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EXECUTIVE SUMMARY

Evaluation of Comcast's Subscriber System

Evaluation of the Existing Institutional Network

Evaluation of PEG Access Signal Transport and Distribution

North Suburban Communications Commission

(Arden Hills, Falcon Heights, Lauderdale, Little Canada,
Moundsview, New Brighton, North Oaks, Roseville,
St. Anthony and Shoreview, Minnesota)

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I. Introduction

As part of the past performance review and needs assessment being conducted by the North Suburban Communications Commission (NSCC), CBG Communications, Inc. (CBG) has been retained to provide technical, consulting and engineering services to evaluate Comcast's residential network, the Institutional network and CTV's Public, Educational and Governmental (PEG) Access signal origination, transport and signal distribution over the cable system and dedicated transmission links.

CBG's overall goals were to evaluate Comcast's compliance with the member cities' franchise documents, and applicable laws and regulations, and to determine the condition of equipment and infrastructure and the operation of this infrastructure in three important areas. These are:

- **Comcast's residential (subscriber) network**
- **The Institutional Network (as required by the member cities' franchise documents)**
- **CTV's PEG Access signal origination, transport and distribution system**

CBG has conducted evaluation tasks, testing and processes to determine the existing condition of Comcast's residential network and its ability to deliver services to residents of the ten member cities effectively, reliably and in a safe manner, consistent with the requirements of the franchise and applicable laws and regulations. In addition, CBG has evaluated the Institutional Network (I-Net) to determine its ability to meet the needs of current users for both video origination and data transportation, both today and into the future. CBG has also worked with NSCC and North Suburbs Access Corporation (CTV) staff to review the current technical operations, equipment and facilities of CTV's Media Center and Master Control to determine the functionality and quality today of the PEG signal (audio, video and other information) transport and distribution system and what will be needed to meet future demands and technologies placed on the related facilities, equipment and systems.

The major findings and recommendations of CBG's review are outlined in this Executive Summary, with more detailed information, supporting data and recommendations that will be provided in a Final Report.

II. Summary of Major Findings related to Comcast's Residential Network

Comcast is operating a Hybrid Fiber Coaxial cable (HFC) network that is designed to provide video (Cable TV), Internet and data services and telephone services to most addresses within the 10 members cities comprising the NSCC service area.

CBG reviewed many facets of the subscriber network, including bandwidth (or capacity), system architecture, system performance, system maintenance and monitoring, and system facilities. A high level summary of each of these areas is provided below.

- **System Design and Architecture**

Comcast's system uses fiber optic infrastructure to send and receive signals to/from nodes located in neighborhoods, throughout the NSCC area, where forward (or downstream) signals are transformed from light, on the fiber optic infrastructure, to Radio Frequencies (RF) for insertion onto the coaxial cable infrastructure for ultimate transmission and distribution to residents and businesses served by the particular node. Forward (or downstream) services include all analog, standard definition (SD) digital and high definition (HD) digital channels including Video-On-Demand (VOD). Additionally, Internet data, traveling from Comcast's headend or hub to subscribers, and telephone or voice service to subscribers is carried on the forward/downstream portion of the network. In addition, the nodes receive RF signals from subscribers via the coaxial infrastructure which feeds these signals into the node. The node converts these signals to light for transmission, via the fiber optic infrastructure, to Comcast's headend or hub. Some return signals include upstream data, ordering information for VOD and other video services as well as telephone traffic.

- **Spectrum or Bandwidth**

Although other system characteristics described in this Executive Summary are important to understand, perhaps the most important is that of system capacity or bandwidth. Comcast's system, as designed and operated today, has a total usable spectrum of 5 MHz to 750 MHz. Simply stated, the system is a 750 MHz system. Further defined, return (or upstream) signals are transmitted between 5 MHz and 42 MHz while forward signals are transmitted between 55 MHz and 750 MHz.

This system was considered at or near state-of-the-art when it was last upgraded in the late 1990s. However, systems being upgraded today are using equipment capable of between 860 MHz and 1,000 MHz (1 GHz). Although this system is not the most advanced system constructed, it is consistent, in terms of bandwidth, with many systems throughout the country.

It is difficult to describe the maximum number of channels, or services, that can be provided on the subscriber network, as the bandwidth utilized for specific channels and services can be determined at the system level. For instance, compression technologies allow for Standard Definition digital TV channels (SD) to commonly utilize one 6 MHz channel to transmit between 7-12 SD channels. Furthermore, 2-3 High Definition digital channels occupy a one 6 MHz channel. In addition, the system is configured and used to provide non-cable TV services, including telephone and Internet service which occupy a portion of the system's bandwidth.

The system, as constructed, equipped and operated today, can provide the services desired by Comcast's customers. However, as more services become available (particularly high definition video programming services) and as subscribers' needs and desires increase, Comcast may need to upgrade its system, depending on the length of any franchise renewal term, to gain additional bandwidth in order to provide these new services. Such upgrades could include using new electronic equipment to increase the system capacity to 1,000 MHz (1 gigahertz or 1 GHz), deploying fiber to the premises or home (FTTP or FTTH) as well as utilizing technologies that conserve bandwidth such as

Switched Digital Video (SDV). The NSCC should, in a renewed Franchise with Comcast, require a mid-term review of the system to determine if it is still capable of meeting the community's cable-related needs and interests, and providing the needed bandwidth for new services that become available in the future.

- **System Facilities**

Comcast serves the NSCC area from its headend located on Fairview Avenue in Roseville, MN, and its hub located at 4640 Churchill Street in Shoreview, MN. Comcast personnel gave us a tour of these headend and hub facilities. The overall condition of these facilities was clean, well kept and with sufficient space for future expansion without having to compromise spacing needs for cooling and maintenance functions. The headend is among the better designed and maintained headends we have toured. Grounding of equipment in various locations throughout the headend and hub is more than adequate for protection of the equipment and personnel having to perform maintenance. Fire suppression systems are professionally installed throughout the two facilities and appeared to be sufficient to protect the building and its contents from fire. Both facilities have backup power provided by large permanent generators, Uninterruptible Power Supplies (UPS) and battery banks. This combination of backup power should allow for seamless transfer between commercial power and backup or standby power in the event of a power failure at the headend or hub. The generators are capable of operating for days or weeks in the event of a lengthy commercial power outage.

- **System Performance**

CBG began its analysis of Comcast's system performance by reviewing the most recent Federal Communication Commission (FCC) Proof-of-Performance (POP) test documents (Summer 2010 and Winter 2011). These documents are required to be stored in Comcast's Public File and are available for anyone to review. This documentation is only required to show testing of analog channels on the system. CBG determined that the results for all test locations within the NSCC service area, as documented in Comcast's Public File, are within FCC specifications. When a system is operating at or above the

minimum specifications required by the FCC, the picture and sound quality on analog channels should be acceptable to subscribers.

In addition to reviewing the previous POP results, CBG accompanied Comcast personnel who performed objective testing of 10 locations within the NSCC service area - one location per member city. Test results were at least at or better than the Federal Communication Commission's FCC minimum requirements at 8 out of the 10 locations. In Arden Hills, the system's Carrier to Noise (CN or C/N) tests were below the FCC's threshold of ≥ 43 dB. Carrier to Noise is a measurement of the ratio of noise on a given channel compared to the channel's video carrier strength. As this ratio decreases, the picture on analog channels will display more noise or have a snowy appearance. As would be expected, when FCC carrier to noise specifications are not met, the picture quality on the analog channels at these locations was significantly below acceptable levels. A lower than desired Carrier-to-Noise ratio can impact digital channels as well, but the results at this location were not severe enough to impact the digital channels. Comcast performed maintenance activities to balance the plant feeding the testpoint shortly after our testing. Subsequent testing found results well with FCC specifications and the picture quality improved on the analog channels.

The New Brighton testpoint also showed test results outside the requirements of the FCC's minimum technical standards. We observed C/N results below the minimum required by the FCC. Comcast performed trouble shooting activities shortly after our testing was complete. It was determined that a section of coaxial cable was likely damaged during road construction which caused deterioration of the cable over time and ultimately led to the poor performance we measured and witnessed. Comcast replaced the suspect cable. We then retested and found performance had improved and was now within specification.

CBG also accompanied Comcast in performing tests of representative digital channels on the system. This testing found that Comcast's system, at all 10 testpoint locations, is operating well within the specifications adopted as standards by the FCC.

- **Analog Channel Reception / PEG Access Channels**

As part of our testing, CBG viewed the analog channels on a television set at the headend and at all 10 testpoint locations to determine through subjective testing what, if any, signal quality problems currently exist. The main focus of the test was on analog channels as they are the most prone to problems within the system. Digital signals are typically either on or off with few if any distortions added by the network outside of undesired attributes that can be introduced as a result of significant compression of channels to conserve bandwidth. However, when distortions and noise are significant enough, pixilation and picture freeze-ups can occur.

Our observations found that, in general, the analog channels were of an acceptable viewing quality. However, it must be noted, the overall quality of the analog channels is not as crisp or void of noise as that found on the digital channels. This is to be expected. Comcast simulcasts all of the PEG channels on the system today. In other words, PEG channels, as well as other channels offered in an analog format, are transmitted on the system in both analog and standard definition digital formats. As a result, the PEG services provided as analog channels are not as clear as those provided over the digital platform. However, the analog PEG channels are consistent in quality with the analog commercial channels. Accordingly, subscribers utilizing a digital converter box will not notice the lower quality on the analog channels, since the converter always tunes to the digital format version of the PEG and other simulcast channels.

The one exception to the above statements regarding analog channels is Channel 18, programmed by the Roseville Area School District. Our viewing of Channel 18 at all 10 locations showed that Channel 18 is affected, to varying degrees, significantly more than the other analog channels, and specifically PEG, channels. This is likely due to ingress or undesirable signals getting onto the system. Comcast needs to address this issue on a site by site basis as problems are reported or discovered, but should provide a strategy for minimizing this problem system-wide. For instance, Comcast could require its technicians and installers to visually check channel 18 at all service calls and installations. When issues with the picture quality are apparent, the technician or installer

should then perform the necessary troubleshooting to determine the cause of the problem and make the correct repairs. This may include replacement or tightening of connectors and the replacement of cables to name a few possible solutions.

- **Standby Power**

Standby power provides the system with the capability to remain operational when commercial power is lost for any period of time. Comcast employs several backup power methodologies, from the headend and hub to the power supplies located on the distribution system in the field.

Comcast has large backup generators located at both the headend and hub. These are designed to provide enough power to keep the headend and hub operational in the event of a power outage at these locations. In addition, because there is a lagtime of several seconds between the loss of power and the generator coming fully on-line, Comcast also has large banks of batteries that are designed to provide power to all headend equipment that operate on -48VDC while continually being recharged as normal procedure. When power is lost, these battery banks will continue to provide power, without any outside power, for a minimum of 8.5 hours. For all critical equipment that operates on 120VAC power, Uninterruptable Power Supplies (UPS) are in place to run this equipment until the back-up generators are operational.

Comcast has power supplies located on the distribution plant to provide power to the nodes and amplifiers used in the field. These power supplies are equipped with batteries that provide backup power in the event of a commercial power outage. Based on information provided by Comcast, these power supplies are capable of running, without commercial or other power sources, for a minimum of 6 hours. This run time will increase based on lower power needs at some power supply locations.

Our review of Comcast's documentation does not indicate a large number of outages or an overall pattern of longer than acceptable repair times when outages occur.

- **Status Monitoring**

Comcast has deployed numerous tools to monitor the operation of the network in real-time. These tools monitor all of the cable modems in the system showing areas of the system that are not responding and that, therefore, are experiencing an outage. Other monitoring tools provide data on the performance of the network. For instance, the signal to noise ratio or C/N and other distortions can be measured and monitored throughout the system via cable modems at subscribers' homes and businesses. Other monitoring tools can measure the health of power supplies in the system and alert Comcast when issues arise that need further troubleshooting and repair. These tools can provide Comcast with data showing where problems occur and often times staff can react to, and repair, problems before the network user knows of the problem.

As stated above, Comcast employs several tools to perform ongoing monitoring of its residential network. These tools are at least comprable to monitoring systems in place in other cable systems throughout the country.

- **Compliance with the National Electrical Code (NEC) and National Electrical Safety Code (NESC)**

CBG performed an independent system drive-out to note any problems with the system plant and drops to residences and businesses pertaining to the condition of underground and aerial appurtenances, grounding and bonding, as well as clearance and attachment issues. If a system is not properly maintained, problems will arise with the aesthetics of the system, but more important, such issues result in potential safety problems. In addition to appearance and safety issues, the integrity of the cable plant is important for proper operation of the network and its ability to deliver high quality signals in a reliable manner.

CBG performed an inspection of a representative sampling of areas throughout each of the 10 member cities. During this sampling, we identified approximately 300 issues that are either violations of NEC or NESC codes or are simply outside of good engineering practices. Examples of our findings include:

Cable TV drops not properly attached to poles. – This creates aesthetic problems as the drops are hanging away from the pole, in some cases several feet, but more importantly these drops can create a tripping or entanglement hazard to the general public as they come in contact with the cables. Furthermore, these cables often times are in what is referred to as the climbing area of the pole. This area is to remain clear in order to provide a safe area of the pole for cable TV and other technicians to climb up to equipment fastened to the pole.

Down guys that are missing, loose or dangling from the pole. – Poles at the end of a run, or where the cables and wires angle off must have a guy wire or down guy to help support and carry the tension from the pole to the ground. Failure to install or properly maintain down guys places additional stress on the poles in question and leads to early failure of the pole(s). In addition, if additional stress is applied to the cable or wire run, such as a pole being hit by a vehicle or ice loading on the cables and wires, one or more poles that would otherwise handle the additional stress may fail without the additional support supplied by the missing or loose down guy. Down guys not properly attached to the pole or anchor can lead to safety problems if the poles become stressed more than usual because the tension placed on the poles is not carried to the ground. Failure of the poles also creates the potential for failure of the Cable TV system as well as the systems of other providers occupying the poles.

Underground drop cables exposed above ground – When an underground drop is first put into service, often times it is not immediately buried. Prior to burying the drop, other utilities must locate their facilities and a crew must be engaged to perform the task of burying the drop. In addition, once the ground has frozen for the winter, drop burying ceases until the spring thaw. These delays in burying drops are understandable. However, there appears to be an unusually large number of drops that are not completely or even partially buried in the ten member cities. This is even more common in the case of multiple dwelling units or apartment building areas.

Having drops lying above ground creates a tripping hazard to people walking in the area. In addition, if the drop is caught on a person's leg or is tangled in a lawnmower or snow thrower, the customer fed by the drop will likely lose service until the drop is repaired.

Power supply and service boxes not locked – All power supplies and the service boxes (fuse boxes) must be locked. Comcast has a significant number of power supplies with built in locks. These appear to be locked in most instances. However, there are also a significant number of power supplies and their corresponding service boxes that do not have permanent built in locks. Many of these are not locked as is required by code. The purpose of having power supplies enclosed in a cabinet is to keep water and debris out. In addition, these cabinets keep unauthorized people out of harm's way by blocking access to power that is harmful or fatal if a person comes in contact with it. Providing locks on the access doors further deters people from accessing the potentially dangerous contents of the power supply.

There are other, less frequent violations of codes that will be listed and described in the Final Report. It is important for the NSCC to require regular system inspections by Comcast and timely repair of issues and code violations that are found.

The NSCC should require Comcast to provide a detailed inspection and repair plan which addresses these and all issues and code violations in the NSCC service area. Documentation of these inspections and repairs needs to be provided to the NSCC on a regular basis, perhaps quarterly.

Residential Network Conclusions and Recommendations

Comcast's system as it is designed, built, equipped and maintained provides many services to its customers with some ability to add new services and react to subscribers' growing desire for additional services. However, there are areas for the NSCC to focus

on and address in the short term as well as into the future during the term of a renewed franchise. Some of the highlights include:

- **System Design and Bandwidth**

As subscribers' desires and needs increase over time, the system's bandwidth or capacity may need to increase. It is difficult to predict what bandwidth needs will be in just a few years, let alone over the course of a 10 year or longer franchise term. For instance, DOCSIS cable modem technology now allows the operator to expand available Internet access speeds and throughputs by utilizing additional channels or space on the system. Furthermore, new services will come along and the number of high definition services or channels will continue to increase as this becomes even more the preferred, if not demanded, means of TV watching.

As previously mentioned, possible methods of minimizing the impact of additional bandwidth needs include upgrading the system to 1,000 MHz, upgrading the system to FTTP architecture and deployment of SDV. These and other options should be reviewed and considered as part of a Franchise mid-term technical review.

- **Analog Channel 18**

The NSCC should work with Comcast to identify the cause of grainy or snowy pictures on the analog version of Channel 18. Based on those findings, Comcast should be required to implement a solution that will bring the quality of this PEG channel in line with the quality of all other analog channels on the system.

- **Regular Inspection of Infrastructure**

Comcast must be required to maintain its system infrastructure in a safe manner and ensure they protect the public as well as technicians and others that must enter the areas around cable TV infrastructure. The NSCC should require a maintenance program designed to regularly inspect all cable TV infrastructure with documentation provided to the NSCC detailing problems found, dates found and repaired and the ultimate resolution.

III. Summary of Major Findings Related to the Institutional Network

CBG worked with the NSCC, CTV staff and I-Net users to gain an understanding of the current state of the I-Net, how it is performing, what changes need to be made and the perceived value of the network.

- **Background Information**

The I-Net serving CTV and the member cities of the NSCC is comprised of two, primarily separate yet related, networks. Comcast provides a fiber optic based network that offers connectivity to approximately 26 locations, including the ten member cities' city halls and municipal buildings, Ramsey County libraries, school district buildings, and the T.I.E.S. building. CTV, NSCC and the institutions provide all of the end user equipment required to light up or activate the fiber optic portion of the institutional network.

In addition to the fiber optic based network, Comcast also provides a HFC based network that utilizes fiber optic infrastructure to send and receive signals to/from nodes located at each of the city halls in the NSCC franchise area. At each of the nodes, forward (downstream) signals are transformed from light, on the fiber optic infrastructure, to Radio Frequencies (RF) for insertion onto the coaxial cable infrastructure for transmission and distribution to institutions served by the particular node. Forward (downstream) services include all analog video programming channels and data transmissions to institutions using the HFC system for data transport. In addition, the nodes receive return (upstream) RF signals from institutions via the coaxial infrastructure which feeds these signals into the node. The node converts these signals to light for transmission, via the fiber optic infrastructure, to the CTV Master Control. Some return signals include upstream data and video origination services.

- **Fiber Optic I-Net**

The fiber optic based I-Net is used at approximately 26 locations today. Based on our discussions with NSCC and CTV staff, and staff representing the libraries, schools and cities, the fiber I-Net that is in place today is serving a significant data transportation need

for its users. It was made clear that the services and applications enabled by this fiber optic I-Net need to remain in place going forward with the ability to expand and enhance these services as needs dictate.

NSCC will need to plan on upgrading the equipment utilized to activate the fiber I-Net over the course of a renewed franchise as bandwidth needs increase and as the existing equipment hits its end-of-life.

- **HFC I-Net**

The HFC I-Net offers (utilized full time or part time) services to approximately 18 institutions and 10 remote locations such as the Roseville bandshell and along parade routes in Roseville, Shoreview, Little Canada, New Brighton, etc. The HFC I-Net is used for data communications at approximately 8 of these locations and is utilized for video applications at the remaining locations. The HFC I-Net fills a significant need for sites generally having lower bandwidth needs than the sites connected via fiber on the fiber optic I-Net. Furthermore, the HFC I-Net allows for connections at virtually any location along the coaxial cable portion of the system. This provides significant flexibility for live productions to be transported back to the CTV Master Control facility for insertion on the subscriber network in one or more of the 10 member cities.

I-Net Concerns and Recommendations

The NSCC requested documentation from Comcast showing historical records of maintenance and testing of the I-Net over the period from January 1, 2006 to December 31, 2010. Comcast's response was that it has no report, records, data or documents responsive to this request. In addition Comcast indicated that no testing was performed during this period. Based on the lack of testing of the HFC I-Net and lack of documentation, it is not possible to determine whether the I-Net has performed in accordance with the agreed upon technical standards defined in the franchise. Comcast did provide outage data for the I-Net. The data provided shows numbers of outages and service degradation to be at a level that would be expected from an HFC based network. The current HFC I-Net was last upgraded over twelve years ago. However, the

amplifiers in use today date back to the 1980s. Some of these have been in operation for nearly 30 years. Therefore, we recommend that, if this HFC I-Net is to be utilized going forward, these amplifiers be replaced rather than hoping that over the course of a renewed franchise term of 10-15 years, they will continue to operate successfully. In addition, many of the power supplies in operation on the HFC I-Net, date back to around 2000. These power supplies will have reached their end-of-life prior to the end of a renewed franchise. Indeed, some may have already reached end-of-life.

Another issue, if it is determined that upgrading the HFC I-Net infrastructure is an option to explore, is that the headend electronics, and in particular the cable modem system would need to be replaced. The current LanCity cable modem system was state-of-the art in the mid to late 1990s. It has not been manufactured or supported by the manufacturer for approximately 10 years. Furthermore, the maximum throughput or bandwidth of this equipment is, and will continue to be, less than what end users will require going forward.

The NSCC should work with Comcast to ensure that the services, and flexibility, offered by the HFC I-Net remain in place over the course of a renewed Franchise term. This likely will not include having Comcast continue to operate and maintain the HFC I-Net as it is built today. Alternative options that allow for transport of data and specifically video over data need to be explored with Comcast.

Some potential solutions for the continued network availability and functionality provided by the HFC I-Net going forward are described in the PEG Access Signal Transport and Distribution section of this Executive Summary.

IV. Summary of Major Findings Related to PEG Access Signal Transport and Distribution

CTV provides playback and master control functions from its Roseville offices for all of the public access channels, as well as for many of the government and educational access

channels, and aggregates the signals for the channels/entities that do their own playback. All of this access signal origination from CTV's Roseville facility is directly connected via fiber to the Comcast headend in Roseville through Comcast's Converged Regional Area Network (CRAN or C-RAN). The C-RAN is a regional interconnect used to transport all of Comcast's video, voice and Internet traffic around the Twin Cities to the various hub locations. This network is used, in the case of PEG programming, to transport services to the Roseville headend and the Shoreview hub for insertion onto the subscriber system serving the member cities.

Beyond this, there are fiber I-Net connections from all of the local government members of the NSCC providing programming from their main City Hall locations, as well as fiber connections from the Roseville Schools, St. Anthony Schools and Moundsview Schools. Additionally, the HFC I-Net provides both frequent and occasional connectivity from a variety of locations throughout the NSCC area, including: Northwestern University, the Roseville Band Shell, Central Park and other locations. Both remote trucks also tie into the HFC I-Net to provide live signal origination from various locations throughout the NSCC area.

Comcast provides access to an interconnect that utilizes infrastructure put in place as part of the C-RAN to provide the NSCC and other local franchise authorities to share video, voice and data services. This interconnect is commonly referred to as the PRISMA network. The equipment used to activate the network has a manufacture's name of PRISMA. Regarding the region-wide interconnect over the PRISMA system, CTV is a primary hub between various access entities throughout the Twin Cities area. This PRISMA interconnect system allows CTV to share programming (both send and receive) with these various entities. It also allows CTV to route around NASA programming, which is first downlinked at Comcast's Roseville headend and then provided through the dedicated CRAN fiber to CTV for further distribution across the interconnect.
A review of these various signal transportation systems revealed the following concerning needs and interests for the future:

- **Access Signal Origination via Fiber Optic Connections**

These connections from fixed locations throughout the NSCC area needed to continue in order to provide programming from the various local governments and school districts to CTV to be further distributed on the access channels. However, these connections are currently provided in a SD (Standard definition) format. In order to meet the needs assessed, they will need to be converted to an HD (high definition) format. This will require upgrading the equipment on both ends (both at the local government and school district signal origination site and at the CTV receive site) in order to enable HD transport.

Similarly, the multiplexed, aggregated, feed from CTVS' offices to Comcast over the C-RAN, currently provides signals in an SD format. Here again, the equipment on both ends (at CTV and at Comcast's Roseville headend) needs to be upgraded in order to provide HD transport.

In each case, this includes upgrading encoders and decoders (for a higher HD encoding rate) as well as optical transport equipment (HD requires a higher transfer rate, and potentially some different multiplexing gear so additional colors of light may be utilized) in order to enable HD signal transport.

- **Upgrade of the HFC I-Net or Replacement with an Alternative**

The HFC I-Net has experienced both some reliability and maintenance issues, as more specifically detailed earlier in this Executive Summary. Since remote video origination also needs to be able to facilitate HD transport, the HFC I-Net will need to be upgraded to provide highly reliable, higher capacity connections. This would enable remote origination in HD for productions provided through use of each of the remote production trucks, or the use of portable "mini-mobile" production equipment (the encoders currently in use by the trucks, as well as that recommended for the mini-mobile unit, would need to be upgraded to HD transport as part of each of these solutions).
One possible method to meet the data transportation needs currently being fulfilled by the HFC I-Net is to implement a high capacity DOCSIS 3.0 cable modem system that would

enable a minimum of 27 Mbps to be provided upstream on the HFC I-Net. Another possible method is to convert the HFC I-Net for all sites that are frequent remote origination sites (such as the Roseville Band Shell) to fully fiber optic connections. These would then be provided with the same transport equipment and system recommended for the upgrade of the existing fiber I-Net which would further satisfactorily enable HD transmissions.

Another alternative for these and other sites on the current HFC I-Net is to provide "nomadic" DOCSIS 3.0 business class modems on the residential system. This could also enable HD transport from those current HFC I-Net origination sites. This would further provide a potential access origination feed from literally anywhere on the subscriber network. An issue here that would need to be addressed from the beginning of a renewed franchise, is the need to give these modems priority so that a high capacity video signal could be delivered without contention or interference from other business class cable modem users.

One other possibility would be to establish a wireless system for signal transport between remote locations and CTV's offices. This could be established in a variety of ways. For example, digital microwave technology could be employed that provides enough capacity for HD transport. This would most likely require microwave send facilities to be added to both production trucks, receive antennas either at the Comcast headend or at CTV's main offices and potentially one or more repeater antennas to be established on tall buildings or towers throughout the NSCC franchise area.

Another, relatively new way would be to establish a 4G cellular (WiMax or other) connection for the remote production trucks and the portable mini-mobile facility through the chosen cellular carrier's network CTV's offices. There is also a relatively new system that will chain 3G links together to provide the necessary bandwidth. Here again, priority "quality of service"(QOS) would need to be established so that other cellular users would not contend for the high capacity, real-time bandwidth needed. This

approach would most likely incur a significant recurring charge with the cellular carrier or at least an occasional surcharge when the circuit is actually in use.
Even if wireless methods are chosen because of their high degree of flexibility to be used anywhere within the NSCC franchise area, we recommend that there always be an alternate wireline solution.

- **Upgrade of the PRISMA Interconnect System**

The current capacity utilized on the PRISMA interconnect system between CTV and other access entities in the Twin Cities has functioned well for both video and data communications across the region. However, with the advent of HD transport between and among entities, it will be necessary to upgrade the PRISMA interconnect as well. Our understanding is that there is significant excess capacity available within the current PRISMA equipment chassis and across the fiber transport links from hub to hub. However, this capacity is gated so that CTV currently is able to only use 20 – 30 Mbps of transport capacity. We believe that at least 50 Mbps per entity, per segment, needs to be dedicated, up to a total limit of 250 Mbps, that can be utilized within the 1 Gbps connection. This should provide significant capacity for HD video as well as data communications.

All of the above findings and recommendations will be explained in more detail in the Full Report.