North Carolina Broadband Rigor in Mapping Initiative: An Assessment of Methods

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Edward Feser, Ken Wilson, Albert Esterline, and Jean-Claude Thill

June 2011

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Introduction

Since 2001 the e-NC Authority (then named the NC Rural Internet Access Authority or RIAA), the state broadband authority for North Carolina, has collected primary data on the availability of the Internet in North Carolina, and more specifically (since 2003) broadband. In 2003, the e-NC Authority was given a mandate by the NC General Assembly to maintain current information on the availability of telecommunications and broadband Internet services in the state, to be made available on e-NC's website.

Based on this mandate, e-NC developed a process of collecting data from telecommunications providers based on the location of infrastructure equipment and access lines across the state. This information was used to estimate the percentage of households in each county that could be served by cable modem or DSL lines and was included in an annual report on the access available in each of North Carolina's 100 counties. This data collection process was the first of its kind in the country, and was useful in providing the most credible basis available for directing infrastructure incentive funds to the most under-served communities. Through iterative rounds of incentive grants e-NC partnered with providers to make broadband available to more than 80 percent of the households in the state with a minimum level exceeding 60 percent in even the most sparsely populated rural counties.

Nevertheless, the data collection process lacked the legal or political leverage to require broadband providers to comply with data requests. Despite on-going efforts to work with providers to improve participation rates, as well as the quality of the data, participation was not adequate. In addition, the labor intensive methodology required estimations about household coverage and resulted in a percentage of coverage but could not show actual coverage within an area. Criticisms targeting the absolute accuracy and timeliness of data presented on the maps that resulted from this process were legitimate.

The advent of the American Recovery and Reinvestment Act (ARRA) funding through the National Telecommunications and Information Administration (NTIA) to support improved broadband mapping was appreciated on several levels, including: 1) establishment of a federal mechanism, in partnership with the states, for collecting and mapping broadband data, as well as standard definitions and structures for data collection, 2) provision of funds to explore and compare data collection options, and 3) creation of a learning laboratory among states to encourage the development of best practices for mapping. The e-NC Authority took advantage of this opportunity to test a variety of promising approaches to collecting broadband data. The goal of this research was to indentify data collection methods, or combinations of methods that will deliver broadband mapping information that is accurate, timely, cost effective and sustainable. Four methods were employed and their relative strengths, along these four criteria, were assessed by an external review panel comprised of four distinguished academic researchers with expertise appropriate to the task. Significant investment was made to develop the database needed to support rigorous and secure comparisons of data from providers, the public and other sources. The attached report presents their findings.

As a starting point, the evaluators' analysis centered on two hypotheses: (1) web mining paired with consumer demand analysis is a practical, cost-effective alternative to reliance on provider-supplied data, and (2) single propagation modeling is a viable means of estimating fixed wireless service availability and quality. Consumer survey data was envisioned not as a direct mean of assembling availability data, but as a means to validate direct sources. The evaluators had two goals in assessing the NC BRIM project data collection experiment: (1) identification of lessons learned in the implementation of each data collection approach and (2) elucidation of the capabilities, strengths and weaknesses of each approach through cross-method comparisons. Notable among the results are three primary insights that form the basis of their recommendations, including:

- A broadband map, created principally with provider-supplied data and the service standard specified by the NTIA, is likely to generate a picture of broadband availability in the U.S that overstates accessibility relative to the experience of the average end user.
- Some of the limitations of using providers as the chief source of availability information will not be redressed with time, learning and experience. Such shortcomings are fundamental and will require work-arounds or coping strategies to yield the most accurate broadband map possible.
- Web mining in conjunction with consumer demand analysis (CDA) does not offer an easy and inexpensive comprehensive fix for the problems associated with provider data supply, at least at the present time. The technique needs more experimentation and refinement.

According to the findings, it is unclear that any particular source, including provider-supplied data, is necessarily the best source (or the “gold standard”). What is evident is that three of the four methods—provider supply, web mining/CDA, and end user surveying—need additional development and refinement if they are to be used with confidence. The fourth method—generation of coverage maps through radio wave propagation modeling—will need fairly frequent updating given the rapid expansion of wireless high-speed services.

We are left with the conclusion that there are no easy or straightforward means of meeting our goals of accurate, timely, cost effective and sustainable data collection. The quest continues and progress is being made. Results of the NC BRIM (North Carolina Broadband Rigor in Mapping) data collection experiment are enormously informative and are already being put to use to improve the quality of North Carolina’s broadband mapping data and to guide infrastructure investment decisions in the state. To that end, the following next steps will be implemented to further refine the data collection process and improve the quality of the mapped data.

Improve the quality of provider data by:

1) Further developing automated ETL tools that will reduce the risk for human error and/or oversight for data collection (ETL, *extract, transform and load*, refers to the process of taking data from the source, reformatting it as needed and loading it in the end target database).
2) Pursuing effective conversion techniques and transition of broadband data collection to 2010-based census block granularity.
3) Developing a brief for providers highlighting the benefits of participation.

4) Exploring options for on-line tutorials and other aids to improve quality of data and compliance with submission formats.
5) Continuing to incorporate best practices emerging from data collection efforts in North Carolina and other states.

Improve the quality of consumer data by:

1) Careful revision of survey instruments using more sophisticated design to improve internal validity and reliability of responses. Changes will be based on additional research conducted on how to most reliably solicit information from consumers concerning their access to broadband services. The resulting revised survey instrument will need to be carefully pre-tested.
2) Assessing survey contact methods to address the changing telephone technology profiles of potential participants and exploring options to increase response rates for users of all types of communications technologies.
3) Focusing the information to avoid areas of speculation (such as "prospective service availability") and to obtain information that is not readily available through other means (for example, typical speed data).

Improve the data validation process by:

1) Designing and implementing a ground truthing experiment on a scale that is both informative and affordable. For example, on-site field studies augmented by heavy citizen surveying in a carefully drawn random sample of census blocks.
2) Continuing to explore a combined web mining/consumer demand analysis approach by possibly undertaking a small-scale experiment (e.g., for a single county or other suitable areal unit) as proposed by the project evaluators.
3) Further developing automated business logic tools that will help e-NC identify characteristics of interest within the data that can be either confirmed or corrected and improved.
4) Continuing to work with the UNC-G Center for Geographic Information Science to increase wireless provider participation in data mapping via advanced propagation models and to further refine customizable elements of the model based on feedback about provider equipment scenarios and business practices.

It is clear that further work is needed to determine the best methods to optimize broadband mapping through broadband data collection. North Carolina remains committed to working with the NTIA and other states to continue to pursue this result. We welcome the opportunity to discuss the outcome of this research in detail with the NTIA and seek input on refining our efforts towards optimizing the quality and usefulness of North Carolina's mapping data. We look forward to such discussions.

Biographies

Dr. Edward Feser

PhD, University of North Carolina at Chapel Hill, 1997

Edward Feser taught at the University of North Carolina at Chapel Hill for seven years prior to coming to the University of llinois at Urbana-Champaign in 2004. He begins teaching at the University of Manchester Business School in Fall 2011.

Feser's research has been supported by the National Science Foundation, the World Bank, the U.S. Economic Development Administration, the Appalachian Regional Commission, and the German Marshall Fund of the United States, as well as multiple state and local agencies. He is involved in the development and operation of NEURUS—the Network for European-U.S. Regional and Urban Studies—a consortium of thirteen universities in the U.S., the Netherlands, Germany, Austria, Hungary, Sweden, Spain, and Korea.

Dr. Ken Wilson

PhD, Purdue University, 1974

Ken Wilson is a professor at East Carolina University in the Department of Sociology. He has also served as the Director of Community Research at ECU since 2004.

Wilson has a particular research interest in developing a better understanding of how the Internet and digital technology are transforming rural life. For almost a decade, the e-NC Authority (and its predecessor organization) has commissioned East Carolina University (Dr. Ken Wilson) to survey North Carolina residents regarding their attitudes and perspectives about Internet and computer usage as well as the changes that have occurred over time. This data has been collected from users of dial-up and broadband and those with no access. The survey was previously conducted in 1999, 2002, 2004 and 2008. The 2010 survey was completed in August 2010. Approximately 1,200 citizens responded to the survey during a two month collection period.

Dr. Albert Esterline

Ph.D. University of Minnesota 1992 Computer Science
Ph.D. University of St. Andrews (Scotland) 1981 Philosophy

Albert Esterline is a professor in the Department of Computer Science at North Carolina A&T State University. He also serves as one of two associate directors of the Autonomous Control Engineering (ACE) Center at North Carolina A&T (1996 to present).

His research interests include:
Multiagent Systems; The World Wide Web and Semantic Web; Sensor Webs; Human-computer Integration; Modal Logics for Software Specification, AI, and Concurrency; Concurrency Formalisms;

Data Fusion; Computer-based Structural Health Management; Rigorous Foundations for Fuzzy Logics; Machine Learning; Web-based Training; and History and Philosophy of Technology.

Dr. Jean Claude Thill

PhD, Universite Catholique de Louvain, Belgium, 1988

Jean Claude Thill is a professor of public policy and geography and earth sciences at UNC Charlotte. His major academic specialties are Urban Change, Transportation and Mobility systems, Geographic Information Science (GIS-T) Spatial Modeling, and Regional Science.

Assessment Introduction

In 2010, the e-NC Authority was awarded a grant from the National Telecommunications and Information Administration (NTIA) under the State Broadband Data and Development Grant Program to develop and implement an approach to collecting timely and accurate data on broadband availability in North Carolina, and to supply those data to NTIA as part of the agency's effort to create a national broadband map. The e-NC Authority brought considerable experience to the initiative. e-NC—originally established as the Rural Internet Access Authority in 2000—is responsible for the longest continuously running effort to map broadband availability in the country. e-NC began collecting annual information on telecommunications infrastructure and services from providers operating in the state in 2002 and has maintained an interactive, publicly accessible, online map of North Carolina broadband availability using those data since 2003. Consequently, the e-NC Authority approached its NTIA project with an intimate familiarity with the particular strengths and weaknesses of mapping broadband availability solely from provider-supplied information.

In principle, broadband service providers are best placed to identify locations where high-speed Internet access is available or can be made available in a very short time frame. In practice, producing an accurate map of broadband availability from provider-supplied data is not at all straightforward. The information maintained by telephone, cable, fixed wireless, mobile wireless, utilities, and other companies and organizations supplying broadband services to consumers, businesses, and public agencies varies widely in its geographical resolution, format, and timeliness. Many suppliers are reluctant to share what they regard as market-sensitive information, even when confidentiality agreements are put in place; and not all providers, especially smaller ones, have the internal resources necessary to fully comply with information requests. All providers have a strong incentive to understate (or simply not report) realized access speeds and none wish to provide pricing data. As a result, provider data are often incomplete and require considerable correction or extrapolation before they are useable for mapping. The adjustments themselves introduce a measure of error.

With those issues in mind, e-NC constructed an experiment in broadband data collection. The Authority proposed to NTIA that they would test several approaches to assembling information on broadband availability by location in the state, including requesting information from service providers directly, assembling broadband access information via combined web mining techniques and consumer demand analysis, using radio wave propagation methods to model the location of fixed wireless Internet services, and surveying consumers directly regarding the services available to them at their homes. Furthermore, e-NC proposed that they would assess the alternative methods with a view toward determining an approach to creating a broadband map that is as complete, accurate, timely, and cost-efficient as possible. This paper reports the results of that assessment.

Approach to the Assessment

None of the data collection approaches discussed in this paper provide a picture of reality "on the ground" at every location in North Carolina. For a variety of reasons that differ somewhat by method, each approach effectively estimates or predicts point locational availability along one or more of several dimensions: simple access, advertised speeds, realized speeds, and price. That is true even of provider-supplied information. For example, suppliers of DSL are able to estimate download and upload speeds at given addresses according to user distance from a central office facility. These speeds may also vary by the quality of the copper wiring at the home and in its immediate neighborhood. Sellers of terrestrial wireless broadband service can predict availability by location with information on user distances from fixed transmission installations (towers) and assumptions about signal attenuation. However, variation in topography, vegetation, and the built environment mean that such predictions are often quite rough. Even mobile wireless service, which is routinely assumed to be available ubiquitously, varies by topography.

Broadband access mapping errors are of two general kinds. A location that is incorrectly identified as served (or potentially served within some pre-defined time horizon) is an error of commission. A location that is incorrectly identified as not served is an error of omission. Whether a location is served or not is itself a matter of definition with respect to service standard and thresholds set for the particular location or spatial unit. The service standard refers to the assumed definition of high-speed access. NTIA has determined that broadband service is available at a given address if an end user at that address can access data transmission technology supplying an advertised Internet downstream speed of at least 768 kilobits per second (kbps) and an advertised upstream speed of greater than 200 kbps, or if a provider could "without an extraordinary commitment of resources" provide such service within a reasonable interval (specified by NTIA as seven-to-ten business days). Thus, the definition has both *actual* and *prospective* high-speed service elements.

The assumed location or spatial area threshold refers to the level of service penetration required for a given geographical unit to be considered served on the broadband map. Point locations—addresses—are simple: an address is or is not served according to the assumed service standard (the location unit threshold is a dichotomous, or yes/no, variable). Locations based on area—blocks, block groups, Census tracts, and counties—are more complex. A very low threshold would consider a block served with broadband if a single address within that block can be identified as served. Alternatively, one could set the threshold higher—25 percent of addresses within the block, 50 percent of addresses, etc.—which would reduce the picture of broadband generated.

A significant challenge for any effort to directly compare alternative methods of assembling broadband mapping data is that methods vary in their capacity to generate equivalent variables for equivalent spatial units of analysis. Providers are most capable of supplying data on the point locations of their current customers and infrastructure, the latter of which can be used to estimate—imperfectly—access for non-customer addresses. Consumer surveys cannot generate reliable information about current access for spatial units much below the level of the county, due to resource constraints that limit sample sizes. Web mining technologies paired with consumer demand analysis would seem to have the greatest potential for generating data equivalent to that supplied by providers, although the approach has additional limitations, as discussed below.

A Selective, Exploratory Assessment

By necessity, this assessment of the BRIM project data collection experiment is highly selective and exploratory. The aim is to identify lessons learned in the implementation of each data collection approach on its own, and then to make a limited number of cross-method comparisons—where feasible and appropriate—to gain additional insights on method capabilities, strengths, and weaknesses.

Using this approach, three things become clear. First, a broadband map created principally with provider-supplied data and the service standard specified by the NTIA is likely to generate a picture of broadband availability in the U.S. that overstates accessibility relative to the experience of the average end user. Errors of commission are more likely than errors of omission. Second, some of the limitations of using providers as the chief source of availability information will not be redressed with time, learning, and experience. They are fundamental and will require "work-arounds" or coping strategies to yield the most accurate broadband map possible. Third, web mining in conjunction with consumer demand analysis does not offer an easy and inexpensive comprehensive fix for the problems associated with provider data supply, at least at the present time. The technique needs more experimentation and refinement.

Lessons Learned by Method

The BRIM project sought to collect broadband mapping data via four means: a direct request of providers; a scan of provider online offerings via web mining joined with consumer demand analysis (a fully third-party intelligence gathering technique, in essence); the development of models to predict fixed wireless availability; and a survey of consumers in 19 counties chosen to represent variation in socioeconomic, demographic, and physical conditions across the state. The BRIM experiment centered on one key hypothesis: that **web mining joined with consumer demand analysis** is a practical, cost-effective alternative to reliance on **provider-supplied data**. A second hypothesis was that **signal propagation modeling** is a viable means of estimating fixed wireless service availability and quality. The **consumer survey** was not envisioned as a direct means of assembling information on availability, but instead as a source of additional information that could be used to help validate direct sources. This section identifies some of the major lessons learned through implementing each data gathering approach.

Provider-Supplied Data

Service providers are the most direct source of information on broadband availability and they are the primary means of assembling mapping data in all of the states under NTIA's national broadband mapping initiative. In two rounds of data collection in 2010, e-NC staff experienced the following major challenges in using providers as the primary mapping data source. First, despite the provision of spreadsheet templates and extensive instructions, the format and completeness of the information supplied by providers varied widely, necessitating repeated, time consuming interaction between e-NC staff and providers—where providers were willing—in order to interpret and adjust the supplied information. Second, some providers simply declined to make available information at all, or information on certain variables, despite multiple requests. That situation created gaps in the data. Third, the telecommunications and broadband industries are highly dynamic and generate considerable merger activity, rapid company expansion and decline, and staff turnover, making it difficult for each provider to build up the kind of internal capacity and institutional memory that would ease periodic data collection going forward. Finally, without dedication of extraordinary additional resources, it proved challenging for providers to supply consistent and reliable information on both *actual* served locations and *prospective* served locations, where the latter are locations that could be served in 7-10 business days. The introduction of a prospective component in the service definition is a major potential source of errors of commission in the provider information.

There is certainly potential for improvement in provider data supply as additional rounds of data collection occur over a series of years. e-NC staff have learned much about how to design information requests, where errors and omissions are likely to occur, and how to best process data supplied in different formats or resolutions. Likewise, providers may gradually begin maintaining service data in the kinds of formats needed for accurate broadband mapping and some ISPs were more cooperative in the second round of data collection than they were in the first. Learning curves and accumulation of trust that data will be used appropriately and confidentiality maintained, thus increasing ISPs' level of cooperation, mean that provider-supplied data should get better with time.

However, some of the problems with provider data supply are fundamental. Staff turnover in the communications industry puts a limit on learning effects, the e-NC Authority's decade of experience shows that ISP cooperation can degrade as well as improve, and the formats and variables needed for mapping do not align perfectly with the nature of the information providers' accumulate in the course of doing business. Such limitations imply that other data gathering methods will be necessary, at least in adjunct form, to generate an accurate map of high-speed availability.

Data via Web Mining and Consumer Demand Analysis

Web mining is a process of extensive, automated online scanning to gather price, offers and promotions, and advertised speed information for broadband services directly from provider web sites. It is typically supplemented with consumer demand analysis via more conventional means, i.e., consumer surveying, to offer supply and demand intelligence to communications companies. Web mining for offer data alone is insufficient to meet the data demands of NTIA's mapping initiative. Web mining in combination with consumer demand analysis (CDA) would seem to promise a reliable and reasonably automated third-party source of information as an alternative, or major adjunct, to provider-supplied data.

The e-NC Authority contracted with a single vendor, Telogical Systems, to provide a single wave of data as a test of the type of information web mining and CDA can generate. Telogical specializes in assembling advertised product, pricing, and promotion intelligence data for communications companies. The firm partnered with a second company (Centris), a consumer demand analysis specialist that uses survey data and modeling to estimate demand for high-speed services.[1] Telogical's proposal to the e-NC Authority was to join the web-pulled supply data with demand-side information from Centris to generate the variables required by NTIA.[2] The test data pull was successful in identifying major satellite

[1] "NC TAG Meeting," (overview of methodology), presentation prepared by Telogical Systems, 15 February 2010.

[2] Ibid. Centris maintains data on telephone and cable company service area boundaries, which were to be joined with offer data generated by Telogical. Centris models developed to estimate demand for high-speed services by Census tract were to be predict penetration rates for DSL, cable modem, fiber based services, and wireless by location.

providers and several other ISPs who declined to submit data to the e-NC Authority, as well as some pricing information.

However, there were some significant limitations in this first iteration of the web mining/CDA concept. First, the approach cannot identify connection-point infrastructure (last and middle mile). Second, it is unable to identify small fixed wireless and mobile wireless providers that do not have an extensive web presence. Third, the data are heavily sample-based. Extrapolation techniques, at least in this initial application, were used extensively, with unclear implications for data reliability. Fourth, the models used in the technique are appropriate for estimating service by Census tract but not Census block, which is ultimately the spatial unit of analysis underlying the national broadband map. Finally, although the cost of the initial data construction was modest, subsequent research by e-NC staff and Telogical personnel regarding approaches that would address some of the shortcomings of the method determined that improved techniques would be considerably more expensive, potentially costing eight times the initial estimates.[3]

Wireless Propagation Methodology

Wireless high-speed services are expected to be an important bridge between comparatively slow wireline services (DSL and cable modem) and the eventual development of very-high-speed, fiber supplied services. Wireless is an especially important option for many rural locations in North Carolina and elsewhere. The aim of the BRIM wireless propagation experiment was to develop and test models that could predict the availability and level of wireless service throughout the state. The e-NC Authority contracted with researchers at the Center for Geographic Information Science (cGIS) at the University of North Carolina at Greensboro to develop and validate models for the same 19-county area selected for the consumer survey, using the working hypothesis that those models could applied to statewide use.

[3] See "Broadband Data Best Practices Recommendations," Draft No. 2, prepared by Telogical Systems for the e-NC Authority, 1 December 2010 – available from the e-NC Authority upon request

Wireless propagation analysis is fundamentally dependent on providers to supply initial information on antenna locations, height, and other technical specifications (e.g., model numbers). Those data are used with three-dimensional models of land cover and assumptions about signal attenuation to generate line-of-sight and non-line-of-sight coverage approximations. Field measurements provide the information necessary to test the approximations and refine coverage prediction models. In the end, different models are generated for different combinations of geography and signal frequency.[4]

The BRIM propagation experiment successfully generated propagation models that can be internally validated by further field measurement.[5] A major advantage of this approach is that it is not contingent on provider claims about service availability by location, but rather depends on infrastructure specifications that are more readily known by the companies. Nevertheless, the companies still must supply those specifications. In the end, only eight of over 40 wireless firms believed to be operating in the state responded to e-NC with complete datasets and another two wireless ISPs sent incomplete data. In some cases, the ISPs were confused about the kinds of technical information that was requested. The limited information meant that the data verification effort had to be restricted to just six counties of the 19-county study area, calling into question the validity of extending these initial models for statewide coverage estimation.

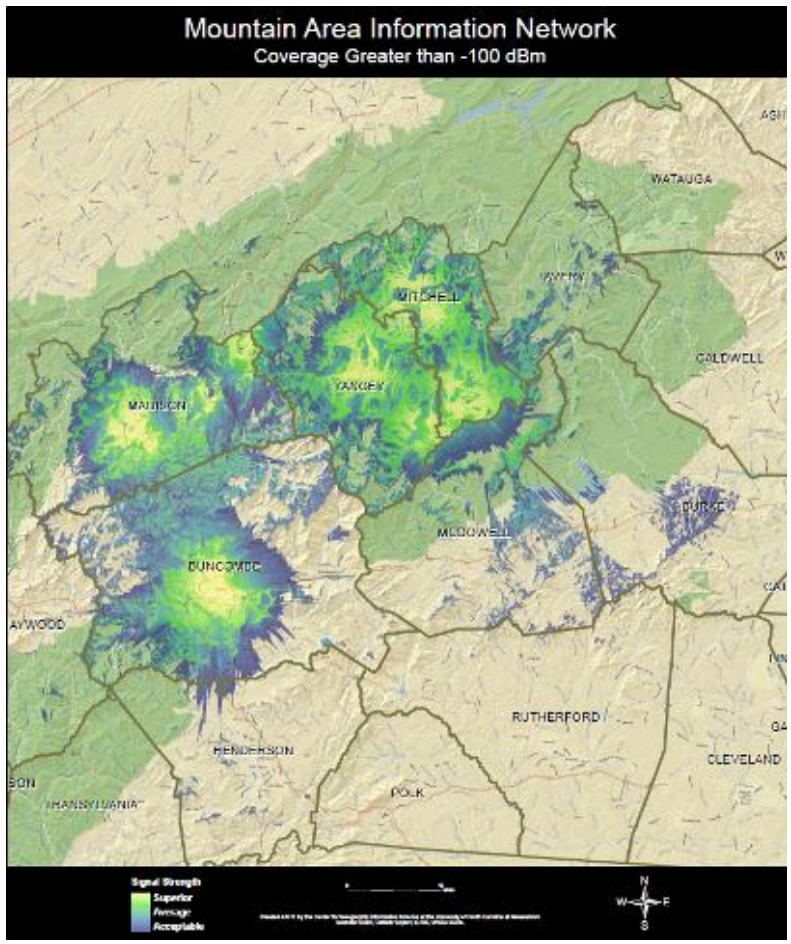

Figure 1. An example of a propagation map (source: cGIS)

There were several additional lessons learned in the course of the propagation modeling

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[4] Bunch, Rick, "GIS and radio wave propagation prediction," Center for Geographic Information Science, University of North Carolina Greensboro, 5/27/2011.

[5] cGIS determined through field testing that the prediction accuracy of the coverage maps was "consistent with acceptable accuracies reported in a number of engineering studies." See "Modeling wireless broadband coverage for North Carolina: Key lessons and best practices," memo prepared by the Center for Geographic Information Science, University of North Carolina Greensboro, 10/28/10.

project.[6] First, there needs to be sufficient time for repeated dialogue between the propagation modeling team and the providers in the data collection phase. cGIS staff believe that allowing additional time to follow up on incomplete information and verify specifications would have substantially improved the accuracy of the coverage maps. Second, wireless providers clearly appreciated the value of the predicted coverage maps for their own advertising purposes, as evidenced by the fact that several posted cGIS-produced maps on their websites. Wireless providers may prove more cooperative in subsequent rounds of data collection as they become more aware of how they can benefit from the results of propagation modeling efforts. Third, cGIS detected appreciable expansion of wireless service, especially into new frequency bands, in a very short period of time. That indicates that coverage maps will need to be updated often.

End-User Surveying

Another approach to mapping high speed Internet services is to ask end users directly what services they have available to them at their location. Resource constraints mean that end-user surveys are able to generate estimates of availability only for larger spatial units, usually counties, as the sample sizes necessary to produce reliable estimates to the Census tract, block group, or block levels would be prohibitively expensive. In the e-NC BRIM project, a telephone survey of one category of end-users — household consumers—in 19 North Carolina counties was used to generate data that could be used to informally validate results created from provider-supplied information and wireless propagation techniques.[7] The 19 counties were selected to represent different regions of the state (coastal, piedmont, and mountain), urban and rural areas, demographic and socioeconomic characteristics, and varying unique challenges with respect to broadband deployment.

The survey was implemented by researchers at the University of North Carolina at Chapel Hill with the assistance of interviewers operating at two call centers established for this purpose (the Rockingham County Business and Technology Center and the Foothills Connect Business and Technology Center). Using wireline and wireless numbers procured from Survey Sampling International, Inc., call center staff completed over 10,000 interviews during an intensive three-week period, including 9,259 wireline and 1,044 wireless calls. The survey instrument queried households on the availability of high-speed service types (dial-up, DSL, cable modem, wireless, mobile cellular service, and satellite service), the household's actual use of those services, the availability of specific providers, the household's particular provider (if applicable) , speed of service, willingness to pay for services, and basic technology use

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6 Ibid.

7 As part of the NC BRIM project, the e-NC Authority also undertook an email survey of 74,000 businesses and organizations and 29,000 households ("online survey") and a statewide telephone survey of a smaller representative sample of households ("citizens survey"). The former was implemented by Strategic Networks Group (SNG, Inc., 2010) and the latter by Dr. Kenneth Wilson of East Carolina University (March 2010). The 2010 citizens survey was the fifth such survey conducted by e-NC since 1999 and was designed to produce a representative picture of computer and broadband use comparable with earlier surveys. The online survey focused on the obstacles and benefits of broadband, especially for businesses. Neither the online survey nor the citizens survey were intended to produce data for the broadband map. However, questions in both surveys were constructed so that selected results from both provide information that can be used to cross-check findings generated from the major mapping data collection methods.

(computer, cell phone, etc.).[8] The response rate exceeded 80 percent overall, but just 30 percent for wireless numbers.

The consumer survey succeeded in producing a rich picture of self-reported household high-speed Internet use and availability in the 19-county study area, and the effort also demonstrated the feasibility of undertaking large-scale telephone interviewing to collect consumer end-user information in a relatively short period of time. The project also uncovered a number of issues associated with end-user surveying that need to be resolved if the approach is to be used regularly as a means of validating other broadband mapping data collection methods.

The biggest issue pertains to the nature and validity of the information that can be realistically collected from the consumer. The BRIM consumer survey instrument solicited two major types of information from households regarding high-speed access: 1) the type and provider of broadband that the household *currently* uses, if applicable; 2) the type and providers available to the household at the fixed address, regardless of current use. Analysis of the responses indicates that end-user surveys are not necessarily a reliable means of assembling *either* kinds of information, although information gathered for the first type—the household's own current service—is more consistent.

Regarding the validity of current service, 2,915 households of 10,303 interviewed reported that they currently have and use a DSL connection *and* do not have or use a cable modem connection to access the Internet. Of those 2,915 "strictly DSL" households, 300—10.3 percent—reported Time Warner, a major cable service supplier, as their high-speed ISP in a subsequent question. Turning the test around, of 2,901 households that reported using cable and not DSL service, 68—or 3.2 percent—reported AT&T as their high-speed provider. Additional modest inconsistencies arise in comparing other reported service types (WI-FI wireless, PC card wireless, mobile telephone, satellite, etc.) and ISPs (e.g., Charter, CenturyLink, MAIN, Verizon, etc.).[9]

Not unexpectedly, the level of uncertainty in the validity of household responses is higher for questions pertaining to *prospective* high-speed service availability at the given address.[10] Of a total of 1,536 respondents reporting that "Only dial-up is available" at the address, 812 (53 percent) also indicated DSL is available, 800 (52 percent) that cable modem service is available, and 704 (46 percent) that both DSL and cable are available.[11] A total 612 of 10,303 respondents reported "only dial-up", while also not

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[8] Findings from the survey are summarized in "Consumer Survey Report: NC Broadband Rigor in Mapping (NC BRIM) Project," prepared by Nicholas Didow, Kenan-Flagler Business School, University of North Carolina at Chapel Hill, 10 December 2010.

[9] The numbers reported in this paragraph were derived from a comparison of responses to questions 7 ("Which of the following types of Internet connection do you currently have and use at your home address?") and 8 ("What company provides your current Internet service at home?" on the survey instrument.

[10] See discussion in "Consumer Survey Report: NC Broadband Rigor in Mapping (NC BRIM) Project," op cit., pages 9-10.

[11] The key "prospective" question is as follows: "Regardless of whether you currently have Internet service at your home address or not, which of the following statements are correct about Internet service available at your home address?" Aside from the redundancy in the phrasing, which may have confused some interviewees,

indicating DSL or cable or answering that they "Don't Know." This set of respondents may represent the best estimate of strictly dial-up service among wireline options. Dropping respondents among the 612 who also indicate availability of wireless or satellite service reduces the estimate of respondents with strictly dial-up access to 462. However, in subsequent questions, 37 of the 462 (8 percent) report that their Internet connection is "always on," nine (1.9 percent) report that they have DSL, and 31 (6.7 percent) indicate that they are able to connect to the Internet at speeds of 384 kbps or higher.

It is tempting to conclude that the source of inconsistent responses is inadequate knowledge on the part of the consumer. While certainly a factor, there are likely additional contributing causes. The design of the survey instrument itself, including the phrasing and sequencing of some questions, was probably one culprit. Giving interviewees the option of contradicting themselves, as was the case for the key question concerning the availability of prospective technologies, is bound to result in inconsistent responses due to confusion or misunderstanding as to what is being asked and not necessarily lack of knowledge.[12] Besides improving the instrument, subsequent surveys could include automated mechanisms for interviewers to double-check inconsistent answers (e.g., respondents giving an inconsistent response might be skipped to an additional clarifying question). Limited knowledge of the interviewer and simple coding errors may have also been factors. While the interviewers for the consumer survey should be commended for doing heroic work in a compressed period, an analysis of coding errors and missing data do suggest that the time frame for training and implementation were probably too short.

More broadly, even with perfect instruments and ideal interviewing conditions, it is questionable what one can learn from household responses about prospective service. Consumers are likely to have a highly idiosyncratic knowledge of what providers, bundles, speeds, and prices are available at their address- knowledge that is contingent on the last time they shopped for service. Consumers are best placed to answer specific questions about the services they are actually using, though the BRIM experiment demonstrates the challenge of soliciting even that kind of information.

Cross-Method Comparisons

This section compares data collection techniques three ways to gain additional insight into their strengths and weaknesses, the validity of the data collected and assembled in the North Carolina broadband map, and the potential for combining approaches in some fashion to generate the most reliable, timely, and cost-effective map going forward. Since there is no "ground truth" against which to

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respondents were also asked to indicate "all answers that apply." That meant that respondents answering affirmative to the option "Only Dial-up is available where I live, faster services like DLS or Cable Modem are not available," were also able to select "DSL Internet service is available where I live," "Cable Modem Internet service is available where I live," etc., increasing the potential for confusion on the part of the respondent.

[12] Note that it is common practice to validate respondents' answers by asking similar questions that present opportunities for contradictions to arise. However, that technique is different than including opportunity for a contradictory response in the same question.

compare the information collected by each method, methods are compared according to whether they produced similar results. This section also compares the cost of each data collection technique.

Agreement: Provider versus Web Mining/Consumer Demand Analysis

To what extent do results generated with provider-supplied data align with the results yielded by web mining and consumer demand analysis? Using Census blocks and counties as the units of analysis, focusing the comparison on the 19-county study area, and comparing three variables (reported maximum advertised upstream and downstream speeds, specific providers available, and high-speed services available) yields an answer: not very well. Agreement in this case is the degree to which findings overlap, expressed in percentage terms. For example, if two providers report that they serve a given Census block while the web mining/CDA method identifies one ISP in the block, and that ISP is also one of the two providers reporting service, the level of agreement between the two methods for the given Census block would be 50 percent (one provider identified by both techniques out of two providers identified in total by both techniques).[13]

The following summarizes major findings from this kind of agreement analysis:[14]

- The level of agreement of the two methods averages 27 percent for Census blocks in the 19-county study area comparing which companies provide service in a block but there is zero agreement in almost 20 percent of the blocks;
- When comparing the maximum speed available at the block level, agreement averages 36 percent on downstream speed and 5 percent on upstream speed;
- Comparing agreement at the level of counties, agreement on companies providing services averages 28 percent, with a range of 10 percent to 50 percent;
- Exploring relationships between the characteristics of Census blocks and the percentage agreement finds that there is a very small ($r=0.03$) but statistically significant correlation ($p<0.001$) between agreement and block population; the two methods are slightly more likely to agree for larger Census blocks. Correlations between size of the block and population density are not statistically significant.
- Looking specifically at maximum advertised upstream speed, the level of agreement is insignificant except in three of the 19 counties, and in two of those three counties, web mining/CDA found a consistent 3 mbps for all Census blocks. Web mining/CDA consistently reports tight speed ranges of around 2-3 mbps while providers almost always report larger ranges (in nine of the counties, ignoring unusual outliers, providers reported 4-7 mbps for all Census blocks and in only two of the nine was there any agreement, and that was effectively insignificant);

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[13] For the given set of categorical responses, agreement is measured as the intersection of sets over the union of sets, expressed as a percent.

[14] A detailed discussion of the provider and web mining/CDA comparison are provided in "NC BRIM Evaluation: Agreement between Telogical and the Providers," by Kenneth Wilson and Albert Esterline, prepared for the e-NC Authority, 11 March 2011.

- In only two counties were there a significant number of Census blocks where the speed reported by the providers was lower than that indicated through web mining/CDA.

A number of factors could explain the low level of observed agreement: incomplete or incorrect data supplied by providers; fundamental limitations in the web mining/CDA technique; and differences in coding provider and web mined data to Census block and county geographies.

Table 1. Dial-up only Census blocks

19 Survey Counties	Number of blocks with at least one respondent indicating dial-up only Internet service availability
Robeson	58
Rutherford	37
Alamance	28
Buncombe	24
Durham	24
Craven	21
Madison	21
Chatham	18
McDowell	18
Montgomery	18
Surry	15
Mitchell	13
Lenoir	12
Martin	10
Person	10
Clay	8
Carteret	6
Jones	5
Dare	0
Other	2
TOTAL	348

Source: NCBRIM Consumer Survey.

Agreement: Provider Data versus Consumer Survey

Although consumer survey sample sizes at the county and block levels are too small to rigorously compare the findings of the survey with information supplied directly by providers, it is still helpful to get a general sense of how the two sources align. A total of 362 of the over 450 survey respondents indicating that only dial-up is available at their location (and who also do not indicate "don't know" to the question of service type or "yes" to the question of whether their service is "always on") reported sufficient address information to identify their Census block. The distribution of blocks by county of those 362 respondents is reported in Table 1 (there are multiple respondents in several of the blocks). The number of blocks is large enough for Robeson County to warrant comparison with the provider supplied information.

Table 2. Robeson County Consumer Survey-Provider Data Comparison

Number of blocks reported as dial-up service only in Consumer Survey	Provider Supplied Database: Number of Asymmetric xDSL providers	Provider Supplied Database: Number of cable modem-Other providers	Provider Supplied Database: Terrestrial mobile wireless providers
4	0	0	0
6	2	0	0
9	1	1	0
20	1	2	0
1	1	3	0
2	1	1	1
16	1	1	2

Source: NC BRIM Consumer Survey & Provider Database

In 58 Robeson Census blocks, respondents to the consumer survey indicated that they are only able to access the Internet via dial-up from their residence. Provider-supplied data, however, suggest that DSL, cable, and/or terrestrial wireless options exist in 54 of those 58 blocks (see Table 2). In six of 58, more than two DSL providers report offering service and, in 20 of 58 blocks, provider-supplied data indicate that both DSL and cable-modem options exist.

The reasons for these differences are unclear. Results for single addresses (e.g., via the consumer survey) are not necessarily a good indicator of broadband availability for entire blocks. Likewise, block-level current or prospective (within seven days) service provision estimated by each provider may ignore locations within blocks where broadband service is limited or wholly unavailable. It is possible that service is actually available at many of the respondents' addresses and they are unaware of it. In general, the difficulty of interpreting the results of this kind of comparison underscores the need for at least some field testing to better understand the data that are being assembled from the various methods. **Future data collection efforts might identify selected blocks for in-depth, on-the-ground research on broadband options at a reasonable sample of locations.**

Cost Comparison

Table 3 summarizes costs for the implementation of each data collection approach as well as estimated costs for subsequent data collection rounds. The true costs to assemble and clean the information supplied by providers were much higher than expected; the e-NC Authority anticipates that they will remain significant, though somewhat lower in subsequent data collection rounds. Application of web mining and consumer demand analysis at a level of detail necessary to satisfy NTIA requirements would be much more expensive than the e-NC Authority originally anticipated. **e-NC estimates that expenses for additional iterations of the consumer survey and for extension of the propagation models would be lower than initial costs, though e-NC's estimates may understate the costs associated with needed additional refinement of those techniques.**

Table 3. Four broadband mapping data collection approaches, estimated costs

Method	Initial Cost	Cost to Repeat	Notes
Provider Data	Approximately $100,000 in staff time and effort	$65,000 per data collection round (salary and benefits for two people for six months each)	Assumes data will be collected statewide at the Census block, street segment, or address levels
Web mining/CDA	$25,000, but for a data pull which proved inadequate	$200,000 per data collection round	Technique remains unproven and costs may adjust with further development
Consumer survey	$166,000, including $88,000 for the development of the survey instrument, oversight of the project, training of call center staff, and basic analysis, and $78,000 for call center costs	$90,000 per data collection round, if no significant changes to instrument or interviewing approach are developed	The estimate includes $70,000 for interview work at the call centers (assuming 20,000 completed interviews) and $20,000 for telephone costs and basic analysis
Wireless propagation modeling	$260,000 for model development and initial testing	$15,000, including $7,500 to apply new technical data to existing models and $7,500 for e-NC staff time to assemble data from providers	Would extend coverage statewide but ignores probable need to re-calibrate models as more extensive provider data accumulate

Source: NC BRIM proposal to NTIA and e-NC Authority estimates.

Summary and Recommendations

The results of the data assembly effort undertaken by the BRIM project underscore the extent of the challenge NTIA faces in attempting to build a continuously updated national map that reflects the reality of experience that consumers, businesses, governments, and other organizations have with broadband access, speed, and price. The BRIM effort shows how variable the results derived with different approaches can be and it is not clear that any particular source, including provider-supplied data, is necessarily the best source (or the “gold standard”). What is evident is that three of the four methods—provider supply, web mining/CDA, and end user surveying—need additional development and refinement if they are to be used with confidence, and the fourth method—generation of coverage maps through radio wave propagation modeling—will need fairly frequent updating given the rapid expansion of wireless high-speed services.

On the basis of this assessment, the BRIM evaluation team recommends that the e-NC Authority undertake the following actions going forward under the national broadband mapping initiative:

- Do not yet abandon the web mining/consumer demand analysis approach as unworkable and/or cost prohibitive. Instead, undertake another small scale experiment (e.g., for a single county or other suitable areal unit) testing a version of the revised approach proposed by Telogical (though Telogical need not necessarily be the supplier).

- Carefully re-think and re-design the consumer survey instrument and interviewing implementation before undertaking another survey. A modest level of research needs to be conducted on how to most reliably solicit information from consumers on their access to broadband services and the resulting revised survey instrument carefully pre-tested.
- Eliminate questions on the consumer survey that pertain to prospective service available to the consumer; concentrate on soliciting information the consumer knows with a higher degree of certainty—his/her specific provider, technology type, speed, and cost.
- Select a sample of Census blocks to “ground truth” through field testing for specific providers, service options, and costs, and compare findings against the information supplied by ISPs. Such an effort will not be capable of providing a statistically sound estimate of error in ISP-supplied information, but it may identify ways to better capture information on broadband gaps through adjunct data collection techniques (e.g., the consumer survey).
- Select a sample of Census blocks to “ground truth” through field testing for specific providers, service options, and costs, and compare findings against the information supplied by ISPs. Such an effort will not be capable of providing a statistically sound estimate of error in ISP-supplied information, but it may identify ways to better capture information on broadband gaps through adjunct data collection techniques (e.g., the consumer survey).

Appendix A

Web Mining Statement of Work and Best Practices Recommendations

PROJECT SUMMARY AND STATEMENT OF WORK

TELOGICAL (Telogical) WILL PROVIDE THE FOLLOWING SERVICES TO THE E-NC AUTHORITY

As noted in the original NOFA attached here as Exhibit F and the e-NC Authority (e-NC) application, attached as Exhibit E, Telogical will provide the web crawling and analytical tools necessary to develop a report to the NTIA for data relating to the broadband services of a Provider as required in the NOFA and reported in a record format in 1.(a) below. Pricing as originally required was removed by NTIA from reporting in an August 11 notice. Federal Communication Commission Registration numbers will be provided by e-NC and is not required to be supplied by Telogical. Telogical will not provide Middle Mile and backhaul information. Telogical agrees it will work with the Contracting Institution to determine how best to gather this middle mile and backhaul information independent of the ability of Telogical to provide it. Street segment and address range will not be provided in the first data delivery to Contracting Institution.

The Statement of Work required will also incorporate the intent and substance of the e-NC application proposal to the NTIA submitted on August 14, 2009 and the subsequent grant awarded by the NTIA on October 5, 2009. Specific data collection and data reporting to the e-NC work will be guided by 1a and 2a below. The reporting format for information to NTIA is an Excel Spread Sheet and will be attached to contract . In this document currently is a saved word version of the excel. Telogical has the noted NOFA spread sheet as created by e-NC from the NTIA NOFA.

1. Broadband Service Availability in Provider's Service Area * ** ***

***(a)* Availability by Service Address-Service Associated with Specific Addresses**

For each facilities-based provider of broadband service to specified end-user locations in their state, awardees shall provide NTIA for each facilities-based provider of broadband service in their state, a list of all census blocks of no greater than two square miles in area in which broadband service is available to end users, along with the associated service characteristics identified in the Technical Appendix. For those census blocks larger in area than two square miles, Awardees must provide NTIA, for each facilities-based provider of broadband service in their state, either the address-specific data as described in the original Notice or a list of all street segments with address ranges in such census blocks, as contained within the U.S. Census Bureau's TIGER/Line Files or such other database of at least equivalent granularity, in which broadband service is available to end users, along with the associated service characteristics identified in the Technical Appendix.

For this purpose, "broadband service" is the provision, on either a commercial or noncommercial basis, of data transmission technology that provides two-way data transmission to and from the Internet with advertised speeds of at least 768 kilobits per second (kbps) downstream **and greater than 200 kbps upstream** to end users, or providing sufficient capacity in a middle mile project to support the provision of broadband service to end-users within the project area.

For this purpose, an "end user" of broadband service is a residential or business party, institution or state or local government entity that may use broadband service for its own purposes and that does not resell such service to other entities or incorporate such service into retail Internet-access services. Internet Service Providers (ISPs) are not "end users" for this purpose. An entity is a "facilities-based" provider of broadband service connections to end user locations if any of the following conditions are met: (1) it owns the portion of the physical facility that terminates at the end user location; (2) it obtains unbundled network elements (UNEs), special access lines, or other leased facilities that terminate at the end user location and provisions/equips them as broadband; or (3) it provisions/equips a broadband wireless channel to the end user location over licensed or unlicensed spectrum.

For this purpose, "broadband service" is "available" at an address if the provider does, or could, within a typical service interval (7 to 10 business days) without an extraordinary commitment of resources, provision two-way data transmission to and from the Internet with advertised speeds of at least 768 kilobits per second (kbps) downstream and greater than 200 kbps upstream to end-users at that address. The list of Census Blocks shall be submitted to NTIA as a tab-delimited text file in which each record has the following format:

Record Format for Census Block Data for Each Provider (replaces address-specific data)

Field	Description	Type	Example
Census Block	Census Block	Integer	370370201005020
Provider Name	Provider Name	Text	Superfone, Inc.
DBA Name	'Doing Business-as" Name	Text	ABC Co.
FRN	Provider FCC Registration Number	Integer	8402202
Technology of Transmission	Category of technology available for the provision of service at the address (see spreadsheet for codes)	Integer	50
Typical Downstream Speed	Speed tier code for the downstream data transfer throughput rate that most subscribers to service at the maximum advertized downstream speed (above) can achieve consistently during expected periods of heavy network usage.	Integer	8
Typical Upstream Speed	Speed tier code for the upstream data transfer throughput rate that most subscribers to service at the maximum advertized upstream speed (above) can achieve consistently during expected periods of heavy network usage.	Integer	4

Maximum Advertised Downstream Speed	Maximum Advertised Downstream Speed (speeds can be reported for the service area or local franchise area)	Integer	7
Maximum Advertised Upload Speed	Speed tier code for the maximum advertised upstream speed that is offered with the above maximum advertised downstream speed available. (speeds can be reported for the service area or local franchise area)	Integer	6

Characteristics of Residential Broadband Service by County for Each Provider
(a) Weighted Average Speed

For each broadband service provider in the state, awardees shall provide NTIA with subscriber-weighted nominal speed (blended average rate). For this purpose, a "residential subscriber" of broadband service is any end user assigned to Category 1, in Part 1.(a) of the NOFA: residential living unit, individual living unit in institutional settings such as college dormitories and nursing homes and other locations designed primarily for residential use at which broadband service is available.
For this purpose, "broadband service" is the provision to end users of two-way data transmission to and from the Internet with advertised speeds of at least 768 kilobits per second (kbps) downstream and greater than 200 kbps upstream.

These data shall be submitted to NTIA as a tab-delimited text file in which each record has the following format:

Record Format for Residential Broadband Service Speed Characteristics by County for Each Provider (Pricing requirements were removed with the August Clarifications)
Record Identifiers :

Field	Description	Type	Example
Provider Name	Provider Name	Text	ABC Co.
DBA Name	"Doing-business-as" name	Text	Superfone, Inc.
FRN	Provider FCC Registration Number	Integer	8402202
County	3-digit County ANSI (FIPS) Code	Integer	560
State	2-digit State ANSI (FIPS) Code	Integer	51
Technology of Transmission	Category of technology used in the provision of service (see details in Part 3 for codes)	Integer	2
Subscriber-Weighted Nominal Speed	Subscriber-weighted nominal speed (blended average rate in kbps) (see details below for methodology)	Float	2753.3

A provider's subscriber-weighted nominal speed (in kbps) should be calculated as the sum of the products of the provider's advertised maximum download data transmission rate (in kbps) for

16

each residential rate tier advertised by the provider in the county, times the average monthly number of residential subscribers receiving the advertised download transmission rate tier for the relevant reporting month (i.e., June or December, as applicable), divided by the average total number of residential subscribers for all the included data transmission rate tiers in the county for that month. This is expressed in the following formula:

(speed tier-1 in kbps x no. of tier-1 subscribers) + (speed tier-2 in kbps x no. of tier-2 subscribers) + ... total average monthly subscribers

For example, if the service provider offers two tiers of service with advertised maximum download speeds of 1500 kbps and 6000 kbps, calculate the product of 1500 kbps times the average monthly number of residential subscribers to the 1500 kbps speed tier plus the product of 6000 kbps times the average monthly number of residential subscribers to the 6000 kbps speed tier and divide the sum by the sum (or total) of the average monthly number of residential subscribers in both tiers.

Data for the entire state or territory should be submitted as a single, tab-delimited plain text file named "pricing_XX.txt" where XX is the two-letter postal abbreviation for the state or territory.

2. Broadband Service Infrastructure in Provider's Service Area

(a) Last-Mile Connection Points

Awardees shall provide NTIA with a list of the locations of the first points of aggregation in the networks (serving facilities) used by facilities-based providers to provide broadband service to end users.

For this purpose, an "end user" of broadband service is a residential or business party, institution, or state or local government entity that may use broadband service for its own purposes and that does not resell such service to other entities or incorporate such service into retail Internet-access service. Internet Service Providers (ISPs) are not "end users" for this purpose. An entity is a "facilities-based" provider of broadband service connections to end user locations if any of the following conditions are met: (1) it owns the portion of the physical facility that terminates at the end user location; (2) it obtains unbundled network elements (UNEs), special access lines, or other leased facilities that terminate at the end user location and provisions/equips them as broadband; or (3) it provisions/equips a broadband wireless channel to the end user location over licensed or unlicensed spectrum.

"Last-mile" infrastructure consists of facilities used to provide broadband service between end-user (including residences, businesses, community anchor institutions, etc.) equipment and the appropriate access point, router or first significant aggregation point in the broadband network. Examples of such facilities include, among other things: for broadband service provided by incumbent local exchange carriers, connections between end users and the central office or remote terminal; for cable modem service, connections between end users and the cable headend or fiber node; for wireless broadband service, connections between the wireless end-user device or customer premises equipment and the wireless tower or base station; for WiFi broadband service, connections between end users and the WiFi access point; or the analogous portion of the facilities of other providers of broadband services. The first points of aggregation in this context are therefore the central office, remote terminal, cable headend, wireless tower or base station, or the like.

For this purpose, "broadband service" is the provision of two-way data transmission with advertised speeds of at least 768 kilobits per second (kbps) downstream and greater than 200 kbps upstream to end users. These data shall be submitted to NTIA as a tab-delimited text file in which each record has the following format:

Record Format for Last-Mile Connection Points Data for Each Provider

Field	Description	Type	Example
Provider Name	Provider Name	Text	ABC Co.
DBA Name	"Doing-business-as" name	Text	Superfone, Inc.
FRN	FCC Registration Number	Integer	8402202
Technology of Transmission	Category of technology for the provision of service (see details in Part 3 for codes)	Integer	10
Serving Facility Backhaul Capacity	Upstream capacity of the serving facility (see details in Part 3 for codes)	Integer	1
Serving Facility Backhaul Type	Type of upstream transport facility (1=Fiber; 2=Copper; 3=Hybrid Fiber Coax (HFC); 4=Wireless)	Integer	1
End-users served	Count of end users served from this point of aggregation	Integer	24
Latitude	Latitude in decimal degrees of facility	Float	38.884560
Longitude	Longitude in decimal degrees of facility	Float	-77.028123
Elevation	Elevation relative to grade to the nearest foot (positive integers indicate above grade, negative below grade)	Integer	2

Coordinates must be expressed using the WGS 1984 geographic coordinate system.

Data for the entire state or territory should be submitted as a single, tab-delimited plain text file named "lastmile_XX.txt" where XX is the two-letter postal abbreviation for the state.

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*August 11 change by NTIA eliminated pricing information as required.

** Census Block information required page 2 first paragraph explains what is needed.

*** Reference to Federal Numbers for providers will be provided by e-NC

3. Format for Wireline and Cable Modem Providers for Reporting by Telogical

Please see the attached excel spread sheet for better layout on format-below is word format related.

NTIA provided codes will be used to identify required elements. The Technology of Transmission codes are as follows:

Code	Description	Details
10	Asymmetric xDSL	
20	Symmetric xDSL	

30	Other Copper Wireline	All Copper-wire based technologies other than xDSL (Ethernet over copper and T-1 are examples)
40	Cable Modem - DOCSIS 3.0	
41	Cable Modem - Other	
50	Optical carrier/Fiber to the end user	Fiber to the home or business end user (does not include "fiber to the curb")
60	Satellite	
70	Terrestrial Fixed Wireless - Unlicensed	
71	Terrestrial Fixed Wireless - Licensed	
80	Terrestrial Mobile Wireless	
90	Electric Power Line	
0	All Other	Any specific technology not listed above

Speed Tier Codes are as follows:

Upload Speed Tier	**Download Speed Tier**	**Description**
1		Less than or equal to 200 kbps
2		Greater than 200 kbps and less than 768 kbps
3	3	Greater than or equal to 768 kbps and less than 1.5 mbps
4	4	Greater than or equal to 1.5 mbps and less than 3 mbps
5	5	Greater than or equal to 3 mbps and less than 6 mbps
6	6	Greater than or equal to 6 mbps and less than 10 mbps
7	7	Greater than or equal to 10 mbps and less than 25 mbps
8	8	Greater than or equal to 25 mbps and less than 50 mbps
9	9	Greater than or equal to 50 mbps and less than 100 mbps
10	10	Greater than or equal to 100 mbps and less than 1 gbps
11	11	Greater than or equal to 1 gbps

Serving Facility Codes are as follows:

data_rate_codes	Data_Rate
1	Less than 1.5 mbps
2	Greater than or equal to 1.5 mbps and less than 3 mbps
3	Greater than or equal to 3 mbps and less than 6 mbps
4	Greater than or equal to 6 mbps and less than 10 mbps
5	Greater than or equal to 10 mbps and less than 25 mbps
6	Greater than or equal to 25 mbps and less than 50 mbps
7	Greater than or equal to 50 mbps and less than 100 mbps
8	Greater than or equal to 100 mbps and less than 1 gbps
9	Greater than or equal to 1 gbps

County Codes are as follows:

FIPS	County
001	Alamance
003	Alexander
005	Alleghany
007	Anson
009	Ashe
011	Avery
013	Beaufort
015	Bertie
017	Bladen
019	Brunswick
021	Buncombe
023	Burke
025	Cabarrus
027	Caldwell
029	Camden
031	Carteret
033	Caswell
035	Catawba
037	Chatham
039	Cherokee
041	Chowan
043	Clay
045	Cleveland
047	Columbus
049	Craven
051	Cumberland
053	Currituck
055	Dare
057	Davidson
059	Davie
061	Duplin
063	Durham
065	Edgecombe
067	Forsyth
069	Franklin
071	Gaston
073	Gates
075	Graham
077	Granville
079	Greene
081	Guilford
083	Halifax
085	Harnett
087	Haywood
089	Henderson
091	Hertford

093	Hoke
095	Hyde
097	Iredell
099	Jackson
101	Johnston
103	Jones
105	Lee
107	Lenoir
109	Lincoln
111	McDowell
113	Macon
115	Madison
117	Martin
119	Mecklenburg
121	Mitchell
123	Montgomery
125	Moore
127	Nash
129	New Hanover
131	Northampton
133	Onslow
135	Orange
137	Pamlico
139	Pasquotank
141	Pender
143	Perquimans
145	Person
147	Pitt
149	Polk
151	Randolph
153	Richmond
155	Robeson
157	Rockingham
159	Rowan
161	Rutherford
163	Sampson
165	Scotland
167	Stanly
169	Stokes
171	Surry
173	Swain
175	Transylvania
177	Tyrrell
179	Union
181	Vance
183	Wake
185	Warren
187	Washington
189	Watauga
191	Wayne

193	Wilkes
195	Wilson
197	Yadkin
199	Yancey

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TELOGICAL Systems™

Broadband Data Best Practices Recommendations

DRAFT No. 2

Presented to:

e-NC

Date:

December 1, 2010

Background

On Tuesday, October 26 2010, Gray Somerville of Telogical Systems met with Jane Patterson and Stephanie Jane Edwards of The e-NC Authority to review The e-NC's broadband data collection efforts and requirements. Following are Telogical's summary observations from that meeting:

1. The e-NC's process for collecting broadband data is to have two sources for every data point - one from the service providers and one from a 3rd party source.
2. The e-NC prefers to manage the process of collecting data from the service providers on its own; however, due to staffing limitations, it would be a great help to the e-NC if it had a single vendor partner who would pull together a comprehensive and integrated 3rd party data solution covering all required data fields (e.g. availability, advertised speed, typical speed, weighted nominal speed, etc).
3. Though the NTIA doesn't currently require broadband pricing data, everyone (including the NTIA) strongly desires it.
4. The proposed solution will be evaluated on the basis of its overall value as measured by data quality, data coverage, cost, and general sustainability.

Telogical's Recommendations

Following are the sources and methods Telogical recommends for meeting the e-NC Authority's needs.

Sources

In the past month, Telogical has done an extensive review of relevant 3rd party data sources. The following table summarizes our recommendations regarding the data sources that should be employed in the solution.

Source	Description	Price
Broadband Scout	The Broadband Scout data (provided by ID Insight) comes from e-commerce transactions that match up an IP address with a physical address. ID Insight states that the Broadband Scout product comprises ~ 20M unique (i.e. de-duplicated) residential household level records per year (roughly 25% - 30% of all residential broadband connections in the US). Each record collected by ID Insight indicates: • Broadband Service Availability • Address (Note that ID Insight, due to licensing restrictions, is not allowed to report the address; however, they can report data at the census block and/or tiger line ID level) • Service Provider • Technology (includes DSL, Cable, Fiber, Satellite, Fixed Wireless, and Mobile Wireless) This data is then paired with speed test data (matched on the IP address) to indicate the measured up and down speed available at a particular address. Speed test results are only available for ~ 20% of the original Broadband Scout records, which means that only about 4M records (5% - 6% of all US broadband households) are sampled each year. Due to the limited sample, it is impossible to get a statistically relevant indication of the "typical speed" at the census block level. (Assuming 30 households in a typical census	~ $75K/yr

	block, only 1 or 2 households per block would have speed test results). However, these data could be used to: 1) Analyze the typical speed per service provider per service tier (we envision doing this analysis at the census tract or county level in order to have a sufficient sample) 2) Identify the highest tier of service available per census block group. (At the CBG level, Broadband Scout would have ~ 50 speed test records. We believe this would be sufficient to identify the highest speed available within that CBG. For example, Time Warner Cable offers a 50 Mb service. Using the Broadband Scout data, you could identify those block groups where this service was available.	
Gadberry Group	The Gadberry Group has a database of over 20M US residential addresses where broadband service is indicated based on the compilation of multiple data sources including consumer surveys and product registration cards. The Gadberry data includes: • Broadband Service Availability • Address • Technology (DSL or Cable) • Confidence Level of Broadband Availability (on a 1 – 5 scale) Due to licensing restrictions, Gadberry cannot report the actual addresses; however, they can provide very precise geographic point data for each record.	~ $50K/yr
Telogical	Telogical is the leading provider of telecom service product, pricing, and promotion data to the US Communications Industry. Our research focuses on the advertised service offerings as found on corporate websites, tv/print/radio ads, direct marketing materials, e-tailers, etc. Rather than delivering a pre-defined data set, we tailor our research to the individual needs of our clients. In the case of the e-NC, we recommend a deliverable that provides the following information regarding residential broadband service offerings: • Service Provider (covering all broadband service providers) • Product Brand Name • Advertised Downstream Speed • Advertised Upstream Speed • MRC (standard) • MRC (promotional) • NRC (standard) • NRC (promotional) • Total Cost of Ownership (over 12 mos period) • County • State	~ 50K/yr
GeoTel	GeoTel's "MetroFiber" product is the only 3rd party data source we were able to identify that even approaches the "mid-mile" data requirements of the NTIA. The GeoTel data offers fiber routes, by service provider, for 270 core based statistical areas (CBSAs) across the country. Unfortunately, GeoTel's data does not have some of the details required by the NTIA such	~ $50K/yr

	as serving facility capacity, serving facility type, and elevation.	

Methodology

1. **Start with Broadband Scout Data** – After reviewing all known sources of relevant data, we believe the Broadband Scout data provides the best single 3rd party source for the date elements required by the NTIA. Therefore, we recommend that Broadband Scout data, aggregated at the census block level (street segment for blocks >2 sq miles), be used to create a "rough draft" of the data set, which will provide a preliminary answer to the following questions:
    - Where is broadband available?
    - Which technology is deployed?
    - Who is the service provider?

Table 1: Broadband Scout Data with Confidence Score					
Record ID	**Geo Type**	**Geo ID**	**Technology**	**Service Provider**	**BB Scout Confidence[15]**
000001	Census Block	BlockID	Cable	Time Warner Cable	5
000002	Census Block	BlockID	Fiber	AT&T	3
000003	Street Seg	TLID	DSL	AT&T	4

2. **Validate & Fill Out Broadband Availability Using Gadberry Data** – The Gadberry Group has over 20 million household level observations (derived from customer surveys, product registration cards, etc) that identify a) broadband availability and b) technology type by either DSL or cable. We envision that in those cases where there is a match between Broadband Scout and Gadberry regarding broadband availability by technology type, the data will be appended to show the Gadberry Data confidence level (a standard field with Gadberry's data). In those cases where the Gadberry data identifies a Census Block/technology pair that was not indicated by the Broadband Scout data, a new record will be added to the data set.

Table 2: Gadberry Data Added & Weighted Confidence Score Calculated (Green highlights indicate new columns/rows of data added during this step.)							
Record ID	**Geo Type**	**Geo ID**	**Tech-nology**	**Service Provider**	**BB Scout Confidence**	**Gadberry Confidence**	**Wtd Confidence**
000001	Census Block	BlockID	Cable	Time Warner Cable	5	5	5
000002	Census Block	BlockID	Fiber	AT&T	3	N/A	3
000003	Street Seg	TLID	DSL	AT&T	4	3	4
000004	Census Block	BlockID	DSL	Unknown	N/A	3	2

[15] We have assumed that a "Confidence Score" (1 – 5 scale) can be calculated by analyzing the number of validating observations per census block and/or census tract. For example, 5+ observations showing the same market segment (e.g. residential), service provider (e.g. AT&T), and technology (e.g. DSL) within a given census block would result in a BB Scout Confidence Score of "5".

3. **Fill in Missing Service Provider Information Using Telogical's Research Services** – Next, we recommend that those records uniquely identified by Gadberry data as served be researched by Telogical (using web research) to fill in the missing service provider information.

Table 3: Web-Scraping Research Used to Fill In Missing Data
(Green highlights indicate data resulting from Telogical research.)

Record ID	Geo Type	Geo ID	Tech-nology	Service Provider	BB Scout Confid	Gadberry Confid	Wtd Confid.
000001	Census Block	BlockID	Cable	Time Warner Cable			5
000002	Census Block	BlockID	Fiber	AT&T			3
000003	Street Seg	TLID	DSL	AT&T			4
000004	Census Block	BlockID	DSL	CenturyLink			2

4. **Using Telogical Data, Append File with Advertised Speed & Price Info –** Telogical will research service provider's advertised speeds and pricing by sampling five unique addresses per county. Typically, advertised speeds and prices are consistent at the county level; however, if Telogical finds variation, it will increase its sample as necessary to identify all unique service offerings. Once all service offerings are identified, the results will be projected down to the census block level. Please note that this step will temporarily inflate the research findings by suggesting that the highest speeds are available in every census block served by that provider. In the next step, these over-stated results will be pared back using Broadband Scout's data.

Table 4: File Appended with Telogical Advertised Speed & Pricing Information
(Green highlights indicate data added in this step of the process.)

Record ID	Geo Type	Geo ID	Technology	Svc Provider	Availability	Adv Dwn Speed	Max Adv Up Speed	MRC (Stand.)	MRC (Promo)	NRC (Stand.)	NRC (Promo)	1 Yr. TCO
				Time Warner		50 M	5 M	$99.95	N/A	$42.50	N/A	$1,241.90
				Time Warner		30 M	5 M	$77.95	$54.95	$42.50	N/A	$701.90
				Time Warner		15 M	1 M	$67.90	$44.90	$42.50	N/A	$581.30
				Time Warner		10 M	1 M	$57.95	$34.95	$42.50	N/A	$461.90
				Time Warner		1.5 M	256 K	$40.95	N/A	$42.50	N/A	$533.90
				Time Warner		768 K	128 K	$30.95	N/A	$42.50	N/A	$413.90

5. **Use Broadband Scout to Add Typical Speeds and to Identify Tiers of Service That Are Unavailable at the Census Block Group Level –** Broadband Scout provides carrier-specific broadband speed test results mapped to actual addresses. Using the Broadband Scout data, we can determine the "Typical Speed" associated with each Advertised Speed. We can also identify Advertised Speeds that are unavailable within a given census block group such that these records can be removed from the data set. Following is the process we envision:
    - Match Broadband Scout Records to Advertised Speeds - Each Broadband Scout record will be matched to the fastest advertised download speed that is <= the Broadband Scout download speed. For example, if the Broadband Scout record showed a download speed of 4.12 Mbps for Service Provider X and the Telogical data showed advertised speeds of 12 Mbps, 6 Mbps, and 3 Mbps for the same provider within that market, the Broadband Scout record would be matched to the 6 Mbps advertised speed.
    - Calculate the Typical Speed – Once each Broadband Scout record has been associated with an advertised speed, we can then calculate the typical speed for that tier of service by taking average of all measured speeds per carrier per advertised speed at the census block group level.
    - Append the Data to the Master Data Set – The resulting typical speed information will then be appended to the master data set.
    - Delete Records That Do Not Show a Typical Speed Associated with an Advertised Speed – Once the typical speed data has been appended to the master data set, there will be a number of records that show an Advertised Speed but do not show a corresponding Typical Speed. We will assume that these tiers of service are not available within that census block group and therefore remove those records from the data set.

Table 5: Typical Speed Added to the Data Set and Not Applicable Records Identified for Deletion

Green: Fields/data added to database

Yellow: Records marked for deletion from database due to absence of service at this tier.

Record ID	Geo Type	Geo ID	Technology	Service Provider	Availability	Adv Dwn Speed	Typical Dwn Speed	Max Adv Up Speed	Typical Up Speed	MRC (Stand.)	MRC (Promo)	NRC (Stand.)	NRC (Promo)	1 Yr. TCO
						50 M	**N/A**	5 M	N/A	$99.95	N/A	$42.50	N/A	$1,241.90
						30 M	**N/A**	5 M	N/A	$77.95	$54.95	$42.50	N/A	$701.90
						15 M	**N/A**	1 M	N/A	$67.90	$44.90	$42.50	N/A	$581.30
						10 M	8.23 M	1 M	.88 M	$57.95	$34.95	$42.50	N/A	$461.90
						1.5 M	1.25 M	256 K	232 K	$40.95	N/A	$42.50	N/A	$533.90
						768 K	705 K	128 K	121 K	$30.95	N/A	$42.50	N/A	$413.90

6. **Calculate Subscriber Weighted Nominal Speed at County Level**
    - Match Broadband Scout measured speed records to Telogical advertised speeds (as detailed above)
    - Calculate provider market share per advertised download speed using Broadband Scout Data

- Apply NTIA formula (Speed Tier_1 * Speed Tier_1 Subs / Total Subs) using Broadband Scout data.

7. **Mid Mile Connection Points** – The best 3rd party source of data available is GeoTel's "MetroFiber" product which provides fiber routes, by service provider, for 270 core based statistical areas (CBSAs) across the country. Unfortunately, GeoTel's data does not have some of the details required by the NTIA such as:
    - Serving Facility Capacity
    - Serving Facility Type
    - Elevation

Appendix B

Consumer Survey

Consumer Survey Report

NC Broadband Rigor in Mapping (NC BRIM) Project

December 10, 2010

Professor Nicholas Didow
Kenan Institute Faculty Fellow
Kenan-Flagler Business School
University of North Carolina
Chapel Hill, NC 27599-3490
919.962.3189 nick_didow@unc.edu

Executive Summary

This report summarizes the consumer survey portion of the NC BRIM project. A consumer survey of households in 19 North Carolina counties was designed, conducted, analyzed, and reported in a manner commonly used for broadband mapping purposes. The key self-report dependent measure was that only Dial-up was available at the household address, faster services like DSL or Cable Modem were not available. By this method an estimated 81.9 percent of households across the 19 counties would be designated as "served" with access to broadband, while 18.1 percent of households would be identified as "unserved". Using more strictly qualified household respondents, this method results in an estimated 92.2 percent of all households identified as "served" with access to broadband and 7.8 percent of all households unserved.

The substantive results from this method of broadband mapping will be compared and contrasted with other broadband mapping methods elsewhere in the NC BRIM project. However, several strengths and weakness, issues, findings and policy recommendations concerning using the consumer survey method in the context of broadband mapping can be identified at this point. Many of them are illustrated within the design, conduct, analysis, and reporting for this consumer survey.

Introduction

The purpose of this report is to summarize the design and conduct of the consumer survey portion of the NC Broadband Rigor in Mapping (NC BRIM) project and to present strengths, weaknesses, issues, findings and policy recommendations resulting from using a consumer survey method in the context of broadband mapping. Geo-coded household-level data from this consumer survey was subsequently included in the larger comprehensive project data base for comparison with other methods of broadband mapping that were part of the NC BRIM project. This report describes the consumer survey method used in this project; identifies prevailing federal court consumer survey research standards for litigation purposes; and discusses both possible intended and unintended effects of consumer surveys on civic engagement, public policy and the political process.

Consumer Survey

Purpose and Design of Survey

The NC BRIM Consumer Survey attempts to replicate one prominent current method of broadband mapping – a survey of households in which an adult in each household is asked to self-report what, if any, Internet service is available at their location and whether they currently make use of it or not. For the purposes of this study, wireless, mobile and satellite Internet service is not considered to provide fully functional broadband access. The common operational definition of an unserved household is one that self-reports they only have access to Dial-up without access to faster wireline services like DSL or Cable Modem. A served household would be one that self-reports they do have access to DSL or Cable Modem.

Population and Sample

The Consumer Survey in this project was a telephone interview of randomly selected households in 19 North Carolina counties. The 19 counties were carefully selected to be representative of the entire state with respect to economic and demographic characteristics, including the mix of predominantly urban versus predominantly rural counties. The 19 counties and their 2008 populations are presented in Table 1 and are mapped in Appendix A.

Table 1. NORTH CAROLINA COUNTIES INCLUDED IN THE CONSUMER SURVEY

NC COUNTY	2008 POP (K)	PERCENT
Jones	10	0.7
Lenoir	56	4.0
Martin	23	1.6
Robeson	129	9.2
Dare	33	2.4
Craven	97	6.9
Carteret	63	4.5
Montgomery	27	1.9
Person	37	2.6
Chatham	63	4.5
Alamance	148	10.5
Durham	263	18.7
Clay	10	0.7
Mitchell	16	1.1
Rutherford	63	4.5
Surry	72	5.1
Madison	20	1.4
McDowell	44	3.1
Buncombe	229	16.3
TOTALS	1,403	100

A random sample of household telephone numbers was obtained from Survey Sampling International, the leading commercial source for samples of this type. It was determined that the number of North Carolina households without traditional wireline telephones or wireless telephones was minimal, as was the number of unlisted telephone numbers within this state. VoIP (Voice over Internet Protocol) telephone numbers, such as those from Vonage customers, were also determined to be minimal across the state, yet are included among traditional wireline telephone numbers by Survey Sampling International. It was also determined that the mix of households with traditional wireline numbers versus wireless numbers was approximately 75 percent to 25 percent, in keeping with the current national averages. Therefore, Survey Sampling International provided a sample mix of 75 percent traditional wireline numbers and 25 percent wireless numbers drawn randomly from the 19 counties in proportion to their relative population. For example, 9.2 percent of the total sample came from Robeson County, 2.4 percent from Dare County, 6.9 percent from Craven County and so forth across the 19 counties.

Survey Sampling International provided the sample in replicates. A replicate is a smaller number of sample numbers drawn to match the relative population. In this case each replicate consisted of 100 randomly selected household telephone numbers with 9 from Robeson County, 2 from Dare County, 7 from Craven County and so forth across the 19 counties in the target population. Survey Sampling International provided 840 traditional wireline household telephone number replicates each with 100 numbers allocated to match the relative population of each county within the 19 county area of interest. They likewise provided 500 wireless telephone number replicates each with 100 numbers.

The call centers implementing the telephone interviews allocated three of their four weeks of field work to calling the traditional wireline telephone numbers and one week to calling the wireless numbers. Telephone interviewers worked from each replicate as a call sheet and made as many as three attempts to contact someone at the number, calling at different times and days, before the number was abandoned.

Using random sampling, replicates and calling instructions like this increased the likelihood that the resulting completed calls would be proportionally representative of the population from each of the 19 counties. That was the case in this study.

Traditional wireline household telephone numbers along with location information are publically provided in various electronic and printed formats, such as telephone directories (except for non-published telephone numbers). Therefore, Survey Sampling International was able to provide sample wireline household numbers along with the name registered to that number, address, county, and pre-coded latitude and longitude of the household address. Wireless numbers, however, are not currently publically published in any format and therefore come only with the county believed to be the “home” county for the wireless number subscriber.

The FCC and the Federal Telephone Consumer Protection Act have established some special requirements for calling wireless numbers in this kind of survey. These include the prohibition of dialing wireless numbers using “automated” telephone equipment or any electronic dialing methods. A copy of Survey Sampling International’s wireless sample agreement is included in Appendix B. In this study, all dialing – both wireless and wired numbers – was done manually.

Appendix B also includes a document from Survey Sampling International that contains hints and best practices for calling wireless numbers. This document notes that refusals are usually much higher when calling wireless numbers and interviewers must be more aware of respondent environment issues – such as answering while driving a car.

Survey Questions and Structure

Appendix C includes a printed copy of the telephone survey instrument, or questionnaire. The survey included 21 questions and took an average of five minutes to complete. The survey was designed to include key questions to capture awareness of access to and utilization of broadband Internet service at the household address. The survey also asked for a self-report of the name of the respondent and household address.

Questions and potential responses were designed to be unbiased and objective. Drafts of the questionnaire were shared among the NCBRIM staff and advisors for feedback and suggestions and to verify objectivity. The final version of the telephone survey was established online using Survey Monkey so the telephone interviewers could enter responses directly into the resulting data base.

The first question in the survey was the key question for broadband mapping using self report data from an adult in the household. After qualifying the respondent to be the adult in the household who is most knowledgeable about the household's computers and access to the Internet, the respondent was asked to indicate what Internet services were available at their household, regardless of whether they currently had Internet service at their home address or not. The responses included only dial-up, DSL, cable modem, wireless Internet, mobile cellular Internet service, satellite Internet service, or don't know. Using this broadband mapping method, the response that "only dial-up is available at this household address, faster services like DSL or cable modem are not available" was taken to indicate that this was an unserved household address. The prevailing practice using this broadband mapping method is to consider only wired Internet service as adequate -- dial-up and any wireless, cellular, or satellite is counted as unserved.

Other questions in the survey asked respondents to name companies that offer Internet service at their home address, to indicate if they do indeed have Internet access at home and if so, what that service is and whether they have a bundled Internet service or a stand-alone service. Respondents were asked how much they paid monthly for their Internet service package and how much more they would pay each month to get twice as fast Internet service as they now have. They were asked to name their current Internet service provider and provide detail as to the maximum speed with which they can currently connect to the Internet. Respondents were invited to log on to their computers and perform a standard speed test. They were also asked if they would authorize the interviewer to act as their agent and contact their Internet service provider to determine the maximum Internet speed their current service package is supposed to provide.

Still other questions capture information about the number of computers at the home address, whether there was a traditional landline telephone there and whether anyone in the household had devices like cell phones and smart phones. Respondents were also asked in an open ended question if they wanted to offer any comments about computers, Internet service, and the quality of the service they received or the cost of the service.

The last set of questions in the survey asked respondents to report their name and contact information.

Call Centers and Interviewers

The telephone interviews were conducted between February 10 and March 12, 2010, by two call centers located in North Carolina. The two call centers with necessary computer and telephone headset technology were established in Reidsville at the Rockingham County Business and Technology Center and in Rutherfordton at the Foothills Connect Business and Technology Center. These two call centers were selected through an RFP process.

Management and training was provided in Chapel Hill, NC, to the two sets of respective call center managers and project leaders. Appendix A includes several outlines and documents that were used for that training, including an Introduction to Basic Call Center Management Issues, Sample Telephone Interviewer Job Description, Optimal Days and Times for Telephone Interviewing by Type and Number, and How Many Surveys are They Really Supposed to Complete? On-site kickoff orientation and interviewer training was provided in Reidsville on February 10 and in Rutherfordton on February 12. Two identical versions of the online telephone interview were established using Survey Monkey – one for training purposes and another serving as the real version. Interviewers were supervised as they practiced using the training version and began using the real version with real telephone numbers as they became comfortable with the language and sequence of the telephone survey. The primary researcher was available by email and cell phone to the site managers and supervisors 24x7 over the four weeks of field work for the project. No problems were encountered by the telephone interviewers or call center management personnel.

In addition to the call center training and telephone interviewer experience, this project provided four weeks of employment for 12 people at each site, or employment in 24 jobs that would have otherwise not have been available in Reidsville and Rutherfordton, North Carolina.

Field Work, Data Entry and Results

Three weeks of calling was dedicated to interviews using the random sample of traditional wireline telephone numbers and one week of calling using the random sample of wireless numbers. Call sheets were organized in replicates that provided sample telephone numbers in proportion to the populations of the 19 counties. The overall response rate was above 80 percent, however the response rate differed significantly between calling traditional wireline numbers versus calling wireless numbers. The wireless number response rate was less than 30 percent. When someone did agree to be interviewed, however, the completion rate was high, with about 95 percent of those who started the survey continuing through the end of the interview. Response data was entered directly online using Survey Monkey software and programming. A 10 percent participation validation sample was conducted independently by different interviewers with no evidence of falsified survey participation by any of the call center interviewers.

There were 10,303 telephone interviews completed in the consumer survey project, including 9,259 completions from calling traditional wireline household telephone numbers and 1,044 from calling wireless numbers. The raw data counts are presented for each question and response in Appendix A. Appendix D provides the recorded verbatim answers offered in response to question 18 – "Are there any comments you want to offer about computers, Internet access, and the quality of service you receive or the cost of the service?"

Table 2 summarizes the 10,303 completions by county and also notes the margin of error by selected sample sizes. Using the telephone sample organized by replicates in proportion to the relative population of each county with three attempts to contact someone at each telephone number resulted in the distribution of the 10,303 completions closely aligned with the distribution of the population of each county. There were 691 respondents – all among the wireless telephone numbers – that could not be classified by county due to respondents declining to self-report their household address.

Table 2. COMPLETIONS BY COUNTY

NC COUNTY	2008 POP (K)	PERCENT	COMPLETIONS #	PERCENT
Jones	10	0.7	53	0.5
Lenoir	56	4.0	340	3.3
Martin	23	1.6	162	1.6
Robeson	129	9.2	801	7.8
Dare	33	2.4	187	1.8
Craven	97	6.9	750	7.3
Carteret	63	4.5	410	4.0
Montgomery	27	1.9	193	1.9
Person	37	2.6	271	2.6
Chatham	63	4.5	424	4.1
Alamance	148	10.5	1,011	9.8
Durham	263	18.7	1,548	15.0
Clay	10	0.7	72	0.7
Mitchell	16	1.1	113	1.1
Rutherford	63	4.5	494	4.8
Surry	72	5.1	515	5.0
Madison	20	1.4	177	1.7
McDowell	44	3.1	330	3.2
Buncombe	229	16.3	1,761	17.1
not classified			691	6.7
TOTALS	**1,403**	**100**	**10,303**	**100**

For this study, the margin of error rate at a 95 percent confidence level is +/-2.43 percent.

Question 1 in the survey was the key question used in consumer survey methodology to estimate broadband availability and broadband mapping. Question 1 and its raw data responses are presented in Table 3. Across the 10,303 completed interviews, 1,536 respondents said that only Dial-up was available where they lived as faster services like DSL or Cable modem were not available, 5,616 said DSL was available where they lived, 5,830 said Cable Modem was available where they lived, 4,073 reported wireless Internet service was available at their household address, 3,387 said mobile Cellular Internet service was available, 3,782 said satellite Internet service was available, and 1,874 said they did not know what was available at their home address.

Table 3. RAW DATA RESPONSES TO QUESTION 1:
Regardless of whether you currently have Internet service at your home address or not, which of the following statements are correct about Internet service available at your home address? (READ AND CHECK ALL ANSWERS THAT APPLY.)

	Response Count	Response Percent
Only Dial-up is available where I live, faster services like DSL or Cable Modem are not available.	1,536	15.1
DSL Internet service is available where I live.	5,616	55.1
Cable Modem Internet service is available where I live.	5,830	57.2
Wireless Internet service is available where I live.	4,073	40
Mobile Cellular Internet service is available where I live.	3,387	33.2
Satellite Internet service is available where I live.	3,782	37.2
DON'T KNOW	1,874	18.4
ANSWERED QUESTION	10,195	
SKIPPED QUESTION	108	

This household survey was comprehensively designed so that a household respondent was asked whether each of the possible services and technologies – only Dial-up, DSL or Cable modem, wireless Internet, mobile Cellular Internet, and satellite Internet service – was available at their home address. Other consumer surveys may be designed so that the respondent is only asked whether Dial-up is available or not at their address. Using a comprehensive survey design for this key question results in some interesting basic findings and raises some key questions for this method of estimating broadband availability.

Specifically, as reported previously in the results for Question 1, across the 10,303 completions, a total of 1,536 respondents said "only Dial-up is available" at their household address. However, across these 1,536 respondents who said "only Dial-up is available,"

- 812 also said DSL was available,
- 800 also said Cable modem was available, and
- 704 of them also said that both DSL and Cable model was available.

Further analysis of the results for Question 1 indicates that across the 10,303 completions, a total of 628 respondents said “only Dial-up is available” without also indicating that DSL and/or Cable modem was available, too. Yet 14 of these 628 respondents also said they “don’t know” what is available at their household address. Therefore, only 614 of the 10,303 respondents said that “only Dial-up is available” and nothing else and are therefore the most “pure” responses that indicate the unavailability of any wireline broadband services beyond Dial-up.

This finding raises some key validation questions for using the consumer survey method of broadband mapping. Assuming there are no intentional attempts to misstate broadband availability or respond erroneously, this does raise the question of whether consumers in general have sufficient knowledge and awareness to answer this key question. It is possible that some of the consumer questionnaires used in ARRA BTOP1 Broadband Deployment proposals and other broadband mapping projects designed this key question only to ask , “Is it the case that only Dial-up is available where you live – faster services like DSL or Cable modem are not available?” An answer of “Yes” to this question would be scored as a household address without access to broadband. However, what is the accurate, true answer? Does one take the respondent at their word when they answer only with respect to Dial-up, or does one more strictly qualify a respondent based on their answers to other items in the questionnaire? Where is the truth and can consumers accurately report it for their household address?

In total 9,583 of the 10,303 completions included adequate information to identify the home address of the respondent at some level of geographic precision. Table 4 summarizes the distribution of addressable responses, the number responding “Don’t Know,” the number responding that only Dial-up was available at their home address, and the percentage of households served with broadband by county using this method of granular geographic analysis.

Overall, 9,583 survey completions were addressable responses and 1,753, or 18.3 percent, of these respondents said they did not know what Internet service was available at their home address. The percentage responding that they did not know varied by county from a low of 12.3 percent saying they did not know in Carteret County to a high of 30.9 percent saying they did not know in Martin County.

In summary, it is reasonable to ask whether all the adults who answered Question 1 had accurate knowledge about broadband access available at their home address. That remains an unanswered question, as there is no available gold standard of truth against which to directly compare the consumer survey responses.

A total of 1,417 addressable responses reported that only Dial-up was available at their home address resulting in an overall rate of 18.1 percent of households across the 19 counties that would be determined to be unserved by broadband using household address-level analysis without cross-checking and deleting households that additionally indicated DSL and/or Cable modem was also available. Using a higher standard to qualify respondents on this key question results in a total of only 614 addressable “pure” internally consistent responses that only Dial-up was available at their household address. This reduces the estimated overall rate of unserved households from 18.1 percent to 7.8 percent.

Using only the initial 1,417 addressable responses qualified only by their response to the question of the availability of Dial-up, the percentage unserved by broadband varied from a low of 13.5 percent in Buncombe County to a high of 37.1 percent unserved by broadband in Madison County. Making these calculations using only the most highly qualified “pure” 614 respondents results in a percentage unserved by broadband range from a low of 5.8 percent in Buncombe County to a high of 16.1 percent unserved in Madison County.

Conversely, again using the initial 1,417 responses over the 19 counties 81.9 percent of the households were found to be served by broadband, wherein the working definition of “adequate broadband service” is the availability of either DSL or Cable Modem. The level of the household population served by broadband varied from a low of 62.9 percent in Madison County to a high of 86.5 percent in Buncombe County. In addition to Buncombe County at 86.5 percent, other counties within the consumer survey study that were found to be relatively more served by broadband at home addresses were Dare County at 85.6 percent, Carteret County at 85.4 percent, Durham County at 85.2 percent, and Lenoir County at 85 percent. In addition to Madison County at 62.9 percent, other counties within the consumer survey study found to be relatively less served by broadband access at home addresses were Montgomery County at 69.9 percent, Martin County at 71.4 percent, Clay County at 72.6 percent, Mitchell County at 73.3 percent, Rutherford County at 74.1 percent, McDowell County at 75 percent, and Robeson County at 76.9 percent. Recalculating these percentages using the most highly qualified “pure” 614 respondents would result in higher estimates of broadband service levels for every county as the unserved gap for each county would be cut by almost half.

Each of these summary calculations using the initial 1,417 responses is presented in Table 4.

Table 4. ADDRESSABLE HOUSEHOLD RESPONSES, DON'T KNOW, ONLY DIAL-UP AVAILABLE, AND PERCENT OF HOUSEHOLDS SERVED BY COUNTY

NC COUNTY	TOTAL	DON'T KNOW (DK)	PERCENT DK/TOTAL	ONLY DIAL-UP AVAILABLE	PERCENT ONLY DIAL-UP/ (TOTAL-DK)	ESTIMATED PERCENT OF COUNTY POPULATION IN SERVED HOUSEHOLDS
Jones	53	9	17.0	8	18.2	81.8
Lenoir	340	94	27.6	37	15.0	85.0
Martin	162	50	30.9	32	28.6	71.4
Robeson	795	207	26.0	136	23.1	76.9
Dare	187	20	10.7	24	14.4	85.6
Craven	750	123	16.4	106	16.9	83.1
Carteret	405	50	12.3	52	14.6	85.4
Montgomery	193	40	20.7	46	30.1	69.9
Person	271	59	21.8	44	20.8	79.2
Chatham	424	61	14.4	72	19.8	80.2
Alamance	1,007	202	20.1	135	16.8	83.2
Durham	1,547	221	14.3	196	14.8	85.2
Clay	72	10	13.9	17	27.4	72.6
Mitchell	113	27	23.9	23	26.7	73.3
Rutherford	494	100	20.2	102	25.9	74.1
Surry	515	113	21.9	70	17.4	82.6
Madison	177	34	19.2	53	37.1	62.9
McDowell	330	78	23.6	63	25.0	75.0
Buncombe	1,748	255	14.6	201	13.5	86.5
TOTALS	9,583	1,753	18.3	1,417	18.1	81.9

The data base was reviewed and corrected, or "scrubbed," three times for spelling errors and transcription errors. This review was conducted by independent personnel. About 800 data entry and spelling errors were identified and corrected. Roughly 400 of these errors were transcription errors from telephone interviewer mistakes in copying the household latitude and longitude data from the information provided with the traditional wireline sample. These mistakes included misplacement of the decimal point and failing to copy and enter the negative sign in the longitude. Even after being scrubbed three times, the data base still contains some number of typos and errors.

Before the database was included within the larger comprehensive database for comparison with other broadband mapping methods, the two sets of household responses – those from calling traditional wireline numbers and those from calling wireless numbers – were geo-coded.

The traditional wireline household telephone numbers provided by Survey Sampling International came with latitude and longitude already geo-coded for each household address. The latitude and longitude data for these 9,259 completed household responses was converted to North Carolina Census Block data using ESRI ARCMap special join between each respondent household's latitude and longitude and the 2000 Census Blocks as depicted by points within TIGER/Line 2000 Census Block boundaries for North Carolina. The method used by Survey Sampling International to geo-code household addresses into latitude and longitude data is unknown. Nor is information provided by Survey Sampling International as to the precision of this geo-coding. That is, geo-coding of household addresses to latitude and longitude data can occur using different data for geo-coding and resulting in levels of precision including geocoding based on the individual household address, a midpoint location of an entire street, and the centroid location of a ZIP Code.

Geo-coding the 1,044 completed surveys for the wireless telephone number household locations depended first on the respondent providing the correct street address for their household. Only 389 respondents of the 1,044 completed wireless number consumer surveys, or 37 percent of the wireless respondents, were willing to provide their home address and contact information. These 389 wireless household addresses were geo-coded to latitude and longitude using Juice Analytics software and data bases. The geo-coding precision reported by Juice Analytics was that 37 percent of the 389 addresses were successfully coded at the household address, 7 percent at the street level of precision, 55 percent at the ZIP Code level of precision, and 1% percent at the city level of precision.

Substantive Findings

The database reported in Appendix A also includes raw response distributions for each of the other questions in the consumer survey. The substantive findings from the consumer survey include the following highlights:

- 5.8 percent of respondents said there was no Internet access at their home address and 11.5 percent said they did not know any company that offered Internet service at their home address.
- Unaided brand awareness of Internet service provider at the respondent's home address was highest for Time Warner (33.5 percent), AT&T (27.8 percent), CenturyLink's brands (25.8 percent) (CenturyLink 9.4 percent, Embarq 10.1 percent, SuddenLink 6.3 percent), Verizon (21.1 percent), and Charter (18.8 percent).
- 76 percent of respondents said they had some form of Internet access at their home address.
- Only 20.9 percent of respondents reported that they had purchased Internet service as a stand-alone service. Internet service was reported as bundled with various combinations of telephone service and/or cable television subscription by 77.3 percent of respondents.
- 71 percent of respondents indicate how much they paid monthly for their Internet service package, while 23.5 percent did not know and 5.6 percent refused to answer.
- 8.7 percent of respondents reported that they have and use Dial-up currently at their home address, 41.3 percent said they have and use DSL or high speed wireline, 41.1 percent cable modem, 11.4 percent wi-fi wireless, 4.2 percent a PC wireless card, 6.5 percent a mobile device like a cellular phone or smart phone, and 2.9 percent satellite, while 2.1 percent of respondents said they have Internet access but they do not know what it is.

- According to respondents' reports of who provides Internet service to their homes, the market shares of major Internet service providers across these 19 North Carolina counties at the time of the consumer survey were Time Warner (30.2 percent), CenturyLink brands (19.3 percent) (CenturyLink 8.3 percent, Embarq 5.7 percent, SuddenLink 5.3 percent), AT&T (17.4 percent), Charter (14.8 percent), and Verizon (10.6 percent).
- 24.2 percent of respondents did not know the speed at which they could connect to the Internet at home and 79.5 percent of respondents said they would not be willing to pay any more to get twice as fast Internet service at home compared to what they now have.
- 325 respondents attempted to perform an Internet service outbound and inbound speed test within the context of the consumer survey.
- 2,200 respondents were willing to authorize the telephone interviewer as their agent to contact their Internet service provider to determine the maximum Internet speed their service package was supposed to provide.
- 18.5 percent of respondents reported they did not have a computer at their home address.
- 87.7 percent said someone in their household had a cell phone and 22.4% of respondents said someone had a Palm Pilot, iPhone, BlackBerry, or some other smart phone.

Respondents were also asked if they wanted to offer any comments about computers, Internet access, and the quality of service or cost of service they received. These comments are reported in Appendix B. About 3,500 respondents offered some comments. The comments varied from some respondents who said they were satisfied with their current Internet access and service to many respondents who expressed dissatisfaction with their access to quality service at a reasonable price. A content analysis of the comments reported in Appendix B in response to Question 18, "Are there any comments you want to offer about computers, Internet access, and the quality of service you receive or the cost of the service?" results in the following general category findings:

- 16 percent are generally happy with the reliability, cost, speed, and quality of their current service.
- 33 percent say the cost of service is too high or service is too expensive.
- 6 percent are dissatisfied with their current Internet service provider.
- 9 percent are dissatisfied with the speed or quality of their service.
- 15 percent say we need more than just Dial-up or DSL, we need faster high-speed broadband service, like fiber optic based FTTH or FIOS.
- 3 percent want more choices among service providers, say we need more competition.
- 4 percent of respondents say they don't have access to the Internet and they don't want it!
- 12 percent offered other miscellaneous comments, such as complaining about computer viruses, spam, and junk email.

Broadband Mapping and Consumer Surveys: Civic Engagement, Public Policy and the Political Process

The consumer survey method is the only broadband mapping method that directly contacts and engages citizens to think about broadband access and utilization. This direct contact and engagement may have both intended and unintended effects on civic engagement, public policy and the political process.

Many households contacted in this consumer survey, for example, determined and reported that they have ample broadband access and take advantage of that access with what they determine to be a quite satisfactory level of service from a competent Internet service provider at a reasonable cost.

Still other households contacted in this survey probably had a different reaction. Participating in this survey by hearing each question, considering the possible answers, and responding to reflect Internet service access and utilization at their home address may have reminded them of continuing frustrations and perceived inequality their household faces because they are geographically located on the wrong side of the Digital Divide. The survey questions and answers remind and inform respondents of the landscape of various Internet service providers and services that are available to some, but not all, households.

The consumer survey method of broadband mapping therefore is the only method that provides for widespread grassroots civic engagement in broadband access and utilization issues. It results in a more informed citizenry who may be more motivated to follow and participate in public debate about broadband access and utilization issues including broadband deployment to unserved and underserved areas, household broadband access as a universal right, broadband as the fourth public utility, the role of high speed broadband in community economic development, state and national standards for an acceptable definition of "broadband" speed for today and tomorrow, and others. This method lays a foundation for broadband access and utilization questions that citizens might pose to elected officials including the role of ARRA federal stimulus funds in broadband deployment efforts and reasonable industry oversight by appropriate state and federal regulatory authorities.

Summary Assessment of Consumer Surveys as a Resource for Broadband Mapping

This report has summarized the consumer survey portion of the NC BRIM project. The consumer survey was designed, conducted, analyzed and reported in a manner commonly used for broadband mapping purposes. The substantive results from this method of broadband mapping will be compared and contrasted with other methods elsewhere in the NC BRIM project. However, several strengths and weakness, issues, findings and policy recommendations concerning the consumer survey method in the context of broadband mapping can be identified. These include the following 16 observations and suggestions:

1. There needs to be a reasonable working definition of “broadband” that appropriately captures the need for high speed Internet service now and in the future.
2. The prevailing consumer survey working definition of adequate broadband access being the availability of DSL and/or Cable Modem service should be reviewed.
3. Not including an array of broadband access questions and responses in the survey nor checking responses for internal logical consistency results in much higher estimates of broadband unavailability.
4. The working definition of “unserved” as “only Dial-up is available where I live, faster services like DSL or Cable Modem are not available” lacks adequate precision for policy makers as normal and ordinary Internet service speeds increase over time.
5. Selecting an appropriate sample of traditional wireline telephone numbers (including VoIP numbers) and wireless telephone numbers representative of a known population of households will become more difficult as the percentage of unpublished numbers increases.
6. Wireless telephone numbers in consumer surveys like this provide their own challenges as they typically have high refusal rates and depend entirely on respondent self-report to capture their name and geographic information including their household address.
7. Calling wireless numbers means sometimes the phone will be answered while the respondent is in a risky situation like driving a vehicle or in a situation that is inappropriate for the interview like at work or out somewhere.
8. Many wireless number holders believe their wireless numbers are confidential and not available to telephone interviewers to call.
9. The consumer survey method involves issues of respondent confidentiality and protection of sensitive household information.
10. Alternative methods of capturing broadband access and utilization at the household level should be investigated, including the possibility of having broadband access and utilization questions as part of the information gathered from every American household in the decennial Census of Population.
11. Another alternative consumer survey household sampling method that should be considered is random digit dialing.
12. The consumer survey method provides a rich opportunity to ask detailed and insightful self-report questions about household broadband access and utilization, including barriers to utilization, satisfaction with current Internet services and service providers, and suggestions for improving the usefulness of broadband for each household.
13. Standards by which consumer surveys can be evaluated have been developed by both the market research profession and by the federal courts within the context of civil litigation. Consumer surveys used for broadband mapping should meet both the prevailing standards for the admissibility of survey research as evidence in federal courts and more comprehensive standards established by the market research profession.

14. Established commercial telephone sample sources should be transparent about the procedures and methods they use to assign latitude and longitude to household addresses and the resulting precision levels of that geo-coding assignment process.
15. Alternative procedures and methods for assigning latitude and longitude information to household addresses and for matching latitude and longitude information with Census Blocks or other standard units of analysis should be reviewed and a single common set of geo-coding methods and procedures should be prescribed along with guidelines for what would be considered as acceptable levels of precision.
16. The consumer survey method may result in increased civic engagement in public policy and the political process with respect to broadband issues

ESTABLISHED CRITERIA FOR CONSUMER SURVEY RESEARCH

Federal Court Standards for Consumer Survey Research

The federal courts have established criteria for consumer survey research studies that are proposed as evidence in civil litigation. Any study proposed as evidence must reasonably meet criteria that have been summarized, discussed and illustrated by Shari Seidman Diamond in "Reference Guide on Survey Research," Reference Manual on Scientific Evidence, Second Edition, Federal Judicial Center, Washington D.C., 2000, pages 229-276; Fred W. Morgan in "Judicial Standards for Survey Research: An Update and Guidelines," Journal of Marketing, Vol. 54 (January 1990), pages 59-70; and Gary T. Ford in "The Impact of the *Daubert* Decision on Survey Research Used in Litigation," Journal of Public Policy & Marketing, Vol. 24 (2) (2005), pages 234-252 and others.

Exhibit 1 summarizes questions proposed by Diamond (2000) by which federal courts can evaluate survey research proposed to be admitted as evidence.

Exhibit 1. FROM DIAMOND (2000)
EVALUATION QUESTIONS FOR SURVEY RESEARCH PROPOSED TO BE ADMITTED AS EVIDENCE IN FEDERAL COURTS

Purpose and design of the survey

- Was the survey designed to address relevant questions?
- Was participation in the design, administration, and interpretation of the survey appropriately controlled to ensure the objectivity of the survey?
- Are the experts who designed, conducted, or analyzed the survey appropriately skilled and experienced?
- Are the experts who will testify about surveys conducted by others appropriately skilled and experienced?

Population definition and sampling

- Was an appropriate universe or population identified?
- Did the sampling frame approximate the population?
- How was the sample selected to approximate the relevant characteristics of the population?

- Was the level of nonresponse sufficient to raise questions about the representativeness of the sample? If so, what is the evidence that nonresponse did not bias the results of the survey?
- What procedures were used to reduce the likelihood of a biased sample?
- What precautions were taken to ensure that only qualified respondents were included in the survey?

Survey questions and structure

- Were questions on the survey framed to be clear, precise, and unbiased?
- Were filter questions provided to reduce guessing?
- Did the survey use open-ended or closed-ended questions? How was the choice in each instance justified?
- If probes were used to clarify ambiguous or incomplete answers, what steps were taken to ensure that the probes were not leading and were administered in a consistent fashion?
- What approach was used to avoid or measure potential order or context effects?
- If the survey was designed to test a causal proposition, did the survey include an appropriate control group or question?
- What limitations are associated with the mode of data collection used in the survey?
    - In-person interviews
    - Telephone surveys
    - Mail surveys
    - Internet surveys

Surveys involving interviewers

- Were the interviewers appropriately selected and trained?
- What did the interviewers know about the survey and its sponsorship?
- What procedures were used to ensure and determine that the survey was administered to minimize error and bias?

Data entry and grouping of responses

- What was done to ensure that the data were recorded accurately?
- What was done to ensure that the grouped data were classified consistently and accurately?

Disclosure and reporting

- When was information about the survey methodology and results disclosed?
- Does the survey report include complete and detailed information on all relevant characteristics?
- In surveys of individuals, what measures were taken to protect the identities of individual respondents?

(From Shari Seidman Diamond “Reference Guide on Survey Research” in Reference Manual on Scientific Evidence, Second Edition, Federal Judicial Center, Washington D.C., 2000, pages 229-276.)

The general criteria for admissible consumer survey research are that the universe is properly defined; a representative sample of that universe was properly taken; the questions asked of respondents were expressed in clear, precise and non-leading language; sound interviewing procedures were followed by professional interviewers under appropriate supervision; respondent data was accurately recorded with minimal opportunity for transcription or data entry error; data is summarized, analyzed and reported using generally accepted descriptive statistics; and the entire process of design, conduct, analysis and reporting was done in an objective manner led by a qualified expert in survey research. These criteria are no different from the criteria by which any consumer research study can be evaluated. With respect to consumer survey methodology, however, the federal courts have established this set of evaluative criteria.

Standards from the Field of Marketing Research

The field of marketing research has established standards and guidelines for the conduct of consumer research that are more comprehensive than those summarized by Morgan (1990) and Diamond (2000). Leading marketing research texts would include Floyd J. Fowler, Jr., Survey Research Methods, Applied Social Research Methods, Vol. 1, 3rd Ed., 2002, and Gilbert A. Churchill and Dawn Iacobucci, Marketing Research: Methodological Foundations, Southwestern, 201

Note:

Consumer survey questionnaire is available at http://e-nc.org

Appendix C

Signal Propagation Modeling

GIS and Radio Wave Propagation Prediction

Rick Bunch
Associate Professor and Director

Center for Geographic Information Science
Department of Geography
University of North Carolina Greensboro

Email: rlbunch@uncg.edu
Cell: 336.608.8253
Office: 336.334.3916

Wagen and Rizk (2003) published an article titled "Radiowave propagation, building databases, and GIS: Anything in common? A radio engineer's viewpoint". In this article, they addressed the problems associated with widely used propagation software, and expressed the need for more accurate and detailed models of the physical and man-made environment. They argued that GIS was ideally suited for this task, and that GIS can provide the necessary data, functionality and architecture for improving the modeling process.

GIS is ideally suited to meet the needs of several (of many) important components in propagation modeling process. The components addressed here are: 1) An equation to capture the behavior of radio waves, 2) An elevation model representing "bare earth", 3) Methods and models for capturing the impacts of clutter such as natural (vegetation) and man-made features (buildings).

The Center uses a unique hybrid approach when selecting or deriving equations to predict coverage. Equations are chosen or derived based on rigorous research and an intimate knowledge of the assumptions behind the equations as well as the geography of the area being predicted. In many cases, multiple equations are used for each antenna within an array to predict network coverage. The flexibility of GIS allows the incorporation of new equations derived from the Center's research or research conducted by engineers. Comparable flexibility is difficult to achieve in most out-of-the-box propagation software packages because the user is simply limited to predetermined choices.

Getting the data is a key element in deriving elevation models for propagation. The Center creates custom elevation models from raw Light Detection and Ranging (LIDAR) remote sensor data flown in the region. Because these data consist of millions and millions of points, models with much higher spatial resolution can be generated.

Representing natural and man-made features in propagation models is another important component. The center derives custom models of the environment using unique datasets and methods that we have developed and tested through previous research and field work.

Propagation Modeling:
Little research has been published yet about modeling broadband frequencies specifically. One study conducted in Europe calculated a formula for 3.6 GHz broadband in suburban areas, but some providers are predominantly using the 2.4 or 5.8 GHz unlicensed bands. No one to date has designed an algorithm specifically for unlicensed broadband applications.
Several studies have surveyed existing algorithms to determine the best choices for broadband modeling. Two models stand out as good choices for this project – the *Stanford University*

Interim Channel Model (SUI) and the COST 231 Walfisch-Ikegami model (Walfisch). Walfisch is designed for urban applications. It is the best choice for calculating the impact of tall buildings separated by grid street patterns. If one has a good 3D model of a city, Walfisch demonstrates high accuracy.

In contrast, SUI is much more versatile. The engineers who designed the SUI algorithm derived multiple formulas which can be differentially applied depending on the unique combination of terrain roughness and urban density. It does not require any ancillary data beyond a terrain model and a classification of the nature of the surroundings.

Non Line of Sight
Propagation modeling takes two steps. First, we generate a non line of sight (NLOS) approximation of coverage. This coverage is close to the transmitter, where the signal is strong enough that the receiver does not need to have a direct view of the transmitter. If the transmitter is located within an urban area (as classified by US Census Bureau), Walfisch is used. If urban building data is unavailable, or if the antenna is located outside an urban area, SUI is used.

Line of Sight
It is well known that radio signals can travel great distances if unobstructed by ground clutter. For that reason, we also generate a line of sight (LOS) coverage approximation. To determine all areas within the line of sight of a transmitter, the complete 3D model of the region is used. If the provider is in the habit of mounting receiving antennas on customer rooftops, then the height of a receiver is estimated at 6 m above ground. If the provider is in the habit of providing portable wireless modems that sit next to the customer's computer, then the height of the receiver is estimated at 1.5 m above ground.

The only two additional factors that will be considered in LOS coverage are free space attenuation (how much a radio wave weakens by distance in a vacuum), and additional attenuation due to the moisture composite of the atmosphere.
Total Wireless Coverage

The two coverage approximations (NLOS and LOS) are overlaid in a Geographic Information

Systems (GIS). A local maximum operation outputs the overall coverage of each transmitting site. Similarly, each coverage area of each transmitter is combined to produce a total wireless coverage estimate.

Assessing and Calibrating the Models
No standard prediction model works perfectly in all situations. Therefore we expect that the SUI and Walfisch models will yield imperfect outputs. Field data collection is conducted across the area of interest. Hundreds of sample values are measured and compared to model outputs. The residuals are used to calibrate the models for better performance the region's unique combination of terrain and ground cover.

When calibrating the model, two methods are customary. Both courses of action will be investigated to determine the best solution for each network of interest. The rest of the region will be recalculated using the improved equations.

1. Adjust coefficients of an existing model based on the analysis of field data to decrease overall error.

2. Derive a new equation to capture non-linear patterns.

Reporting
For reporting ease, numerical field strength values are assigned one of the following signal strength categories: superior, average and acceptable. Next the wireless coverage output is converted from a raster to a vector data model. A geospatial dataset for each provider is delivered.

Modeling Wireless Broadband Coverage for North Carolina: Key Lessons and Best Practices

The purpose of this project was to create coverage maps for wireless broadband Internet in North Carolina using propagation prediction techniques and Geographic Information Systems (GIS). Creating coverage maps required knowledge of the region's characteristics (e.g., urban, rural) as well as accurate representations of the environment (e.g., buildings and terrain), and an equation to predict signal strength. The coverage maps for selected counties were assessed and calibrated through signal strength measurements collected from field work.

The prediction accuracy of coverage maps for all providers was very good. Field data was collected along 720 miles of roadways were taken as known values and compared to corresponding values predicted by the model. Analysis of the results yielded a mean error of 12.3 dBm and a Standard Error of 8.3 dBm. These values were consistent with acceptable accuracies reported in a number of engineering studies.

Lessons
The accuracy of the coverage predictions was related to the level of detail received from the providers. The primary challenge in receiving complete network information was the limited time to conduct back and forth inquiries among designated individuals, especially given tight deadlines. Frequent and expanded dialogue between information receivers and givers would greatly increase the accuracy of the predicted coverage maps.

Similar to the suggestion of promoting more dialogue between parties, value was discovered in the exchange of coverage maps. The coverage modelers were able to glean useful information from even imprecise maps of estimated coverage that the providers had previously drawn for themselves. These low tech coverage maps were found on provider websites. Conversely, several of the providers expressed interest in receiving improved coverage maps for their service area. Exchanging the provider's network information for better coverage maps could be an avenue for creating future partnerships.

The difference between network data received in the spring and data received in the fall indicated rapid growth of wireless Internet in North Carolina. This trend suggests a need to update prediction models and coverage maps on a regular basis. As the demand for the technology grew, providers were rapidly adding new transmitters at new frequencies. For example, at the beginning of the project year there was almost no use of the 3.7 GHz band among small providers in North Carolina. By the end of the project year, almost all the small providers were operating within this band. The use of new frequency bands demands timely field testing to maintain the accuracy of the modeling. Meanwhile, the addition of new infrastructure demands that the coverage maps be updated frequently.

Best Practices

Wagen and Rizk (2003) published an article titled "Radiowave propagation, building databases, and GIS: Anything in common? A radio engineer's viewpoint". In this article, they addressed the problems associated with widely used propagation software, and expressed the need for more accurate and detailed models of the physical and man-made environment. They argued that GIS was ideally suited for this task, and that GIS can provide the necessary data, functionality and architecture for improving the modeling process.

In that spirit, this project used GIS and a hybrid approach for predicting coverage. In many cases, different equations were used based on the characteristics of the region being predicted. Custom models were created from raw data to produce more accurate representation of terrain, and natural and man-made features.

The flexibility of this project's modeling approach offered a number of best practices. The model is accurate, efficient, and testable, and it can be successfully applied to any region; especially in rural areas where wireless is the preferred technology for serving broadband. The costs for maintenance and updating, once the initial model is complete, is cost effective. This project has led to practices that will raise the bar on what has previously been considered acceptable error for a variety of regions and geographies.

Appendix D

Citizen Survey

A Decade of Change: Digital Technology and Internet Access in North Carolina
1999 to 2010

Kenneth Wilson, Ph.D.
East Carolina University
August 2010

Executive Summary

New technologies generate social change. They may undermine some old social patterns but reinforce others. Groups that have the resources and inclination to embrace the new opportunities will find their quality of life improving. Broadband Internet is an example of a new technology that has the potential to be a platform for transformative change in many arenas. Five surveys related to Internet and broadband access in North Carolina conducted between 1999 and 2010 document progress in adoption of this technology and the and remaining divides. Interviews for the most recent survey began on January 26, 2010 and were completed on March 24, 2010.

In the past decade, North Carolina has experienced an amazing transformation. In 1999, only 53 percent of households had home computers. By 2010 that figure has risen to 82 percent. In just eleven years, the proportion of homes without a computer has dropped 62 percent. In 1999, the proportion of all homes with Internet access was 36 percent but this has risen to 80 percent in 2010. In that same time frame, the proportion of homes without Internet access has dropped 69 percent.

While a gap remains in the usage of computers and the Internet in the state's rural and urban communities, the relative size of the gap has been steadily declining, from 17 percent in the 1999 survey to 8 percent in the current survey. For the period from 1999 to 2010, the rate of change in home access is over twice as large in rural households as in urban counties.

In 1999 the proportion of North Carolinians who used the Internet anywhere (at home, work, public access, etc.) was 62 percent. By 2008 it had climbed to 82 percent. In the 2010 survey, this figure has stabilized at 82 percent. Respondents were asked if they use the Internet outside their home. Over half (54%) reported that they used the Internet somewhere outside their home, 28 percent reported that they only use the Internet at home and 18 reported that did not use the Internet anywhere.

As new technology is adopted by wider segments of the population, periods of rapid social change draws to an end. Basic technology has become cheaper, easier to use and widely available. The past two years have been economically challenging times and the rapid progress of the preceding nine years has slowed, particularly for groups living on the wrong side of the digital divide. Groups with economic and social resources (e.g., income, education, communities with the best available infrastructure, etc) have integrated the basic technology into their lives and they are now adopting more advanced broadband technology applications to take better advantage of emerging opportunities.

While progress among disadvantaged groups has been dramatic (see 2008 report), significant segments of these groups have not yet been able to incorporate digital technology into their lives. African Americans and Native Americans are less likely to use digital technology than White Americans (27% and 37% vs. 16%). Roughly half of poorer (Less than $15,000) and less-educated respondents do not use the Internet anywhere. While the progress in rural regions has been substantial, 20 percent of rural respondents do not use the Internet anywhere. If progress does not continue among these groups, their disadvantaged status will be cemented for the foreseeable future.

There was a sharp increase in the percentage of respondents who knew their county government had a website, but the percentage of respondents living in cities who knew their city government had a website remained unchanged from 2010. Over one-third (36%) currently use their town, city or county website, visiting 1-3 times a month. They reported that it saves them some time. Of those who had not used the websites, 45 percent where "interested" or "definitely interested" in using them in the future, while 42 percent where "not interested" or "definitely not interested".

The attitude questions show that North Carolinians' opinions of the Internet have not changed very much during the past two years. Most respondents recognize that the Internet is necessary to maintain a decent standard of living and young children must master technology skills. North Carolinians support state subsidies for both home and business access. However, they continue to be concerned about possible threats to privacy and the easy availability of obscene material over the Internet.

Although this study was not designed to assess the impact of temporary economic turbulence, the economic decline that has occurred since the last survey in 2008 needs to be considered when viewing these results. Families squeezed by the recession face complex and difficult choices. Some social strata (lower income, lower education, minorities, residents of rural counties and people with more dependents to support) are more vulnerable and less able to juggle resources to deal with immediate needs. Higher levels of unemployment and fear of job loss may influence discretionary spending, such as broadband access in the home. In this environment, the use of public access is growing as people have to find ways that are more economical, if less convenient, to access web-based resources, such as job training, virtual education and health services.

Forward

North Carolina is unique among states in having a detailed chronological record that documents changes in citizens' awareness, attitudes and adoption of broadband Internet. Since 1999 the e-NC Authority has commissioned East Carolina University to survey North Carolina residents regarding their attitudes and perspectives about Internet and computer usage as well to document the changes that have occurred over time. This data has been collected from users of dial-up and broadband and those with no access. Results of these surveys have informed development of policy and programmatic efforts of the e-NC Authority to ensure that all citizens in North Carolina have access and the ability to use this critical infrastructure. Results have been validated by the convergence of access data obtained from broadband service providers and other third parties sources. Confidence in this survey approach is high, leading to continued use of the Citizen Survey as an important planning tool in North Carolina's Broadband Data Development and Planning project that is funded through the American Recovery and Reinvestment Act's Broadband Technology Opportunities Program that is administered by the National Telecommunications and Information Administration of the U.S. Department of Commerce. To meet the requirement of this project the survey will be administered in 2010, 2011 and 2014. The results of the 2010 survey are presented in the report that follows.

Introduction

Since 1999, five citizen surveys have documented the level of home computer ownership and Internet access in North Carolina. Minor changes in methodology have been adopted to accommodate the growing use of cell phones and evolving information and communications technologies, such as increased use of cell phones and mobile devices that support Internet access. Such changes have kept the surveys relevant without sacrificing the basic knowledge they yield or the comparability of results over time.

STUDY 1: In 1999, the North Carolina Board of Science and Technology included a set of questions concerning computer and Internet usage in a more general study of public perceptions of the role and importance of science and technology in the North Carolina economy. A general population telephone survey employed random digit dialing. A total of 522 respondents completed the interview. The complete report is available on the e-NC Authority website at http://e-nc.org/public/citizen_survey.

STUDY 2: After viewing the results of the 1999 survey, many local decision makers wanted to see specific results for their counties. Unfortunately, the sample size (N=500) made it impossible to provide reliable information at the county level. In 2001, the Rural Internet Access Authority (RIAA, the organization that preceded the e-NC Authority) planned to extend the work started by Vision 2030 as it related to computer and Internet access of North Carolina citizens and to make it more relevant to local decision makers in every part of the state. Independent random samples were drawn from each of North Carolina's 100 counties, resulting in a total sample of 12,904 North Carolinians that comprised Study 2, completed in June 2002. So that the results could be generalized to the entire state, the data were weighted by the county's population and the respondent's education. Results can be viewed at http://e-nc.org/citizen_survey_results.asp.

STUDY 3: The third study continued to track computer and Internet use in North Carolina.

Interviewing began on Jan. 14, 2004 and was completed on Feb. 11, 2004. A total of 20 interviewers were chosen, trained and subsequently worked on the project. The interviewer corps was predominantly female (four males) and ranged in age from 19-72. There were 1,197 completed interviews. Quotas were used to ensure adequate representation of rural counties. The sample of telephone numbers was purchased from Survey Sampling, Inc., a Connecticut firm with an excellent reputation that has provided samples for many years to East Carolina University (ECU) and other universities with very satisfactory results. A significant number of interviews were conducted in Spanish, using a bi-lingual interviewer. This is important to remember when results for Hispanic respondents are compared to other studies in this series that only interviewed English-speaking Hispanics. So that the results can be generalized to the entire state, the data were weighted by the county's population and the respondent's education. See this study at http://e-nc.org/2004CitizensSurvey.asp.

STUDY 4: The fourth study tracking computer and Internet use in North Carolina was compiled through interviews conducted Sept. 14 through Oct. 8, 2008. A total of 26 interviewers were chosen, trained and actually worked on the project. The interviewer corps was predominantly female (four males). There were 1,244 completed interviews. Quotas were used to ensure that there was an adequate representation of rural counties. The sample of telephone numbers was purchased from Survey Sampling, Inc., the same Connecticut firm used in the 2004 study. In this survey, households without landlines were contacted and 5 percent of the final sample consisted of households with cell phones but no landlines.

STUDY 5: The fifth Citizen Survey continued to track computer and Internet use in North Carolina. Interviewing began on Jan. 26, 2010 and was completed on March 24, 2010. A total of 19 interviewers were chosen, trained and subsequently worked on the project. The interviewer corps was predominantly female (one male). There were 1,234 completed interviews. Quotas were used to ensure adequate representation of rural counties. The sample of telephone numbers was purchased from Survey Sampling, Inc. Separate samples of households with landlines and cell phone numbers were used. In the final sample, 17 percent were respondents from the cell phone sample. The increased representation of cell-phone respondents in Study 5 reflects a societal trend of increased use of cell phones to the exclusion of telephone services supported by landlines. So that the results can be generalized to the entire state, the data were weighted by the county's population and the respondent's education.

Changing Levels of Home Computer Ownership

The steady increase in the level of home computer ownership seems to be slowing. Table 1 presents the results of the five surveys in a format for easy comparison. While the average yearly increase from 1999 to 2008 was over 3 percentage points, the average yearly increase between 2008 and 2010 was 1%. Groups that had previously achieved a high level of computer ownership (men, young people, white respondents, urban respondents, richer and better educated) seem to slow after the level passes 80 percent. However, the level of ownership in lagging groups continues to increase.

Table 1: Computer Penetration Demographics

Percentage of North Carolina Households that Have a Home Computer					
	1999	**2002**	**2004**	**2008**	**2010**
Overall	**53%**	**60%**	**65%**	**80%**	**82%**
Gender					
Men	**59%**	**65%**	**68%**	**88%**	**85%**
Women	**53%**	**57%**	**63%**	**78%**	**80%**
Generations					
Ages 18-27	**55%**	**68%**	**76%**	**96%**	**97%**
Ages 28-39	**60%**	**71%**	**79%**	**95%**	**93%**
Ages 40-49	**60%**	**72%**	**70%**	**90%**	**93%**
Ages 50-58	**66%**	**58%**	**73%**	**86%**	**87%**
Ages 59-68	**44%**	**43%**	**50%**	**81%**	**79%**
Age 69+	**24%**	**28%**	**35%**	**47%**	**65%**
Race and ethnicity					
Whites	**61%**	**65%**	**68%**	**84%**	**83%**
African-American	**31%**	**44%**	**63%**	**63%**	**74%**
Native American		**50%**	**39%**	**55%**	**56%**
Hispanic		**37%**	**31%**	**67%**	**90%**
Other		**65%**	**74%**	**77%**	**83%**
County Type					
Urban	**58%**	**64%**	**71%**	**83%**	**86%**
Rural	**46%**	**55%**	**59%**	**76%**	**80%**
Household Income					
Less than $15,000	**35%**	**34%**	**31%**	**65%**	**47%**
$15,000 to $24,999	**25%**	**43%**	**43%**	**45%**	**68%**
$25,000 to $29,999	**37%**	**60%**	**64%**	**82%**	**73%**
$30,000 to $49,999	**43%**	**71%**	**78%**	**84%**	**89%**
$50,000 to $74,999	**49%**	**79%**	**88%**	**97%**	**95%**
$75,000 to $99,999	**50%**	**86%**	**92%**	**100%**	**97%**
$100,000 and above	**66%**	**91%**	**97%**	**96%**	**98%**
Educational Attainment					
Less than High School	**20%**	**33%**	**36%**	**55%**	**49%**
High School Graduates	**47%**	**60%**	**65%**	**81%**	**72%**
Community College Degree	**65%**	**75%**	**78%**	**90%**	**83%**
College Degree	**76%**	**84%**	**87%**	**96%**	**93%**
Graduate Degree	**78%**	**87%**	**93%**	**87%**	**96%**
Children Living at Home					
Yes	**64%**	**69%**	**81%**	**93%**	**95%**
No	**49%**	**54%**	**55%**	**75%**	**76%**

When examining Table 1, be sure to notice:

- Home computer ownership overall has continued to rise, but the rate of increase has slowed.

- The elderly remain the least likely to own a home computer, but their level of ownership has increased much more than any other age group. In younger households, the increase has almost stopped, with 9 out of 10 households owning a computer.

- While white households continue to have a high level of computer ownership, other races and ethnic groups are closing the gap. Because the number of Hispanic households is small, the large jump in computer ownership by Hispanic households may be partially due to sampling error.

- Computer ownership in households with incomes above $50,000 per year remains almost universal. Progress continues in lower income households but the dramatic increases in the lowest income category noted in 2008 have reversed. Possible explanations for this include sampling error or possible effects of the worsening economy that especially affect this income category.

- Computer ownership among people with college degrees is almost universal, but computer ownership among citizens with high school diplomas or less education remains stubbornly low.

- In every survey over the past decade, the presence of children in the home is associated with a significant (at least 15 percentage points) increase in home computer ownership. Today, almost every household with children living at home has a home computer, while computer ownership in households without children has stabilized at a lower level.

Internet Access: Introduction

There are various ways of looking at Internet access. Some stress home Internet access, while other approaches stress more general access to resources and assess the use of the Internet anywhere – at home, work, school or elsewhere. This report considers each type of approach.

Proportion of All North Carolina Households: Many people are interested in the proportion of households that subscribe to home Internet access. In these households, people can do private research and children can do their Web-assisted homework with help from their parents. Today 80 percent of all North Carolina households subscribe to home Internet access.

Proportion of North Carolinians Who Use the Internet Anywhere: Some people choose not to subscribe to home Internet access because they can use the Internet at work or somewhere else. To understand the full extent to which North Carolinians are involved with the Internet we have to consider all options available for Internet access. Today 82 percent of North Carolinians use the Internet somewhere.

Home Internet Access: Proportion of All North Carolina Households

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Table 2: Internet Penetration Demographic Percentage of ALL North Carolina Households That Have Home Internet Access					
	1999	**2002**	**2004**	**2008**	**2010**
Overall	**36%**	**52%**	**58%**	**70%**	**80%**
Gender					
Men	**41%**	**58%**	**61%**	**77%**	**84%**
Women	**35%**	**49%**	**55%**	**69%**	**77%**
Generations					
Ages 18-27	**40%**	**59%**	**65%**	**81%**	**100%**
Ages 28-39	**40%**	**63%**	**72%**	**85%**	**91%**
Ages 40-49	**42%**	**64%**	**67%**	**90%**	**90%**
Ages 50-58	**49%**	**50%**	**65%**	**80%**	**86%**
Ages 59-68	**23%**	**34%**	**43%**	**73%**	**78%**
Age 69+	**12%**	**24%**	**29%**	**37%**	**62%**
Race and ethnicity					
Whites	**43%**	**57%**	**62%**	**74%**	**82%**
African-American	**19%**	**34%**	**49%**	**60%**	**71%**
Native American		**37%**	**38%**	**43%**	**56%**
Hispanic		**35%**	**22%**	**52%**	**91%**
Other		**57%**	**67%**	**61%**	**83%**
County Type					
Urban	**43%**	**57%**	**62%**	**74%**	**85%**
Rural	**26%**	**46%**	**51%**	**66%**	**77%**
Household Income					
Less than $15,000	**9%**	**25%**	**25%**	**49%**	**43%**
$15,000 to $24,999	**4%**	**33%**	**32%**	**33%**	**68%**
$25,000 to $29,999	**27%**	**52%**	**55%**	**72%**	**72%**
$30,000 to $49,999	**23%**	**62%**	**68%**	**79%**	**85%**
$50,000 to $74,999	**34%**	**73%**	**83%**	**92%**	**95%**
$75,000 to $99,999	**31%**	**81%**	**87%**	**97%**	**99%**
$100,000 and above	**43%**	**85%**	**94%**	**91%**	**98%**
Educational Attainment					
Less than High School	**2%**	**26%**	**28%**	**48%**	**46%**
High School Graduates	**30%**	**51%**	**57%**	**72%**	**68%**
Community College Degree	**45%**	**65%**	**69%**	**83%**	**81%**
College Degree	**58%**	**78%**	**83%**	**91%**	**95%**
Graduate Degree	**64%**	**83%**	**88%**	**84%**	**95%**
Children Living at Home					
Yes	**43%**	**61%**	**74%**	**88%**	**94%**
No	**34%**	**46%**	**48%**	**65%**	**74%**

When examining Table 2, be sure to notice:

- The proportion of households with home Internet access continues to increase. In the preceding two years, the proportion of households with home Internet access has increased almost 15 percent and it has more than doubled in the decade between 1999 and 2010.

- For people less than 50 years old, home Internet access is almost universal. Access continues to grow in older ages groups and has increased considerably among those 69 or older.

- Home Internet access continues to increase in all racial and ethnic groups. The dramatic increase in home Internet access in Hispanic households continues, but readers need to remember that the option of interviewing Spanish-speaking households in Spanish was only available in 2004. This may explain the 2004 result that is counter to the trend in Hispanic households and in North Carolina households overall.

- While the gap between urban and rural households remains, there has been steady progress in both urban and rural areas. The size of this gap has been steadily declining, from 17 percent 8 percent. For the period overall from 1999 to 2010, the change in home access is nearly 98 percent in urban counties and 196 percent in rural counties. In North Carolina, the rate of growth is over twice a fast in rural counties as in urban counties. While many factors have contributed to this dramatic increase in rural counties, it seems reasonable to conclude that e-NC's focus on extending Internet access in these rural counties is a significant factor.

- The dramatic progress in households earning less than $15,000 reversed in 2008, but stabilized at levels higher than in 2004. There was dramatic improvement in the level of home Internet access for household earning $15,000 to $24,999. Since households with cell phones (even poorer households) are much more likely to have home Internet access, this increase may be partially due to efforts to include more cell phone households in the survey.

- In households earning $50,000 or more and households with college degrees, home Internet access is almost universal.

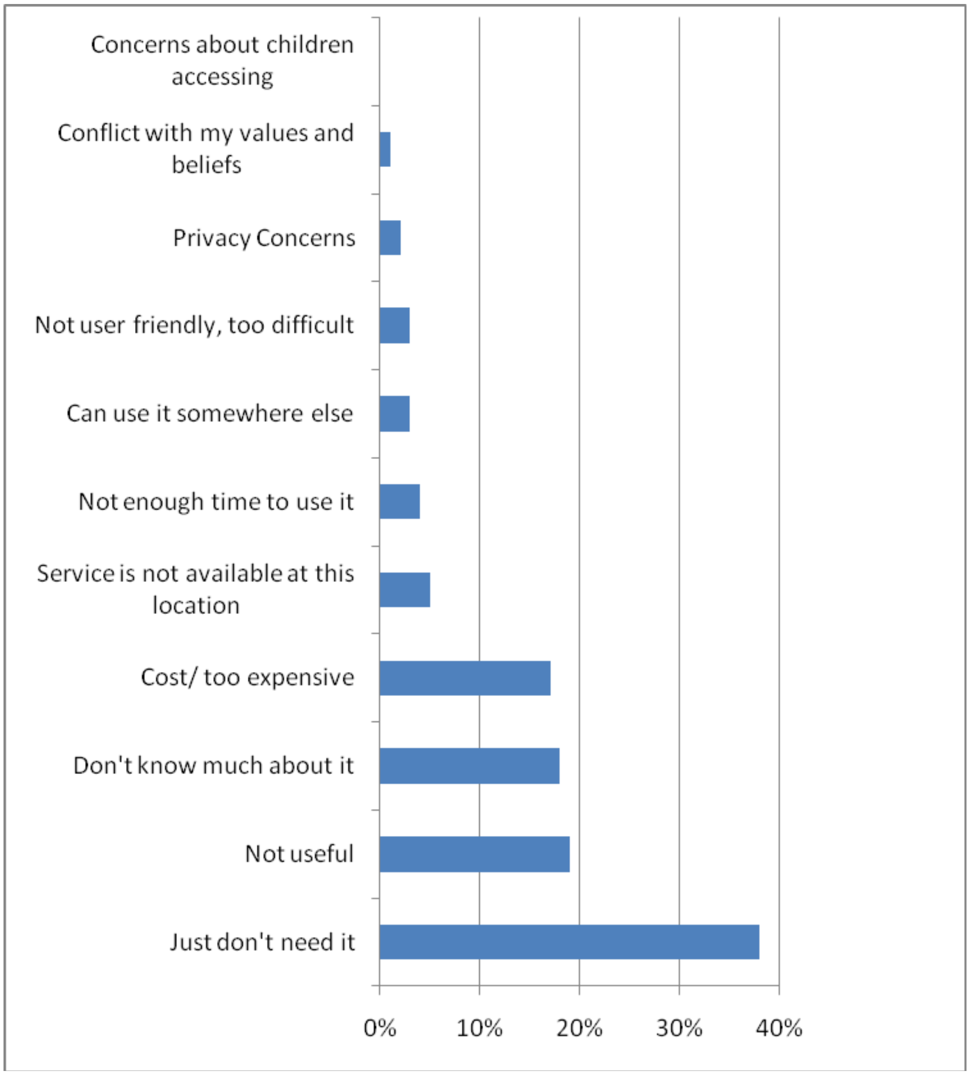
- In households with high school degrees or less, home Internet access has stabilized or decreased slightly since the 2008 survey.

- Home Internet access is almost universal for households with children living at home is increasing for other households.

- While respondents were not asked directly about the impact of recent economic decline on the update of broadband in their homes, it seems reasonable to suggest that the small declines registered in lover income and less educated households might be explained by the disproportionate impact that higher unemployment and a poor economy has on the discretionary spending for broadband access for these segments of the sample

Respondents who did not have home Internet access were asked "Why?" Their reasons are presented in Graph 1.

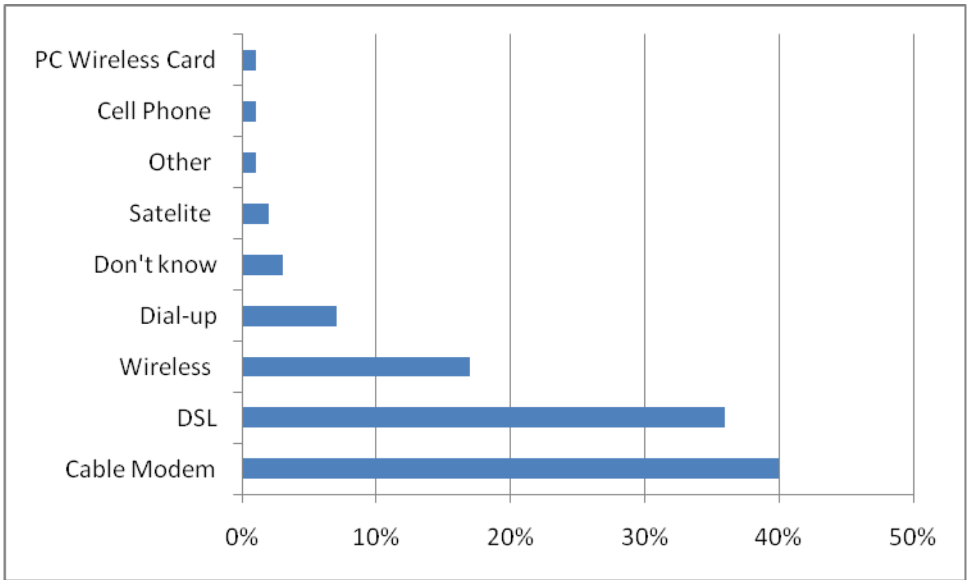
Graph 1
Reasons Offered for Not Having Internet



The most common response was that the home Internet access "just was not needed." The next two most common responses, "Not useful" and "Don't know much about it," followed in this same vein. However 17 percent of the respondents reported that home Internet access was too expensive and another 5 percent reported that it was not available at their location. Over half (57%) of those who answered that service was not available, reported that they had actually contacted service providers to try to have service extended to their home.

Respondents who had home Internet access were asked to describe the kind of service they received.

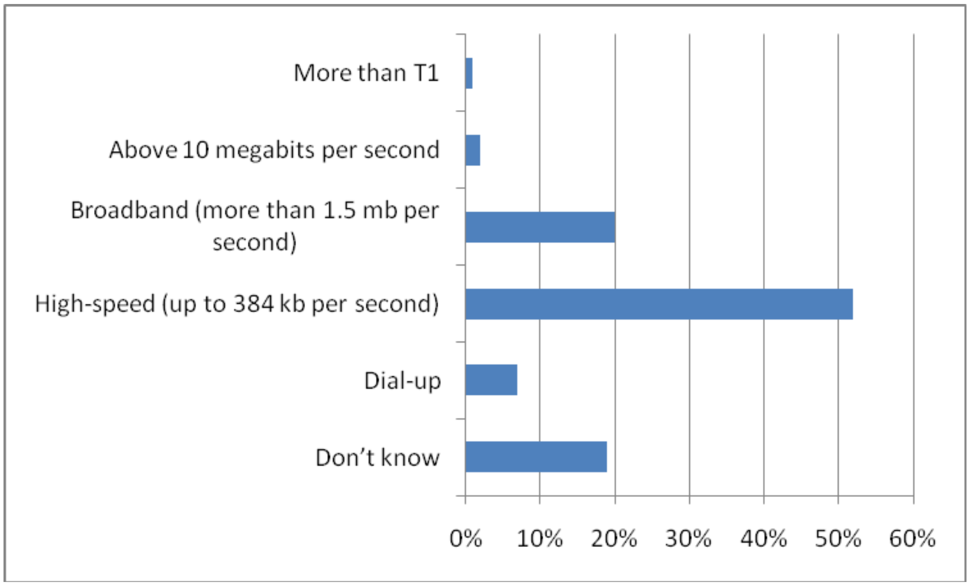
Graph 2
Type of Home Interent Access



The most common types of home Internet access are cable modem (40%) and DSL (36%). Both of these means of home Internet access have increased their share of the market during the last two years. While only 17 percent of the households have wireless connections, this method has doubled its market share. The proportion of households relying on dial-up connections has dropped from 14 percent to 7 percent in the last two years.

Next, respondents were asked to describe the speed of their home Internet connection. Almost one respondent-in-five (19%) did not know how to describe the speed. Over half (52%) reported that they had high-speed Internet while another 20 percent had broadband. The type of technology used to access the Internet matters to the extent that it affects speed of transmission. It is a fact that practical use of an increasing number of high-value applications (such as virtual educatioand job training applications) will depend of the user having access with sufficient bandwidth and speed.

Graph 3
Respondents Internet Access Speeds



Only 1.6 percent of the respondents report that they need to make a long distence call to access the Internet. This is almost idential to the percentage (1.5%) found in 2008. Since people can connect to the Internet without making a long distance call anwhere in North Carolina, these respondents must be unaware of their options.

Internet Access: Proportion of North Carolina Citizens Who Use the Internet Anywhere

Respondents were asked if they used the Internet outside their home. Over half (54%) reported that they used the Internet somewhere else, 28 percent reported that they only used it at home and 18 percent reported that did not use the Internet anywhere.

Table 3: Internet Penetration Demographic: Percentage of ALL Respondents Who Use the Internet Anywhere

	2002	2004	2008	2010
Overall	65%	71%	82%	82%
Gender				
Men	71%	75%	90%	86%
Women	62%	68%	79%	78%
Generations				
Ages 18-27	86%	89%	96%	98%
Ages 28-39	79%	87%	100%	96%
Ages 40-49	73%	84%	98%	97%
Ages 50-58	59%	75%	89%	88%
Ages 59-68	39%	53%	84%	81%
Ages 69+	26%	31%	38%	59%
Race and ethnicity				
Whites	69%	75%	84%	84%
African-American	55%	62%	79%	73%
Native American	53%	42%	48%	63%
Hispanic	57%	46%	58%	100%
Other	66%	82%	61%	82%
County Type				
Urban	69%	73%	84%	86%
Rural	60%	67%	79%	80%
Household Income				
Less than $15,000	44%	34%	60%	50%
$15,000 to $24,999	53%	61%	46%	79%
$25,000 to $29,999	66%	77%	91%	79%
$30,000 to $49,999	75%	81%	85%	89%
$50,000 to $74,999	84%	90%	96%	96%
$75,000 to $99,999	92%	95%	100%	99%
$100,000 and above	88%	99%	96%	99%
Educational Attainment				
Less than High School	36%	43%	58%	49%
High School Graduates	66%	72%	83%	72%
Community College Degree	82%	79%	92%	83%
College Degree	89%	91%	96%	97%
Graduate Degree	92%	96%	82%	93%

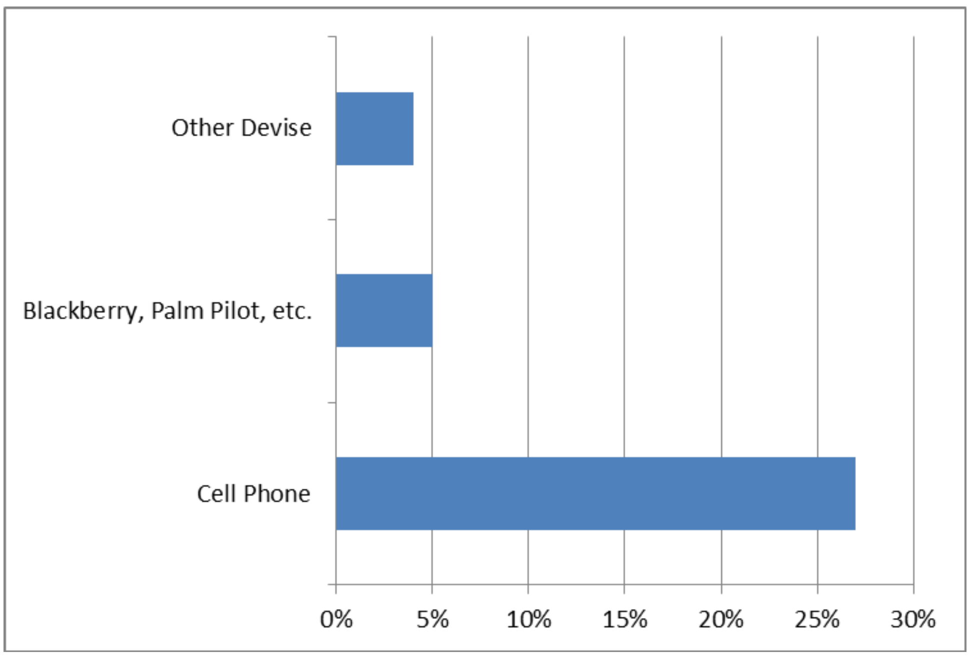
When examining Table 3, be sure to notice:

- The increase in the percentage of respondents who use the Internet anywhere has leveled off at 82 percent. Usage has stabilized in both urban and rural regions.
- Use of the Internet is almost universal among adults under age 50 and very high among adults 68 and younger.
- Although adults age 69 and older have historically been much less likely to use the Internet anywhere than any other age group, the gap is closing. Adults 69 and older had a dramatic 19 percentage point increase in their Internet usage.
- Among the youngest respondents (age 18-27) 100 percent report using the Internet at home, but only 98 percent report using the Internet Anywhere. This is the result of one young person giving inconsistent answers to these two questions. Both results are included since we have no way of knowing which is correct.
- Internet usage among White North Carolinians has stabilized and it has decreased among African-Americans. Internet usage among other minorities increased.
- Internet usage is almost universal in households earning $50,000 or more and very high in household earning over $30,000. Internet usage in lower income households is significantly lower and does not seem to be increasing.
- Internet usage is almost universal among people with college degrees. Internet usage among people with less education seems to be decreasing.

Other Access Devices

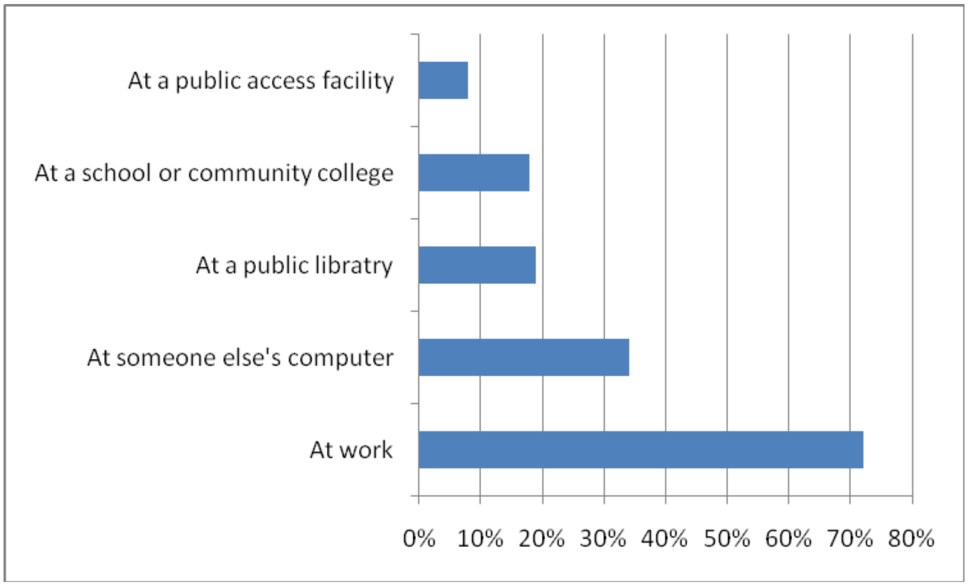
The respondents were also asked about their use of devices other than a computer to access the Internet (Graph 4). By far the most common device respondents used to access the Internet was their cell phone. The percentage of respondents who reported using their cell phone to access the Internet increased from 17 percent in 2008 to 27 percent in 2010. Five percent reported using some type of pocket organizer (Palm Pilot, Blackberry, etc.) and 4 percent reported using some other type of device to access the Internet. In total, 66 percent of respondents reported that they did not use any device other than a computer to access the Internet. All of these respondents also had a home computer and home Internet access.

Graph 4
Other Internet Access Devices



Of those who use the Internet outside the home, most (72%) use it at work and a third uses someone else's computer (34%). Use of public facilities remains strong, with 19 percent using libraries, 18 percent using schools or community colleges and 8 percent using public access facilities. (Graph 5)

Graph 5
Internet Access Outside of the Home



Government Websites

Governments at all levels in North Carolina—state, county and local – are moving more of their interactions with each other, with business and with citizens to an online platform. This move is being driven by the expectation that e-government will enhance the efficiency and effectiveness in the public sector and deliver improved services, better accessibility of public services, and more transparency and accountability to constituents. Beginning in 2004, respondents to this survey have been asked about their familiarity and use of the Internet to obtain information and services from their local government.

City and County Government Websites:

- All respondents were asked if their county had a Website and 74 percent reported they knew their county government had a Website. This is a sharp increase from 39 percent in 2004 and 62 percent in 2008.

- Respondents were asked if they lived in a town or city. Of those who live in towns or cities, 66 percent knew their local government had a website. While this percentage increased substantially between 2004 and 2008 (43% to 65%), there was almost no change between 2008 and 2010.

- Over one-third (36%) currently use their town, city or county website, visiting 1-3 times a month. Sixty percent of those who used the websites reported that they saved "some time", with another 26 reporting that it saved a lot of time.

- Of those who had not used the websites, 45 percent where interested or definitely interested in using them in the future, while 42 percent where not interested or definitely not interested.

Attitudes, Beliefs and Opinions

Respondents were asked to respond to a series of questions that addressed their attitudes, beliefs and opinions on a number of issues related to the Internet.

Obscene Material

- Do you support the use of constitutionally-valid protective actions to limit the distribution of obscene material to children via the Internet?
  - 87 percent of all respondents said “Yes.” (virtually unchanged from 2004 and 2008)
  - 90 percent of respondents with children living at home said “Yes.” This is a small decrease compared with 92 percent in 2004 and a small increase from 86 percent in 2008.

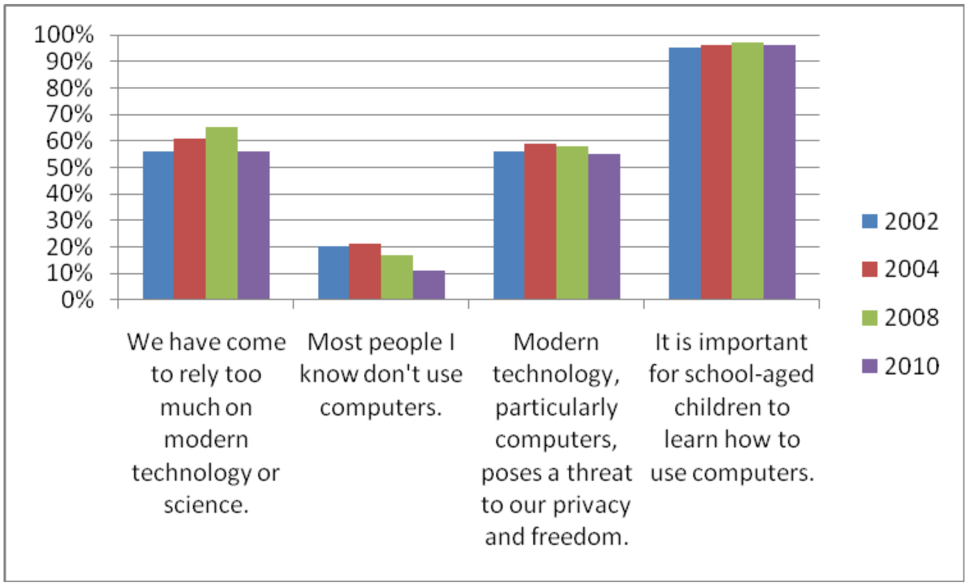
- Have you ever had a problem with your children accessing obscene material on the Internet?
  - 12 percent of all respondents said “Yes.” (virtually unchanged from 2004 and 2008)
  - 20 percent of respondents with children living at home said “Yes.” This is a small decrease from the figure of 24 percent in 2004 and 23 percent in 2008.

Attitudes about the Importance of Technolog

The attitude questions show that::

- People are concerned about obscene material on the Internet that children can access.
- Almost everyone recognizes that it is important for school-aged children to learn to use the computer
- Over half of North Carolinians worry that the new technology invades our privacy and that we rely on it too much.
- Few people live in groups or communities where most people don’t use a computer.

Graph 6
Attitudes About Computers and the Internet



Most North Carolinians continue to believe that Internet access is essential for a decent standard of living. They support programs to bring Internet access to everyone's home who wants it and to bring high-speed access to all North Carolina businesses that need it.

Graph 7

Is The Internet So Essential It Should Be Subsidized