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March 26, 2010

Mr. Joel Gurin
Chief, Consumer and Governmental Affairs Bureau
Federal Communications Commission
445 12th Street, S.W.
Washington D.C. 20554

Re: National Broadband Plan, GN Docket No. 09-51
Consumer Information and Disclosure, CG Docket No. 09-158

Dear Mr. Gurin:

The National Cable & Telecommunications Association (NCTA) shares the Commission's goal of providing consumers with additional relevant and meaningful data regarding the speed of their broadband connections and other appropriate network performance data. We agree that such information may help consumers to better choose among competing providers and choose the right plan for their needs.

The National Broadband Plan contains some sound recommendations for achieving this objective, including the use of third-party contractors and the creation of an industry/consumer advisory council. But the Plan also relies heavily on results obtained from online speed tests[1] to support its conclusion that there is a significant gap between the "actual" speed consumers experience and the "advertised" speed that providers offer. In this letter and in the attached report, we identify substantial shortcomings with using online speed tests to measure this purported gap.[2] We encourage the Commission, going forward, to focus on alternative measurement approaches that are likely to produce more accurate and meaningful data. We look forward to working with the Commission and other stakeholders on these important issues and offer the following in the spirit of constructive collaboration.

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[1] We use the term "online speed tests" to refer to web sites that measure the speed at which material from a test site on the Internet is sent or received by a consumer's computer.

[2] In addition, it is not entirely accurate to refer to a gap between "advertised" speed and "actual" speed as the Plan does. *See, e.g.*, Plan at 21. As NCTA has explained previously, because broadband speed is affected by so many factors beyond the control of the broadband provider, cable operators and other providers make clear in their advertising and other consumer materials that the speeds experienced by consumers will vary from the maximum available speed. *See* Comments of the National Cable & Telecommunications Association on NBP Public Notice #24, GN Docket No. 09-51 (filed December 14, 2009) at 7 (NCTA PN #24 Comments).

The Limitations of Online Speed Test Data

The National Broadband Plan includes an analysis of the importance of transparency in the retail broadband market. The Plan raises concerns about the information available to retail consumers regarding the "actual speed and performance of the service they purchase" but also acknowledges that attempts to measure such performance raise a variety of "difficult issues."[3] As discussed below, we support development of a common standard for measuring broadband performance and believe the Plan's recommendation that federal agencies work toward that goal with input from an advisory council of industry and consumer representatives represents a sound starting point from which to address these issues.[4] Similarly, we support the recommendation that the Commission contract with a third party to conduct a national broadband performance study similar to the approach taken by Ofcom in the United Kingdom.[5]

Given the Plan's acknowledgement that there is no standardized method of measuring broadband performance, it would appear that the Plan's conclusion that "actual performance experienced by consumers often is much less than the advertised peak speed" is more definitive than warranted by the record.[6] Indeed, the primary support provided for this conclusion is a citation to a "comScore database" that is "on file with the FCC,"[7] but that is not publicly available and has not been subject to peer review, as far as we are aware. Relying on undisclosed data and methodologies to reach such broad conclusions not only runs counter to the principles of transparency espoused in the Plan, but it also seems to contravene the Commission's own Information Quality Guidelines.[8]

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[3] CONNECTING AMERICA: THE NATIONAL BROADBAND PLAN (Plan) at 44,45.

[4] *Id*. at 45.

[5] *Id*.

[6] *Id*. at 21, 46. As the Commission consistently has acknowledged, "factors beyond the control of service providers may compromise the ability of service providers to report actual speeds experienced by consumers." *Development of Nationwide Broadband Data to Evaluate Reasonable and Timely Deployment of Advanced Services to All Americans, Improvement of Wireless Broadband Subscribership Data, and Development of Data on Interconnected Voice over Internet Protocol (VoIP) Subscribership*, Report & Order and Further Notice of Proposed Rulemaking, 23 FCC Rcd 9691 ¶ 36 (2008); *see also* Plan at 25, n.50 ("Note that speeds experienced by the end-user can be impacted by many factors including the user's own equipment, the service provider network, and the applications and sites being accessed online.").

[7] *Id*. at 64, n.54; *id*. at 64, n.34. The Plan also attempts to quantify the purported "gap" by comparing the average nationwide download speed from the comScore study to the average nationwide advertised speed, which appears to be derived from an OECD study and the Commission's Form 477. Plan at 21, 25, n. 47. Even if there were no flaws in any of the three underlying reports (which is not the case), the results of such a comparison are not meaningful unless the various studies all make the same assumptions about what providers, and what tiers, customers actually use. The Plan provides no information on the assumptions used in deriving these numbers, but it seems highly unlikely that all three reports made the same assumptions. The Plan also includes numerous cites to a report prepared by the Broadband team entitled "Broadband Performance" but that report apparently is "forthcoming" and has not yet been released. Plan at 24, n.4.

[8] *Implementation of Guidelines for Ensuring and Maximizing Quality, Objectivity, Utility, and Integrity of Information Pursuant to Section 515 of Public Law No. 105-554*, Information Quality Guidelines, 17 FCC Rcd 19890, 19896 (2002) ("data should have full, unbiased, reliable, accurate, transparent documentation").

As demonstrated in the attached report prepared by Peter Sevcik of NetForecast, Inc., the comScore data cited in the Plan suffers from a variety of problems and should not serve as the basis for concluding that there is such a significant gap between maximum speeds and "actual" speeds.[9] In particular, Sevcik documents a variety of data gathering errors in the comScore data, all of which "result in an underreporting of the actual speed delivered by an ISP on its network."[10] In addition, and perhaps more significant, he explains that comScore makes assumptions about the tier of service a customer has purchased that often are incorrect.[11] The net effect of these errors is that the comScore data understates the "actual" speed received by a customer and overstates the maximum speed the customer purchased, thereby creating a "gap" measurement that "is of extremely limited utility for determining the absolute value of a specific ISP's speed performance."[12]

NCTA has discussed the general limitations of online speed tests in a variety of submissions to the Commission, both in the National Broadband Plan proceeding and in earlier dockets. For example, in comments filed in June 2007, we stated that "we are skeptical that a [customer-initiated, online] speed test . . . can accurately account for the fact that download speed is affected by factors beyond the control of the broadband provider . . . ."[13] In our December 2009 comments in response to NBP Public Notice #24, we explained that "the varying nature of speed tests themselves may make them an unreliable basis for adopting specific conclusions or recommendations in the National Broadband Plan."[14] We reiterated these concerns in a February 2010 meeting with you and other members of the Broadband team, explaining that "a poorly designed speed test provides no useful information to consumers."[15]

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[9] *See comScore ISP Speed Test Accuracy*, Peter Sevcik, Principal, NetForecast, Inc. (March 2010) (NetForecast Report). One of NCTA's members purchased the data from comScore at significant expense and provided it to NetForecast for the purpose of this analysis.

[10] NetForecast Report at 1.

[11] *Id.* at 8-12. In the Plan, there is a suggestion that comScore confirmed its assumptions regarding customers' speed tiers by reviewing "a sample of bills in tandem with the FCC." NBP at 25, n.48. In the absence of any explanation of how this sampling exercise was performed, we are not in a position to address its validity or determine the extent to which it alleviates any of the concerns identified in the NetForecast Report.

[12] NetForecast Report at 1.

[13] Comments of the National Cable & Telecommunications Association, WC Docket No. 07-38 (filed June 15, 2007) at 7.

[14] NCTA PN #24 Comments at 6; *Id*. ("Speed tests conducted on the same computer at the same time will typically reveal varying results depending on which speed test is used. The different outcomes are largely the result of the design aspects of the particular speed test, such as the location of and load on the servers used for the test, the number of simultaneous threads or connections utilized in the test, the size of the files transmitted in the test, the protocols used in the test, the distance between the user and the test server, and the networks those servers rely upon. The variances in these factors can significantly alter a given speed test result.").

[15] Letter from Steven F. Morris, Vice President and Associate General Counsel, NCTA, to Marlene H. Dortch, Secretary, Federal Communications Commission, GN Docket No. 09-51 (filed Feb. 26, 2010) at 2 (NCTA Letter). The limitations we have identified do not mean that online speed tests are worthless. As we explained in our December 2009 comments, such tests can provide useful information to individual subscribers about their experience at a particular point in time. *See* NCTA PN #24 Comments at 4 n.11. But the results of such testing should not be considered a reliable measure of the performance of a subscriber's broadband connection as suggested in the Plan.

Indeed, in some cases speed test results may lead consumers to think they are experiencing problems with their broadband service even when the service is working flawlessly.

The Commission's recent experience with its own online speed tests provides further confirmation that these tests should not be viewed as tools to provide reliable measurement of broadband service offerings. Earlier this month, the Commission added links to two online speed tests – from Ookla and M-Lab – to the broadband.gov website. The Commission's preliminary analysis of data from those sites shows that there is wide variability in results between the two tests.[16] As explained in a blog post by Commission staff, part of the explanation for these disparate results is the distance a test message must travel to the test server.[17] But there are many other factors that affect the results of these types of tests generally, as explained in our December 2009 comments.[18]

NCTA appreciates your recent comments acknowledging the significant problems with the broadband.gov online speed tests.[19] The two steps that you have suggested – clarifying that the Commission does not endorse the test results and adding disclaimers regarding the accuracy of the test data – could ease some of the confusion that has been created if the Commission decides not to remove the tests from its website until it develops more accurate measures of broadband performance. Whether the Commission chooses to remove the tests or merely disclaim their results, it is critically important that it step up its efforts to provide consumers with "additional information regarding their home computer equipment and networks, as well as information regarding the performance of web sites and transport networks."[20] Given the significant role these factors play in a consumer's overall online experience, the Plan gives them

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[16] *See Consumer Broadband Test Update*, posted by Jordan Usdan, Attorney Advisor, Broadband Task Force (posted Mar. 17, 2010), available at http://blog.broadband.gov/?entryId=292153.

[17] *Id*. Part of the reason the Ookla service produces faster results is that it has more test servers and highlights the server(s) closest to the user. The M-Labs service uses fewer servers and does not make clear which test server will be used.

[18] NCTA PN #24 Comments at 8 ("the Commission must describe how the speed test accounts for factors beyond the control of the broadband provider, including factors specific to a subscriber's computer (*e.g.*, the presence of viruses, automatic updating, low memory capacity, processor capabilities, the type and capabilities of the operating system, the version and configuration of the web browser software used), factors specific to a subscriber's household network (*e.g.*, the presence and capabilities of a router, whether several computers or other devices are accessing the Internet simultaneously, whether and what type of WiFi is used, whether other devices, such as cordless phones or adjacent networks, are in use which may cause interference with WiFi devices, the distance from the consumer's computer to the WiFi access point, whether and what type of WiFi encryption is used), and factors specific to the testing websites a subscriber visits.").

[19] David Lazarus, *How fast is your broadband? Even the feds can't be sure*, Los Angeles Times (Mar. 19, 2010), available at http://www.latimes.com/business/la-fi-lazarus19-2010mar19,0,6447947,full.column ("'There might be more confusion for consumers than we realized,' responded Joel Gurin, head of the agency's Consumer and Government Affairs Bureau. 'We need to make it more clear that the FCC doesn't endorse these tests and that they're not absolutely reliable.'").

[20] NCTA Letter at 2. Some cable operators already provide such information on their web sites. *See, e.g.*, *Getting the Most from Your Comcast High-Speed Internet Service*, at http://customer.comcast.com/Pages/FAQViewer.aspx?Guid=ad45488f-d845-4db8-9e2b-7740252b3091&fss=speedtest (last visited Mar. 26, 2010).

minimal attention,[21] and offers little in terms of concrete recommendations for educating consumers about how they affect broadband performance.

Alternative Approaches to Measuring Broadband Performance

Given the shortcomings of the comScore data and the significant variability in the Commission's own online test data, NCTA encourages the Commission to avoid basing any policy decisions on the results produced by these or other online speed tests that fail to account for factors beyond the control of broadband service providers. This is not to suggest that the Commission should abandon its efforts to provide consumers with data regarding broadband performance. Rather, it is our hope that the Commission will avoid a rush to judgment based on flawed data and instead take the time to work together with broadband providers and others to develop meaningful metrics. The Commission should, as the Chairman recently stated, implement the National Broadband Plan through "[p]rocesses that are open, participatory, fact-based, and analytically rigorous."[22]

We think the National Broadband Plan has identified two key steps to moving forward on these issues in a positive direction. First, the Plan proposes that the Commission hire a third party to test for and prepare a report on broadband performance that is similar to a report prepared for Ofcom, the United Kingdom regulator, by a company called SamKnows.[23] NCTA supports that recommendation because we believe such tests, if conducted properly, should produce more meaningful data than the online speed test data discussed above. We note that the Commission already has issued a Request for Quotation (RFQ) in connection with this project and that proposals were due on March 25, 2010.[24] The RFQ seeks a "hardware-based" approach to testing in which a device is installed in a user's home to eliminate the bias that otherwise would result due to a slow computer or a slow home network.[25] The approach proposed in the RFQ appears to be fact-based and analytically rigorous, but it also should be open and participatory. Accordingly, the Commission should solicit public input on the testing process before finalizing the testing procedure. In particular, the Commission should consider what level of involvement by broadband providers is necessary to ensure that the process will not interfere with the normal operation of broadband networks; that it will achieve the desired result without confusing or inconveniencing consumers; and that differences in service offering tiers within and among broadband providers can be meaningfully accommodated. While NCTA is aware of the

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[21] *See* Plan at 25, n.50.

[22] Written Statement of Julius Genachowski, Chairman, Federal Communications Commission, before the House Subcommittee on Communications, Technology, and the Internet (March 25, 2010) at 4.

[23] Plan at 45.

[24] *See* Federal Communications Commission Request for Quotation for Residential Fixed Broadband Services Testing and Measurement Solution, RFQ-10-000013 (Mar. 12, 2010) at 7, available at https://www.fbo.gov/download/cb7/cb712eb3ef384ebe25bfbf6b0a5dfa16/RFQ_10-000013_dtd_20100312.pdf.

[25] *See* File RFQ-10-000013 – Questions and Answers dtd 20100322, Question 11 at 3, available at https://www.fbo.gov/download/b4f/b4f652dcb2692fe069c1de4da9b40aab/RFQ-10-000013_Questions_and_Answers_dtd_20100322.pdf.

expedited time frame that the RFQ process contemplates, even a short public comment period will enable the Commission to receive valuable input to better inform the process.

A second recommendation that the Commission should pursue is the development of technical industry standards and methodologies for measuring broadband performance.[26] To that end, the Commission should act quickly on the recommendation to encourage the creation of a Broadband Measurement Advisory Council ("BMAC") to provide input from industry and consumer representatives necessary to achieve the objectives in a meaningful and workable manner. Developing a measurement regime that is capable of producing data that will be helpful to consumers and enable them to make accurate comparisons among different broadband technologies will be a major challenge. Notwithstanding the technical expertise available within the federal government, the Plan appropriately recognizes that private sector participation will be necessary for such a project to succeed. Indeed, at this early stage of the process, the Commission should not rule out the possibility that voluntary compliance with standards established by the BMAC would eliminate the need for mandatory federal standards.

* * *

Cable operators have a strong track record of investing in their networks in order to provide high quality, high speed Internet access to their customers. They recognize the importance of developing improved methods of measuring broadband performance to better serve their customers and some companies already are working with third parties to develop tools that would measure the performance of a cable operator's broadband network. In addition, NCTA has been working with our member companies in an attempt to develop a common set of measurement standards that could be endorsed by the industry. We look forward to working with the Commission and other interested parties as these various efforts proceed.

Respectfully submitted,

/s/ Neal M. Goldberg

Neal M. Goldberg

cc: P. Bowen
B. Neal
M. Stone

Attachment

[26] Plan at 45.

comScore ISP Speed Test Accuracy

by Peter Sevcik
March 2010

As part of a suite of tests tracking many aspects of users' experiences on the Internet, comScore performs Internet service speed tests. The results of these speed tests are sold in the form of reports that document the relative rankings of ISP performance within markets. Recently, the FCC has used comScore speed test results as an absolute indicator of specific ISPs' performance. This study analyzes the accuracy of the comScore speed test methodology, and assess the appropriateness of using the data to reach conclusions about the actual performance ISPs deliver to their subscribers.

To fully understand the comScore speed test methodology and assess whether or not it accurately reflects the service delivered by broadband ISPs, the National Cable & Telecommunications Association (NCTA) retained NetForecast to perform an independent examination of comScore's technical and statistical methodology, and to analyze the comScore data to assess whether it accurately reflects the performance of broadband ISPs. This report describes the comScore testing methodology and the findings of NetForecast's investigation.

Executive Summary of Findings

NetForecast's investigation of comScore's ISP speed test methodology uncovered the following data gathering and data interpretation errors:

- Data gathering errors
  - Only one TCP connection is used
  - Client-server delay is variable
  - Participants' computers may be resource constrained
  - Test traffic may conflict with home traffic
  - Decimal math is incorrect
  - Protocol overhead is unaccounted for
- Data interpretation errors
  - Purchased speed tiers are incorrectly identified

All of the data gathering errors result in an underreporting of the actual speed delivered by an ISP on its network, and the individual errors create a compounding effect when aggregated in an individual subscriber's speed measurement. The result is that the actual speed delivered by each ISP tested is higher than the comScore reported speed for each result of every test. Although this report specifically addresses comScore's testing methodology and data analysis, with a few exceptions noted in the report, other broadband user speed tests are also prone to the same data gathering errors.

The data interpretation errors discovered are important because they cause the test results to overstate the disparity between the median actual and maximum advertised speeds. The problem stems from a flaw in the method for determining the advertised speed that often incorrectly bumps subscribers to a higher speed tier than they actually purchased, and effectively penalizes the ISP for having surpassed its advertised speed.

ComScore calculates the "average actual speed relative to the advertised speed" by dividing the consistently underreported speed delivered by a frequently inflated purchased speed. The combination of an inaccurately low numerator and inaccurately high denominator leads to a ratio that incorrectly shows ISPs delivering dramatically low performance relative to what they sold to their subscribers. The actual/advertised effective performance ratio based on this methodology is incorrect to such an extent that it is of extremely limited utility for determining the absolute value of a specific ISP's speed performance.

NetForecast Report NFR5103

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This report describes each source of inaccuracy in the context of how broadband Internet access services and the Internet in general operate. Broadband ISP technologies operate independent upstream and downstream channels; however, comScore only tests downstream speeds so this report focuses only on the downstream services.

comScore Speed Test Methodology

The architecture of the comScore speed test is shown in Figure 1. The test is automatically initiated by the comScore client software on the comScore panelist's PC every 18 hours. When the communications protocol stack is inactive, the client software connects to Akamai's content delivery network which discovers the test PC's location and assigns a server on the Akamai network for that test.

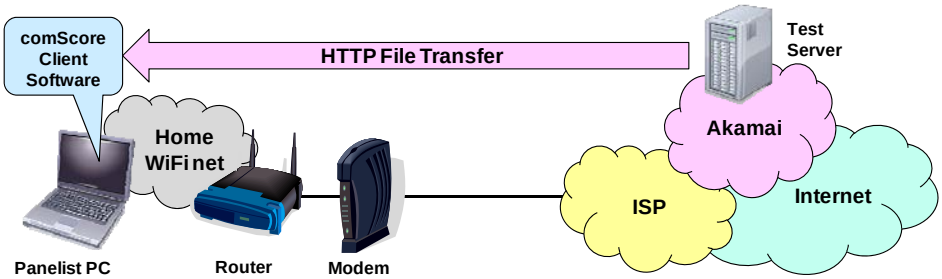


Figure 1 - comScore Speed Test Elements

ISP Identification

ComScore collects the IP address of each panelist machine, conducts a reverse DNS look-up to identify the domain associated with the IP address, and maps the domain to an ISP.

ISP Speed Test

ComScore's client software performs a speed test with the goal of one test every 18 hours that a machine is connected to the Internet. The measurement is taken during a time when the machine has an active connection and the network stack indicates that the machine is idle. A single download speed test measurement consists of at most four steps, depending on the type of connection for the panelist's machine.

Step 1
Two zero-byte tests are conducted to measure round-trip time and control for latency (delay).

Step 2
A 20KB file is sent to test if the machine is a narrow band or broadband machine. If the speed is less than 80Kbps, suggesting a narrow band connection, then no further testing is performed and the value for this preliminary test is registered as the speed test value.

Step 3
If the speed for this preliminary test is greater than 80Kbps, suggesting a broadband connection, a 512KB file is downloaded. If the speed for this second-tier test registers less than 500Kbps, then no further testing is performed, and the value for this second-tier test is registered as the speed test value.

Step 4

If the speed for the second-tier test is greater than 500Kbps, a larger file is downloaded based on the following table, and the value for this third-tier test is registered as the speed test value:

Speed Range Detected (rounded to nearest 100Kbps)	Step 4 Test File Size
500Kbps-1Mbps	1MB
1.1Mbps-2Mbps	2MB
2.1Mbps-3Mbps	3MB
3.1Mbps-4Mbps	4MB
4.1Mbps-5Mbps	5MB
5.1Mbps-6Mbps	6MB
6.1Mbps-7Mbps	7MB
7.1Mbps-8Mbps	8MB
8.1Mbps-10Mbps	9MB
>10Mbps	15MB

Speed Read Formula

The following formula is used to calculate the speed read (i.e., test result) value.

$$\mathrm{SR} = \frac{8TFS}{End - Start - \min(D_1, D_2)}$$

Where:
SR = Speed Read (Mbps)
TFS = Test File Size (MB)
End = Test end time (seconds)
Start = Test start time (seconds)
D_1 = First zero byte delay test to Akamai server (seconds)
D_2 = Second zero byte delay test to Akamai server (seconds)

Example

If a 15MB file (from above list in step 4) took 3.5 seconds to download (End - Start), and the minimum initial latency result is 0.5 seconds, then the results would be:

SR = (8*15,000,000)/(3.5 - 0.5) = 40,000,000 = 40.0 Mbps

Statistical Trimming

Speed measurements can be grouped by ISP, region, weekday, day part and a variety of other dimensions for any period of time (month, quarter, 6 months, etc.). A speed test indicates the effective speed achieved by the machine in downloading a file of known size. It does not indicate the maximum or minimum speed achieved during the download session.

Speed test results within +/- 6 standard deviations of the group average are used for calculating measures. Any speed test results falling outside of that range are discarded.

Advertised Speed Tier Identification

The advertised tier associated with any particular panelist is assigned based on advertised tiers for the relevant ISP. For ISPs that do not have power boost, comScore assigns a machine an advertised ISP tier based on the maximum speed read for the machine and publicly advertised tiers plus 10%. For example if an ISP had 5Mbps, 10Mbps and 15Mbps tiers, a machine with a 10.8Mbps maximum download speed would be assigned to the 10Mbps tier since it was within 10% of the maximum speed of the 10Mbps tier.

For Cox, Comcast, and Time Warner—ISPs which offer power boost—machines are assigned to an advertised tier based on the maximum power boost download speed

achieved during testing. For example, if an ISP had an advertised tier of 12Mbps with an advertised power boost download speed of 15Mbps, then machines with an observed maximum speed up to 15Mbps would be put in the 12Mbps advertised tier. If that observed speed was higher than the advertised power boost download speed, then machines would be put into a higher speed tier.

Average Drop Off

ComScore defines the average drop off as the average speed measured divided by the advertised speed for each tier shown as a percentage. For buckets with multiple tiers, the drop off is a weighted average based on the number of speed reads in each tier. The comScore term "drop-off" does not reflect the percentage that measured speed was lower than advertized but rather reflects effective performance delivered. A "drop off" of 20% actually means that the service delivered 80% of the advertised rate.

Note: We have modified the comScore description to use unambiguous terminology: MB is Mega Byte (data size)**,** Mbps is million bits per second (data transfer speed)**.** ComScore uses MB to indicate both.

Only One TCP Connection is Used

The comScore testing methodology uses only one TCP connection between the Akamai server and the comScore client. *A single TCP connection by nature has limited performance*. This limitation exists at high, but not at low (e.g., dialup), speeds; however, the limitation becomes significant as broadband access rates increase.

Distance, TCP window size, and packet loss make effective throughput lower than the bandwidth of the slowest link along the path. The reason for this hinges on the Automatic Repeat Request (ARQ) mechanism within TCP.

ARQ uses a sliding window to enable the sender to transmit multiple packets before waiting for an acknowledgement from the receiver. The idea behind the sliding window is to move more data at a time over the network to minimize network idle time.

The effective throughput for a single flow traversing a WAN is calculated using the following formula:

$$ET = \min\left[\left(B\min\left(1, \frac{8W}{BD}\right)\left(1-\sqrt{L}\right)\right), \left(\frac{8MSS}{D\sqrt{L}}\right)\right]$$

Where:
ET= Effective Throughput (bits/sec)
B = Bandwidth (slowest link) (bits/sec)
W = TCP Window size (bytes)
D = Round trip delay (RTT) (sec)
L = Packet loss (>0) (fraction)
MSS = Maximum Segment Size (1460 bytes)

For a detailed description of this effect, see “Improving Effective WAN Throughput for Large Data Flows” [2].

Bandwidth: The bandwidth value in the effective throughput formula is for the slowest link in the path between the Akamai server and the panelist's PC. We assume that the subscriber's broadband access line is the slowest link; however, it's not always the case.

TCP Window Size: The TCP window size range in most operating systems is 8KB to 64KB, and most servers support 64KB. The maximum window size in the original TCP protocol specification is 64KB—a number set in the 1970s when T1 circuits were the fastest available option. RFC 1323 describes a method for supporting larger receive window sizes. However, there has been limited adoption of RFC 1323 in the majority

of typical consumer Internet traffic flows due to the inertia of older implementations and inconsistent support at web servers and data centers.

While the commonly used 64KB TCP window size works well to synchronize data transmission with less than 5 Mbps capacity, it does not work well for higher capacity WAN connections. As circuit capacity increases, the time it takes to transmit the return ACK becomes increasingly important because the circuit remains idle while the source TCP waits for the ACK before it can send more data.

A faster circuit puts a window's worth of data in flight faster and then must wait before sending more, so the percentage of idle time increases compared to a slower circuit. The faster the circuit, the more dramatically the ACK wait time lowers WAN effectiveness because no data can be transmitted while the data and ACK are in flight.

Delay: Round trip time (also known as latency) can have a tremendous range. This is because round trip is distance-related, and WAN distances over the Internet can sometimes be as great as 18,000 miles—two thirds of the way around the world.

TCP Performance over Typical Service Tiers

NetForecast modeled the effective performance of a single TCP connection using the bandwidth specified by typical cable ISP service tiers at an extremely low packet loss rate of 0.0001%. The TCP window size used in the calculations is 64KB, which is the default setting on most current Windows machines. The results are shown in Figure 2.

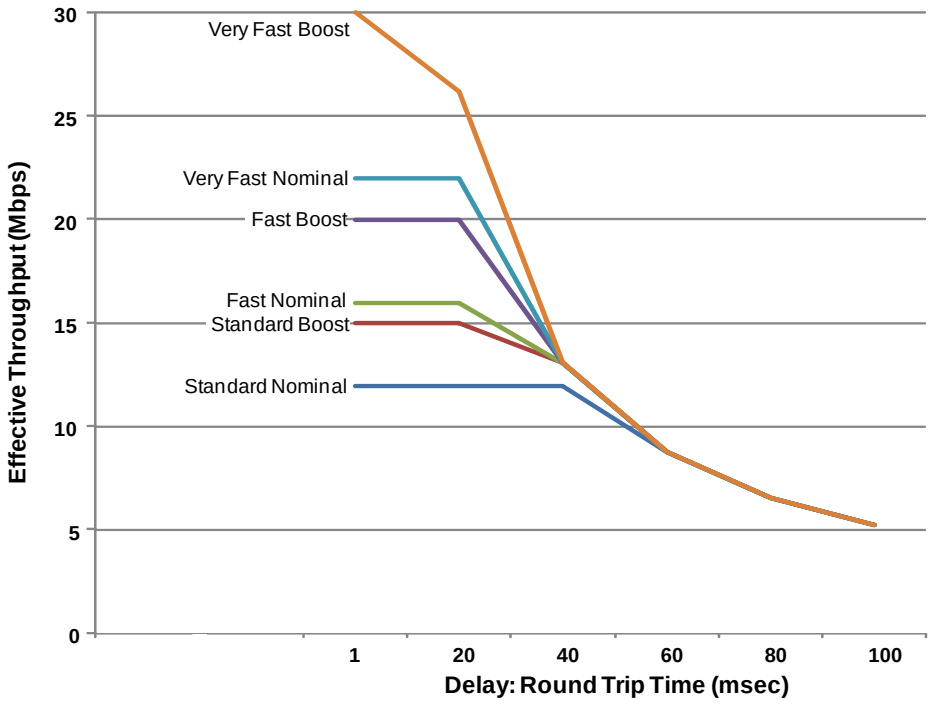


Figure 2 – Effective Throughput for One TCP Flow - 64KB TCP Window

Figure 2 shows that the delay-bandwidth product effect is very evident at high speeds. The important point is that comScore's approach introduces delay variability from test to test because different Akamai servers may be assigned to each test. The slopes of the lines show that a small change in delay results in a large change in recorded performance just at the "network near" 20 to 40msec range. It is difficult for Akamai to position a server to introduce less than 20msec of latency

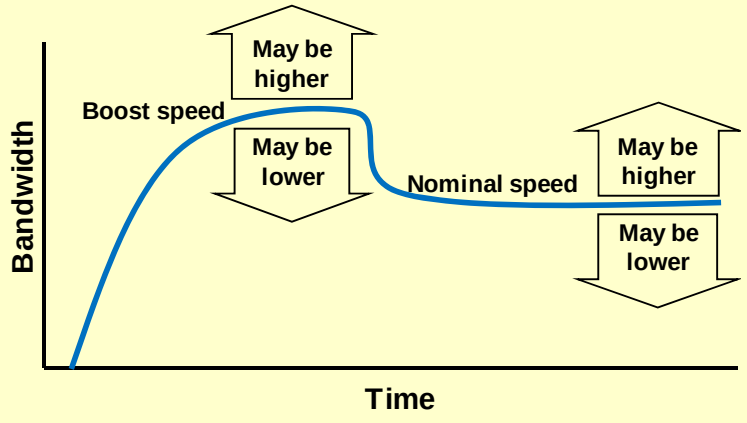
How Power Boost Works

Boost service is a popular DOCSIS standard mechanism that provides higher performance than the nominal rate for a short duration. It is particularly helpful to the user at the start of the interaction with a media-rich website.

Boost technology provides all of the available bandwidth to a subscriber if: a) that subscriber has not exhausted his boost token bucket; and b) there is no traffic destined to another subscriber on that particular HFC interface (neighborhood) that consumes available bandwidth.

The token bucket is refreshed at the nominal rate whenever the subscriber is not using the downstream service. Each DOCSIS network leverages quadrature amplitude modulation (QAM) on a downstream RF channel of the cable plant. The maximum digital speed of a QAM is 38.8Mbps. This means that boost is sometimes capable of delivering nearly 38.8Mbps. Some cable-based ISPs offer very high speed downstream services achieved by bonding multiple QAMs.

The actual boost performance is a probabilistic distribution strongly driven by how much competing traffic exists in a neighborhood at any given time. The performance profile from boost to nominal speed is shown below.



Why Buy More Bandwidth?

Figure 2 would appear to indicate that subscribers need not purchase high-speed service since they will rarely be able to take full advantage of the service if a server is distant. There are three important advantages to high-speed service.

First, many applications open and operate multiple TCP connections in parallel so that they can sum the performance of each TCP connection. It is now standard practice that most new browsers open 4 to 6 connections per web page. Using multiple threads counteracts the negative effect of delay shown in Figure 2. Thus comScore's use of a single thread is not only inconsistent with standard practice associated with newer web browsers, but it also disproportionately amplifies the effects of delay.

Second, there are applications and services that do not use TCP. For example, streaming video can be delivered without the encumbrance of the TCP window mechanism.

Third, subscribers often have more than one user in their homes. Many U.S. households have several users as well as unattended machines that all access the Internet. Higher bandwidth supports the aggregate needs of these simultaneous users.

The Takeaway

The fact that comScore uses only one TCP connection for its speed test severely limits the accuracy of its results. Many speed test services operate multiple parallel TCP connections to more accurately and realistically measure ISP performance.

Client-Server Delay Is Variable

The speed test is initiated by a connection from the comScore client to Akamai. Akamai uses reverse DNS lookup to identify the ISP network the client is using. Akamai then assigns the "best" server to the client test. The best server may be the one closest to the client, resulting in the lowest network latency—or, it may be one that is relatively close, with spare capacity for the assignment. In general, Akamai's service chooses a server that is close to the user's ISP network—but is not necessarily closest.

The peering relationship with the panelist's ISP may be so complex that the test path introduces high delay. As discussed in the previous section, effective performance degrades when delay increases. There is no guarantee that the Akamai-client path is optimal for the speed test. In addition, variability is inherent in comScore's testing because the test path changes over time as Akamai's resources, Akamai's traffic, Internet loads, and ISP peering arrangements change.

Participants' Computers May Be Resource-Constrained

The speed test is performed by the same software used in all comScore measurements. It is installed by comScore panelists and operates without the panelist's intervention. There is no minimum requirement for a panelist computer (anyone can join), other than it must be a Windows machine.

The panelist's computer may have other software running during the test. In fact, comScore recruits panelists by providing them software such as screen savers that operate when the panelist is not actively using the network. The other software can reduce the computing resources available for the speed test.

Furthermore, accurately testing the high data rates now available from broadband ISPs requires a high-performance computer that is dedicated to the speed test task in order to properly take advantage of the bandwidth.

Test Traffic May Conflict with Home Traffic

Like most other speed tests, comScore's tests are performed by software operating on a consumer's PC in a home setting. The typical home has a local network that often includes a Wi-Fi wireless LAN. This test configuration opens potential speed test errors.

- The Wi-Fi network adds substantial delay to the client-server path. As explained above, additional delay degrades the TCP connection's effective throughput.
- Other PCs or machines may be directly connected or using the Wi-Fi network to access the Internet, and this competing traffic reduces the bandwidth available to the speed test. In the case of ISPs that provide boost rate services, the competing traffic can consume the speed boost token bucket, thus forcing the speed test into the nominal speed rate. (See box for speed boost description.)
- If the client is using a Wi-Fi network, the wireless path may be degraded by interference from adjacent Wi-Fi networks, cordless phones operating on the same unlicensed frequency, distance to the access point (and resulting signal strength), and other interference.

Decimal Math Is Incorrect

The comScore test files are defined in megabytes. Mega is a unit used in computers which count in binary. This is different than counting in decimal. One million bytes equals 1,000,000 while one megabyte equals 1,048,576. NetForecast was supplied with a copy of the 15MB file and found it to be 15,728,640 bytes which is 15 times the "mega" number and not the "million" number. Plugging the mega number into the speed read formula example described on page 3 yields an answer of 41.9Mbps.

Although it may not sound like much, the difference between 40.0Mbps and 41.9Mbps is an error of -4.5%. A negative error indicates that comScore is underreporting true performance by that percentage. This decimal versus binary method of calculation introduces the -4.5% error consistently for all of the files in step 4.

Protocol Overhead Is Unaccounted for

Most PC-based speed tests use software that sits above the protocol stack. This software places files onto the stack or takes files from the stack. The protocol stack adds bytes to the traffic that must be transported by the ISP. This activity is, however, invisible to the software itself, so the application does not see what occurs in the transport and network layers to move the file.

To illustrate, let's say you give a 1kg object to a shipping company to deliver. The object arrives safely at its destination, and you receive the shipping invoice. The invoice shows that you have been charged for a box, packing material and the additional weight they both add. The additional material that assured the object's safe delivery was important and no one disputes its need or its cost.

The comScore speed test fails to account for the overhead that TCP/IP/Ethernet protocols add to the size of test files by the test PC and server. If the test executes perfectly under ideal conditions and none of the conditions described in this report occur, then the speed measured is approximately 4% lower than the speed of the ISP infrastructure delivering the content because of the bytes added by the protocol stack.

A consumer PC-based testing organization such as comScore should know the protocols used in its test approach. For accuracy's sake, a correction factor should be added to account for protocol overhead. The byte count should match what the ISP counts in its service definition.

Purchased Speed Tiers Are Incorrectly Identified

ComScore goes a step further than most speed testing services because it attempts to determine the advertised speed tier purchased by the subscriber for each panelist's machine. All broadband access services supply a range of speeds known as service tiers. ComScore uses the advertised speed tiers for each ISP in each service footprint to determine the available options. The process assigns a tier to each panelist machine from the table of offered service tiers.

Table 1 shows typical cable-based ISP service tiers. It is important to note that since comScore only tests the downlink speed, only the two down columns are used. However, if a service footprint has enabled boost capability, the process uses only the boost column in the table.

Table 1
Typical Cable ISP Speed Tiers (Mbps)

	Down		Up	
	Nominal Rate	Boost Rate	Nominal Rate	Boost Rate
Standard	12	15	2	3
Fast	16	20	2	4
Very Fast	22	30	5	7

ComScore's speed test methodology assigns each panelist machine to the ISP service tier that they are believed to have purchased (although comScore has no direct knowledge of the speed tier to which the customer is actually subscribed). ComScore then calculates the effective speed delivered to a sample population based on the average speed measured across all samples divided by the assigned advertised tier speed. ComScore refers to this measure of how much less than the advertised speed is delivered as "drop off." Determining the correct purchased speed tier is extremely important because it defines the denominator in the "drop off" formula.

Let us use the following example of the Standard tier that has the advertised down rates of 12Mbps nominal (base) and 15 Mbps boost. Assume there are five Standard subscribers sharing the 38.8Mbps QAM channel. Subscriber 1 is a comScore panelist who has not used the service for a while (and no other user in his home has either). Subscribers 2 through 5 each use 4Mbps down, which is within their nominal Standard tier. The boost algorithm permits subscriber 1 to receive the *remaining available bandwidth*, which is 22.8Mbps during the boost period (38.8 - 4x4).

The comScore speed test will record a result that is lower than 22.8Mbps due to the errors in the methodology described in this report. However, it is likely that it will record a speed that is higher than 15Mbps.As a result comScore will incorrectly mark this panelist as having purchased the next highest tier of service, and then incorrectly report that such panelist did not meet his applicable advertised speeds.

Speed Tier Identification Flaws

ComScore's speed tier identification has two major flaws. First, if any test within a reporting period is above the boost rate, the panelist's PC will be marked with the next higher speed tier. Note that there is no margin for error at boost rate as there is at the nominal rate. However, as discussed earlier, the boost speed delivered by ISPs is not an exact value. This is not the ISP's fault but rather a byproduct of the DOCSIS specification.

Second, assignment into a service tier is made dynamically by comScore at the time the report is generated. Since reports often cover a long period, the odds of seeing higher-than-the-advertised boost speed only once are high. The panelist's PC will execute a speed test every 18 hours. In a one-week reporting period, the PC will have performed 9 speed tests. However, in a month-long reporting period, the same PC will have performed 40 speed tests. Chances are high that one of the 9 tests in the week will be above the purchased speed tier. However, there is a much higher probability that at least one out of the 40 tests will incorrectly bump the user up to a higher speed tier.

NetForecast estimates that it is highly likely that comScore incorrectly places many panelists' PCs into higher tiers than the subscribers purchased.

Subscriber Tier Inflation Evidence

Figure 4 illustrates the subscriber assignment shift to higher tiers using the comScore report [3] supplied to NetForecast. The report describes seven speed-tier buckets for the major US cable-based ISPs (Comcast, TWC, Charter, Cox, Cablevision, Bright House). There are two reports of this user population in the document. The first is for the six-month period of the first half of 2009 (240 tests per PC). The second is for the week ending September 15, 2009 (9 tests per PC).

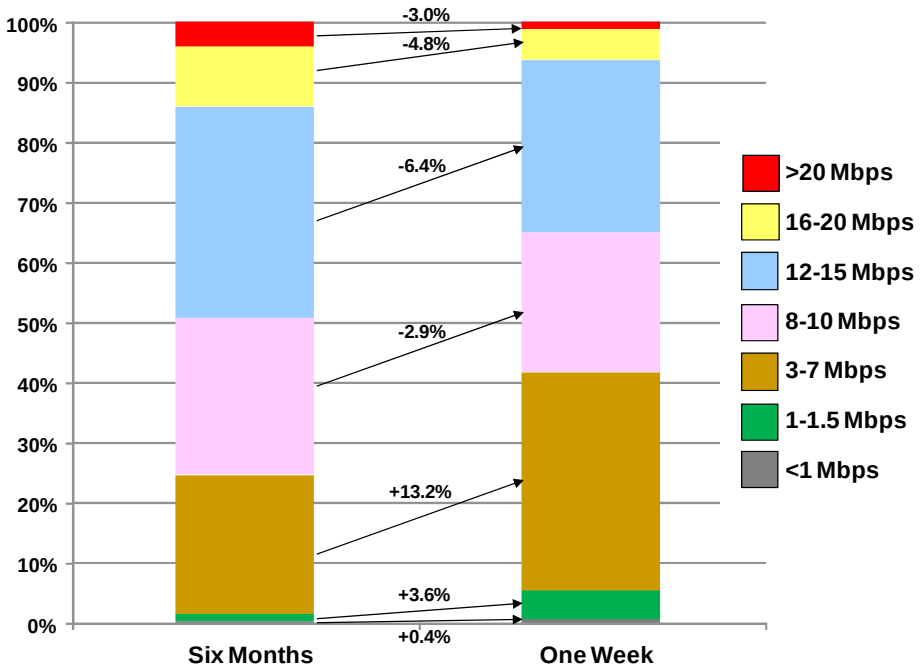


Figure 4 - comScore Speed Tier Assignments for Cable ISPs

Figure 4 shows the distribution of observations (tests) for each of the tiers comScore used. The first stacked distribution bar is for the six-month period. It shows many users in high-performance tiers. The second stacked distribution bar is the one-week report. Note the dramatic increase in lower-speed tiers. The percentage arrows show the population shift for each tier. It is striking that all of the lower-speed tiers gained subscribers, while all higher-speed tiers lost subscribers. The overall shift is 17%.

Clearly, the six-month report assigned too many subscribers to higher speed tiers because the probability that the ISP provided service faster than the advertised speed increased when the sample size increased.

Improper Service Identification Affects All Broadband Technologies

The comScore report incorrectly places subscribers into higher-than-purchased tiers for all broadband technologies, not just for cable. ComScore's report shows that all high-speed tiers lost subscribers to lower-speed services when the sample size changed. Table 2 shows high-to-low-tier shifts of 17% for cable, 12% for DSL, and 16% for fiber between the six-month and the one-week views. Note that the one-week results also have subscribers assigned to the wrong tier, although not as many subscribers are incorrectly identified.

Table 2
comScore Shifts in Service Tier Assignments

Cable Comcast, TWC, Charter, Cox, Cablevision, BH		DSL ATT, Verizon, Qwest, Embarq		Fiber ATT, Verizon	
comScore Tier Group	**Shift** 6 mo. to 1 wk.	**comScore Tier Group**	**Shift** 6 mo. to 1 wk.	**comScore Tier Group**	**Shift** 6 mo. to 1 wk.
< 1 Mbps	0%	< 1 Mbps	5%	1.5-10 Mbps	16%
1-1.5 Mbps	4%	1-1.5 Mbps	7%	12-15 Mbps	-7%
3-7 Mbps	13%	3-7 Mbps	-9%	16-20 Mbps	-8%
8-10 Mbps	-3%	8-10 Mbps	-3%	>20 Mbps	-1%
12-15 Mbps	-6%	>10 Mbps	0%		
16-20 Mbps	-5%				
>20 Mbps	-3%				

In 2009, broadband ISPs vigorously promoted triple-play bundles, most of which included higher-speed service to encourage adoption. NetForecast believes that as a result of these promotions, the percentage of customers buying higher-speed services grew rather than declined as the comScore data indicates. *NetForecast believes that the decline reflected in the comScore data is due not to a market trend, but rather to errors in the comScore tier assignment process.*

In each case showing 12% to 17% more subscribers in lower tiers in September relative to January through June, comScore's reporting error is understated. The true error cannot be determined based on available information, but certainly a significantly higher number of subscribers are incorrectly identified by the drop off calculation.

Statistical Nature of Packet Switching

comScore also incorrectly identifies subscriber-purchased service tiers because it fails to account for the fundamental way in which packet switching works. Packet switching, on which the Internet is based, is a statistical technology that does not reserve capacity for a specific user. This permits highly efficient sharing of a scarce resource—bandwidth—across a large user population (neighborhood).

To understand how packet switching works, it is helpful to compare it to circuit switching, which underlies the telephone network. Circuit switching uses a call set-up process to reserve defined bandwidth for the duration of a call. If bandwidth between the two endpoints is insufficient, the call is blocked, and the caller receives an "all circuits are busy" message.

Unlike circuit switching, a packet-switched service does not use a call set-up process to establish a dedicated path between endpoints. Rather, it provides some bandwidth and statistically reshuffles the momentarily available bandwidth to all currently communicating endpoints. Often an end-to-end connection is established using TCP as described above. The TCP connection is controlled by the endpoints, not the service provider. This control is a key feature of the "Internet end-to-end principle"—i.e., that endpoints (e.g., the consumer and website) play a significant role in how the connection or session performs.

Since packet switching is a dynamic statistical service, an ISP must carefully engineer its systems to provide the advertised service at a capacity "design point." This is the point at which shared resources can adequately accommodate expected traffic loads. Circuit-switched systems have an equivalent design point for call volume.

Any network (packet or circuit) is constantly operating within three performance zones: a) below the design point (more capacity than is currently being used); b) at the design point; or c) above the design point (the system is stressed and some subscribers will receive degraded performance). Table 3 illustrates the difference in performance delivered for a speed test machine (PC) under these three traffic conditions.

Table 3
Performance Delivered to the Next Subscriber Asking for Service
(The speed test machine)

Traffic Condition	Packet Switching Delivers	Circuit Switching Delivers
Below Design Point	More than advertised bandwidth	Advertised bandwidth
At Design Point	Advertised bandwidth	Advertised bandwidth
Above Design Point	Less than advertised bandwidth	No bandwidth (new calls are blocked)

As this analysis shows, comScore's methodology is well-suited to circuit-switched networks, but ill-suited to packet-switched networks like the Internet because it incorrectly assigns a substantial percentage of subscribers to higher-than-purchased speed tiers.

Conclusions

The effective service speeds comScore reports are low by a large margin because in its data calculations the numerator is too low (many errors result in under-reported performance) and the denominator is too high (many subscribers are placed in a performance tier higher than they purchased). The comScore speed test was originally designed for ISPs to compare their performance to one another in specific markets. NetForecast believes that although appropriate for its original use, it is inappropriate to use the inconsistent speed results in a non-relativistic way as an absolute value for the average drop off calculation because the combination of an improper numerator and often incorrect speed tier identification renders average drop off values questionable.

How to Improve Speed Tests

Most speed test services share a common problem—they use a variant of the architecture shown in Figure 1. This architecture creates a long path between the tester's machine (his/her PC) and a test server somewhere on the Internet. The maximum speed that can be observed depends on the aggregate performance of *all elements in the path*. The list of elements is long, including: the PC, home network, ISP service, DNS services, backbone Internet service providers, content delivery networks, server access network, test server. In many cases the path includes more than one service provider for each category. The local broadband ISP under test is one of approximately ten suppliers in the path. Measurements that include 10 players and focus the result on only one of the 10 are ill-advised.

Most speed tests are actually a measure of the "Internet experience" as seen when a user connects to a website. The comScore speed test aims to track the user experience. The client software is present on all Internet sessions. By design it must be a light-weight and unobtrusive monitor of Internet activity. Many of the design choices in the speed test reflect this light-touch approach. The resulting design, although useful for constantly tracking user behavior, is not effective for testing local broadband service.

Proper broadband access services speed testing requires eliminating elements in the path that are not germane. The focus must be the ISP access line. Furthermore, the test design must account for how the specific access technology operates, and the test equipment must be sufficiently powerful to properly and reliably stress the speed of the access line. Consistently and reliably pumping 50Mbps even for a few seconds is not a light-touch event. It is an infrequent but effective and non-destructive "hammer blow" to the system under test.

It is essential that ISP speed tests be thoroughly understood and that their results are truly representative and accurate. The industry should define standardized and transparent targeted methodologies for ISP speed testing and foster their widespread adoption.

About the Author

Peter Sevcik is a Principal of NetForecast and is a leading authority on Internet traffic, performance and technology. Peter has contributed to the design of more than 100 networks, holds the patent on application response-time prediction, and pioneered many performance management techniques including Apdex. At BBN Peter played a pivotal role in the development of the Internet. He can be reached at peter@netforecast.com.

Sources and References

The description of the comScore methodology is based on: documentation [1] received from comScore; a November 30, 2009 meeting with Brian Jurutka at comScore headquarters in Reston, Virginia; and subsequent email exchanges in which comScore answered NetForecast's questions.

1. "ISP Speed Test Methodology – October 2009," Methodology tab in an Excel spreadsheet from comScore.

2. "Improving Effective WAN Throughput for Large Data Flows," by Peter Sevcik and Rebecca Wetzel, November 2008, NetForecast Report 5095.

3. "comScore_Comcast_Speed_FCC_data_20091112 Option B," name of Excel spreadsheet file from comScore.

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