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Technical Review of the Comcast Cable System Serving Seattle, Washington

By

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Introduction and Background

CBG Communications, Inc. (CBG) has, at the request of the city of Seattle (City) performed a technical review and physical inspection of the Comcast system serving the City. The primary goals of our review were to assess the extent of compliance with applicable codes and standards and determine the over-all effectiveness of Comcast's Plan of Correction for National Electrical Safety Code (NESC) and National Electrical Code (NEC) Violations on Utility Poles in the city of Seattle as outlined in its letter to the City dated March 14, 2006. To this end, CBG inspected a representative portion of the Comcast cable system in the city of Seattle to inspect and audit the cable system's physical plant and gain an understanding of the system's compliance with construction and safety codes as outlined by the NEC and NESC and required by the Franchise with the City and the Seattle Municipal Code.

In addition, the scope of our review included touring Comcast's headend and hub facilities to determine the overall ability of these facilities to offer services to residents of the City in a highly reliable manner as well as to oversee performance testing of the system by Comcast personnel. CBG also assessed information supplied by Comcast (see Appendix A) in response to an initial Information Request (IR) developed by CBG, and sent by Tony Perez Director, Seattle Office of Cable Communications to Comcast in September 2008. CBG analyzed a number of documents related to the Comcast system, including FCC required system testing and certification information and other documentation.

CBG received information from Comcast during a site visit in October 2008. Included was a letter dated October 20, 2008 from Comcast to Dick Nielsen, Senior Engineer for CBG with many of the system's operating parameters and characteristics, subscriber numbers, headend and hub locations as well as logs of signal leakage, outages and trouble calls. Comcast also provided additional information and explanation throughout our visit and did not deny us any requested information that was pertinent to our fully understanding the technical operation of the system. We subsequently reviewed this

information which gave us the baseline to proceed with the audit of Comcast’s system serving residents and businesses in the city of Seattle. CBG has reviewed the information provided by Comcast and worked with Comcast’s technical and engineering staff to tour Comcast’s facilities and conduct performance testing of the system and presents the following findings and recommendations.

Findings

System Design Characteristics

- **Spectrum**

As stated in the Comcast October 20th documentation, the Comcast cable system has active and passive devices capable of passing a minimum of 750 MHz. This means that the highest usable frequency in the downstream direction, as designed and built, is 750 MHz with an active return operating between 5 MHz and 40 MHz.

CATV Band	Analog Channel Assignment*	Frequency Range
Sub Band	T7 – T13 (Return)	7 – 47.5 MHz
VHF Band	2 -22, 95 – 99	54 – 216 MHz
Super Band	23 – 36	216 – 300 MHz
Hyper Band	37 – 62	300 – 456 MHz
Ultra Band	63 – 158	457 – 1,002 MHz (1.002 GHz)

*Digital services can be inserted throughout the entire spectrum.

However, Comcast is transmitting signals in the downstream direction from 55.25 to 775.26 MHz. This means that Comcast is using spectrum that the system was not designed to pass; that being between 750 MHz and 775.26 MHz. The impact of using spectrum outside of the design parameters of the system is that it can lead to signals rolling off (signal levels are lower than desired), which potentially leads to the channels or services carried in this bandwidth to not work. Using spectrum outside of the system’s design parameters has been done by operators that do not have sufficient bandwidth

available on their networks to transport the number of channels or services they desire to offer to their customers. Comcast's use of the return spectrum of 11MHz to 34 MHz to transmit signals back to the headend from subscribers is similar to other two-way HFC systems.

Comcast is using the forward spectrum from approximately 55.25 MHz to 553 MHz to primarily transmit analog signals totaling approximately 73 channels. Then spectrum from 553 MHz to 775 MHz is utilized to transmit digital services including: standard digital channels, High Definition Television channels (HDTV) and music channels.

At present, Comcast has utilized all of its current available bandwidth. Indeed, Comcast is transmitting signals outside of the designed bandwidth of some of the equipment in place in its Seattle system today in order to add services to its lineup that would not be available without using this spectrum. In effect, this suggests that more bandwidth is required. Many cable systems, including Comcast systems such as Denver Colorado, have fully upgraded to a capacity of 860 MHz or 870 MHz (specifically, 50-860 MHz or 870 MHz in the forward direction, with 5-40 MHz or 42MHz in the reverse direction). Furthermore, some systems that are being upgraded today are increasing system bandwidth to 1 GHz capacity as this equipment has become more readily available. One example of this is Cox Communications' upgrade of its systems to a minimum of 860 MHz and 80% of the homes they pass will be 1 GHz enabled by the end of 2010. By today's standards, 860 MHz to 1 GHz is considered to be the state-of-the-art upgrade, and such a system provides significant capacity for a wide variety of analog, digital and advanced services.

Comcast has deployed some equipment in its system that will allow utilization of the bandwidth between 750 and 870 MHz. However, based on the existence of amplifiers in the system designed to only 750 MHz, Comcast cannot utilize this additional bandwidth throughout the City without upgrading this 750 MHz equipment to gear that has a frequency passband of 870 MHz or higher equipment. A pertinent analogy is that a chain is only as strong as its weakest link. In other words, the system as a whole can only operate successfully at the lowest top frequency (750 MHz) available throughout the system, so the benefits of the upgraded portion of the system are not realized. Comcast

does have forms of bandwidth recovery and redeployment available to it today that could be used in the future. One such method of recovering bandwidth is the deployment of Switched Digital Video (SDV). SDV operates in much the same manner as VOD whereby a channel is not broadcast to all subscribers but rather is transmitted as a video stream only when one or more subscribers elect to watch it. Comcast, over time, will likely replace its analog channels with digital channels freeing up more bandwidth. A channel transmitted in digital form requires as little as one tenth of the bandwidth of a single analog channel.

An increasing number of systems are being built as fiber to the home [FTTH] systems. Examples of this are Verizon's FIOS network and the Utah Telecommunication Open Infrastructure Agency (UTOPIA) system. Because they are building networks from scratch, it is cost effective to build it entirely with fiber optic infrastructure. These systems are capable of providing a much greater capacity into individual residences than current HFC systems facilitate; however, because a total rebuild or overbuild of the existing system, including the drop to subscribers' homes is required, these FTTH systems continue to be more expensive to implement than upgrading existing HFC systems, and while emerging, are not yet the majority form of implementation in the industry.

- **Facilities**

Comcast serves the City, and neighboring communities, from its Burien headend. We were provided a tour of the headend facility by Comcast personnel. The overall condition of the headend 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 is more than adequate for protection of the equipment and personnel having to perform maintenance. Fire suppression systems are professionally installed throughout the headend and appeared to be sufficient to protect the building and its contents from fire.

The headend building has backup power provided by two 800 KW (800,000 Watts) 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. The generators are capable of operating for days or weeks in the event of a lengthy commercial power outage. The hub locations have backup batteries capable of providing power for several hours with quick connection points for connecting portable generators in the event that a commercial power failure lasts an extended period of time.

- **System Architecture**

From the headend, fiber optics feed nodes located throughout the City. These nodes convert the signals from optics on the fiber to electronic signals on coaxial cables that then feed subscribers' homes and business locations. Signal strength diminishes as it passes through coaxial cables and therefore amplifiers are utilized to increase the signal level to provide sufficient signal strength to televisions as well as cable and telephony modems connected to the network. This system architecture is known as a hybrid fiber coaxial (HFC) cable system, which is the major form of distribution architecture employed today by the cable industry.

Comcast built the Seattle system with an architecture of optical nodes plus five amplifiers. This means that customers have no more than 5 amplifiers in cascade between their location and the node. Amplifier cascade is an important design characteristic as each amplifier adds distortions and noise to the system and as an active device, offers a point of failure. A five amplifier limit is consistent with current state-of-the-art HFC systems.

Another architectural component indicative of a state-of-the-art system is the number of homes passed per system node. This design specification varies widely in the industry, from as little as 125 homes per node to as many as 1200 homes per node and more (although such large nodes typically incorporate the ability to be subdivided to smaller node sizes over time by making greater use of existing or spare fiber capacity to the node and placing additional forward and reverse electronics within the node and at the headend). Comcast serves City households from nodes throughout the City. Based on the number of homes passed and the number of nodes shown on maps provided by Comcast, the Seattle system has just under 900 homes passed per node with

approximately 500 customers on average served from each node. This number of customers per node is on the high end as compared to other systems in the country. Node size is important because the fewer customers per node, the higher the effective bandwidth per home in both the return and forward directions. Higher effective bandwidth allows for greater provision of services by Comcast, such as Video-on-Demand, and services that will continue to require more bandwidth to and from the home such as high speed data-over-cable (cable modem) services. The more homes sharing a node will also decrease the internet speeds available to users during peak times.

- **System Performance**

CBG began its analysis of Comcast's system performance by reviewing the most recent FCC Proof-of-Performance (POP) test documents (Winter and Summer 2008). CBG determined that the results for all 17 test locations within the City, shown below, 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.

Comcast Seattle System FCC Proof-Of-Performance Testpoint Locations

- | | | |
|-----------------------------------|--|-----------------------------------|
| 1. 2812 Westlake Ave N | 2. 3138 Fairview Ave N | 3. 2821 10 th Ave W |
| 4. 3203 W Bertona St | 5. 101 N 77 th St | 6. 2900 Alki Ave SW |
| 7. 5503 S Othello St | 8. 212 E Martin St | 9. 9402 Merton Way S |
| 10. 14300 35 th Ave NE | 11. 1000 NW 125 th St | 12. 2117 NE 77 th St |
| 13. 406 NW 45 th St | 14. 2548 57 th Ave SW | 15. 11007 2 nd Ave NW |
| 16. 4305 NE 60 th St | 17. 7424 92 nd PL SE
(Outside City limits) | 18. 11305 12 th Ave NE |

Analog Channel Reception

As a portion of our testing, CBG viewed the analog channels on a television to determine what, if any, picture quality problems currently exist. The main focus of the test was analog channels as they are the most prone to problems within the system. Analog signals are prone to show deterioration when signal levels are below or above standard anywhere on the network whereas digital signals are either on or off with few if any distortions added by the network.

During our oversight of proof-of-performance testing of the system, we found a problem that affected three of the nodes in the City we tested and likely many more. The carrier to noise ratio was below the FCC standard of ≥ 43 dB on these nodes. 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 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. In particular, the lower analog channels from channel 2 to approximately channel 24 were very snowy due to carrier to noise measurement results as low as 41.8 dB. The remaining analog channels also showed varying degrees of snowiness. These substandard results were found at the following locations:

- 9402 Merton Way South
- 3019 South Andover Street
- 1700 24th Avenue

The testing of the three locations above occurred on the first day of system testing with Comcast. Comcast personnel subsequently changed to a different existing fiber optic cable leading from the headend to the hub. Upon retesting these locations on our final day of testing Comcast had fixed the Carrier to Noise measurements to fall within FCC specifications. A subsequent check of the picture quality found a significant improvement on all channels and specifically on the lower analog channels.

- **Network Standby Power**

Comcast indicates their entire network is outfitted with backup power serving the system nodes and distribution system. Their backup or standby power supplies would be capable of operating for approximately four to six hours during a power failure, therefore allowing the network to continue operating. In this case, subscribers would not notice a change in their service unless these batteries ran out of power.

Adequate standby power is key to maintaining a reliable system now and into the future. High capacity, automatic backup power is extremely beneficial to cable systems by helping to promote a high degree of system reliability. Comcast's availability of backup power throughout its system is consistent with what is found in current state-of-the-art HFC cable television systems.

- **System Status Monitoring**

Comcast is utilizing various methods of status monitoring in the headend, hubs and distribution system, as well as monitoring of cable modems in customers' homes. These monitoring tools apprise Comcast personnel of potential and existing problems in the network that may affect customers. These tools watch over the powering of the network from the headend to the distribution system and notify personnel if commercial power is interrupted. Other monitoring tools document signal quality at cable modem locations and alert Comcast personnel of less than designed system operation. This combination of system monitoring is consistent with industry standards and other cable TV systems that are offering advanced services such as Internet and telephone. These monitoring tools allow Comcast to react to problems as they develop and often times prior to subscribers being affected.

- **Signal Leakage**

Comcast is required by FCC rules and regulations in 47 CFR Part 76, Sections 76.605 (a)13, 76.611 (Cable television basic signal leakage performance criteria) and 76.614 (Cable television system regular monitoring) to comply with Federal rules and regulations related to signal leakage within the cable system. Excessive signal leakage can result in interference problems with emergency radio services, other government and

public safety communications and aeronautical navigation radio (aircraft navigation and radio systems). Also, wherever signal leakage (egress) is present, it also provides an opportunity for signals to enter the network (ingress) that will interfere with video, data and voice communications provided over the cable system.

Our review of Comcast's annual FCC Cumulative Leaking Index (CLI) filings from 2008 and Leakage Repair Logs indicates compliance with FCC regulations. Specific to the FCC CLI filings, Comcast used a "fly-over" (airspace) measurement methodology for its required annual CLI test, and arrived at a value of 99.9600% (points \leq 10 microvolts/meter). These test results are better than the FCC requirement of 90% under this test methodology. We recommend that future CLI filings be forwarded to the City for its review so that the City is continually aware of how the system performs pertaining to system leakage in the future.

System Construction, Installation and Maintenance

- **National Electrical Code and National Electrical Safety Code**

- **System Grounding and Bonding**

A system must be grounded properly to provide a path to ground for stray voltages such as lightning or power conductors coming into contact with the cable system. In a similar manner, the distribution system and drops must be bonded to other utilities in order to ensure all have an equal ground. If one ground is better than the others there may be a difference in electrical potential between the systems, thereby producing a shock hazard if both utilities are touched at the same time. Code requirements for grounding and bonding of cable TV networks and drops are required by the NEC and NESC.

- **System and Drop Clearances**

A cable TV system must be designed and maintained to have proper clearances between its facilities and the ground as well as between cable lines and equipment and facilities owned by other utilities and companies such as City owned power and telecommunications lines and lines and equipment owned by phone companies. These

clearances must be maintained throughout the entire network including the drop to the residence as required by the NEC and NESC.

Equipment and lines installed or maintained with insufficient clearances to the ground can result in people walking near the cable becoming tangled in the cable, thus causing a potential hazard to the person. In the case of lines over roadways and driveways, trucks can become entangled and tear the lines off of poles or homes creating damage to the truck as well as the pole or residence.

- **Field Survey Findings**

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 are the 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.

In August and September, 2004, Kramer.Firm performed a field survey of the cable system serving the city of Seattle to determine the level of the system physical plant and Comcast's compliance with the NESC and NEC. The Kramer Report issued to the City found:

- Numerous unlocked power supplies associated with cable telephony service
- Cable plant sagging into or below telephone facilities
- Abandoned plant left over from the rebuild (rebuild occurred between 1997 and 1999)
- Incomplete pole change-outs and abandoned telephone stubs
- Missing down guys and down guy guards
- Cable drops not grounded as required by applicable codes

- Improper clearances of cable drops from telephone and power facilities on homes and businesses
- Low drops over roadways and driveways
- Cut drops dangling from telephone poles
- Loose wiring and other general workmanship issues

After numerous correspondence between the City and Comcast, the City and Comcast agreed upon a Corrective Action Plan wherein Comcast staff were to have identified and repaired all system-wide code violations (including drops going to residences and pole attachment issues) not requiring coordination with the pole joint use community by December 31, 2007. Based on the number of issues found and repaired, as reported by Comcast in its Corrective Action Plan Reports, significant remedial work has been completed. However, based on CBG's findings during our field survey, there is still substantial work, as described below, that needs to be done by Comcast.

Considering the nature of a cable television system, including outdoor locations and being accessible by other utility workers and the general public, it should be noted that no system is or can be perfect regarding continuous complete code compliance. Even as an operator cures problems over time, new problems will evolve. However, a system operator must have the goal, and take necessary actions to continually maintain, its system to as nearly perfect as possible. This requires regular inspection, internal reporting of issues and violations found, and timely resolution of these issues. Overall, our findings indicate significant improvement since the 2004 Kramer.Firm Report as related to grounding and bonding at the residence. Specifically, the Kramer.Firm Report estimated "that approximately 10% of the subscriber drops (active and inactive) exhibit one or more grounding code violations". During the CBG field survey, we found fewer than 15 instances of grounding or bonding violations at residences, which would translate into fewer than 1% of subscriber drops exhibiting one or more grounding code violations. This indicates Comcast has improved this facet of installation and service at residences and, compared to other inspections we have performed, shows a high level of compliance

for grounding at the home. Comcast appears to have focused efforts on improving grounding over the past three to four years since the Kramer report.

Comcast still needs improvement in other areas, and must focus its efforts on inspection of its network and drops for all other violations of the NEC and NESC.

- Drop Clearance

Drop clearance to the ground is a sizable issue in the northwestern corner of the City, with drops as low as less than 12 feet over roadways when the NESC requires a minimum of 15 feet 6 inches. CBG noted approximately 28 locations, included in Appendix B, of drops below the NESC required 15 feet 6 inches. With the maximum clearance of trucks being 13 feet 6 inches, these drops are in danger of being torn down. In addition to damage to the reliability of the drop in question, there is also the potential for injury and damage to the truck, the residence and other facilities on the utility pole. A low drop from the pole or residence is also a tripping hazard for the public. Because of the prevalence of low drops, Comcast needs to fix this problem in the City. In addition to drops listed as non compliant with Codes in Appendix B of this report, there were numerous drops that were measured that make the clearance requirement, but only by 1 or 2 inches, potentially creating a problem in the future, as the headroom may dwindle because of ice loading, tree branches adding weight to the drop, a pole shifting slightly or in the case of a midspan drop, the span between the poles changing slightly over time. As Comcast cures problems with low hanging drops, drops that are a few inches within specification should also be addressed in a proactive manner.



14311 22nd Ave NE – Drop is only 13’ 5” over road. NESC Section 23 requires 15’ 6”

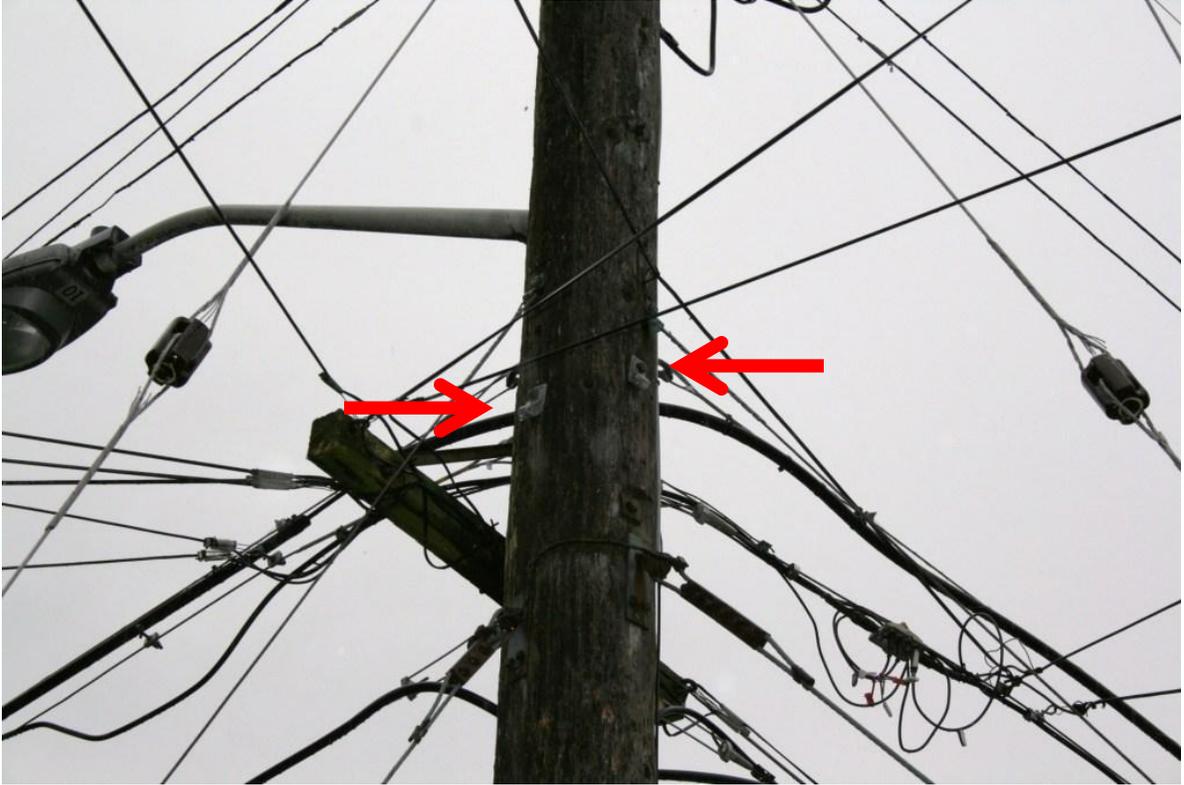
- **Power Mast Attachments**

We found approximately 80 instances where Comcast has utilized a power mast to connect the drop to a residence. This finding, when applied City wide, suggests a significant issue of non compliance with NEC Code 820.10 which only allows drops to be attached to masts not carrying power. In addition, many of these drops are too close to power at the home and therefore present a danger to Comcast personnel of coming into contact with power while installing or repairing the drop. This issue needs to be addressed by Comcast with a plan to cure the existing violations and to ensure that installation of future drops are not made to power masts.



Cable TV drop attached to power mast.

There are also many incomplete pole transfers, missing down guys and missing down guy guards. Based on the Kramer.Firm Report and the subsequent letters from Comcast to the City, Comcast stated they were going to focus on fixing these problems throughout the City, but, except for bonding and grounding of subscriber drops, they have not to any appreciable degree. Comcast must develop a methodology, or improve on its current processes, that discover construction related issues such as these and includes a plan to make repairs in a timely manner.



Missing down guys

- **Power supplies**

CBG found only a couple of power supplies throughout the areas driven that have been locked and noted 18 power supplies that do not have locks which secure the electrical equipment inside the enclosures from entrance by unauthorized individuals. As pointed out in the Kramer.Firm Report, these power supplies are required by NESC Code 224B2c to be locked. Furthermore, as was also discussed in the Kramer.Firm Report, CBG found 9 abandoned power supplies still attached to poles in the City. Considering Comcast upgraded its plant eight to 10 years ago in all areas of the City, there is no reason for these supplies to still be in place. They take up valuable space on poles, can be unsafe to personnel working on the poles and are unsightly.



Loose down guy and missing guy guard



Unlocked power supply



Obsolete power supply (Power is disconnected)

Overall, we found that Comcast has fixed some of the problems pointed out in the Kramer.Firm Report. For instance, we found few remaining problems related to grounding and bonding of drops at homes and businesses. However, it also appears that Comcast may have overlooked other problems, for example, low hanging drops, drops attached to power masts, abandoned power supplies that remain on poles eight to 10 years after the upgrade and four years after the Kramer.Firm Report; the large majority of active power supplies not having locks; down guys and guy guards missing or loose; and low drops. Given that it has been over four years since the Kramer.Firm Report, Comcast should have corrected most of these problems before now.

In light of these deficiencies, we believe that it would be beneficial for the City to require further follow-up and timely completion of the action plan by Comcast in order to resolve its remaining issues with compliance to NEC and NESC Codes. Although Comcast has shown that inspections and repairs have been done over the course of a few years, too many issues still remain. Since Comcast has not corrected all the problems, the City

should require Comcast to systematically inspect, repair and report its findings to the City within a very short period of time. As this occurs, the City can re-inspect these areas to determine the level of compliance with codes.

Conclusions and Recommendations

Technical audits and reviews discover and determine compliance issues with existing Franchise requirements, as well as the potential need to upgrade a system or make other improvements that would provide technical and practical benefits to Comcast, the City and its citizens/subscribers. As detailed herein, we have determined some compliance issues that need to be addressed and resolved, and have also recommended some areas for enhancement. Based on this, we offer the following recommendations for action by Comcast and/or the City:

- 1. *Inspection and Resolution of Infrastructure Problems*** – The City should require Comcast to complete its required systematic, focused inspection of its cable TV plant serving residents of the City. It has been said that a cable operator cannot truly inspect its own plant. Outside inspectors such as Kramer.Firm or CBG are able to view a system with fresh eyes and detect obsolete power supplies on poles in excess of eight to 10 years, unlocked power supplies, drops attached to power masts, drops that don't have sufficient clearance over roads, missing and loose down guys and missing guy guards.

Comcast should complete its plan by inspecting the entire City for violations on the plant, including drops, and provide its overall findings within 6 months. In addition, Comcast should divide the City into quadrants and complete repairs of issues and violations found during the inspection, one quadrant per calendar quarter starting immediately and running concurrent with the system inspection. Comcast should then provide the City with a quarterly report showing which quadrant has been completed as well as the address of violations or problems found, the date found, actions taken to repair the problems and completion dates. The City should perform spot inspections of

each quadrant of the City, as Comcast completes its repairs, to determine the level of compliance with the NEC and NESC. The City should report violations found during these spot checks to Comcast.

We also believe the City should continue to inspect Comcast's plant, after the corrective plan is completed, on an annual basis until it is determined that Comcast has established a high level of compliance with the NEC and NESC. At that point, an inspection should be performed by the City every third year. We believe that such a focused effort will continue to spot physical plant problems and serve to resolve them in the quickest, most comprehensive manner.

2. ***System Capacity*** – Based on the top frequency limitation of some of its system distribution equipment, Comcast's system operational bandwidth is 750 MHz. By operating beyond the limits of the equipment, Comcast is providing a variety of services utilizing the current system as it is. However, exceeding the bandwidth specifications for equipment in its system will create problems concerning reliable provision of services that are transmitted above 750 MHz and will continue to serve as an inhibitor for providing new and additional services in the future. Accordingly, to meet the needs and interests of the City's residents for more and as yet unknown services going forward, as well as to ensure the highest quality and reliability of these services, Comcast will need to increase its bandwidth or the capabilities of its current bandwidth to provide capacity for new services. The City should also ensure that it maintains its oversight authority related to system review to determine when system enhancements and expansion are needed. Consequently, beyond resolving the current bandwidth limitations, at some point in the future the City should revisit the ability of the cable system to provide the services desired by the residents of the City in a reliable manner.

Appendix A

Information Requested from Comcast

The September, 2008 information requested included the following:

- A general description of Comcast's cable system serving Seattle, including:
 - Number of plant miles, by aerial and underground
 - Age and condition of the system
 - Number of homes passed
 - Number of subscribers
- A description of system operating parameters, including:
 - System operating bandwidth and bottom and top frequencies, both forward and reverse
 - Subscriber system tap drop specifications (tap output levels)
 - Typical signal levels at the input to the subscriber terminal device (TV or converter)
- Node tree and amplifier schematic indicating:
 - Headend and hub locations including a delineation of areas served from each
 - Node locations and fiber routing
 - Amplifier cascades
 - System boundaries
- System design end-of-line performance specifications indicating worst case values for:
 - Carrier to noise
 - Carrier to composite triple beat
 - Carrier to second order
 - Cross modulation

- The previous two (2) Proof of Performance documents
- The latest FCC Cumulative Leakage Index (CLI) test results.
- The last three (3) quarters of signal leakage logs.
- Outage logs with associated down-time, response time, and resolutions.
- Trouble call logs with response times, problem resolution times and resolutions.
- A copy of the Subscriber Complaint log for the past 12 months.
- A line materials and equipment list and specifications including:
 - Fiber node optronics
 - Trunk amplifiers
 - Line extender amplifiers
 - Feeder line taps and other passives
 - Trunk cable
 - Feeder cable
- A description of the current interactive capabilities of the subscriber network including operating specifications for return amplifiers.
- A description of existing network status monitoring systems.
- A description of current backup powering systems, including standby run times, for the headend, hubs and the distribution system.
- A description of construction practices including, whether, and what size conduit has been utilized for underground system installation.
- Headend and hub equipment diagrams showing signal flow from input sources (satellite receive dishes, off-air receive antenna, etc.) to the combining network and headend and hub output.
- A description of the local Emergency Alert capabilities of the system. Include the method of local access by the City to the system as well as the testing schedule.
- A frequency allocation chart for all services on the subscriber system that indicates current total system capacity, channels in use and services provided.

- An equipment list and specifications for all subscriber converters.
- A description of digital video and audio and cable modem technologies currently deployed over the subscriber network and the associated services provided to subscribers via these technologies.
- A complete description of any in-process or planned upgrades to the subscriber network, including, but not limited to: elements such as future capacity expansion; enhancements to reliability of the system; the timetable for completion; infrastructure upgrades.

Appendix B

Under separate cover

Comcast System Driveout Findings