interoperability efforts already underway for P25 use on these channels – the last line of defense for voice communications. The claim that ND Public Safety does not have use for narrowband channels now is short-sighted at best: Once neighboring jurisdictions deploy public safety voice networks using narrow band spectrum, ND will be at a disadvantage.**

This was addressed above. North Dakota and other rural states are at a disadvantage because the national requirements are not financial feasible. As stated earlier, there would be no need for narrowband spectrum to be a consideration if the fallow PSBL and D Block could be made available. There is sufficient spectrum and it is preferable to support public safety broadband communications in these bands and the narrowband spectrum will not be necessary.