Technical Memorandum

VDOT/DRPT TELEWORK STUDY

Prepared under contract to:

Parsons Transportation Group

For:

VIRGINIA DEPARTMENT OF TRANSPORTATION

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Executive Summary

The primary purpose for this study is to provide a comprehensive analysis of teleworking to assist the General Assembly Study Team with decisions on the level of involvement in future teleworking implementation activities. This study team comprised of the staff from the Secretary of Transportation, Secretary of Technology, and Secretary of Finance, was formed as a result of House Bill 30, Item 506-D (see Appendix A). The bill directed that the study investigate the potential benefits of teleworking to the Commonwealth of Virginia. Specifically, the bill directed that the following items be included in the study:

1. The definition of teleworking
2. Costs of teleworking to employers and to government
3. The impact of teleworking on congestion
4. The applicability of teleworking in all regions of the state
5. Performance measures that can adequately and appropriately gauge the benefits of teleworking to the employee and employer as well as congestion relief
6. Alternatives for encouraging the use of teleworking in Virginia

An extensive literature review was performed as part of this study. Additionally, as teleworking data were available only for the Northern Virginia area, it was suggested that additional data be collected through surveys in three metropolitan areas. More than 1,800 individuals were contacted in the Hampton Roads, Richmond, and Roanoke urban areas for this purpose.

Section 1: Introduction

The report is divided into four major sections. Section 1 describes the impetus for and background of this study and highlights some of the general discussions on the definition of teleworking. In this study, the definitions specified by the General Assembly Study Team have been used for teleworking. Teleworking is defined as a work arrangement where managers/supervisors direct or permit employees to perform their usual job duties away from their central workplace, in accordance with their same performance expectations and other agency-approved or agreed-upon terms. A teleworker is an employee who works away from his/her central workplace all or part of the work week, either at home or at another designated or approved alternate work location. The central workplace is an employee's work headquarters or official duty station where he/she would normally report to work if not teleworking. Finally, an alternate work location is defined as approved work sites that include the employee's home or satellite offices where official business is performed. It should be noted that teleworking may also include work arrangements where a person is self-employed or has a home-based business. However, because of the focus on transportation issues in this study, such persons were not considered.

Section 2: Teleworking

Section 2 provides background information on teleworking. This section is based on information presented in a white paper created by the Virginia Department of Transportation (VDOT) and used to establish its teleworking policy. This white paper was in turn based on two earlier studies – A Management Services Division's report on telecommuting (1995) and a briefing paper "Telecommuting as a Transportation Demand Management Option" prepared by the Virginia Transportation Research Council for the Executive Leadership Group of VDOT. Specifically, this section outlines the following topics:

- the research defining the types of work best suited to teleworking
- management issues related to company teleworking programs
- transportation characteristics of commuters and the effect of telecommuting on peak-period travel
- traffic congestion and air quality impacts
- nationwide examples of costs and benefits associated with teleworking and expected cost savings for participant companies

Section 3: The Effects of Teleworking in Virginia

Section 3 outlines results of research into the effects of teleworking in Virginia. The two primary topics presented in Section 3 include the applicability of teleworking in different areas of Virginia, and the impact of teleworking on congestion. The intent to telework is typically considered to depend on three factors: the type of work to be performed, commute length, and traffic congestion in an area. A review of the population and employment data show that over 65% of Virginia residents live and work in three major urban areas: Northern Virginia, Hampton Roads, and Richmond. Another 15 percent live and work in five other urban areas, including Charlottesville, Danville, Harrisonburg, Lynchburg, and Roanoke. As these eight urban areas constitute approximately 80 percent of Virginia's population, and as teleworking is more prevalent in urban areas, the focus in Section 3 was placed on these eight urban areas. Although Fredericksburg is part of the Northern Virginia Metropolitan Statistical Area (MSA), it was considered separately because of its unique characteristics.

Applicability of Teleworking in Different Areas of Virginia

Employment data obtained from the Virginia Employment Commission show that the composition of the different occupation types is similar across the nine urban areas. Thus, the type of work most likely plays only a small role in the different teleworking participation rates in the urban areas. The 2001 surveys (MWCOG 2001, Southeastern Institute of Research 2001) show that 15 percent of the workforce telecommutes in Northern Virginia, 8.3 percent in the Richmond area, 6.7 percent in the Hampton Roads area, and 4.7 percent in the Roanoke area. Additionally, the average one-way commute distance for teleworkers is 18.2 miles in Northern Virginia, 15.6 miles in Richmond and Hampton Roads, and 8.3 miles in Roanoke. These data demonstrate that teleworking is more prevalent in larger urban areas, which typically have longer and more congested commutes. It is estimated that approximately 8 percent (approximately 260,000 people) of Virginia residents telework. A survey conducted in 2000 (Nilles 2000) estimated that there were 11.5 million teleworkers in the U.S.

Impact of Teleworking on Roadway Congestion

Nationwide data show that teleworkers work from an alternate location (primarily from home) 2.5 days/week. The teleworking frequency in Virginia is lower, and ranges from 1.43 days per week in the Northern Virginia urban area to 2.35 days per week in the Richmond urban area. It is estimated that if an additional 5 percent of the workforce began teleworking, the vehicle miles traveled (VMT) would be reduced by 0.5 to 1.5 percent in each of the nine urban areas evaluated. Various methods can be used to estimate the impact of teleworking on roadway congestion. A methodology developed by the Texas Transportation Institute (TTI) is based on the level of congestion on primary roadways (Freeways/Expressways and Principal Arterials). The level of congestion is based on travel speeds associated with traffic volume ranges, which are used to determine travel delay and costs related to travel delay. Excess fuel consumed because of congestion is also considered.

The TTI methodology was applied in this study to estimate the potential reduction in travel delay and costs due to increased teleworking. A limited number of roadways, which were deemed representative of all the roadways in each urban area, were studied. In addition to the existing level of teleworking, scenarios of additional 2.5 percent to 5 percent of the workforce teleworking were estimated in all the urban areas except Northern Virginia. For Northern Virginia, it was assumed that an additional 5 percent to 10 percent of the workforce would telework. If an additional 5 percent of the workforce teleworks, the total travel costs are expected to decrease by less than 1 percent in small urban areas such as Charlottesville and Lynchburg. For the same increase in teleworking, the travel costs are expected to decrease by 1 percent in Northern Virginia, 2 percent in Hampton Roads, and 5 percent in Richmond. A more comprehensive evaluation could be performed by considering all primary roadways in an urban area, compared to the limited number considered in this study.

Impact of Teleworking on Air Quality

The reduction in travel trips and VMT is expected to have a positive impact on air quality. There are five urban areas in Virginia where air quality is of principal concern. Much of Northern Virginia is part of the Washington, D.C. serious ozone nonattainment area and is therefore subject to conformity and air quality planning requirements. The Richmond and Hampton Roads areas are currently designated as maintenance areas for the one-hour National Ambient Air Quality Standard for ozone. Roanoke and Fredericksburg are currently in attainment for the one-hour ozone standard, but may be designated nonattainment under a new, more stringent ozone standard that EPA has promulgated.

The impact of teleworking was examined using the VMT reductions expected. These were multiplied with emission factors obtained from the MOBILE5b model. This model accepts local data such as temperatures, vehicle fleet mixes and ages, emission control programs, and speeds as inputs and produces emission factors that represent vehicles operating within the study area. It is estimated that if an additional 5 percent of the workforce began teleworking, a decrease of about 2 percent could be expected in the volatile organic compounds (VOC) and nitrous oxides (NO_x) emissions in the Richmond and Hampton Roads urban areas, and a 0.5 percent decrease in emissions in the Northern Virginia urban area. Although these decreases appear small, they are significant given that most urban areas have small emission margins for conformity. The emission reductions become important when a region faces the possibility of exceeding the conformity emissions budget.

Section 4: Costs and Performance Measures

Section 4 describes the resource and management issues associated with teleworking. Specifically, the costs and benefits associated with teleworking are discussed in detail, and the costs experienced by both public and private organizations are outlined. Performance measures that have been used to evaluate the impact of teleworking, and others that could be used, are discussed. Finally, teleworking programs in other states in the U.S. are summarized.

Performance Measures

Various performance measures that are now used or could be used to evaluate the impacts of teleworking were reviewed as part of this study. These measures can be classified in four main categories: employee, employer, community, and government. Most of the information in the literature pertains to performance measures used for the first two categories, and these include worker productivity, turnover rates, and absenteeism. However, it is likely that performance measures related to the community and government will gain acceptance and will become the focus in the future. The primary challenge with performance measures is a consistent measurement methodology. Data for these measures are typically collected by performing surveys of teleworkers, non-teleworkers, and managers. When there is inconsistency in the responses by different segments of the workforce, further analysis is needed.

Benefits and Costs of Teleworking

The costs and benefits associated with teleworking are typically defined from an employers' perspective. Various studies have identified the benefits of teleworking. The principal benefit identified in most studies is the reduced cost of real estate. This reduction is possible only if there is a sharing of work space at the central place of work, an arrangement that is also termed as hoteling. The General Services Administration (GSA) has estimated that it costs approximately $10,200/year to provide the office space and equipment for an employee in a traditional environment, and $ 9,500/year for an employee in an innovative office environment.

In addition to reduced real estate costs, other cost reductions are also important. These include the reduced costs associated with decreasing turnover and absenteeism and increased productivity. As noted in Section 2, considering various data sources, it is estimated that these amounts can average up to $10,500/year in reduced costs for each teleworker.

However, there are definite costs to the employers. The fixed or non-recurring costs (also called development costs) are those required to start a teleworking program. These costs include start-up computer hardware, software, including any office reservation/space management costs, phone lines, and other office equipment, as well as initial outlays for marketing and training materials. The operations or recurring costs of telework include all recurring costs to maintain the program, including administration costs (management salaries and related management expenses such as cellular phone charges, pager, travel, and training or conference costs), marketing and advertising costs, employee and manager training costs, and equipment upgrades and maintenance. Although there is a significant variability in these costs, in a typical scenario, the development cost for a home-based teleworker is approximately $6,000, and for a

workstation at a telecenter it is approximately $9,500. The annual recurring costs range from $2,500 to $3,500 for the home-based and telecenter-based teleworking.
As a demonstration, two hypothetical cost-benefit analyses were performed as part of this study. In both analyses, it was assumed that 50 teleworkers would work from an alternate location two days a week, and would share the office space at the central place of work the remaining three days of the week. In the first scenario the alternate location for work was home, and in the second it was a telecenter. The cost-benefit analyses performed showed that over a three-year period, the home-based teleworking would result in a benefit of $450,000 and the telecenter-based teleworking would result in a benefit of approximately $250,000. The lower benefits for the telecenter-based teleworking were because of duplicated equipment costs at the telecenter and the primary place of work.

Teleworking Initiatives in Virginia and Other States
A wide range of teleworking initiatives is provided by different states. The Commonwealth of Virginia supports two primary teleworking initiatives. Telework!Va is a pilot program that includes reimbursement of lease costs and consultant/technical assistance expenses. It reimburses a variable percentage of the lease expense for equipment; telework center space; technical assistance for setting up programs and installing equipment; and provides training for teleworkers and supervisors. The program is administered by the Virginia Department of Rail and Public Transportation (DRPT) through the Metropolitan Washington Council of Governments (MWCOG). In the first three months of the program, approximately 30 companies have received preliminary approval. DRPT also provides support for the Telework Resource Center that is managed by MWCOG in the Washington, D.C. metropolitan area.

Other states with teleworking programs and initiatives include Arizona, California, Florida, Maryland, Oregon, and Washington. In many of these states, the teleworking programs were started in an attempt to meet federal air quality standards. In all these cases, the state legislatures and/or executive branches (through Executive Order) mandated some form of teleworking program be piloted or established, and that a central administrative state agency be charged with overall implementation responsibility. This central agency then distributes or delegates that authority to other individual state agencies for actual program management.

In Arizona, state agencies operating in Maricopa County are required to have 15 percent of their state employees participating in teleworking pilot programs. To date, 71 state agencies have implemented this program. Florida is unique in that it stresses the advantages teleworking may have in employment of individuals who have special needs that fall under the Americans with Disabilities Act (ADA). Maryland has implemented a comprehensive telework program for state employees that is administered by the Department of Budget and Management (DBM). It provides extensive resources and manuals to all state agencies and the general public. The Maryland Department of Transportation (MDOT) also provides statewide outreach through MDOT's Telework Partnership with Employers (TPE) which offers free professional telework consulting services to Maryland employers. Implementation of the TPE is a coordinated effort between MDOT, MWCOG and the Baltimore Metropolitan Council. Oregon is a founding member of the Telework Collaborative, along with Arizona, California, and Washington. This collaborative develops telecommuting materials, including a management briefing and stand-alone telecommuter/supervisor training package.

Conclusions

The general conclusion of the report is that teleworking can be a viable transportation demand measure, particularly in the Northern Virginia region and in other major metropolitan areas where traffic congestion and resulting air quality degradation is substantial. Existing and potential federal and state initiatives can have an incremental impact on congestion and air quality, and therefore teleworking initiatives have a potential return on investment. With proper oversight, various programs could be successful in other areas of the Commonwealth as well.

The success of telecommuting programs can only happen with strong management at all levels providing active and consistent encouragement and oversight. Telework programs can be successful and yield measurable results for organizations and employees. The results of the research performed for this report show that positive benefits in costs, productivity, congestion and air quality can be achieved through a comprehensive program of teleworking. Aspects that are critical to the success of a teleworking program include adequate resources for managing the program, a training program for both managers and employees, and marketing efforts to publicize the program. Most states that have a defined teleworking program have a specific group or department specifically for the purpose of managing the telework activities in the State. Typically this group or department provides information on the benefits of teleworking to the individual, business or community, administers incentive programs, and provides management training materials needed to ensure the success of programs at all levels.

1. INTRODUCTION

House Bill 30, Item 506-D, directed the Secretary of Transportation and Secretary of Finance to study the potential benefits of teleworking to the Commonwealth of Virginia (in this document the terms teleworking and telecommuting are used interchangeably). The study team formed for this purpose also included staff from the Secretary of Technology. The bill specified that the following items were to be included in the study:

1. The definition of teleworking
2. Costs of teleworking to employers and to government
3. The impact of teleworking on congestion
4. The applicability of teleworking in all regions of the state
5. Performance measures that can adequately and appropriately gauge the benefits of teleworking to the employee and employer as well as congestion relief
6. Alternatives for encouraging the use of teleworking in Virginia

The telework study was initiated by the Virginia Department of Transportation (VDOT), and a consultant team consisting of Fitzgerald and Halliday Inc. and Parsons Transportation Group was asked to perform the study. This final report discusses all the issues identified in House Bill 30, Item 506-D. Specifically, this report presents information related to various elements of telecommuting, such as costs, benefits, performance measures, specific impacts on traffic congestion and air quality, and applicability across different parts of the Commonwealth.

There were several components of the overall telework study. These include:

1. Performing an extensive literature review of various teleworking articles and publications.
2. Identifying areas for which specific information is not available and suggesting appropriate data collection efforts where needed.
3. Estimating the range of costs to employers and government to implement teleworking programs, and costs to employees to participate in such programs.
4. Estimating the roadway congestion and air quality impacts of teleworking.
5. Identifying performance measures that can be used to gauge the impact of teleworking on employers, employees, and the community.
6. Identifying the applicability of teleworking across Virginia, and alternatives for encouraging the use of teleworking in Virginia.

These components are documented in this report. During the course of the study, the need for additional data on the prevalence of teleworking in Virginia was identified, and a survey was subsequently performed in three urban areas (Roanoke, Richmond, and Hampton Roads). A separate report documenting the survey and its results has been prepared by the Southeastern Institute of Research, and a summary of those survey results are presented in this report.

2. TELEWORKING

Teleworking, the practice of reducing the distance traveled to a central place of employment by working from an alternate location, is not a new concept. The energy crisis of the 1970s brought telecommuting into the mainstream. The number of workers participating in teleworking programs has increased steadily since then without a great deal of fanfare. Increasing congestion in many urban areas has again focused attention on telecommuting as a means of reducing both peak period trips and total vehicle miles of travel (VMT).

Teleworking may be broadly understood to entail solutions such as the completion of even routine tasks remotely. Reading at home to allow full concentration or plan review for convenience at a third-party location are typical examples. The material presented in this section is based on information presented in a white paper prepared by VDOT, which was used to establish its teleworking program. This white paper was in turn based on two earlier reports: the Management Services Division's report on telecommuting (1995) and the briefing paper, "Telecommuting as a Transportation Demand Management Option" prepared by the Virginia Transportation Research Council (VTRC) for the Executive Leadership Group of VDOT. The scope of the Management Services Division study was to research public and private sector telecommuting programs, reported benefits, equipment utilization, and eligible participants for telecommuting, and to develop a department-wide program. The scope of the VTRC briefing paper was limited to telecommuting in the public sector and the potential benefits for the Commonwealth of Virginia.

2.1 Definitions Related to Teleworking

The following definitions related to teleworking have been specified for this study by the General Assembly Study Team (Telework Study Group 2001):

Teleworking – A work arrangement where managers/supervisors direct or permit employees to perform their usual job duties away from their central workplace, in accordance with their same performance expectations and other agency-approved or agreed-upon terms.

Teleworker – An employee who works away from his/her central workplace all or part of the work week, either at home or at another designated or approved alternate work location.

Central workplace – An employee's work headquarters or official duty station where he/she would normally report to work if not teleworking.

Alternate work location – Approved work sites that include the employee's home or satellite offices where official business is performed.

Teleworking may also include work arrangements where a person is self-employed or has a home-based business. However, because of the focus on transportation issues in this study, such persons were not considered.

2.2 Characteristics of Teleworking

Telecommuting is not a technology or collection of technologies. Rather, it is a work option that reduces dependence on transportation by using information and telecommunication technologies. Computer and telecommunication advances in recent years, including computer networks, facsimile machines, and electronic mail, have widened the choice of workplace. As a result, employees whose work focuses on the creation, distribution, or use of information can work wherever the telecommunication tools are available, including the home. More and more job tasks, in a variety of employment categories, are likely to be candidates for telecommuting in the future as technological advances continue.

2.2.1 Tasks Related to Teleworking

The continuation of technological advances and on-line resources has led to an expanding population of worker categories for whom telecommuting is deemed an option. The U.S. workforce has been shifting from being industry-based to one where the information technology (IT) and management segments have grown tremendously. The new economy has been a huge benefit for the new "information workers". The literature varies widely on the definition of information workers, but many studies refer to them as the pool from which telecommuters will be drawn, and place the percentage of the overall workforce that fits this definition at between 50 and 70 percent. Of course, there are other factors affecting the immediate, or even future, institution of telecommuting options for these professionals, such as supervisor/employer acceptance of telecommuting or additional tasks that can be performed remotely but not necessarily electronically.

The type of work performed by employees is the most important selection criterion for telecommuters. The creation, use, and distribution of information permeate almost all business activity. Many employees now spend significant portions of their time with paperwork and its electronic equivalent, computer files. As a result, technological advances require that employees use computers, fax machines, e-mail, the Internet, cable, and telephones. These technologies have made the decentralization of work possible.

Organizations find surveys useful for determining the level of technology use across position classifications. The surveys also allow assessment of the type of tasks (e.g., writing, reading, thinking, research) and the frequency of occurrence of tasks among the different position classifications. Survey results, along with knowledge of the positions and the organization, enable employers to identify positions suitable to telecommuting.

The Los Angeles County government extended telecommuting options to a wide range of positions. Table 1 presents a list of County positions suitable for telecommuting:

Table 1
Designated Telecommuting Positions for Los Angeles County

Accountants	Electricians	Property Agents
Administrators	Environmental Health Spec.	Psychologists
Analysts	Investigators	Tax Collectors
Auditors	Nurses	Transcription Typists
Clerical Staff	Office Managers	Word Processors
Data Processors	Personnel Clerks	
Division Chiefs	Personnel Managers	

Even if one's job is considered appropriate for telecommuting, this does not necessarily mean that the employee who holds that job will want to telecommute. Factors that may preclude an employee from wanting to telecommute include the desire for social interactions at the workplace, a fear that telecommuting will slow career advancement, or unsuitable conditions in the home. However, external factors such as the severity of commute congestion, the commute trip length, commute costs (including tolls and parking charges), and the cost to an employee to telecommute can influence an individual's desire to telecommute. Estimates in the literature for the percentage of workers who want to telecommute range from 46 percent to 88 percent of those whose jobs could be performed through telecommuting.

The number of workers participating in a telecommuting program primarily depends on the number of jobs available that are suitable for telecommuting. A Washington State publication (Cooperative Extension Energy Program 1997) produced a list of occupational tasks that were deemed suitable for telecommuting. These tasks are shown in Table 2.

Table 2
Typical Tasks Conducive to Telecommuting

Analysis	Dictating	Record keeping
Auditing reports	Editing	Research
Batch work	Evaluations	Sending/receiving e-mail
Calculating	Field visits	Spreadsheet analysis
Computer programming	Graphics	Typing/word processing
Contracts	Planning	Writing
Data entry	Preparing budgets	
Design Work	Reading	

Source: (Cooperative Extension Energy Program 1997)

2.2.2 Teleworking Equipment Needs

Although an employee can telecommute with simply a telephone, paper, and pencil, the increasing availability of information and communication technologies to the general population has expanded telework capabilities to many different professions. Professionals who rely on access to sophisticated databases and software to accomplish daily business can now access these remotely. As technical advances continue to offer office mobility for the professional worker, telecommuting will continue as a viable work option. Telecommuting trends over the last decade demonstrate that telecommuting has become a desirable way to work. High-speed Internet access is advancing the ability to share, review, manipulate, and discuss information between individuals and in teams from remote locations. Further advances in telecommunications technology, such as video conferencing, could accelerate this trend.

Technology improvements, among other factors, have changed the nature of work considerably in the last 10 years. According to the U.S. Department of Transportation's (U.S. DOT) Bureau of Transportation Statistics, in the early 1990s 36 percent of telecommuter households had personal computers and 16 percent of telecommuter households had modems (U.S. DOT 1993). The most common tool used by telecommuters was the telephone. At that time, approximately 95 percent of all telecommuters used basic residential telephone service and 26 percent used more than one line (U.S. DOT 1993). Today, according to Cahner In-Stat Group, a high-tech research firm, nearly 70 percent of telecommuter households have access to the Internet (InnoVisions Canada 2001). Another survey (Nilles 2000) showed that almost 90 percent of the teleworkers working at home have a computer; 85 percent have telephone answering machines; and 65 percent have fax machines. These teleworkers spend an average of seven hours every week reading and sending e-mail. This compares with the average four-and-a-half hours that non-teleworkers spend on e-mail every week.

"Equipped with laptop computers, hand held Internet appliances, fax machines, voicemail, e-mail, and other technologies, a new 'anytime, anywhere' work culture is emerging" (Van Horn and Storen 2000). Electronic messaging has become an essential tool for project teams. According to a 2001 WorldCom Conferencing Study, 61 percent of employees in large companies (more than 500 employees) have participated in virtual project teams (Modalis Research Technologies Inc. 2001). Most virtual project teams are using e-mail and audio conferencing as the leading tools for telework communications. Other commonly used tools include fax, cellular phones, intranet or extranet access, online calendar or scheduling tools, paging, and web conferencing, among others.

2.2.3 Locations of Teleworkers

There are also a greater number of alternatives for performing work away from the primary office. The locations from which people telework include the home, satellite offices, telecenters, and executive office suites. While some telework locations are used more than others, each location has its own set of benefits and its own set of issues. Providing a variety of locations for teleworkers can maximize flexibility. Since today's white-collar workforce spends much of its time working away from the primary office either by meeting clients, working with teams, or conducting research or fieldwork, providing a variety of locations for teleworkers may enhance their overall employee productivity.

2.2.3.1 Home

Typically, telecommuters work out of their homes. To provide flexibility in a program, home-based telecommuting can be implemented on an individual basis. The home-based telecommuter designates an area in his or her home as the office. One major advantage of home-based telecommuting is that it completely eliminates the commute to and from the office. This not only can improve one's psychological well-being by avoiding roadway congestion, but saves time for alternative use or enjoyment. It can also improve morale and decrease absenteeism by increasing one's physical proximity to schools, child care, and enabling the employee to conduct home-related business during lunch. Potential disadvantages of home-based telecommuting include issues related to child care, visiting friends, or other home-related distractions. There are also many legal issues that need to be closely examined prior to establishing a regular home-based telework program. These may involve zoning, home-office business licensing, home insurance, taxation, and employee protection issues, such as worker compensation.

Home-based telework offers employees an opportunity to improve the balance between work and family, especially if flexible hours are permitted. However, traditional forms of management need to change in order to promote effective telework arrangements. By working at home, the employee can do laundry or grocery shopping during the lunch hour, attend a school performance, provide classroom assistance, or meet the plumber, roofer or receive furniture deliveries without taking leave. Such activities may improve overall morale, thereby improving productivity. By allowing employees to take an hour or two off during the day and making it up in the evening, employers can further improve the work and family relationship for employees with home-based teleworking. In order for such flexibility to occur, however, a major shift in thinking needs to occur on behalf of the manager. The manager's focus needs to shift from the traditional "who's at the office" to "what's getting done." Performance measures need to reflect that shift.

Without such a shift in thinking, office managers are reluctant to allow employees to work at home because of concerns that the employees may be distracted by home-related functions, friends, or even children. Employees need to know that telework is not a substitute for child care, and they should consider how they plan to avoid home-related distractions. Communication about how the employee plans to handle distractions is vital to a successful home-based teleworking arrangement. Often this communication is facilitated by company training videos or courses. Open communication can ensure the manager that work is getting done in a timely manner. Performance measures need to reflect communication.

Many legal issues can affect home-based telework and should be examined prior to initiating a regular program (Zabrosky 2000). Zoning and business licensing are local regulatory affairs which the employee should investigate prior to initiating a regular home-based telework program. An office use may not be permitted in a particular residential zone, and a particular local jurisdiction may require a business license fee for working at home. Insurance companies should be consulted to determine whether increased premiums are required for working at home or to determine which entity is responsible in the case of theft or fire. Tax accountants should also be asked to determine whether taxes are required and whether the expenses associated with traveling between the home-based office and the primary workplace are chargeable as reimbursable expenses or accounted as income (Zabrosky 2000). Finally, there are worker protection issues that the employer may want to consider. Although the Labor Department withdrew a department advisory in January 2000, saying that employers are responsible for the health and safety of people working from home (Burn 2000), it is still unclear as to where the liability falls. Workers' compensation is another ambiguous area where the employer may be required to make payments. It gets more complex if the telecommuter's home is in a different state than the primary office, and the employer may be required to make payments to the telecommuter's home state (Zabrosky 2000) and not the state of the primary office.

2.2.3.2 Satellite Offices

An alternative to home-based telecommuting is satellite offices. Satellite offices are established by a single organization that provides the technology and support for a group of telecommuters within that organization. Although some telecommuters may still have to travel to get to the center, the commute is usually shorter than to the central office. Some private sector companies have established satellite offices after experiencing successful use of traditional telecenters, which tend to be managed by public entities. In fact, the Antelope Valley Telebusiness Center in Los Angeles County, California which had a 100 percent utilization rate and was financially successful, ultimately closed its doors in 1999, when most of its clients abandoned it in favor of their parent company's decision to develop a private satellite office (Gutierrez interview). In other cases, the establishment of satellite offices has been difficult due to the high cost of the commercial real estate market.

2.2.3.3 Telecenters

Another alternative to home-based telecommuting is telecenters. Telecenters are used by telecommuters from different organizations. Telecommuters share space and equipment at the telecenters, and the employers share the costs by paying workstation user fees. One of the greatest advantages of telecenters is that they are incubators for other forms of teleworking. Companies sometimes use them to test the telework concept before establishing home-based telework options or satellite offices. Telecenters can provide an employer with added security in knowing that the employee cannot be distracted by home-related functions. While Atlanta's telecenters were not intended to be such, they ultimately served as incubators for home-based telework, allowing managers and employees to become comfortable with telework in an office environment prior to offering what is now exclusively home-based telework. Other telecenters, such as the Antelope Valley Telebusiness Center, functioned as incubators for satellite offices, allowing companies to gauge demand and analyze office needs and work processes prior to investing in such a facility.

The primary issue with telecenters is financial viability. Initially, telecenters were established in the early 1990s to provide an alternative work environment for employees wanting to avoid lengthy commutes and were heavily subsidized by public and sometimes private funds. There are few documented cases of financially self-sustaining facilities. Underutilization has resulted in the inability to cover operating expenses, culminating in the closure of many centers. For example, four telecenters in Atlanta, Georgia closed in 2000, one telecenter in Minnesota closed in 1999, and numerous telecenters in California have closed since 1997, all due to underutilization. A recent study commissioned by the General Services Administration (GSA) to review the financial performance of the 15 telecenters in the greater Metropolitan Washington, D.C. area has recommended that all but one work center be closed due to underutilization.[1] Several factors appear to be affecting the success of telecenters in the United States, specifically:

Manager Resistance

One reason for telecenter underutilization may be as simple as an organization manager's resistance to telecommuting. Surveys of telecenter users in various geographic locations indicate high user satisfaction with telecenter operations and personal benefits gained from participation. A former telecenter director in the Atlanta, Georgia metropolitan area believes underutilization of the four Atlanta telecenters was due to management resistance in allowing employees to telecommute (Hunter interview). Telecenter coordinators in Northern Virginia have noted that many interested employees often stop their inquiries upon following up with their supervisors. Thus, while telecenters in general have not been financially successful, it is conceivable that telecenter utilization may increase as telecommuting becomes more accepted in the workplace. The Executive Director for a telecenter located in Manassas, Virginia, says that the number of inquiries has noticeably increased since the congressional mandate to increase federal telecommuting and since Governor Gilmore's Telework!Va initiative to provide financial incentives to employers (Dobberfuhl interview). Furthermore, GSA reports that telecenter usage has increased dramatically within the last year, coinciding with passage of the law requiring increased federal telecommuting[2].

Greater Availability of Home-Based Teleworking

A second reason for telecenter underutilization may be that technological advances have enabled home-based teleworking; however, this view has not been well documented. Many people interviewed for this study believe that the availability of high-speed Internet access is enabling more people to telecommute from home, thus decreasing the demand for telecenter usage. Others oppose this view, indicating that there is still a preference for telecenters by many employees who either have issues that interfere with working from home or who prefer the social opportunities available at telecenters. It is therefore unclear as to what effect the increase in home-based telecommuting is having on telecenter demand.

Market Analysis and Planning

A third possible reason why telecenters are closing is the lack of market analysis and a well- defined planning process when they are established. Most telecenters were not developed with business objectives in mind but were instead transportation demand management solutions for road congestion that were also expected to help workers cope better with the increasing difficulties they have balancing work and family. Therefore, in the greater Washington, D.C. metropolitan area, several telecenters have been located in overlapping market areas, and virtually no center was opened with a clear understanding of where employees live (Ernst & Young, AEW Capital

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[1] According to GSA, there are no current plans to close any existing telecenters in the greater Washington, D.C. metropolitan area (Einarsen and Michael interviews). One telecenter director reported that GSA is waiting to decide on the outcome of legislation sponsored by Congressman Wolf, which requires federal agencies to increase the number of federal teleworkers.

[2] An AEW Management study, commissioned by GSA and completed in February 2000, identifies 362 telecenter users in the last quarter of fiscal year 2000. On June 20, 2001, GSA's Internet web site identified 638 users.

Management). Poor planning has been linked to underutilization at telecenters located in Washington, D.C., California, and Minnesota. Understanding market needs is essential to facility planning and asset performance.

2.2.3.4 Executive Suites as Teleworking Locations

A fourth alternative teleworking location is the executive office suites model. The executive office suites model may have evolved out of the traditional telecenter concept and appears to be succeeding well financially. These work centers offer a premium office address and greater diversity of services than the traditional telecenter, and therefore costs more than the typical telecenter. In addition to the commuting professional, executive office suites attract home-based teleworkers who need periodic access to equipment and social interaction; traveling professionals on business who need "touch down" workspace; collaborative teams that need workspace for a specific project purpose with a defined duration; and small businesses that need temporary conference or meeting space or simply a larger facility. Centers are equipped with state-of-the-art equipment. Concierge services are typically available. Conference space and private offices, as well as open cubicles, are available. The executive office suites concept provides the mobile office worker with maximum flexibility in a full service facility. Two examples of these executive office suites are located in the District of Columbia and have premier addresses in Dupont Circle and Georgetown. Another example is at Tysons Corner in Northern Virginia. The owner of these office suites reports high utilization and profitability (Wiatrowski interview). Executive office suites are available worldwide. According to a former telecenter director in California, the only functioning "telecenters" in California that remain open have evolved into executive office suites (Gutierrez interview).

2.2.3.5 Teleworking Location Summary

Any of the above location alternatives can impact individual employee satisfaction as well as reduce the overall number of vehicle miles traveled by telecommuters. Home-based telecommuting, however, consistently offers the greatest potential for reduction in vehicle miles traveled because of fewer "linked trips," defined as travel activities immediately before, after, or during the work day. The results of an analysis of the State of California Telecommuting Pilot Project, which was performed to determine the impact of telecommuting on household travel behavior, confirmed that home-based telecommuting substantially reduced travel and was not offset noticeably by the generation of new trips. On telecommuting days, the telecommuters made virtually no commute trips, reduced peak-period trips by 60 percent, reduced total distance traveled by 75 percent, and reduced freeway miles traveled by 90 percent. Telecommuters also chose non-work destinations that were closer to home.

2.2.4 Managing Teleworkers

Telecommuting management has grown with the practice of telecommuting itself. An Internet review of telecommuting and management brings up many sites ranging from defining the role of the telecommuting manager to outlining specific rules for telecommuting that have been developed by various organizations.

Generally, successful telecommuting managers are those who manage by results. Because employees will be away from the office, the manager can no longer monitor performance by observation, but must rely on the tangible results of employee output. Employees selected for telecommuting usually have a history of good performance on annual evaluations. In the federal government's Flexiplace Program, 80 percent of the participants' job performance ratings were in the "Exceeds", "Fully Successful" or "Outstanding" range (Joice and Sterling 1993). The participant group had proportionally more employees with outstanding job performance ratings than the federal workforce in general.

To maximize results, some organizations limit the telecommuting option to professional positions. The Florida Department of Transportation (FDOT) has authorized 40 positions for telecommuting and requires written requests for additional positions. FDOT uses a coordinator who reviews the positions as well as employees selected for telecommuting. Other programs have telecommuting coordinators or program managers. The coordinator is the focal point of the program and serves as a liaison between management and employees. Generally, the telecommuting coordinator performs the following services:

- manages the telecommuting program
- evaluates and monitors the program
- trains telecommuting participants

Once the organization has identified positions for telecommuting, employee selection is the next step. The telecommuting arrangement is an agreement between the employee and supervisor where both must agree to all terms. If there is disagreement over terms of the arrangement that cannot be resolved, the employee is not allowed to telecommute. Furthermore, both parties have the right to terminate the telecommuting arrangement at any point.

The federal government has recognized the growing possibilities for telecommuting for its workers. Recent legislation co-sponsored by Congressman Frank Wolf of Northern Virginia has required that certain identified members of the federal workforce be afforded opportunities for telecommuting within the next four years. It has been estimated that 40 to 50 percent of the current federal workforce will be eligible for this program (Wolf 2001). The initial 25 percent of this eligible number has been identified in 2001, with another 25 percent scheduled to be identified in each of the next three years. The federal government experience should assist state and local governments in defining categories of workers eligible for telecommuting opportunities and the results defined by that experience should help to refine the management/employee relationship.

2.3 Prevalence of Teleworking

Nationwide, the public sector (local, state, and federal government) employs three percent of all telecommuters. According to an October 1999 GSA report, about 26,000 federal employees work at home or at off-site telecommuting centers. The federal Treasury, Defense, Health and Human Services and Labor departments have the most telecommuters.

Research by the Conference Board discovered that 80 percent of all organizations, public and private, had informal telecommuting as a work option. Typically, informal telecommuting is arranged between the supervisor and employee without the knowledge of upper management or the human resources department. The arrangements have worked well, but they often lacked key elements, such as written agreements and training. According to one research firm, Gartner Group, companies need to be careful of informal programs (Roberts 2001). An informal telework program is three to five times more expensive to run than a formal program because costs are not controlled. Companies with informal programs do not have consistent standards, have not aggregated their buying power on supplies and technology, and do not track the return on investment. Office space once used by teleworkers is not reclaimed and redeployed for a more advantageous use.

Due to the proven success of pilot telecommuting projects as well as energy, infrastructure, and air quality concerns, the use of telecommuting is expected to increase in both the private and public sectors. In order to maximize the general benefits of telecommuting, employers must evaluate and consider equipment and supply acquisition, location of telecommuters, and manager and employee selection. These evaluations will enable each employer to develop a program which best fits the needs, culture, and business objectives of his/her organization.

2.3.1 Number of Teleworkers Nationwide

Various studies have estimated the number of teleworkers nationwide. It is important to consider the definition of teleworkers used in these studies, as the definitions are often different. In one study, it was estimated that 30 percent of the entire U.S. workforce works at home at least part of the time (United States Department of Transportation 1993). In this study, telecommuters were defined as follows:

> *..company employees in any occupational group working part- or full-time during normal business hours, for whom the commute is eliminated, shifted out of the rush-hour period, or shortened through the performance of the work role at home or at an alternative remote location, and who communicate with the usual place of work using electronic or other means instead of traveling there.*

The same study noted that in 1992, a total of 4.2 million employees were telecommuting based on the results of an annual survey performed by LINK Resources (1992). The estimate of 4.2 million included 1.8 million telecommuters who were working at home on contract or on self-employment activities. Thus, 2.4 million employees, representing 1.9 percent of the U.S. workforce, were estimated to be really telecommuting in 1992, based on the teleworking definition used in this study.

Other studies performed in the mid 1990s provided different estimates of the number of telecommuters. The 1994 annual survey by LINK Resources estimated the number to be 5.1 million teleworkers. Studies by FIND/SVP estimated that there were 9.1 million teleworkers in 1995 and 13 million in 1997.

A recent comprehensive survey (Nilles 2000) of 1,877 individuals estimated that in the year 2000 there were 16.5 million teleworkers who, on average, teleworked at least one day per month. In this study, teleworking was defined as follows: *With the help of modern technologies many types of work can now be done at home using telephones, faxes and computers. This is called teleworking or telecommuting.*

The 16.5 million teleworkers represent 12.2 percent of the total U.S. workforce. Of this number, 89 percent of the teleworkers worked at home only, 7 percent worked at telework centers, and 4 percent worked both at home and at telework centers. The study reported that approximately 30 percent of the teleworkers were either self-employed or were home business operators. Therefore, for comparing the estimate in this study with the 2.4 million estimate from the 1993 USDOT study, it can be said that there were approximately 11.5 million teleworkers in the year 2000. This represents a very significant five-fold increase over a period of eight years. The estimates from various studies are presented in Table 3.

Table 3
Estimated Number of Teleworkers Nationwide[1]

Source	Year				
	1992	1994	1995	1997	2000
USDOT (United States Department of Transportation 1993)	2.4[2]				
LINK Resources (LINK Resources 1994)		5.1			
FIND/SVP			9.1	13.0	
TWA 2000 (Nilles 2000)					11.5[2]

[1] Different studies have used different definitions for teleworkers.
[2] Excludes self-employed or home business teleworkers.

Previous studies provided a variety of estimates of the growth in telecommuting. The 1993 USDOT study estimated that there will be between 7.5 and 15 million teleworkers by the year 2002. The study also projected that these teleworkers would average three to four telework days per week, as compared to one to two days per week in 1992. The Nilles study estimated that on an average people telework 2.5 days/week and 20.4 hours/week. The study also reported a clear demand for teleworking, and estimated that there may be as many as 30 million teleworkers (this includes home business operators and self-employed teleworkers) by the end of 2004.

2.3.2 Number of Teleworkers in Virginia

Telecommuting has also grown in Virginia in the last decade. In 1994, LINK Resources estimated that there were 220,000 telecommuters in Virginia, or 7.6 percent of the total labor force. In the metropolitan Washington, D.C., area, which includes Northern Virginia, teleworking surveys have been performed by the Metropolitan Washington Council of Governments (MWCOG) in 1996, 1998 and 2001. The 1998 survey found that approximately 250,000 people (12 percent of the workforce) telecommutes an average of 1.60 days per week (Ramfos, Sivasailam et al. 1999). Approximately 90 percent of the teleworkers worked from home and the remainder worked at telecenters. The 2001 survey showed that the number of teleworkers has increased to approximately 315,000 (15.1% of the workforce). This includes approximately 80,000 teleworkers in Northern Virginia. However, the teleworking frequency has decreased to 1.43 days/week.

As part of the VDOT/DRPT study, the Southeastern Institute of Research (SIR) performed a survey in the Richmond, Roanoke and Norfolk-Virginia Beach-Newport News (Hampton Roads) Metropolitan Statistical Areas (MSAs). Teleworking participation rates in terms of the workforce in each of the areas were 8.3 percent in Richmond, 6.7 percent in Hampton Roads, and 4.7 percent in Roanoke. The teleworking frequency was also the highest in the Richmond area, averaging at 2.35 days/week. The teleworking frequency in Hampton Roads was 1.58 days/week and in Roanoke 1.79 days/week. It is expected that the teleworking participation rates in other small urban areas, such as Charlottesville, Danville, Harrisonburg and Lynchburg, would be similar to the participation rate in Roanoke. Even if none of the people in the other areas of Virginia telework, the average teleworking participation rate across the state would be approximately 8 percent (approximately 260,000 teleworkers).

2.4 Commuting Characteristics

Telecommuting is an option that has been considered not only as convenience to workers but also as a means of reducing travel demand, and therefore congestion. While the impact of telecommuting on congestion varies, telecommuting has the potential to remove work trips from the roadways during peak periods. To quantify the potential effects of telecommuting on congestion, it is necessary to determine the percentage of work trips that occur during the peak hours. Various estimates are presented in different publications.

2.4.1 Work Trips during Peak Periods

Considering nationwide travel data reported in the 1995 Nationwide Personal Transportation Survey (NPTS - Federal Highway Administration 1997), commuting for work accounts for only 18 percent of daily person-trips and 22 percent of daily person-miles. Work trips are typically defined as those trips that have one trip end at the work location. It should be noted that most surveys do not account for trip chaining, where stops are made to and from another destination and therefore, do not get counted as a home-based work trip. Examples include dropping off a child at daycare before work in the morning, or shopping on the way home from work. The NPTS data show that 14 percent of total daily trips occurred during the morning peak period (6:00 to 9:00 AM), comprised of 5 percent work trips and 9 percent non-work trips. During the evening peak period (4:00 to 7:00 PM), 23 percent of total daily trips occurred, comprised of 5 percent work trips and 18 percent non-work trips. In total, during the peak period only 27 percent of the trips are work trips and the remaining 73 percent trips are non-work trips.

Other data for urban areas present different estimates. A 1990 household survey in the San Francisco Bay area estimated that 66 percent of the trips in the morning peak period (6:30 to 8:30 AM) are work-related, and 40 percent of the trips in the evening peak period (4:30 to 6:30 PM) are work-related (Purvis 1994). Additionally, there were 26 percent more trips in the evening peak period compared to the morning peak period. A survey conducted in the Hampton Roads, Virginia (Hampton Roads Planning District Commission 1994) area, showed that 35 percent of the morning peak period (7:00 to 9:00 AM) trips and 30 percent of the evening peak period (4:00 to 6:00 PM) trips were work-related.

Few studies have looked at the impact of trip chaining. One such study (Sivasailam 1998) used travel diary data for the metropolitan Washington region. Trips made on the way to work, on the way back from work, and other trips made while at work were classified as work-related, non-work trips. It was determined that although only 30 percent of the automobile trips were home-based work trips, an additional 24.3 percent of the automobile trips were work-related, non-work trips.

The variability of these data suggest that it is important to consider local travel behavior when considering the impact of telecommuting on traffic congestion. The emphasis on work travel and its impact on congestion will continue to be an important issue. As described in the NPTS study the number of additional miles that employed adults travel versus those without jobs is 6,600 per year. The study noted that these trips determine how, when, and where other travel is accomplished. Furthermore, the temporal and geographic concentration of work trips results in the largest strain on all transportation systems. Although the potential impact that telecommuting may have on congestion may be limited, the time and cost savings for the individual are significant.

2.4.2 Changes in Travel Patterns of Telecommuters

If an individual chooses to telecommute, the question remains as to whether this action will result in a removal of a trip from the roadway. Telecommuting by workers who previously carpooled or used transit will not necessarily result in an eliminated trip. Also, the travel behavior of the telecommuter may change in response to the increased flexibility. The key question is whether the reduction in work trips might be balanced by new trips made possible or necessary by telecommuting. Examples of possible new or longer trips include:

- shopping trips normally made while en route to or from work
- drop-off and pick-up at a daycare facility that otherwise would have been part of the work trip
- trips by other household members made possible by the availability of the vehicle
- trips made possible by the flexible work schedule
- trips necessitated by working at home - such as to the post office or to obtain office supplies

A compilation of data from approximately 10 telecommuting programs in California do not support the above concerns. This study found the following:

- Non-commute trips do not increase.
- Telecommuters make proportionally fewer linked trips.
- Telecommuters tend to shift activities to destinations closer to home.
- Proportionally fewer peak period trips are made when telecommuting.

One comprehensive study (Pratt 1999) indicated that 87 percent of teleworkers drive to and from work alone. When the teleworkers have to work at their main office location, on average it takes them 27 minutes to cover an 18-mile, one-way route to work. Additionally, on typical workdays they drive 7.9 extra miles for personal needs during the commute. On days when the teleworkers stay home, they report driving an average 9.3 miles per day for errands. The study concluded that such teleworkers save the equivalent of one hour per day when working at home, with a reduction in mileage of approximately 35 miles per day. Other studies have shown similar significant reductions in trip by telecommuters. The California Telecommuting Pilot project showed that on telecommuting days, telecommuters reduced peak-period trips by 60 percent, reduced total distance traveled by 75 percent, and reduced freeway miles traveled by 90 percent.

2.5 Impacts of Teleworking

The number of people who telecommute is influenced by a number of key factors, including occupation, supervisor/employee acceptance of telecommuting, employee/employer need for face-to-face interactions in the workplace, perceptions that telecommuting might negatively affect career advancement, and the suitability of the home as a telecommuting office. As both employers and employees become more accustomed to the practice of telecommuting, and as commute times lengthen as a result of congestion, the frequency of telecommuting is likely to increase. Likewise, as the number of telecommuters increase, more employers will evaluate and consider the benefits of telecommuting. The general benefits of telecommuting for the employee include:

- reduced commuting time and commuting stress
- decreased costs for transportation, parking, clothing, and food
- increased job satisfaction and quality of life
- increased work efficiency due to the telecommuter's ability to work away from normal office distractions

Expected general benefits for the employer include:

- increased productivity
- decreased absenteeism
- increased employee retention and attraction
- decreased long-term disability costs
- reduced overhead and office space costs
- reduced parking space needs
- improved morale

2.5.1 Traffic Congestion

Although the effects of teleworking on congestion are not well-documented for the Commonwealth of Virginia, there are some congestion statistics for at least two key metropolitan regions within the state. The 2001 Urban Mobility Report summarized the results of a study that evaluated the operations on freeways and principal arterial street networks (Texas Transportation Institute 2001). The report noted that 78 percent of the freeway person-miles of travel and 83 percent of the arterial miles of travel in the Washington, D.C. metropolitan area were through congested conditions. In Hampton Roads, during the same period, 46 percent each of the freeway and arterial person-miles of travel were through congested conditions. In terms of annual delay, drivers in Hampton Roads experienced 24 hours of delay in 1999, while commuters in Washington spent 46 hours delayed in their vehicles. Annual congestion costs were estimated at $2.73 billion for motorists in Washington and $430 million in Hampton Roads.

It is evident that the most beneficial effects of telecommuting are during peak period travel, the morning and evening commuter peak periods. Because these periods represent the most congested conditions of the weekday, any removal of traffic from the roadway system during these critical hours is beneficial in improving operating conditions. Therefore, the amount of work-related travel during the peak hours becomes an important factor when quantifying the impacts of teleworking. As discussed in Section 2.4.1, this is a difficult percentage to estimate and varies by location.

Previous studies referenced in Section 2.4.2 support the fact that telecommuters experience a reduction in vehicle miles traveled on their telecommuting days. These studies also provide documentation that the majority of commuters travel to work alone in their own vehicle, indicating that any increase in telecommuting would translate into a reduction in peak hour travel. Therefore, it is likely that both the employee and the employer will benefit from telecommuting. While employees can expect a reduction in total commute time because of fewer trips to the office, employers should get a more relaxed worker. Secondary benefits include reductions in fuel consumption and emissions of organic gases and pollutants, and improved quality of life.

2.5.2 Transportation Infrastructure

Lower transportation costs and reduced emissions of organic gases that permit telecommuting to be a viable option to meet the objectives of plans such as the Virginia Energy Plan. Because of the anticipated increase in the peak period traffic volumes, it is expected that commuters will travel at very slow speeds due to increasing gridlock. VDOT conducted a study for the 1992 House of Delegates, in which it determined that it would take $10 billion to keep traffic moving at the speed it moved in 1988. Similarly, a study conducted by a task force of Virginia government agencies concluded that it costs an estimated $580 million for each one percent increase in work force to keep traffic flowing at prevailing 1988 rates in Northern Virginia. Conversely, $580 million could be saved for each one percent reduction in commuters. A study of traffic congestion in major metropolitan areas in the country estimated that annual congestion costs were $2.73 billion for motorists in Washington and $430 million in Hampton Roads (Texas Transportation Institute 2001).

2.5.3 Air Quality

Many of the aspects of teleworking that tend to reduce congestion also result in reducing motor vehicle emissions. To the extent that teleworking reduces vehicle miles traveled (VMT), air quality benefits will be realized because fewer miles of travel result in fewer emissions produced. Emissions associated with starting and shutting off a vehicle (referred to as cold starts and hot soaks) are also affected by teleworking activity, so to the extent that the number of vehicle trips change, emissions can also change.

Reports from several telework studies show that considerable VMT reductions can be achieved when workers telework. Many of the studies also account for changes in non-commute trip-making behavior on telework days and find that even when the number of trips taken by teleworkers increases there are air quality benefits because VMT reductions are usually significant. This has been found to apply to home-based as well as center-based teleworking.

A recent report (Ramfos, Sivasailam et al. 1999) provides some insight into the emission benefits of a teleworking program. The report presents an estimate of reductions in vehicle trips, VMT, and tons of nitrogen oxides (NO_x) and volatile organic compounds (VOC)[3] from teleworking in the Washington, D.C., metropolitan area, which includes Northern Virginia. This region is designated as a nonattainment area under Environmental Protection Agency's (EPA) one-hour ozone standard. The report focused on MWCOG's Telework Resource Center, which provides information, training, and assistance to individuals and businesses to promote in-home and telecenter-based telework programs on a full-time or part-time basis. The analysis calculated the number of new teleworkers in the region and the reductions in VMT and trips as a result of teleworking.

The report referred to telework surveys conducted in 1996 (baseline) and 1998, which were detailed in Section 2.3.2 of this effort. The study found that the increased teleworking in the metropolitan Washington, D.C. region above the 1996 baseline, aided by MWCOG's Telework Resource Center program, resulted in an additional annual reduction of 34,910 daily vehicle trips and 606,908 daily VMT over 1996 reductions. The additional emission benefits were calculated to be 0.96 ton per day of NO_x and 0.5 ton per day of VOC. The MWCOG's Board of Directors adopted a resolution establishing a goal of increasing teleworking activity to 20 percent of the workforce by 2005, which would result in even greater emission reductions.

In 2000, MWCOG collected new data and revised the estimate of VMT and emission reductions for the Washington, D.C. region. The new data showed a higher level of teleworking activity than previously estimated – a participation rate of 12 percent of the workforce, a lower rate of telecommuters who drive alone during days they drive to their work location, and a slightly lower frequency of telecommuting. MWCOG estimated that in 2000, their program was responsible for a VMT daily reduction of 958,121, and daily VOC and NO_x reductions of 0.53 ton and 1.40 tons respectively.

While the estimated reductions in emissions attributed to teleworking are a small fraction of total daily emissions from all on-road vehicles, they are significant as far as travel demand measures go. The reductions are instrumental in demonstrating air quality conformity of the region's transportation plans and programs. Conformity is a Clean Air Act requirement that must be met before the region can receive federal funding for transportation projects. It is a technical process that requires modeling baseline and future emissions from the surface transportation network. For a finding of conformity, it must be shown that emissions resulting from all the projects in a

[3] NO_x and VOC are the primary chemicals that can combine in the atmosphere to form ozone. Ozone is a criteria pollutant regulated by the Clean Air Act. Vehicle emissions are a significant source of NO_x and VOC in most areas that do not meet the air quality standard for ozone.

transportation plan are less than or equal to (in conformity with) an emissions budget that has been established in the region's approved air quality plan. The emission reductions resulting from the telework program, as well as several other travel demand management projects, were necessary in order for the region to demonstrate conformity as reported in one of the most recent transportation plan and program updates (Metropolitan Washington Council of Governments 2000).

Two other metropolitan areas in Virginia have experienced air quality problems – Richmond and Hampton Roads. These regions are designated as ozone maintenance areas under the Clean Air Act, which means that at one time they did not meet the EPA ozone air quality standard but have since attained the standard. As maintenance areas, they must go through the technical exercise of demonstrating conformity, as the Washington, D.C. nonattainment area does. Each of these areas has relied on travel demand measures to demonstrate conformity in the past (as have many areas in the country). Many travel demand measures reduce vehicle emissions by only 1 to 2 percent, but nevertheless are important to transportation departments' efforts to reduce emissions from motor vehicles. The air quality benefits of teleworking activity in the Richmond and Hampton Roads areas are not currently analyzed for use in achieving conformity.

Several other areas of Virginia may be designated as nonattainment under EPA's 8-hour ozone standard promulgated in 1997. This more stringent standard has been subject to litigation, but was recently upheld by the U.S. Supreme Court. EPA is now in the process of developing an implementation plan for the 8-hour ozone standard. As required by the Clean Air Act, governors of many affected states have submitted recommended nonattainment designations to EPA. In Virginia, these areas include Fredericksburg, Roanoke, parts of Shenandoah National Park, Frederick County; and additional counties that would be part of the existing nonattainment or maintenance areas of Northern Virginia, Richmond, and Hampton Roads. Under current federal guidance, these areas would be required to demonstrate transportation conformity and reduce vehicle emissions. Teleworking programs would be one way to achieve some of the required vehicle emission reductions.

Rep. Frank Wolf (R-VA) introduced HR 2556, *The National Telecommuting and Air Quality Act,* in July 1999. This bill provides incentives to businesses to establish telecommuting programs by allowing participating companies to receive pollution credits for the emission reductions resulting from teleworking employees. The companies would be able to hold, buy, or sell the credits to entities that must meet emission requirements imposed by other environmental regulations. The legislation is currently in committee.

Emission benefits of teleworking have been estimated in other parts of the country. In California, the travel and emission impacts of a pilot teleworking program were estimated in 1995 (Koenig, Henderson et al. 1996). In this study, a comparison of participants' telecommuting day travel behavior with their prior non-telecommuting behavior showed (per telecommuter per day they telecommuted):

- the number of personal vehicle trips was reduced 27 percent
- VMT decreased 77 percent

- VOC was reduced 48 percent
- NO_x was reduced 69 percent

A small increase in non-commute trips was observed, but emissions increases from these additional trips were far outweighed by the emission reductions from decreased VMT.

Another study in the Puget Sound region of Washington analyzed the emission effects of telecommuting from telework centers (Henderson and Mokhtarian 1996). The analysis, which used travel diary data, focused on the travel behavior of teleworkers using the Washington State Telework Center in North Seattle. The analysis found that:

- VMT was reduced 53.7 percent, from an average 63.25 miles on non-teleworking days to 29.3 miles on telework days
- NO_x emissions decreased 69 percent per telecommuter per day

VOC emissions remained relatively unchanged because the teleworkers still produced cold start and hot soak VOC emissions, which produce relatively higher levels of emissions, outweighing the savings from VMT reduction. It should be cautioned that in some of the early studies, states or localities mandated the travel demand management measures. Results may be different in areas where measures are voluntary.

2.5.4 Productivity and Related Issues

As the prevalence of telecommuting increases worldwide, there is growing consensus that this type of work has a significant effect on worker productivity. The annual growth in national worker productivity has doubled from the early 1980s (one percent) to 1998 (two percent). This period has also seen a tremendous amount of private Information Technology (IT) funding, and some have suggested that teleworking has contributed greatly to the doubling of the annual growth in worker productivity. While that direct connection is difficult to determine, the success of individual telecommuting programs is known and the list of organizations engaging in telecommuting programs continues to grow.

The list of private firms that have conducted their own research on the issue of telecommuter productivity also continues to grow. Findings of a small portion of that research include (Lake 1998):

- 3Com moved 120 workers to home-based offices and concluded that their time spent weekly with customers increased from 15 to 25 hours. They also found that 40 percent less time was devoted to internal meetings.
- Nortel found that worker productivity increased by 30 percent, worker satisfaction increased by 45 percent, and worker stress was reduced by 46 percent for its telecommuters.
- American Express found that its telecommuting staff handles 26 percent more calls and 43 percent more business than their co-workers in the office.
- Compaq noted worker productivity increases of between 15 and 45 percent for its home-based staff.

MWCOG led a multi-firm telework assessment project in 1999 (Shirazi 1999). Five private organizations and the Maryland Department of Transportation took part in that telework study that sought, in part, to assess work performance of teleworkers by management, participants, and co-workers before and after a pilot teleworking program was implemented. Productivity was examined in this study by determining the perceptions of each worker category for six measures and by teleworkers and co-workers individually for two other measures. The two measures for teleworkers and co-workers were viewed as an assessment of conditions after implementation of the program and did not have initial perceived values.

For most of the measures taken before and after the study, the perceptions improved slightly. For one measure teleworkers felt that work was more productive, while managers and co-workers felt slightly more negative on this issue. The measure of the level of teleworkers' distractions was strongly in support of the teleworker program. However, the assessment by co-workers for their work level while others were telecommuting was slightly negative. A summary of the conclusions follows:

- Managers and teleworkers both assessed their hours worked as slightly more positive than before the program. Co-worker assessments of this measure remained constant.
- All worker categories disagreed slightly more strongly with the statement that teleworkers work less than their coworkers.
- Teleworkers believed that job productivity increased slightly while managers and co-workers felt slightly less positive.
- All worker categories agreed that teleworkers completed their work on time.
- All worker categories believed that the quality of work by teleworkers improved.
- Each worker category was more positive about the amount of work completed by teleworkers.
- Teleworkers strongly disagreed with the concern about distractions experienced by teleworkers.
- Co-workers believed that they were slightly less likely to get more work done when teleworkers are not in the office.

In September 1990, the Los Angeles County government initiated a program of teleworking for its workers. This program has since grown to include more than 5,000 workers today. A survey of attitudes was conducted at the outset of the program that sought to measure expected results of the telework program against perceptions of telework itself prior to implementation of the program. A few hundred people took part in the first phase of telework implementation. The results of the surveys that were administered are summarized (Shirazi and Associates, 1994) in Table 4 on the following page.

The survey was a study of attitudes aimed at determining expectations from teleworking prior to institution of the program and similar feelings after the program had been implemented for one year. As an example, prior to starting teleworking 18 percent of those who took part in the program said that they would work more hours at home as part of the teleworking program.

Table 4
Los Angeles County Government Survey Productivity and Work Quality Results

WORK HOURS	MORE	SAME	LESS
Prior	18%	80%	2%
One year later	28%	70%	2%
PRODUCTIVITY	INCREASED	SAME	DECREASED
Prior	61%	34%	5%
One year later	65%	32.5%	2.5%
QUALITY OF WORK	IMPROVED	SAME	DECREASED
Prior	50%	45%	5%
One year later	48%	52%	0%
PROBLEM COMPLETING WORK	AGREE	NEUTRAL	DISAGREE
Prior	6%	18%	76%
One year later	0%	30%	93%

After the program was in place for one year, 28 percent of the workforce believed that they were now working more hours. For productivity, 61 percent of workers believed that they would be producing more and 65 percent believed that they were producing more after one year in the program. (Shirazi, phone interview, 2001). The general results of this study show that, predominantly, work was produced at similar or higher levels than what was expected prior to starting teleworking. The survey affirmed the positive impacts of teleworking, as teleworkers worked more hours, were more productive and their quality of work improved.

Although some Los Angeles County government telecommuters reported a decrease or no change in productivity, for those who reported an increase in productivity, the average increase was 20 percent. Employees represented 25 departments and telecommuted an average of two days per week. In addition to the increase in productivity, survey respondents indicated that telecommuting promoted recruitment and retention, decreased stress, and presented wider opportunities for the disabled.

The Minnesota Department of Administration participated in a detailed analysis of a telecommuting program in 1995 and 1996 (Minnesota Department of Administration 1997). The program involved 60 telecommuters from 15 divisions. Interviews were conducted with the telecommuters, supervisors and office-based employees to determine the effects on the quantity and quality of work performed while participating in the program. The results of this study show that:

- Seventy-nine percent of telecommuters reported that work done at home was of higher quality.
- Seventy-six percent of telecommuters reported a greater quantity of work being completed from home, with 17 percent reporting increases of more than 50 percent.
- All of the supervisors reported increases in employee morale.
- Eighty-two percent of telecommuters reported less job stress.

Participants in the federal government's Flexiplace Project reported similar results (Joice and Sterling 1993). Flexiplace, which is a synonym for telecommuting, involved 700 employees from

13 federal agencies. The employees reported increased job performance, reduced job-related and transportation costs, and reduced sick leave.

The North Carolina State Auditor has performed a preliminary assessment of the benefits to the state of instituting a minimal level of telecommuting activities and reports that:

> *By our own conservative estimate, the state could save over $23 million in improved productivity, reduced costs in office space, and avoid personal turnover costs versus the cost of implementing such a program for only 5 percent of our workforce.* (North Carolina State Auditor Ralph Campbell as reported by InnoVisions Canada 2001)

2.5.5 Financial -- the "Bottom Line"

Telecommuting can be promoted and encouraged by educating employers on the benefits to the "bottom line." In addition to community benefits demonstrated by positive transportation and air quality impacts and individual benefits demonstrated by decreased commute time and better balance of family and work responsibilities, businesses and government alike can realize significant economic benefits by introducing telework as an option. When employees work from remote locations, especially from home, there are quantifiable savings attributable to reduced overhead associated with the need for office space, utilities and parking space. In some instances where all employees work exclusively from a remote location, primary office space may be virtually eliminated. In most instances, however, only a percentage of a company's employees will telework. In order to maximize the utilization of the vacated space by teleworkers and reduce associated real estate and related facility costs at the main office, organizations can institute a shared office environment or what is more commonly called "hoteling." In addition to reduced real estate and facilities costs, telework can realize savings attributed to increased productivity, reduced absenteeism and sick leave, and reduced employee turnover. These economic benefits, in addition to legislative requirements and tax relief, can be significant incentives for more skeptical employers to pursue telecommuting programs.

2.5.5.1 Real Estate Cost Avoidance Benefits

By establishing telework arrangements in conjunction with a shared office environment, or hoteling at the main office, employers can substantially reduce real estate costs and thereby reap astounding benefits. Companies like Merrill Lynch, AT&T, and IBM are saving millions of dollars annually by implementing well-planned and managed telework programs. While the public sector has been slow to give up space in favor of hoteling, some agencies have begun to analyze the associated benefits in an effort to create financially successful telework programs. The Internal Revenue Service's (IRS) pilot telework program, for example, accounts for potential real estate savings in its cost-benefit analysis, and the Commerce Departments' Patent and Trademark Office (PTO) plans to implement a hoteling pilot in the near future as an extension of its current telework program (Cohns interview). Organizations everywhere are testing innovative work arrangements that support a new definition of "work." More employees are willing to share space in exchange for teleworking, and employers are benefiting from large-scale reductions in real estate as a result.

Employee surveys continually indicate a high demand for telework. According to the Work Trends national survey sponsored by the John J. Heidrich Center for Workforce Development at Rutgers University, 59 percent of employees would telework for all or part of the week if offered the option by their employer (Van Horn and Storen). Telework is becoming such a sought-after benefit that it is becoming a standard benefit offered by businesses to remain competitive in retaining employees. The interest in improving the balance between work and family is so high that employees are willing to share office space and forgo higher paid positions in exchange for telework opportunities. According to the Telework America Survey 2000, 64 percent of employee teleworkers polled said that the ability to telework had influenced their decision to stay with their employer (Nilles 2000). In a 1996 survey of its employees, Arizona State University found that 69 percent were willing to share offices to telework (www.telworkarizona.com/program.htm).

While real estate and related facility costs are affected by particular geographic locations and rental markets, the per-person savings can be estimated based on other company findings. AT&T, for example, reports an annual reduced space demand of $3,000 to $5,000 per person (www.ecatt.com). Using the low end of this range, in a 500-person company, if only 15 employees were permitted to telework (3 percent), sharing space on a 2:1 ratio (two employees sharing one workspace), that company could save $22,500 annually.

To test the applicability of AT&T's figure in a local context, savings from a hypothetical office arrangement can be quantified. If the 15 employees in the example above occupy an average of 230 rentable square feet per person (GSA 1999), and these employees share space conservatively on a 2:1 ratio at the central office (i.e., IBM shares space on a 5:1 employee to workspace ratio), then that company could reduce its space by 1,725 square feet. Multiplied against a GSA-based rental rate for Richmond of $15.00 per year per rentable square foot, that space reduction yields an annual savings of $25,875.

The estimated benefits may actually be considerably to the conservative side. For instance, by using the statistic indicating that 59 percent of employees wish to have telework opportunities, if only half of those are considered (30 percent) in a 500-person company, then 150 teleworkers could potentially share space. Using the same utilization and rental rates as described above, sharing space on a 2:1 ratio could yield a space reduction of 17,250 square feet, or $258,750 in savings annually. While these scenarios do not account for increased conference and meeting space, they do provide a general idea of the range of potential savings.

Regarding the potential savings in real estate costs, it is important to recognize that these savings could ultimately influence regional market conditions. If a significant number of workers were to engage in formal telecommuting programs, and large amounts of office space were vacated, then the surplus in space could cause the cost of real estate and office rents to fall. This would result in overall reduced leasing costs to companies and agencies. However, such impacts could not occur unless significant increases in telecommuting were to occur all at once, along with optimal use of hoteling space. Thus actual impacts on real estate costs would probably be gradual and could perhaps be offset by inflation. An oversupply of office space can be offset by other demands as well, such as adaptive renovation for residential or other uses.

While some agencies are actively quantifying costs and benefits, the public sector has not been as progressive as the private sector in adopting space savings strategies in connection with telework. A cultural shift in the way government assigns and designs work space is needed in order to begin saving real estate costs with telework in the public sector. Three potential inhibitors to this shift in thinking include: lack of performance measures, complex organizational structures, and long-held attitudes on controlling space in the public sector.

The apparent lack of public sector space savings in connection with telework may be attributable to the lack of models available in the past to measure the performance of complex work environments. However, GSA's creation of a Cost per Person model may facilitate and prompt greater analysis of teleworking costs and benefits in the public sector. As suggested by GSA's Innovative Workplaces Division, public sector agencies need to expand traditional real estate thinking to include other costs associated with creating a work environment. These include telecommunications and alternative work environment costs among others, which have been difficult to quantify in the past.

Another reason governments have not claimed dramatic space savings may be due to the complexities inherent in governmental organizations which can make inter-office coordination difficult. Analyzing the costs and benefits of telework requires an agency to coordinate between several offices. Any cost-benefit analysis should be a collaborative effort between a company's Human Resources, Information Technology, Facilities, Finance & Business Units (Lovelace, The Nuts and Bolts of Telework). In a large governmental organization, such coordination can be difficult. Agency leaders may expedite this process by identifying telework in strategic plans and designating an administrator to lead the agency's program and be responsible for conducting overall cost-benefit analysis. This will require commitment and reports from the various offices that affect the overall analysis outcome.

A third and more elusive reason that the public sector has not proactively quantified costs and benefits may be related to the reluctance by departmental managers to relinquish space. Thus while the U.S. Departments of Treasury, Defense, Health and Human Services, and Labor lead the federal government in numbers of telecommuters, there has been little effort within these agencies to capture potential real estate savings. The IRS is the only large department that has piloted and documented an approach to give up space and create a shared and mobile work environment. Incentives for government managers to give up space in connection with telework could hasten the speed at which telework programs are implemented and real estate cost savings are realized.

2.5.5.2 Productivity Benefits

Attempts to quantify productivity can be dubious given the inherent bias of employee-based surveys. In fact, many surveys indicate high degrees of variability within the teleworker groups polled. Many teleworkers report higher productivity than when not teleworking, others report the same, and a small percentage report lower productivity. It is important to remember, however that all people are different, and telecommuting is not for everyone. Thus, as the authors of a recent study (Doherty, Andrey, and Johnson 2000) caution, although telework can increase the performance for many, universal and substantial productivity gains cannot be assumed.

Gil Gordon, a recognized leader in telework, also cautions those who seek to quantify the productivity benefits of telework. According to Gordon, the difficulty with quantifying productivity in the modern office lies in the nature of modern work. Whereas farm and factory era work could easily be measured by the units of labor as correlated with the units of output, today's information-age work is not so easy to define (Gordon 1997). Gordon therefore recommends that organizations take a broader view of productivity in order to account for this "knowledge work" which comprises the modern workplace. Gordon suggests that productivity be discussed in the context of "effectiveness." While "productivity" focuses on quantity (how much gets done), "effectiveness" includes "quality" (how well it gets done), "timeliness" (when it gets done), and "multiple priorities" (how many things can be done at once), in addition to "quantity." (Gordon 1997). Although difficult to measure, teleworking can improve more than just the quantity of work that gets done, and these benefits can improve overall productivity.

Despite the difficulties in measuring productivity, most companies report productivity increases due to telecommuting. According to the Telework America Survey 2000, teleworkers are 15 percent more productive when working at home and 30 percent more productive when working at a telecenter (Nilles 2000). Furthermore organizations are translating these increases into financial benefits. In one study (Baffour and Betsey 2000) the estimated average dollar value for the productivity gained due to telework was reported as $685 per worker per annum. Authors of another study (Shafizadeh and Mokhtarian 1993) estimate even greater benefits for productivity – a net present value of $3,150 per telecommuter, based on an assumed 9 percent increase in productivity from a $35,000-per-year employee. Finally, the 1999 and 2000 Telework America Surveys estimate $1,850 and $9,712 respectively in annual savings per teleworker. Using $1,850 per worker, the mid-figure of the three lower estimates, if only three percent of a company with 500 employees were to telecommute, the opportunity cost of not teleworking would be $27,750 in lost productivity per year.

2.5.5.3 Reduced Turnover Benefits

One of the greatest benefits of telework for employers is retaining good employees, thereby avoiding significant turnover costs, and expanding the labor pool for attracting new employees. Attracting and retaining employees is becoming difficult in a tight labor market, and experts are forecasting labor shortages to continue through the next decade (www.teleworkarizona.com/flexarticle.htm). Flexible work arrangements are becoming essential to public and private organizations as a means to have a competitive advantage in the marketplace. "In a recent survey of 352 human resource executives by The American Management Association, flexible schedules were ranked as a more effective retention tool than stock options, pay-for-performance and bonuses" (www.teleworkarizona.com/flexarticle.htm). Davis Wright Tremaine LLP, a law practice with several offices across the country, began offering telework as a work option to its employees in 1990, as a competitive advantage measure (Stanley interview). Retaining and attracting employees were also the primary reasons the IRS initiated its telework program in 2000 (Thormahlen interview).

Many company surveys report decreased turnover as a result of telework. Citing a 1993 study by the Families and Work Institute, the State of Arizona indicates that turnover costs range from 95 to 150 percent of an employee's annual salary (www.teleworkarizona.com). Using the lower end of the range, the State of Arizona identifies the three aspects of turnover that can be quantified – recruiting costs (33 percent of an employee's salary), training costs (10 percent of an employee's salary), and the cost of the learning curve (50 percent of an employee's salary).[4] Based on these assumptions, the telecommuting administrator for the State of Arizona estimated an avoidable State turnover rate of 10 percent in fiscal year 1998-99. With these categories, the opportunity cost of not using telework as a means to avoid this turnover was between $83 and $134 million.

In the Telework America Survey for 2000, Jack Nilles reported his belief that the cost of replacing a skilled worker is at least equal to the worker's annual salary (Nilles 2000).[5] Nilles identifies the effective mean turnover reduction rate as $4,857 per teleworker. Based on these figures, if only 15 or three percent of employees in a 500 person company were to telework, then the opportunity cost of not providing telework as a work option would be $72,855.

2.5.5.4 Reduced Absenteeism

In addition to the financial benefits associated with real estate reductions, increased productivity, and turnover reductions, employers can also benefit from reduced absenteeism and sick leave. Working at home gives the employee the flexibility to intersperse work and life tasks (Pratt 1999). In the 1999 Telework America National Telework Survey, Joanne Pratt estimated the average annual cost per employee for personal, child- and adult-related absenteeism at $1,227 for those employees who better manage work and life through telework. The average annual cost per employee who did not have that flexibility but instead took a day's leave for each incident that could not be answered at the office was estimated at $3,313. This yields an annual cost savings of $2,086 per employee (Pratt 1999). Given this estimate, if only 15 employees in a 500-person company were to telework, then the opportunity cost of not providing employee flexibility through telework would be $31,290 annually.

Moreover, the financial impacts of telework can significantly affect a company's net revenues. The example of a 500-person company used with the estimated savings per person for various

[4] The IRS uses the same formula but references a different source: "The Business Case for Work-Family Programs," Arlene A. Johnson, Journal of Accountancy, August 1995.
[5] In the 1999 Telework America National Telework Survey, Joanne Pratt's assumptions differ from Nilles'. Pratt assumes organizations spend an average of one-third of an employee's salary to recruit that employee. Based on her survey findings, companies can save $7,920 per teleworker by retaining employees through telework.

components affecting the bottom line are summarized in Table 5. As can be seen in this table, the opportunity cost is approximately $155,000, or $10,500 for each teleworker.

Table 5
Opportunity Costs Associated with Teleworking

Cost Components	Annual Opportunity Cost of Not Providing Telework & Hoteling
Real Estate	$ 25,875
Productivity	$ 27,750
Turnover	$ 72,855
Absenteeism	$ 31,290
Total Savings Potential:	$ 154,395

2.5.5.5 Case Studies: Telework Benefits in Private Sector Companies

Organizations in the private sector report significant cost savings from telecommuting (InnoVisions Canada 2001):

- Merrill Lynch Inc. employs 70,700 people worldwide. Since establishing its telecommuting program in 1996, approximately 3,500 of its employees work from home an average of three days a week. The company's telecommuting program continues to grow, and it reports saving $1 million annually at one location alone (Myholics interview).

- In 1998, slightly over half of AT&T's then 55,900 managers telecommuted at least once a month. The key benefits have been productivity gains and real property savings. The company has reduced its office space costs by 50 percent and saves $75 million annually in office leasing costs (AT&T 2001).

- Nortel, an international information technology company employing about 75,000 people worldwide, initiated its telecommuting program in 1995. By 2000, 17 percent of Nortel's employees telecommuted at least one day a week. Of the company's telecommuting employees, 4,000 (5 percent of the total company) have relinquished dedicated office space in a Nortel building. The program saves $20 million in real estate costs every year (equivalent rental cost for two 20-story office buildings of 40,000 square feet per floor) (Kosan 2000).

- IBM began teleworking as a strategy to overcome serious financial problems in the early 1990s. The company saves 40 to 60 percent in real estate costs per site (Telecommute CT! 2001). In 1993, when IBM began telecommuting, the company's main objective was to cut costs by implementing hoteling. This drastically reduced the need for office space, allowing for large annual savings across the company. In 1995, IBM mandated telework for 10,000 salespeople and consultants in North America, requiring employees to share office space at a 4:1 employee-to-office-space ratio (www.cio.com). As a result from this mobility initiative, IBM saves $75 million per year (www.cio.com). In addition to substantial real estate and overhead savings, the company reports benefits from enhanced productivity, lower absenteeism and turnover rates, and increased revenues due to improved customer service.

- Herman Miller, an office interiors company consisting of nearly 10,000 employees worldwide, offers a telecommuting incentive package to its employees (Rodgers and Teicholz 2001). Approximately 175 Herman Miller employees telecommute in North America. Most of them work at home at least 50 percent of the time. In exchange for vacating their space at the main office, the company provides its telecommuters with a phone line, laptop, $1,500 stipend, and their favorite Herman Miller chair. When workers have to go to headquarters, they operate out of a "campsite," a place where they can hook up their computers, use the phones, and meet colleagues (Rodgers and Teicholz 2001). Although Herman Miller has not yet quantified office space savings attributable to telework, the company is saving facilities costs and is succeeding financially. In January 2001, Forbes Magazine named Herman Miller to its "Platinum List" of the 400 Best Big Companies in America because they have been an industry leader in long-term and short-term return on capital, growth in both sales and earnings, and in other financial measures.

- Pacific Bell saved about $20 million in office leasing over a five-year period (InnoVisions Canada 2001).

- Georgia Power, an investor-owned utility company, has 8,700 employees within the state of Georgia (Browning). The company established its telework program in response to space supply issues in 1993 (www.ecatt.com). At that time, there were 35 telecommuting employees; now there are 250 (almost 3 percent of all employees). The company saves $6,000 per telecommuter, which translates to a 20 percent reduction in real estate needs (Franklin and Browning).

2.5.5.6 Case Studies: Telework Benefits in Public Sector Agencies

In addition to private businesses, public sector agencies are beginning to quantify costs and benefits associated with their telework programs. A few agencies within federal and state governments are notable:

- The Federal Railroad Administration has closed numerous field offices since implementing its telework program in 1995, and estimates a savings of $200,000 per year in facility cost savings (Joice 2000).

- The Consumer Product Safety Commission (CPSC) also has implemented telework in its field organization, thereby reducing facility costs. Since it began its pilot telework program in 1995, CPSC has saved nearly $3 million in leasing costs (Joice 2000).

- PTO has not quantified benefits yet but attests to positive impacts. PTO experimented with its telework pilot program from 1997 to 1999 (Cohn interview). The pilot involved 18 trademark attorneys. PTO has since expanded its program to a total of 90 attorneys who work at home an average of two days a week. The agency provides all necessary equipment for teleworkers. The use of hoteling as a means to share space at the main office will be piloted in future. At that time, PTO expects to realize office space savings. While the agency has not yet quantified business savings, Debbie Cohn, PTO's telework manager, reports that customer service and overall work quality remains high, and employee turnover is noticeably lower than normal. Productivity has been positively affected because the number of hours spent examining trademark applications has increased.

- IRS appears to have made the greatest progress quantifying costs and benefits in the public sector. IRS is one of the few public organizations that has attempted to capture space savings as a result of a well-planned and managed pilot telework program. IRS conducted a cost-benefit analysis for its Flexiplace/Hoteling Pilot Program held from June to October 2000 (Information Technology Services 2001). A total of 20 program participants worked at home one to three days a week ("flexiplace"), 13 of whom reserved an available workstation on days they were at the main office ("hoteling"). A space reservation system was developed for the pilot using Microsoft ACCESS software, and primary and alternate concierges were responsible for determining workstation availability. Reservations were requested by e-mail or telephone.

- IRS-reported benefits include a reduced need for office space, reduced recruitment costs associated with employee turnover, and increased productivity. By reducing daily space utilization in the agency's existing facility and consolidating groups from other locations, the agency has the potential to save $414,000 per year if it expands its pilot program to a total of 100 participants. IRS also concluded that by expanding its telework program to 100 participants, it can potentially save $165,620 per year in recruitment costs. Furthermore, 82 percent of the program's participants reported increases in productivity.

3. THE EFFECTS OF TELEWORKING IN VIRGINIA

3.1 Population and Employment Distribution Across Virginia

The population and employment in Virginia is concentrated in three large urban areas, namely the Northern Virginia portion of the Washington, D.C. Metropolitan Statistical Area (MSA), the Richmond MSA, and the Virginia portion of the Norfolk-Virginia Beach-Newport News MSA (referred to as the Hampton Roads urban area in this report). There were five other concentrations of population and employment specifically considered in this study, and these are listed in Table 6. Although Fredericksburg city and the surrounding counties of King George, Spotsylvania, and Stafford are included in the Northern Virginia urban area (which is part of the Washington, D.C. MSA), information for the Fredericksburg area is presented separately in the table. The population data are available for year 2000 (Census 2000 Redistricting Data - Public Law 94-171 - Summary File, U.S. Census Bureau), and the employment data are interpolated for the year 2000 by assuming a uniform growth between the data presented for 1998 and 2008 (Virginia Employment Commission, http://www.vec.state.va.us/lbrmkt/projpubl.htm). Different data years are used for the employment data, as the occupation classification information is provided only for those years by the Virginia Employment Commission (VEC), and these occupation data are considered later.

Table 6
Population and Employment Data (Year 2000) for Urban Areas in Virginia

No.	Urban Area	Population	Employment
1	Charlottesville	159,576	83,682
2	Danville	110,156	46,895
3	Fredericksburg[1]	218,923	121,752[2]
4	Harrisonburg	40,468	20,169[3]
5	Lynchburg	214,911	101,410
6	Northern Virginia[4]	1,994,540	997,611[2]
7	Richmond	996,512	550,189
8	Roanoke	235,932	146,110
9	Hampton Roads	1,551,351	696,557
	Sub-total	**5,522,369**	2,752,341
	Virginia Total	*7,078,515*	3,443,230
	% Represented	**78.0%**	79.9%

[1] Includes King George, Spotsylvania and Stafford counties.
[2] Employment data estimated based on proportion of population of Northern Virginia MSA (which is part of the Washington, D.C. MSA).
[3] Employment data estimated based on proportion of population of state.
[4] Excludes Fredericksburg urban area.

Table 6 shows that almost 80 percent of Virginians live and work in these nine urban areas. The remaining 20 percent live in rural, less-populated areas. As the motivation to telework is partially dependent on roadway congestion and commute length, and as these factors are typically relatively minor in lesser populated areas, the focus of this analysis is on the nine urban areas.

3.2 Teleworking and Traffic Congestion in Virginia

As detailed previously (Section 2.4.1), the proportion of work-related trips to all the trips varies significantly. However, there is no doubt that work-related trips are a significant proportion of trips during the usually congested periods of travel. Data on the characteristics of people teleworking have been previously collected only in the Northern Virginia area, as part of the surveys performed by MWCOG. The results of these surveys were summarized in Section 2.3.2. The 1998 survey showed that approximately 12 percent of the workforce was teleworking an average of 1.60 days/week. The 2001 survey showed that 15.1 percent of the workforce teleworks an average of 1.43 days/week.

During the course of this study, it was determined that additional data on teleworking in other areas of the Commonwealth were needed. A separate survey for three different urban areas (Richmond, Roanoke, and Hampton Roads) was authorized. This survey, which was performed by Southeastern Institute of Research, showed that the teleworking participation rates were 8.3 percent in Richmond, 6.7 percent in Hampton Roads, and 4.7 percent in Roanoke. Additionally, the teleworking frequency ranged from a high of 2.35 days/week in Richmond to a low of 1.58 days/week in Hampton Roads.

The potential impacts of teleworking on roadway congestion depend on the levels of roadway congestion that currently exist in Virginia. Roadway congestion in two areas of the state, Northern Virginia and Hampton Roads, has been studied as part of the Urban Mobility Annual Report (Texas Transportation Institute, 2001) and the results were detailed earlier (see Section 2.5.1). However, the remaining urban areas in the state do not have this type of documentation available regarding congestion levels on major roadways. Quantification of these impacts is discussed in the next section.

3.3 Roadway Congestion Impacts

Various measures of effectiveness can be used to calculate the impact of different travel demand strategies on roadway congestion. The principal measure of effectiveness is travel delay. However, it is difficult to determine the change in travel delay due to specific efforts, and therefore related effects, such as the volume-to-capacity ratio (v/c ratio) or density, are often used. The methodology developed by the Texas Transportation Institute (TTI) for the Urban Mobility Annual Report uses specific travel speeds associated with traffic volume ranges. Based on the different travel speeds, the travel delay is estimated. An alternate methodology involves using a travel demand model, such as MINUTP, to determine v/c ratios and travel time or delay for different scenarios of traffic volumes. Another alternative involves the use of a microsimulation tool such as CORSIM to directly estimate the travel delay. The TTI methodology provides a comprehensive method of determining current congestion levels, and projecting potential reductions in congestion resulting from telecommuting, and was therefore used in this study.

3.3.1 Roadway Congestion Methodology

The TTI methodology uses a number of key factors to develop a performance measure known as Roadway System Performance for MSAs. The factors include daily vehicle miles traveled (DVMT), population data, and percent of travel during peak periods. Other factors considered in this methodology including vehicle occupancy, number of working days, average cost of time, commercial vehicle operating cost, and vehicle mix. Also included in the analysis are vehicle speeds, which are calculated values based on the computed levels of congestion.

TTI's criteria for determining congestion levels on roadways are based on Average Daily Traffic (ADT) per lane for two classifications of roadways, freeway/expressway and principal arterials. Table 7 from Appendix B of TTI's Urban Mobility Annual Report describes these thresholds and the associated speeds assumed at each level.

Table 7
Daily Traffic Volume Per Lane and Estimated Speed Used in Delay Calculation[1]

Functional Classification	Parameters	Uncongested	Congested			
			Moderate	Heavy	Severe	Extreme
Freeway/ Expressway	ADT/Lane	Under 15,000	15,001-17,500	17,501-20,000	20,001-25000	Over 25,000
	Speed(mph)	60	45	38	35	32
Principal Arterial Street	ADT/Lane	Under 5,500	5,501-7,000	7,001-8,500	8,501-10,000	Over 10,000
	Speed(mph)	35	30	27	23	21

[1] Urban Mobility Annual Report, 2001 – Appendix B (Texas Transportation Institute, 2001)

Travel delay is the key component of the Roadway System Performance (RSP). Travel delay is defined as "the amount of extra time spent traveling due to congestion." Two components make up travel delay, recurring travel delay and incident-related travel delay. The step-by-step procedure for estimating recurring travel delay is presented in Figure 1. In summary, these steps include the following:

- Collect travel and roadway characteristics
- Isolate peak-period travel (peak period estimated to be 6:00 to 9:30 A.M. and 3:30 to 7:00 P.M.; peak period travel estimated to be 50 percent of daily travel)
- Identify the usually congested time of day within peak period (based on the Roadway Congestion Index – a ratio of daily traffic volume to the supply of roadway)
- Identify congestion level of each section of roadway (based on the threshold levels detailed in Table 7)
- Apply speed estimates in each congestion group
- Sum VMT in each congestion group
- Obtain estimate of average speed
- Estimate travel delay

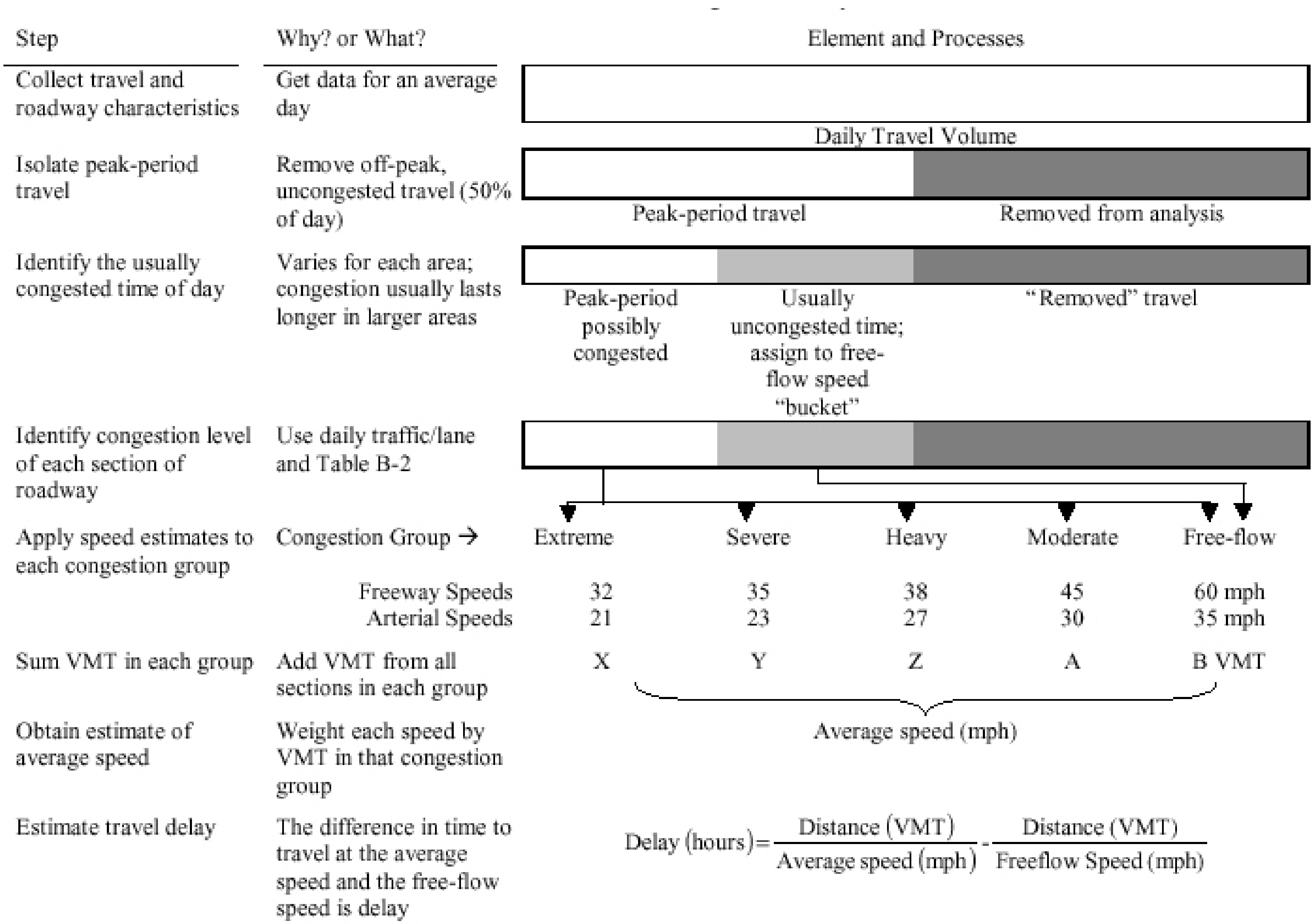

Figure 1 TTI Methodology for Estimating Recurring Travel Delay

Incident-related travel delay occurs due to an accident or disabled vehicle. This type of delay is estimated based on the frequency of crashes and vehicle breakdowns and the ease with which those incidents are removed from the roadway. The incident vehicle hours of delay are calculated by multiplying the recurring travel delay with a factor termed Recurring to Incident Delay Ratio. This ratio was developed by TTI for the MSAs included in the Urban Mobility Annual Report based on a model developed earlier by the Federal Highway Administration. This model analyzes the effect of incidents relative to design characteristics and estimated volume patterns. TTI also reviewed each area's freeway characteristics and volumes when developing the ratio.

Since these data were only available for the two areas of Virginia studied by TTI in the annual report (Hampton Roads and Northern Virginia), assumptions were required regarding the remaining urban areas analyzed for this report. These assumptions were based on a review of urban areas in the TTI report which are similar to those areas of Virginia being studied. These assumptions are shown in worksheets and are included in Appendix B.

Based on the formulas presented in the Urban Mobility Report, the RSP was calculated for each urban area. The indices that quantify the level of congestion on the major roadways in a metropolitan area and that constitute the RSP are detailed next:

- **Travel Rate Index** – the amount of additional time that is required to make a trip because of congested conditions on the roadway – recurring delay only.
- **Travel Time Index** – similar to the Travel Rate Index, however includes recurring and incident delay.
- **Wasted Fuel –** based on the average fuel consumption calculation, estimation of the wasted fuel due to vehicles moving at slower speeds than free-flow during peak period travel.
- **Congestion Cost –** the cost due to travel delay and wasted fuel due to congestion resulting from incident and recurring delay.
- **Roadway Congestion Index** –a ratio of daily traffic volume to the supply of roadway.

3.3.2 Existing Roadway Congestion in Urban Areas

For the nine urban areas studied, the primary commuter routes in each road classification were identified to represent the roadway system (the number of routes was relative to the geographic size of the urban area). A maximum of ten roadway segments in each of the two classification groups (freeways/expressways and principal arterials) were selected. Congestion levels were computed for these roadways according to the TTI methodology. The results of these analyses were used in TTI's "Congestion Calculator" which determines RSP. The results for existing conditions in each urban area are summarized in Table 8. It was assumed that the selected roadway segments identified are representative of the roadway facilities in each urban area. To obtain a comprehensive idea of congestion costs, the total VMT in each area was considered (based on data contained in the *Average Daily Traffic Volumes with Vehicle Classification Data on Interstate, Primary and Arterial Routes,* VDOT, 2000). The calculation worksheets for each urban area are included in Appendix B.

Table 8
Existing RSP in Urban Areas in Virginia

Urban Area	Travel Rate Index	Travel Time Index	Annual Hours of Delay (1000 person hours)	Total Annual Excess Fuel Consumed (million gal)	Annual Congestion Cost ($ million)	Annual Congestion Cost per Capita ($)	Roadway Congestion Index
Charlottesville	1.09	1.11	889	1	14	85	0.86
Danville	1.04	1.07	710	1	12	107	0.75
Fredericksburg	1.07	1.12	4,087	6	71	294	1.20
Harrisonburg	1.20	1.20	0	0	0	0	0.90
Lynchburg	1.04	1.06	1,035	1	16	77	0.69
Northern Virginia	1.47	1.99	154,094	217	2,533	1,259	1.91
Richmond	1.14	1.27	35,400	56	614	616	1.06
Roanoke	1.13	1.16	2,566	2	37	157	1.02
Hampton Roads	1.19	1.35	57,639	83	956	616	1.48

As expected, the highest congestion cost is estimated for the Northern Virginia urban area. Excluding Fredericksburg, the next two areas in terms of high congestion costs are the Richmond and Hampton Roads areas.

3.3.3 Impact of Teleworking on Roadway Congestion

The effects of telecommuting on congestion were evaluated based on the expected decrease in VMT resulting from fewer vehicles on the roadway during peak hours. This decrease is related to the number of teleworkers who typically drive alone to work, but do not have to go to work on the days they telecommute. As mentioned in earlier sections, many studies have demonstrated that VMT reductions are close to the commute distance typically covered by workers. The following data sources were used while estimating the VMT reductions.

- **Telework trips per day per teleworker**: For Northern Virginia and Fredericksburg, a 0.572 telecommuting trip per day per teleworker was assumed. This is based on 2001 survey results in the Washington, D.C. region that found the average telework frequency of participants is 1.43 days per week. This results in 2.86 telework trips per week, or 0.572 per day. Survey results from Southeastern Institute of Research (SIR) were used for the Richmond, Roanoke, and Hampton Roads areas at rates of 2.35, 1.79, and 1.58 telework trips per week, respectively. The data for Roanoke was also used for the areas of Charlottesville, Danville, Harrisonburg, and Lynchburg.

- **Employment**: The employment in each urban area was estimated for year 2000, based on the year 1998 and 2008 estimates obtained from VEC. These estimates were presented in Table 6.

- **Single Occupancy Vehicle (SOV) rate**: In the Northern Virginia area the SOV rate used in the MWCOG Transportation Emission Reduction Measures (TERM) analysis was used. For Fredericksburg, the SOV rate was obtained from VDOT. For Hampton Roads, Richmond, and Roanoke, data for the SOV rate was obtained from the survey data collected by the SIR, amounting to 89.6 percent, 91.5 percent, and 93.4 percent respectively for those three areas. For the remaining urban areas, the 93.4 percent rate from Roanoke was used.

- **Work trip length**: In the Northern Virginia area, the trip length used in MWCOG's TERM analysis was applied. The average work trip length for Fredericksburg was obtained from VDOT. For Hampton Roads, Richmond, and Roanoke, the trip length for teleworkers was derived from the SIR survey data. The one-way trip length for teleworkers is 15.6 miles in Hampton Roads and Richmond, and 8.3 miles in Roanoke. The trip length from Roanoke was used in the remaining urban areas.

The number of teleworkers was estimated based on the total employment in each urban area. The SIR survey data indicated that existing teleworking rate in Roanoke is approximately 5 percent. Therefore this rate was considered as the base, or low, rate of teleworking in Roanoke. To indicate increased telework participation, rates of 7.5 percent and 10 percent were applied for the medium and high rates in Roanoke. These same data were assumed for the regions of Charlottesville, Danville, Harrisonburg, and Lynchburg.

The SIR survey data reflected current teleworking rates of 8.3 percent in Richmond and 6.7 percent in Hampton Roads. The medium and high levels of teleworking participation in these two areas was estimated at 10 percent and 12.5 percent, respectively. In Northern Virginia telework participation rates of 15 percent, 20 percent, and 25 percent were used, because the telework participation rate is currently 15 percent.

The resulting number of teleworkers was multiplied by daily telework trips per teleworker to arrive at total daily telework trips in each region. This result was further multiplied by the SOV rate to determine the number of those trips that are made by workers who drive alone. This result was then multiplied by the average work trip length. The end result is the VMT reduction resulting from telework activity in each urban area. This is also shown in the equation below. The assumptions and the resulting VMT reductions are summarized in Table 9.

VMT Reduction (miles) = Employment * % Teleworkers * Daily Trips per Teleworker * SOV Rate * Work Trip Length

Table 9
Estimated VMT Reduction Due to Teleworking

Urban Area	Employment (2000)	Daily VMT	SOV Rate	Teleworker Daily Trip Distance	VMT Reduction (%) for Teleworking Participation Rates[1] 7.5%10%/ 20%	10%/12.5%/ 25%
Charlottesville	83,682	4,462,354	93.4%	16.6	0.26%	0.52%
Danville	46,895	2,682,595	93.4%	16.6	0.25%	0.49%
Fredericksburg	121,752	7,782,344	91.5%	68.0	0.63%	1.25%
Harrisonburg	20,169	797,010	93.4%	16.6	0.35%	0.70%
Lynchburg	101,410	5,144,802	93.4%	16.6	0.28%	0.55%
Northern Virginia	997,611	47,281,522	48.4%	36.4	0.52%	1.04%
Richmond	550,189	24,437,581	91.5%	31.2	0.76%	1.56%
Roanoke	146,110	6,832,481	93.4%	16.6	0.30%	0.60%
Hampton Roads	696,557	34,600,000	89.6%	31.2	0.45%	0.89%

[1] Low percentages for teleworking in each range apply to Charlottesville, Danville, Fredericksburg, Harrisonburg and Lynchburg; the middle rates apply to Richmond and Hampton Roads regions; the high rates apply to Northern Virginia only.

The VMT reduction at the lowest level of teleworking varies from approximately 0.25 percent to 0.76 percent. However, the impact on the peak period travel is considered to be greater. When teleworkers are working at their primary place of work, they typically travel to and from work during the morning and afternoon peak periods. The TTI methodology assumes that half the VMT occurs during these peak periods. Thus, the impact of teleworking in terms of roadway congestion is considered to be double the reductions shown in Table 9.

The Roadway Congestion Index was first calculated for the base condition, which considers that the existing percentage of teleworkers is already factored in the VMTs. These reductions described above were then used to reduce VMTs in each area for two levels of teleworking participation increases, medium and high. Additionally, as in the case for the base conditions, the total VMT for the two different facility types (freeway/expressway and principal arterial) was considered for each urban area. The results are summarized in Table 10.

These results show that the impact of teleworking in terms of the reduction in congestion cost is negligible in the smaller urban areas. In the Northern Virginia area, a cost reduction of $53 million is estimated for an increase in teleworking from 15 to 25 percent, and in the Richmond area a cost reduction of $74 million is estimated for an increase in teleworking from 7.5 to 12.5 percent. A decrease of only $17 million is estimated for the Hampton Roads area for an overall increase of 5 percent in teleworking. However, congestion on only a limited number of roadway segments was evaluated. Although total VMT and total lane-miles in an area were included in the congestion calculator, a more comprehensive evaluation could be performed by considering congestion on all the roadway segments in an urban area.

Table 10
Roadway System Performance in Urban Areas in Virginia for Different Levels of Teleworking Participation

Urban Area	Travel Rate Index	Travel Time Index	Annual Hrs of Delay (1000 person hours)	Total Annual Excess Fuel Consumed (million gal)	Annual Congestion Cost ($ million)	Annual Congestion Cost per Capita ($)	Roadway Congestion Index
Charlottesville – Base 5% TW	1.09	1.11	889	1	14	85	0.86
7.5% TW (Medium)	1.09	1.11	884	1	14	85	0.85
10% TW (High)	1.09	1.11	880	1	13	84	0.85
Danville –Base 5% TW	1.04	1.07	710	1	12	107	0.75
7.5% TW (Medium)	1.03	1.05	504	1	8	76	0.75
10% TW (High)	1.03	1.05	502	1	8	75	0.74
Fredericksburg –Base 5% TW	1.07	1.12	4,087	6	71	294	1.20
7.5% TW (Medium)	1.06	1.12	3,951	6	69	284	1.18
10% TW (High)	1.06	1.12	3,901	6	68	281	1.17
Harrisonburg – Base 5% TW	1.20	1.20	0	0	0	0	0.90
7.5% TW (Medium)	1.21	1.21	0	0	0	0	0.90
10% TW (High)	1.21	1.21	0	0	0	0	0.89
Lynchburg – Base 5% TW	1.04	1.06	1,035	1	16	77	0.69
7.5% TW (Medium)	1.04	1.06	1,029	1	16	76	0.69
10% TW (High)	1.04	1.06	1,023	1	16	76	0.68
Northern VA– Base 15% TW	1.47	1.99	154,094	217	2,533	1,259	1.91
20% TW (Medium)	1.47	1.99	152,491	215	2,507	1,246	1.89
25% TW (High)	1.47	1.99	150,888	212	2,480	1,233	1.87
Richmond - Base 7.5% TW	1.14	1.27	35,400	56	614	616	1.06
10% TW (Medium)	1.14	1.26	34,054	54	591	593	1.04
12.5% TW (High)	1.13	1.25	31,021	49	540	541	1.03
Roanoke – Base 5% TW	1.13	1.16	2,566	2	37	157	1.02
7.5% TW (Medium)	1.13	1.16	2,551	2	37	156	1.02
10% TW (High)	1.13	1.16	2,535	2	37	155	1.01
Hampton Roads-Base 7.5% TW	1.19	1.35	57,639	83	956	616	1.48
10% TW (Medium)	1.19	1.35	57,125	82	948	611	1.47
12.5% TW (High)	1.19	1.35	56,611	81	939	605	1.46

3.4 Air Quality Impacts

The emission reduction benefits of teleworking were analyzed for several areas of the state using survey findings and known travel behavior data. For each teleworking event, a reduction in trip making, and therefore VMT, occurs, resulting in an emission benefit.

This section presents the areas analyzed for emission benefits and the methodology used to calculate the reductions. A summary table of findings is then presented.

3.4.1 Areas Analyzed for Emission Reductions

The emission analysis was performed for five urban areas:

- Hampton Roads
- Richmond
- Northern Virginia (including Washington, D.C.)
- Fredericksburg
- Roanoke

These areas were chosen due to existing or possible air quality attainment status, as discussed earlier (see Section 2.5.3). The Richmond and Hampton Roads areas are currently designated as maintenance areas for the one-hour National Ambient Air Quality Standard for ozone. This designation imposes air quality planning procedures on the region, including transportation conformity. Conformity is a Clean Air Act requirement that must be met before the region can receive federal funding for transportation projects. It requires a modeling analysis that demonstrates that emissions resulting from all transportation projects in a transportation plan are less than or equal to an emissions budget that has been established in the region's approved air quality plan. Much of Northern Virginia is part of the Washington, D.C. serious ozone nonattainment area and is therefore subject to conformity and air quality planning requirements.

Roanoke and Fredericksburg are currently in attainment for the one-hour ozone standard, but may be designated nonattainment under a new, more stringent ozone standard that EPA has promulgated. Implementation of the new ozone standard has been delayed due to litigation, but the Commonwealth, as required by the Clean Air Act, has recommended to EPA that these two areas be designated nonattainment under the new standard. If that designation does occur, which may happen in the 2003 – 2004 time frame, these areas will also have to undertake air quality planning procedures, including transportation conformity.

3.4.2 Assumptions and Data Sources

As in the case of roadway congestion impacts, the air quality impacts are based on the reduction in teleworker trips. The assumptions considered in the previous section regarding VMT reduction are applicable in determining the air quality impacts also. A major variance is that the area considered for Richmond, Hampton Roads and Northern Virginia is different, as it is based on the EPA conformity analysis performed for those regions. Therefore, the boundaries of the air quality conformity areas are different from the MSA boundaries, and therefore the employment data for those three areas do not match the MSA employment data presented in Table 9. A summary of the data considered is presented in Table 11.

Table 11
Assumptions used in Emissions Analysis

Region	Air Quality Conformity Area Employment (2000)	SOV Rate	Work Trip Length (miles)
Hampton Roads	938,246	89.6%	15.6
Richmond	501,954	91.5%	15.6
Roanoke	146,110	93.4%	8.3
Fredericksburg	121,752	91.5%	34.0
Northern VA[1]	2,796,900	48.4%	18.2

[1]As part of the Washington, D.C. Ozone Nonattainment Area.

3.4.3 Emissions Estimation Methodology

Emission reductions were estimated using a methodology employed by MWCOG, the metropolitan planning agency for the Washington, D.C. region. As discussed previously, MWCOG operates a telework program and estimates emission benefits that are used in the region's conformity demonstration. This methodology was adapted to the remaining four areas using data specific to those regions. In the Northern Virginia/Washington, D.C. calculations, the existing MWCOG telework emission calculations were used for the low range of teleworking, and these results were extrapolated to derive medium and high range results.

The VMT reductions in each area were also calculated using the methodology presented earlier while determining the roadway congestion impacts. Emission factors were produced using the MOBILE5b model. MOBILE5b is the model approved for use by EPA in all states except California for producing on-road vehicle emission estimates used for regulatory purposes (e.g., conformity). The model accepts local data such as temperatures, vehicle fleet mixes and ages, emission control programs, and speeds as inputs and produces emission factors that reflect vehicles operating within the study area. The factors are stated in grams/mile and are multiplied by VMT to obtain emissions. In this case, the emission factors were multiplied by VMT reduction due to teleworking to arrive at emission reductions.

The MOBILE5b input files used in Richmond and Hampton Roads conformity analysis were obtained and modified for this study. The primary change made was to modify the VMT mix used in the model to calculate emission factors that represent only light-duty cars and trucks by assigning zero VMT to heavy-duty vehicles. This change was made because it is reasonable to assume that teleworkers would not drive heavy-duty trucks and buses to work and it helps develop more accurate emission factors resulting from the vehicles that the commuting public drives.

MOBILE5b input files were not available for the Roanoke and Fredericksburg areas because the areas are in attainment. The MOBILE5b input files for Richmond were used to produce emission factors for Roanoke and Fredericksburg. Changes were made to remove the emission benefits of reformulated gasoline and stage II vapor recover gasoline nozzles, which are required in the Richmond ozone maintenance area, but are not required in Roanoke and Fredericksburg. For the Northern Virginia area, emission factors produced by MWCOG were used.

The emission factors for each area were multiplied by the VMT reductions from telework trips to obtain total emission reductions. The results are presented in Table 12 on page 42. It may be noted that in all areas except Northern Virginia this analysis only examined home-based telework activity because telework centers do not exist in many of the analyzed areas.

As mentioned above, data used in the Northern Virginia/Washington, D.C. calculations were taken from MWCOG's analysis and applied here using a 15 percent telework participation rate. MWCOG's analysis looks only at new telework trips above and beyond those occurring in 1996 because MWCOG began a program after 1996 to encourage teleworking, and therefore measures the effectiveness of the program by examining telework increases since 1996. In this analysis, however, benefits are presented in terms of all current teleworking activity, not just the increase over 1996 activity. This figure is presented as the base year, and a medium and high level are also presented. This applies to the other four areas also.

It should be noted that the Fredericksburg area is adjacent to the Northern Virginia portion of the Washington, D.C. ozone nonattainment area. It is likely that teleworking in the Fredericksburg area results in VMT reductions, and therefore emission reductions, which actually are considered part of the Washington, D.C. nonattainment area. All calculations are based on these variables and the MOBILE5b emission factors described previously.

3.4.4 Summary of Emissions Estimates

The figures in Table 12 show that VMT and emission reductions from teleworking are notable, if not significant. At the middle range (7.5%) of teleworking, the VMT reductions in Hampton Roads and Richmond are about 2 percent of total daily VMT. In the Washington, D.C. region the middle range of 20% teleworking results in under a 2 percent reduction in VMT. While the VMT reduction percentages are low, the absolute VMT reductions are noteworthy when compared with many other traditional transportation demand management (TDM) measures.

Similarly, the emission reductions are a small percentage of total emissions in the maintenance areas of Richmond and Hampton Roads and the Washington, D.C. nonattainment area. In the Hampton Roads and Richmond areas, the middle range of teleworking (10%) results in a decrease in on-road emissions of about 1 percent for both VOC and NO_x. The reductions must be viewed in light of the emission margins for conformity, which are less than two tons over the allowable emission limits. Emission reductions in the range of those shown in Table 9 become important when a region faces the possibility of exceeding the conformity emissions budget.

Table 12
Reductions from Teleworking (emission reductions stated in tons per day), Year 2000[1]

Teleworking Rate/	Total	Existing Teleworking Rates 5%/7.5%/15%			Medium Teleworking Rates 7.5%/10%/20%			High Teleworking Rates 10%/12.5%/25%		
Region	VMT	VMT	VOC	NO_x	VMT	VOC	NO_x	VMT	VOC	NO_x
Hampton Roads	34,600,000	621,624	0.37	0.63	828,832	0.49	0.84	1,036,040	0.62	1.05
Richmond	24,437,581	505,125	0.33	0.65	673,500	0.44	0.86	841,875	0.55	1.07
Roanoke	6,382,481	40,550	0.03	0.05	60,835	0.05	0.08	81,099	0.07	0.11
Fredericksburg	7,782,344	108,328	0.09	0.14	162,493	0.14	0.21	216,657	0.18	0.29
Northern Virginia[2]	152,013,358	1,886,796	1.69	3.01	2,499,068	2.24	3.98	3,123,834	2.79	4.98

[1] The low telework rate in each range apply to Roanoke and Fredericksburg; the middle rates apply to Richmond and Hampton Roads regions; the high rates apply to Northern Virginia only.
[2] As part of the Washington, D.C. Ozone Nonattainment Area.

3.5 Applicability of Teleworking in Different Areas of Virginia

The prevalence of teleworking appears to be related to three primary factors that vary in different places, and these include length of commute, traffic congestion, and the type of work being performed. The first two factors have been considered while determining the RSP for the nine urban areas. However, it is possible that the types of work being performed varies by geographical area, and also in urban versus rural areas. This factor was evaluated by comparing the occupation types in the nine urban areas identified earlier.

VEC publishes data on the number of people in more than 800 occupation types. These data are published for existing conditions (1998 data available) and a future scenario ten years away (2008). The occupation types are grouped together in a specific classification system, and the eight major groups are:

- Executive, Administrative & Managerial Occupations
- Professional Specialty Occupations
- Marketing & Sales Occupations
- Administrative Support Occupations, Clerical
- Service Occupations
- Agriculture, Forestry, & Fishing Occupations
- Precision Production, Craft & Repair Occupations
- Operators, Fabricators, & Laborers

Based on the tasks that are performed by people with different occupations, it is generally believed that a greater proportion of people in the first four occupations on the list above can and will telework. A comparison of the percentage of people in each of these eight groups of classification is presented in Figure 2 on page 44. A subjective examination of the figure shows that in most urban areas, both small and large, there is little variation in the proportion of workers in different occupation types. The only notable differences are the higher-than-average proportion of the last occupation type in Danville and Lynchburg. However, when the two primary sets of occupation type groups are considered (first four of bulleted list vs. second four), the differences are relatively small. Based on this comparison, it is inferred that the occupation group does not result in a significant difference in the proportion of people teleworking in different urban areas in Virginia.

The recent teleworking survey conducted in the Roanoke, Richmond, and Hampton Roads urban areas, and data from the teleworking survey performed in the Northern Virginia (Washington, D.C.) area show that teleworking is more prevalent in the larger urban areas. Approximately 15 percent of the workforce teleworks in the Northern Virginia area, compared to 8.3 percent in Richmond and 6.7 percent in Hampton Roads. The teleworking participation rate in Roanoke is the least, at 4.7 percent. Thus, it appears that the intent to telework is possibly related to the size of an urban area, and that the teleworking participation rates in other smaller urban areas are likely similar to that in the Roanoke area (approximately 5 percent). It also appears that the intent to telework starts after a certain threshold level, and thus may not play a significant role in small and medium-sized urban areas.

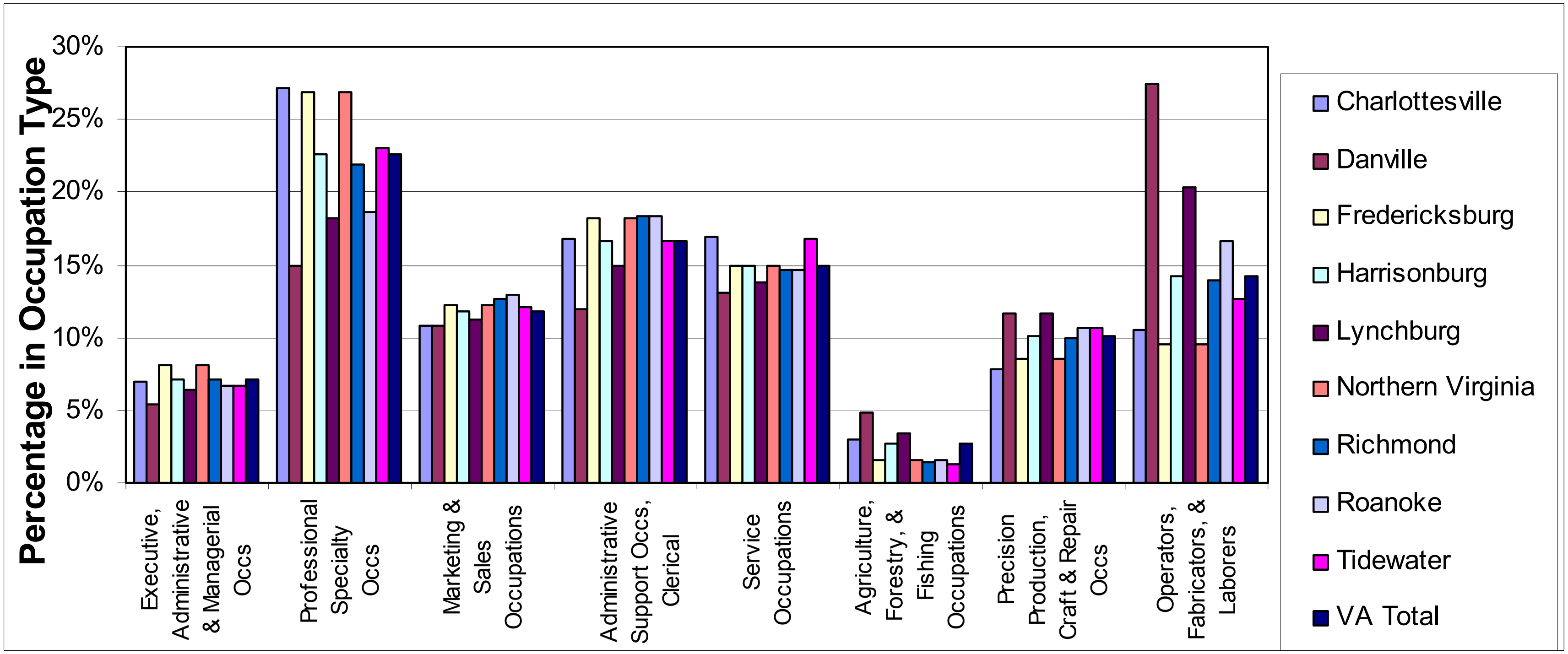

Figure 2 Occupation Type Proportion in Nine Urban Areas of Virginia

4. COSTS AND PERFORMANCE MEASURES

4.1 Teleworking Costs

An employer's outlays to establish a telework program includes development and operations costs. Development costs are those fixed or non-recurring costs required to launch a program. These costs include start-up computer hardware, software (including any office reservation/space management costs), phone lines, and other office equipment, as well as initial outlays for marketing and training materials. Telecenter development includes additional facility improvement costs, security costs, and professional development fees. The operations costs of telework include all recurring costs to maintain the program, including administrative costs (management salaries and related management expenses such as cellular phone charges, pager, travel, and training or conference costs), marketing and advertising costs, employee and manager training costs, and equipment upgrades and maintenance. Telecenter operations include these costs plus costs for leasing and utilities.

Because there is little cost information in the published literature, various organizations were contacted to obtain specific cost data and develop a comprehensive summary of the costs and benefits associated with telework. While many private sector companies were willing to share the quantified benefits of their telework programs, they were not willing to share program costs. Various agencies within the public sector, on the other hand, were willing to share both cost and benefit data if available. However, many public sector agencies do not proactively quantify costs and benefits. This may be due to the inherent nature of a governmental entity's non-income-generating status.

In a 1999 *Workplace Evaluation Study*, GSA introduced a Cost per Person model to help organizations measure the performance of the modern work environment which expands the traditional real estate cost and utility measures. The additional costs that are considered include costs associated with telecommunications, information technology, workstation furniture, and alternative work scenarios. As a government-wide baseline, GSA estimates the Cost per Person in year one and in years two and three to differentiate between start-up and ongoing costs. The average Cost per Person for fiscal year 1999, assuming 10 percent of federal employees are teleworking, is reported to be $15,581 in the first year and $10,929 in the second and third years (GSA 1999).

The model, which is available from GSA's Office of Real Property, allows organizations to compare the cost implications of various workplace scenarios within organizational units. This is especially useful when considering the implications of alternative work arrangements such as telework and office hoteling. The model provides managers with a means to perform sensitivity testing to analyze the cost implications of a traditional versus alternative workplace environment. GSA's baseline data is a mix of empirical data from research and policy targets (GSA 1999). Those data have been used to test a theoretical before-and-after example illustrating the model's use in alternative work strategy analysis (GSA 1999). The results from GSA's modeling two theoretical work scenarios for a hypothetical "Southern California Company," in Los Angeles, as shown in Table 13, clearly illustrates the benefits to be gained from telework on a Cost per Person basis (GSA 1999).

Table 13
Average Cost per Person for Fiscal Year 1999
Hypothetical Southern California Company, Los Angeles, CA[1]

	Example A: Traditional Office Environment	Example B: Innovative Office Environment
No. of full-time employees	4,000	4,000
No. of workstations	4,000	3,000
No. of teleworkers	-	1,500
Full-time home workers	-	500
Part-time home workers	-	1,000
No. of shared workstations	-	500
Cost per Person (year 1)	**$13,343**	**$11,979**
Cost per Person (years 2-3)	**$8,689**	**$8,301**

[1] U.S. General Services Administration, *Workplace Evaluation Study*, 1999. In this study, GSA presents a comparative analysis of two hypothetical scenarios for "Southern California Company." Details on model input assumptions and Cost per Person outputs are provided in Appendix C.

IBM also calculates "cost per person" as a performance measure (GSA 1999). IBM's reported "cost per person" for 1997 was $9,000.

The various costs associated with telework are described below.

4.1.1 Development Costs

Program development costs are greater for organizations that provide equipment for employees. Some employers, however, including Merrill Lynch, Herman Miller, and IRS claim that these costs are offset, if not exceeded, by the efficiency gained on the information technology support side during program operations, which is a recurring cost. There is also the cost avoidance of associated computer downtime, which affects employee productivity. Some firms also provide furniture for employees, which further increases program development costs. Finally, it is notable that many development costs can be substantially reduced by implementing a shared work environment at the main office and abandoning individually assigned workstations. The primary development costs that are detailed in this section relate to equipment, space management, and training. Development costs related to telecenters are detailed separately.

4.1.1.1 Equipment Costs

Equipment costs depend on a number of factors related to an organization's mission, central office network characteristics, and whether or not it uses hoteling in conjunction with a planned telework program. For example, an organization planning to institute a shared work environment may decide to maximize mobility and cost reductions by using laptops and docking stations instead of desktop computers. Costs will also vary due to policy differences in providing employees with equipment. Given this situation-dependent variability, ranges of costs have been developed (see Table 14) and these can be applied to different telework scenarios. Detailed cost for individual elements used by teleworkers are presented in Table D-1 in Appendix D.

Table 14
Range of Equipment Costs[1]

Range of Costs		Possible Equipment Provisions
Low end	\$0 - \$1,000	Answering machine or voice mail, furniture and office supplies.
Mid-range	\$1,000 - \$3,000	Low-end computer, modem, printer or multifunction device, answering machine or voice mail, furniture and office supplies.
High end	\$3,000 - \$9,000	High-end computer, modem, printer/fax, second phone line/ISDN line/DSL/cable modem, upgraded phone or cell phone, voice mail, pager, furniture and office supplies.

[1] Based on information obtained from Georgia Power.

Equipment costs depend on the extent to which an organization is willing to provide teleworkers with equipment. Policies vary according to organization, and many organizations do not have formal policies but examine equipment needs on a case-by-case basis. According to the Telework America Survey 2000, in nearly 54 percent of employer teleworker cases, the employee pays for some equipment and maintenance (Nilles 2000). Based on literature reviews and interviews conducted, it appears that private companies have been more willing than public agencies to provide employees with equipment. However, that may change as government agencies continue to evaluate the costs and benefits of telework and move to a mobile or shared work environment.

Most telecommuters in the federal government who consider the home as their primary telecommuting location use their personal telephone lines and computers to support their work from home (Vega and Brennan 2000). Typically, when a department upgrades its equipment, it offers surplus computers to teleworkers. Because this equipment is often outdated, however, issues of compatibility with newer equipment may ensue. In an effort to avoid the configuration, network compatibility, and technological support issues resulting from the use of inconsistent equipment, some agencies such as IRS and PTO have provided equipment to employees. Budgetary constraints and opposition to duplicating equipment costs may be the issue preventing agencies from developing formal policies on equipment provision.

This lack of policy on equipment provision also appears to be the case in some state agencies as well. California's Department of General Services, which started its telecommuting program in 1988, generally does not provide equipment except in special cases. Telecommunications equipment (i.e., computers, fax machines, modems), and the acquisition and maintenance of that equipment has been the responsibility of the telecommuter. More than 80 percent of telecommuters owned their personal computer and reported an average maintenance cost of \$250 annually. The

State of California paid for telephone services, with 36 percent of the telecommuters requiring multiple telephone lines. At that time, the average telecommuter, with two to three days telecommuting, paid an average of $9.43 more per month than other employees for telephone services.

California's Department of General Services also allowed telecommuters to use office supplies (i.e., paper, pencils, diskettes) that are a part of state stock. However, telecommuters were not reimbursed for supplies that they purchased on their own even though it may have been for state business (see Table 14).

Telecommuters in the Los Angeles County government pilot program also used their personal equipment or equipment provided by the telecommuter's department. Forty-eight percent of the telecommuters used personal computers. Electricity and telephone bills were the responsibility of the telecommuters and the individual county department, respectively.

Georgia Power Company, a private investor-owned utility company, provides equipment for telecommuters on a case-by-case basis. The company considers three ranges of equipment costs when deciding on equipment provisions for employees.

4.1.1.2 Space Management Software

As noted earlier, in order to optimize real estate facility costs and effectively avoid double overhead for equipment, and in the case of telecenters, total workspace costs, companies and agencies are beginning to institute a shared work environment or "hoteling" in conjunction with telework. The hoteling concept recognizes that office space is an asset that has value, and such value is maximized when usage is maximized. Citing the Cornell University Workplace Initiative, John Vivadelli, President of AgilQuest, a space management software and consulting company, says that the average occupancy rate of all office workspace during normal business hours is between 30 and 50 percent, yielding an average office workspace vacancy rate between 50 and 70 percent (Vivadelli). Vivadelli points out how easily this could be possible given an individual's flexible work arrangements and vacations, personal and sick days off, in addition to the normal mobility patterns of the modern work day. The increased use of cellular phones and laptop computers has added to the mobility of workers. Gil Gordon points out "work is something you do, not some place you go" (Lovelace, The Nuts and Bolts of Telework).

When employees share workspace, companies can maximize office use, thereby maximizing the asset value of the office space. Office reservation software systems facilitate this space sharing process by enabling employees to reserve and modify reservations for workspace at their main office location. This system is currently being used by telecenter operators as a means to manage temporary workstations within the telecenter facilities.

Pricing for such a system ultimately depends on the number of workstations used with the system. Overall costs can decrease with volume. There are companies that provide either software and/or consulting services for using such a system. Using an example of 100 desks in a particular facility, AgilQuest conservatively estimates that a reservation software system for year one would cost approximately $60,000. This fee would include software installation, implementation and training, as well as usage for 100 workspaces during the first year. Usage fees are recurring annually, and in this example, that fee would be approximately $216 per year per workstation, or $21,600 per year. This is a rough estimate and does not account for annual license fees that would be obtained by large entities.

The cost of this tool is only a fraction of the cost of work environments in general. According to a 1999 GSA Workplace Evaluation Study, it costs $10,000 per employee per year to provide a fully costed work environment. This Cost per Person includes the sum of fully serviced real estate costs, telecommunications costs, information technology costs, furniture costs, and alternative work environment costs (GSA 1999). The "alternative work environment" component of the model allows an organization to account for costs and benefits associated with home-based and telecenter based telework options. The average Cost per Person is approximately triple that of the leasing costs alone and has been grossly under counted in the past (GSA 1999).

4.1.1.3 Telework Training Costs

There are a variety of alternatives for training employees and supervisors on the issues of telework. Training can be accomplished through workbooks, videos, on-line training or seminar courses, and workshops. Training costs vary according to the extent, quality, and quantity of materials purchased or produced. Some organizations, such as cooperative governmental groups, have large training budgets to accommodate the large-scale production of training materials for sale to other organizations. Other organizations, particularly small or informal ones, may choose not to provide any training for teleworkers. Such organizations, however, may encounter hidden costs associated with issues, such as a lack of communication between employees and management or the employee's difficulty avoiding distractions when teleworking at home. These hidden costs, which can perhaps be avoided with proper training tools, will inevitably affect the overall performance of an organization. Given the variability of costs that can be associated with training, organizations that want to enhance their telework programs should carefully assess training needs prior to choosing a training method.

While training costs were not provided by any of the private sector companies interviewed, some public agencies indicate that the costs can be controlled by providing one training event and video recording that event for viewing by all employees. Hard training costs can be fixed at the front end of a telework initiative, with the only ongoing expense being employee time allocated for training purposes. The IRS also economized training costs in its pilot program by paying for a professional training seminar that was recorded for viewing by all employees (IRS Report on OIRM Flexiplace and Hoteling Pilot). The cost of that training was $7,941 for a one-time contract with a training vendor and $9,000 in video recording costs, or a total of $16,941, in 2000. The IRS office implementing this pilot program did not consider training as a recurring cost.

The Telework Collaborative, on the other hand, an organization of five states devoted to promoting telework on the West Coast, updates its training videos every five years (Carey interview).[6] According to the State of Oregon's Office of Energy, one of the participating members in the Collaborative, videos should be updated because styles and fashions, along with knowledge regarding telework as a work process, change (Carey interview). The videos are intended to introduce or sell the telework concept to managers and employees; dated videos may be counterproductive in this regard.

The cost of developing each of three training kits offered by the Collaborative was $30,000 to $50,000. This included writing, video production, printing, and development of the accompanying workbook, travel costs for participants, and production of 500 kits. The Oregon Office of Energy, which leads the Collaborative in its telework training initiatives, won a national award for one video from the Association for Commuter Transportation.

The Telework Collaborative sells its training materials and provides consulting to interested organizations. Because Oregon leads the Collaborative in its training initiative, organizations located in Oregon are provided free training services (Carey interview). The training materials provided by the Collaborative are reality-based, including interviews with Fortune 500 company managers. These materials, including three different training kits and a step-by-step guidebook, and their respective costs are described below:

- Introduction to Telework Kit: $102.95
  A video geared to Chief Executive Officers, managers and supervisors but also used as an introduction for employees.

- Step-by-Step Guidebook: $102.95
  A comprehensive review of telework, with information on establishing a successful program.

- The Manager's Telework Kit: $153.95
  A video designed for managers and supervisors and a guide with tips and forms for managing telework.

- Telework Training Kit: $153.95
  A video and training workbook to facilitate individual telework arrangements and a sample telework policy which can be used by the teleworker/manager or by a trainer in a classroom.

- Complete Package (all of the above at a 30% discount): $357.95

The State of Arizona, another member of the Telework Collaborative, also uses these training videos and workbooks to train employees (Corbett interview). Arizona and other members of the Collaborative are working to economize training costs even further by providing on-line training to employees through the Internet. The Telework Collaborative is developing on-line training in a CD-ROM format and plans to sell each at a cost of $200.

[6] Members of the Telework Collaborative include the states of Oregon, Arizona, California, Washington, and Texas. The organization was established in 1993.

As an alternative to directly purchasing these materials, the Telework Collaborative plans to offer associate memberships to others. The annual dues will be approximately $5,000. Associate members will participate in continuing program and product development and will receive (Carey interview):

- five sets of the Introduction, Manager's Guide, and Training kits per year, valued at roughly $1,750

- 20 on-line training sessions valued at $200 each

- one on-site training session for the teleworker, manager, or training specialist, valued at $1,000

The Collaborative, which is currently comprised of only West Coast members, is interested in partnering with East Coast organizations (Carey interview). Member representatives usually communicate virtually, but they meet face-to-face once or twice a year to develop telework conference sessions and presentations. Such an associate membership could facilitate the ability for states like Virginia to become actively involved in a well-regarded program and to benefit from years of experience already accumulated by Collaborative members.

Another approach to training is to conduct on-site seminars on an as-needed basis. Merrill Lynch holds such in-house training sessions for its employees. The Telework Collaborative offers on-site training consultations at a cost of $500, plus travel and related expenses, for one to two employees (estimated total cost of $2,500.00). Local training vendors might be even less expensive.

In summary, there are a variety of possible approaches to telework training. The use of any one approach depends on an organization's specific mission, size and intended purpose. Some organizations, especially state governments, might find it most useful to become a member of the existing Telework Collaborative on the West Coast. This would be an easy way to leverage an existing experience base to a similarly organized and structured bureaucracy. Other organizations may find it more useful to write and produce their own tailored training materials, the cost of which will vary depending on the size of the audience and the number of products required. Smaller organizations might, on the other hand, limit their training expenses to a single training kit available for purchase from organizations such as the Telework Collaborative. Additionally, the nature of the specific program will also determine the importance of updating any training materials and influence the decision to make training a recurring cost as opposed to a fixed start-up cost. Possible training costs are summarized in Table 15. Some organizations consider these as non-recurring costs, while others consider these as recurring costs over a time period ranging from five to seven years.

Table 15
Summary of Possible Training Costs

Training Item	Training Cost
Package of 3 training kits plus step-by-step guidebook	$ 358.00
1 of 4 possible training kits	$ 102.95 - $153.95
On-line training	$ 200.00
On-site training by the Telework Collaborative (incl. Travel)	$ 2,500.00
Hired Training Consultant & Video Production (small-scale)	$ 17,000
Video Production (large-scale)	$ 30,000 to $50,000
Telework Collaborative membership	$ 6,000

4.1.1.4 Telecenter Development Costs

In a 1998 study of the telecenters operating in the greater Washington metropolitan area, Ernst & Young reported that telecenter development costs for a facility with 30 workstations can range between $280,000 and $384,000, or $9,333 to $12,800 per workstation (see Table 16).

Table 16
Prototypical Telecenter Development Costs (based on 30 workstations)[1]

Development Costs	Low End	High End
Furniture	$91,000	$112,000
Computer Network/Equipment	$144,000	$178,000
Telephone System	$28,000	$51,000
Office Equipment	$7,000	$13,000
Security System	$4,000	$9,000
Project Management and Professional Fees	$6,000	$21,000
Total Development Costs	**$280,000**	**$384,000**
Total Cost per Workstation	**$9,333**	**$12,800**

[1] An Analysis and Review of the Telecommuting Centers in Greater Metropolitan Washington, D.C.(1998, Ernst & Young).

As shown in Figure 3, using the midpoint of the range of development costs as an average, furniture and equipment are the most significant development costs. Computer equipment and furniture costs together comprise more than three quarters of the development costs, while computer equipment alone comprises nearly half all the development costs.

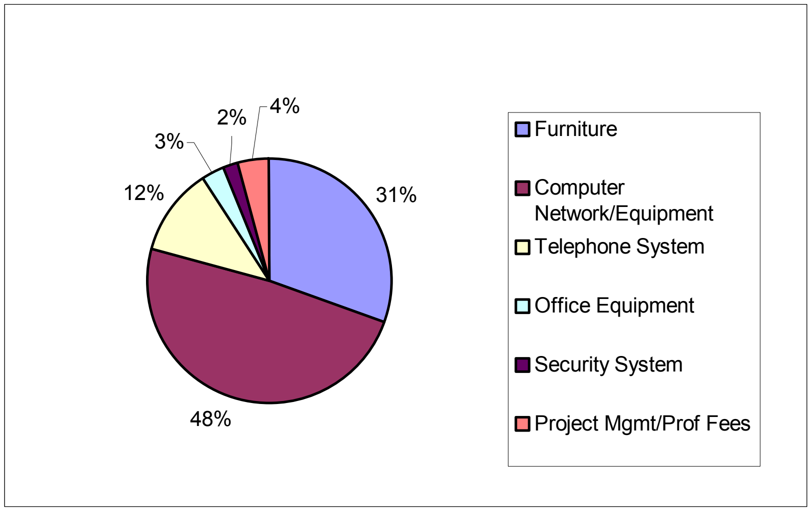

Figure 3 Telecenter Development Costs

4.1.2 Operations Costs

Operations costs are considered as costs that recur over time. These include facility costs, program administration costs, and marketing costs. Training costs, which can be considered as either recurring or non-recurring, were described in the earlier "Development Costs" section.

4.1.2.1 Telecenter Facility Costs

A telecenter lease is an operational expense that varies according to geographic location. For this study, the average fully serviced rental rates for class A office space in three locations within the state of Virginia (Hegedus interview) were obtained from GSA's Region 3. These rates are summarized in Table 17. In a typical telecenter environment the amount of space provided per person ranges from 200 to 225 square feet. Assuming these utilization rates and annual leasing cost provided by GSA, that annual cost per person for leasing at a telecenter in Richmond would range from $3,000 to $3,375. It may be noted that leasing costs in larger metropolitan areas, such as in Northern Virginia, could be significantly higher.

Table 17
Telecenter Leasing Costs (Annual) – GSA Region 3

City	Leasing Cost Per Square Foot
Richmond	$15.00
Norfolk	$16.50 - $18.00
Newport News	$14.50 - $16.00

4.1.2.2 Program Administration Costs

Formal telework programs can require more staff than informal ones. However, in some cases telework is only a small fraction of the primary staff function. The State of Arizona is a case in point. The state has one telework administrator whose only function is developing, coordinating, and marketing the state's telework program. Each of more than 100 state agencies has a designated coordinator who is responsible for program implementation within the specific agency. However, this function is only a small fraction of the coordinator's main job function, and the coordinator receives no funding for implementing the program. The statewide telework administrator provides coordinators with all marketing materials, guidelines, forms, and the overall strategy and planning framework for coordinators to produce travel reduction plans to meet prescribed telework goals at the agency level.

Minnesota's Department of Transportation is another case where the staff of 14 who manage the telework program are assigned other program management duties within the Office of Environmental Services. According to Robert Works, who oversees MNDOT's Office of Environmental Services, when the agency initiated its telework program in the early 1990s, there were as many as three mid-level transportation planners assigned full-time to telework program development. After approximately two years of working on piloting and launching the program, other staff began sharing responsibility for the program. Ongoing management responsibilities include preparing and executing quarterly training sessions for interested employees.

4.1.2.3 Marketing Costs

Marketing telework within individual public agencies and private companies does not appear to be substantial, as costs could not be identified by most of those interviewed. Marketing initiatives however, can be extensive for certain organizations, such as cooperative governmental organizations or telecenter operators that have a mission to promote telework. The State of Oregon's Office of Energy, for example, is in charge of marketing for the Telework Collaborative. It cost the Office of Energy $4,000 to produce a polished brochure entitled "Why Work Isn't Always the Best Place to Work" (Carey). This fee included the production of 5,000 copies for out-of-state use and 5,000 copies for in-state use.

Telecenter operators also have a specific need and budget for marketing expenses. These expenses can include producing and distributing flyers, brochures, radio or newspaper advertisements, and materials for workshops. According to a 1998 study prepared by Ernst & Young for GSA, marketing has increased telecenter use, and actively marketed telecenters had the highest occupancy rates. It is important to note, however, that marketing efforts be limited to the population of potential users, which is best defined by a thorough market analysis during the telecenter site selection and planning process. Ernst & Young identified a range of marketing costs for prototypical telecenters having 30 workstations. These costs ranged from $1,000 to $12,000 (or between than 1% to 5% of total operating costs) and are in line with those marketing expenses budgeted for the Stafford, Virginia telecenter for fiscal year 2001.

In the same report, Ernst & Young recommended that telecenter marketing for the entire federal telecenter program be centralized under the administration of a single individual who would coordinate with individual telecenter directors. This would consolidate the function and economize costs even further.

Table 18
Prototypical Telecenter Operating Costs (Based on 30 workstations)[1]

Operating Costs	Low End	High End
Lease or Rent Expense	$33,000	$74,000
Management/Personnel	$33,000	$70,000
Administrative and General	$1,000	$9,000
Operations, Maintenance and Security	$2,000	$11,000
Utilities	$5,000	$6,000
Telecommunications	$18,000	$36,000
Marketing	$1,000	$12,000
Reserve for Replacement (Equipment Upgrades)	$29,000	$36,000
Total Operating Costs	**$122,000**	**$254,000**
Total Cost per Workstation	**$4,067**	**$8,467**

[1] An Analysis and Review of the Telecommuting Centers in Greater Metropolitan Washington, D.C. (1998, Ernst & Young).

As depicted in Figure 4, using the midpoint of the range of operations costs as an average, real estate and staffing are the most significant operating costs. Facilities costs, including utilities and telecommunications costs, comprise close to 50 percent of the telecenter operation costs. However, as noted earlier, an efficient space management program that maximizes the hoteling concept could offset these facilities costs considerably. Dr. Wendell Joice, GSA's Telework Team Leader, believes the greatest deterrent to telecenter success is the double overhead created by duplicating work space without hoteling.

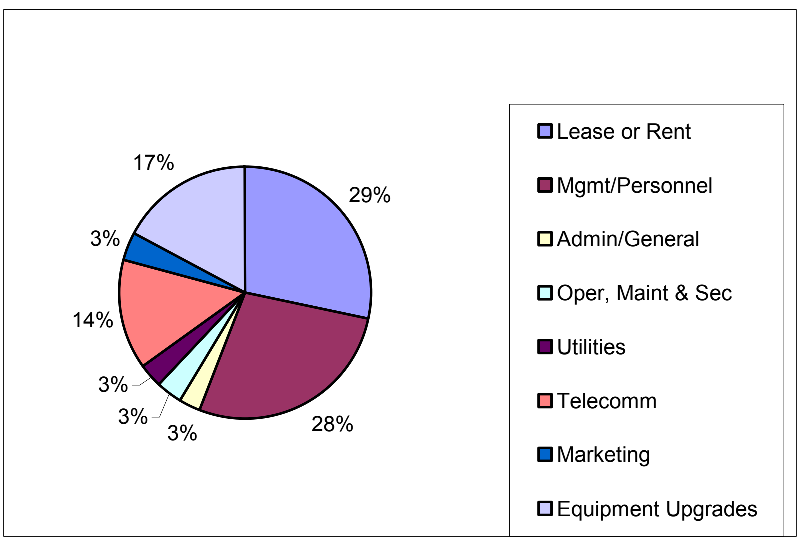

Figure 4 Telecenter Operating Costs

4.1.3 Summary of Teleworking Costs

As detailed in this section, there are a range of development and operational costs associated with home-based and telecenter-based teleworking. An example scenario was considered, assuming 50 teleworkers who telework on average 2 days/week. The costs associated with the two primary types of teleworking are summarized in Table 19. In the home-based case, it is assumed that teleworkers are provided with laptops, and space sharing is implemented at the main office where 30 offices with docking stations are provided. In the telecenter-based case, 20 workstations (with desktop computers) are provided at the telecenter and 30 workstations (with desktop computers) at the main office.

For this particular scenario, the costs for home-based teleworking appear to be lower. This is partially due to the following assumptions:

1. Home-based teleworkers use laptops which they will take to the main office on the days they work there.
2. Telecenter-based teleworkers use desktop computers at both the telecenter and the main office.
3. Home-based teleworkers will not be provided any funds to purchase furniture for the home workstation.

The costs will be different for each program, and the costs in Table 19 should only be considered illustrative. However, based on the information presented in the table, the development cost for a home-based teleworker could be approximately $6,000 and for a telecenter based-teleworker is approximately $9,500. The annual recurring costs could be in the range of $2,500 to $3,500 per teleworker.

Table 19
Typical Telework Costs for 50 Teleworkers (In 2001 Dollars, rounded to nearest 100)

Cost Components	Home-Based Telework[1]	Telecenter (2400 S.F., 20 workstations)[1]
Program Development (Non-Recurring)[2]		
Workstation Cost		
- Furniture[3]	-	$79,200
- Computer/Office Equipment[4]	$212,500	$133,400
- Telecommunications[5]	$38,500	$30,800
Training Tools for Empl/Mgrs[6]	$17,600	-
Security System	-	$5,000
Project Mgmt & Professional Fees	-	$10,500
Subtotal Program Development	*$268,600*	*$258,900*
Cost Per Workstation		*$12,900*
Cost Per Teleworker	*$5,400*	*$5,200*
Including Hoteling		
Hotel Docking/Shared Station[7]	$170,900	$246,000
Space Mgmt Software Installation[8]	$18,000	$30,000
Total Program Development	*$457,500*	*$534,900*
Cost Per Workstation		*$26,700*
Cost Per Teleworker	*$9,200*	*$10,700*
Operations (Recurring Annually)[9]		
Program Administration		
- Mgmt Staff Salary[10]	$60,900	$60,900
- General Admin	$6,000	$6,000
- Staff Training/Conference	$1,200	$1,200
- Marketing[11]	-	$7,300
Info Tech and Telecomm Equip		
Equipment/Software Upgrades[12]	$19,600	$7,800
Phone Service[13]	$30,000	$26,400
Internet Access[14]	$2,500	$4,000
Leasing	-	$43,500
Supplies	$1,800	$1,800
Subtotal Operations	*$122,000*	*$158,900*
Cost Per Workstation	-	*$7,900*
Cost Per Teleworker	*$2,400*	*$3,200*
Including Hoteling		
Hotel Docking/Shared Station[15]	$30,000	$30,000
Space Mgmt Software User Fee[16]	$6,500	$10,800
Total Operations	*$158,500*	*$199,700*
Cost Per Workstation	-	*$10,000*
Cost Per Teleworker	*$3,200*	*$4,000*

Notes:

[1] Both home-based and telecenter scenarios assume 50 teleworkers telework 2 days per week and hotel space at the main office.
[2] All non-recurring telecenter costs, except for those associated with hoteling, are based on GSA's 1998 study by Ernst & Young LLP, *An Analysis and Review of Telecommuting Centers in Greater Metropolitan Washington, D.C.*, using the mid-point of the provided range and pro-rating for 20 workstations. Assumed year for the dollars provided was 1997, since study's telecenter profile summary describes 1997 as base year.
[3] Assumes no stipend for furniture in the home-based scenario because the telework is only part-time. In a full-time home-based scenario, a furniture stipend might be considered.
[4] Home-based figures assume full high-end cost of a laptop and basic software and middle range cost of a printer for a total of $4,250 each (see Appendix D).
[5] Home-based figures assume phone line installation costs ($120.00 ea.), facsimile costs ($500.00 ea.), and digital service line modem/installation costs ($150.00 ea.).
[6] Based on IRS one-time training costs plus video recording costs for recurring use (2000 dollars).
Assumes 4% inflation. No training costs are assumed for telecenter scenario since federal agencies, the greatest users of existing centers, do not typically conduct training for employees.
[7] Home-based figures assume 30 docking stations in shared cubicles at the main office equipped with monitor, keyboard and mouse at $695.00 per station (based on IRS' pilot study figures); in addition to furniture at $4,300 per systems cubicle, phone at $300, and IT workstation and LAN set-up at $400 (based on GSA's cost components in its Cost per Person Model). Telecenter scenario assumes 30 shared cubicles at the main office with desktop computers and telephones for a total workspace cost of $8,200 each ($3,600 for IT equipment and set-up, $4,300 for furniture, and $300 for phone). In both cases, 30 shared workspaces was assumed because teleworking two days a week translates to a 40 percent vacancy rate at the main office.
[8] Based on estimate of $60,000 provided by AgilQuest for 100 workstations and pro-rated for 30 workstations in the home-based scenario and 50 workstations in the telecenter scenario. Assumes space management system
is required in the telecenter and at the main office for the telecenter scenario.
[9] All recurring telecenter costs, except for those associated with hoteling, are based on a 2001 budget for the Stafford County telecenter in VA. Actual budget identified costs for two other telecenters in addition to Stafford. Some cost categories reflected a total cost for all three centers. In these cases, a cost for Stafford was obtained by pro-rating the total against the number of workstations at the Stafford telecenter. These costs are in line with average operating costs cited in AEW Capital Management's 2001 study, *An Evaluation of Feasibility of Telecommuting Centers*, commissioned by GSA.
[10] Program administration assumes one full-time director with a salary and related administrative overhead equal to that of a telecenter operator. Telecenter scenario does not assume an administrator in the main office.
[11] No marketing costs are provided for the home-based teleworking scenario because it would be internal to the organization. Private companies did not disclose these costs during interviews. Most public agencies could not quantify these costs or reported them negligible.
[12] Home-based equipment upgrades were obtained by taking the budgeted equipment costs per telecenter workstation and allocating it ($391.50) for each home-based teleworker.
[13] Home-based figure assumes average monthly phone bills of $50/month.
[14] Internet access for home-based teleworkers is assumed to be on the low end at $50/month.
[15] Figures represents annually recurring cost of ISDN per workspace.
[16] Assumes fees for 30 workstations in home-based scenario and 50 in telecenter scenario.

4.2 Cost-Benefit Analysis

There are many different teleworking scenarios, but the most common scenario is home-based teleworking. As many studies have shown, more than 90 percent of teleworkers telework from home. In Table 20, characteristics of five companies/agencies that have implemented teleworking are presented. Costs and benefits that these companies have realized are also detailed. Similar information is also presented on the organizations surveyed as part of the Telework America 2000 survey.

Table 20
Characteristics, Costs and Benefits of Various Teleworking Programs in Companies/Agencies

	Merrill Lynch	**AT&T**	**IBM**	**State of Arizona**	**Internal Revenue Service (pilot)**	**Telework America Survey 2000**
Background						
Business Type	Financial Services	Communications	Information Technology	State Government	Info. Services Management	Most surveyed represented manufacturing/ business services
No. Employees	70,700	80,000	300,000	21,300	2,300+	50% work for companies with 1,500+ employees
No. Teleworkers (%)	3,500 (5%)	8,000 (11%) full-time 44,800 (56%) total	10,000 (3%) mobile	3,334 (15.6%)	20 (<1%)	11.5 million
Ave. Frequency of Telework	3 days/wk	Not available	Not available	Less than a day/month	1-3 days/wk	20 hrs/wk
Yr. Program Estab.	1996	1992	1995	1990	2000	Not applicable
Company Pays for Equipment?	Yes	Generally on a case by case basis	Yes	Sometimes; case by case basis as determined by individual agencies	Yes	In 54% of employee teleworker cases, employee pays for some to all equipment/ maintenance
Company Pays for Office Furniture?	No	Not available	Not available	No	No	Not provided

Table 20 (contd.)

	Merrill Lynch	AT&T	IBM	State of Arizona	Internal Revenue Service (pilot)	Telework America Survey 2000
Benefits						
Office Space	$1 million cost avoidance at one NJ location due to hoteling.	$75 million/yr in leasing (50% reduction in office space) $3,000 - $5,000 per person overall reduced demand/yr. $500 million saved between 1991-1998	$75 million/yr (40-60% reduction in office space)	Dept of Health Services saved $11,102 in 1st year by eliminating 6 offices. 69% of employees indicated they would share space is asked.	$18,000 with potential to save $414,000/yr with an expanded program of 100 participants	12% of all teleworkers share space
Turnover/Retention	$4.5 million	$7,920/empl/ yr (67% of participants have declined other job offers due to teleworking)	Unquantified savings reported	10% turnover in FY 1998-99 was avoidable through telework (a cost of $83 to $134 million)	53% of participants said less likely to look for another job	64% of employee teleworkers said ability to telework influenced them to stay ($4,857 per teleworker)
Absenteeism	4 sick days less per yr/teleworker	$2,086/empl/ year	Unquantified reductions reported	Not available	Not available	Not available
Productivity	10-40% Increase	77% of teleworkers said productivity increased 25%	Unquantified increases reported	80% of supervisors said 1990 pilot increased	82% of participants reported	$9,712/year/ teleworker 15% increase for home-based, 30%

	Merrill Lynch	AT&T	IBM	State of Arizona	Internal Revenue Service (pilot)	Telework America Survey 2000
		(1.5 hrs/day)		productivity	increases	for telecenter-based

Table 20 (contd.)

	Merrill Lynch	AT&T	IBM	State of Arizona	Internal Revenue Service (pilot)	Telework America Survey 2000
Costs						
Equipment/ Telecommunications	$5,500/ teleworker/yr	Not provided	$8,306,000/yr (capital costs) $18,198,000/yr (telecomm/ maint/printer)	Not available	$14,429 (telecomm) $74,600 (computer)	Not provided
Program Staffing	Not provided	Not provided	Not provided	Salary of One Telework Administrator (agency coordinators have other jobs)	Not quantified; only part-time staff 1-2 hr/wk	Not provided
Marketing	Not provided	Not provided	Not provided	Minimal	Not applicable	Not provided
Training	Not provided	Not provided	Not provided	Not provided	$16,941	Not provided

A cost-benefit analysis can be performed from two different perspectives – an employer perspective and an employee perspective. In Table 21, a simple cost-benefit analysis for a pilot program is summarized. For larger programs with greater numbers of teleworkers, it may be useful to expand the analysis to account for a longer planning horizon and discounted future costs and benefits. Depreciation might be another variable to consider in an expanded analysis. Costs such as equipment costs are usually treated by accountants as a capital investment; they have a depreciation value that does not actually affect the organization's bottom line (Gordon 1997).

Table 21
IRS Flexiplace Cost-Benefit Analysis[1]

Program	Participants	Training[1]	Telecomm[2]	Computing Equipment[3]	Space Mgmt Software[4]	Space Cost Avoidance[5]	Recruitment Cost Avoidance[6]	Total Cost
Pilot Costs								
	20	$16,941	$14,429	$74,600		($18,000)		$87,990
Implementation Costs								
Year 1	100		$238,404	$207,900	$27,800	($414,000)	($165,620)	($105,516)
Year 2	100		$218,659		$10,800	($414,000)	($165,620)	($350,161)
Year 3	100		$218,659		$10,800	($414,000)	($165,620)	($350,161)
Total for 3 Years								($805,839)

[1] IRS, *Report on OIRM Flexiplace and Hoteling Pilot June 19 – October 20, 2000*, April 12, 2001.

Notes:

[1] Training costs include $7,941 for the training vendor and $9,000 TV studio costs to create videotapes for future use.

[2] Telecommunications costs in first year composed of one-time charge to set up Traveling Phone number for each participant and estimated monthly cell phone bills (based on the upper limit of the average cell phone bill during the pilot).

[3] Computing Equipment cost based on difference in cost between a laptop and desktop computer and includes the cost of equipping hoteling cubicles with docking stations, each configured with monitor, full size keyboard, and mouse. Life cycle of equipment is assumed to be 3 years; therefore cyclical equipment costs would appear again in year four.

[4] Space Management Software allows individuals to make and modify reservations for workspace needed at the main office. Cost estimates were provided by AgilQuest Inc. and are based on 100 spaces being managed. First year costs estimated to increase by $215 and outyear costs by $108, for each additional space managed.

[5] Space Cost Avoidance is based on number of unneeded cubicles due to flexiplace. During the pilot, of the thirteen cubicles made available for hoteling, six cubicles were occupied on an average daily basis. The maximum usage of the thirteen reserved cubicles was ten on any given day, which yields a space utilization of 77 percent. The end result is that 23 percent of the available cubicles could be reassigned. The fully loaded cost of a cubicle at the IRS building is $18,000 per year.

[6] Recruitment assumptions are based on surveys conducted by IRS before and after the pilot program. According to the survey results, 53% of the participants indicated they were less likely to look for another job if they could telecommute on a regular basis. This translates into an estimated reduced recruitment need of 5 employees each year. Based on other studies, the IRS estimated the cost of employee turnover as 93% of the employee's annual salary. Given a 2000 General Schedule pay scale for a grade 9 step 4 (the median grade/step of all employees leaving the branch during 1998 and 1999), the salary used was $35,617.

A more comprehensive comparison of costs and benefits is provided below for home-based and telecenter-based teleworking. The main assumptions in constructing this cost-benefit analysis are the same as used to demonstrate the typical teleworking costs in Section 4.1.3. For both cases it was assumed that there were 50 teleworkers who on average telework two days per week. At the telecenter 20 workstations are provided, and at the main office 30 workstations are provided. The costs for these two example programs were detailed previously in Table 21. The summary cost-benefit analyses considering three-year scenarios are presented in **Table 22** and Table 23. As shown in these tables, both modes are expected to result in net benefits for the employer. This benefit is estimated as approximately $2,900 per year per teleworker for the home-based case, and approximately $1,500 per year per teleworker for the telecenter-based case.

Table 22
Cost-Benefit Analysis for Home-based Teleworking
50 Teleworkers, 2 days/week (hoteling 30 workstations)

Costs	Year 1	Year 2	Year 3
Non-recurring[1]	($457,500)		
Recurring[2]	($158,500)	($158,500)	($158,500)
Total Costs	*($616,000)*	*($158,500)*	*($158,500)*
Benefits			
Reduced Real Estate ($15.00/sf[3]* 230 sf/person	$69,000	$69,000	$69,000
Reduced Telecomm ($300/phone - fixed; $1,000 ISDN - recurring)[4]	$6,000	$20,000	$20,000
Reduced Furniture ($4,300/workstation)[5]	$86,000		
Reduced IT ($400 installation - fixed; $3,200 equip - recurring)[6]	$72,000	$64,000	$64,000
Productivity ($1,800/teleworker)[7]	$90,000	$90,000	$90,000
Turnover ($4,857/teleworker)[8]	$242,850		
Reduced Absenteeism ($2,086/teleworker)[9]	$104,300	$104,300	$104,300
Total Benefits	*$690,150*	*$347,300*	*$347,300*
Net Benefits	*$74,150*	*$188,800*	*$188,800*

Table 23
Cost-Benefit Analysis for Telecenter-based Teleworking
50 Teleworkers, 20 workstations (hoteling for 30 workstations)

Costs	Year 1	Year 2	Year 3
Non-recurring[10]	($534,900)		
Recurring[11]	($199,700)	($199,700)	($199,700)
Total Costs	***($734,600)***	***($199,700)***	***($199,700)***
Benefits			
Reduced Real Estate ($15.00/sf[3]* 230 sf/person)	$69,000	$69,000	$69,000
Reduced Telecomm ($300/phone - fixed; $1,000 ISDN - recurring)[4]	$6,000	$20,000	$20,000
Reduced Furniture ($4,300/workstation)[5]	$86,000		
Reduced IT ($400 installation - fixed; $3,200 equip - recurring)[6]	$72,000	$64,000	$64,000
Productivity ($1,800/teleworker)[7]	$90,000	$90,000	$90,000
Turnover ($4,857/teleworker)[8]	$242,850		
Reduced Absenteeism ($2,086/teleworker)[9]	$104,300	$104,300	$104,300
Total Benefits	*$690,150*	*$347,300*	*$347,300*
Net Benefits	*($44,450)*	*$147,600*	*$147,600*

Notes:

[1] Non-recurring costs for home-based telework include the full high-end cost of basic computer equipment, including a laptop, basic software and middle level printer as detailed in Appendix C (total $4,250 per package); telecommunications equipment and service, including phone line installation as provided by Verizon, facsimile cost and digital service line with modem and installation costs as detailed in Appendix C (total $770 per teleworker); initial training seminar with video production based on IRS flexiplace and hoteling pilot costs; hoteling costs, including 30 docking stations for laptop compatibility based on IRS flexiplace and hoteling pilot study, furniture for shared systems cubicles, phones and information technology installation/set-up (total $5,000 per teleworker) as provided in GSA's 1999 Workplace Evaluation Study, and space management software installation costs based on an estimate provided by AgilQuest.
[2] Recurring costs for home-based telework include program administrator assumptions based on the similar requirement for telecenter operator administrators, as estimated for the Stafford County, VA telecenter; computer equipment upgrades based on the similar requirement for telecenter computer equipment upgrades, as estimated for the Stafford County, VA telecenter; monthly phone bills at $50.00/month, a low-end assumption as itemized in Appendix C; internet access at $50.00/month, a low-end assumption as itemized in Appendix C; and hoteling costs, including recurring ISDN cost ($1,000/person/year) as provided in GSA's 1999 Workplace Evaluation Study, and annual license fees for using space management software for 30 shared workstations ($216/person).
[3] Reduced Real Estate Benefits are based on GSA-Region 3's 2001 leasing costs for Richmond.
[4] Reduced Telecommunications Benefits are based on GSA's 1999 Workplace Evaluation Study.
[5] Reduced Furniture Benefits are based on GSA's 1999 Workplace Evaluation Study.
[6] Reduced Information Technology (computer equipment) Benefits are based on GSA's 1999 Workplace Evaluation Study.
[7] Productivity Benefits based on the 1999 Telework America Survey.
[8] Turnover Benefits are based on the 2000 Telework America Survey.
[9] Reduced Absenteeism Benefits are based on the 1999 Telework America Survey.
[10] All non-recurring costs for telecenter-based telework, except for those associated with hoteling, are based on GSA's 1998 Analysis and Review of Telecommuting Centers in Washington, DC. Hoteling assumes costs for 30 shared cubicles at the main office (total $8,200 per workspace) as detailed in GSA's 1999 Workplace Evaluation Study, and space management software installation costs for 20 workstations at the telecenter and 30 workstations at the main office, as based on an estimate provided by AgilQuest.
[11] All recurring costs for telecenter-based telework, except for those associated with hoteling, are based on a 2001 budget for the Stafford County, VA telecenter. Hoteling assumptions include recurring ISDN cost for 30 workstations at the main office ($1,000/person/year) as provided in GSA's 1999 Workplace Evaluation Study, and annual license fees for using space management software for 50 shared workstations ($216/person).

Although each cost-benefit analysis will require assumptions that may be unique to that company's particular circumstances (e.g., cost of office space or salaries vary according to time and place), most surveys indicate that telework is succeeding in reducing costs, and employers are realizing the benefits.[7] Referring to the fact that business leaders are looking at the bottom-line benefits of telework, ITAC President John Edwards, also CEO and executive director of TeleworkNetwork, says: "Telework is a business strategy."

It should be noted that employees will also have individual costs and benefits related to teleworking. The main benefits include the reduced cost of commuting to work (travel time and cost of operating a vehicle), and possibly the reduced cost of purchasing and maintaining traditional office attire. For home-based teleworkers, the primary costs include dedication of space in the home, cost of additional furniture or equipment not provided by the employer, and possibly increased utility costs. The costs and benefits will be different for individual workers, and it is likely that they will equal each other and thus the net impact will be minimal. Other intangible benefits, such as the flexibility gained by a home-based teleworker working from home or a telecenter-based teleworker working closer to home, are difficult to quantify.

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[7] T-Manage offers a financial analysis tool or "financial impact calculator" to show companies what their potential financial impacts are based on program assumptions. (www.telsuccess.com.)

4.3 Existing State Programs for Teleworking

While there is evidence of a significant increase in teleworking programs, both formal and informal, most of the teleworking initiatives appear to be started voluntarily and without direct financial support being provided as one of the primary incentives. Rather, programs begin as a result of private or public sector managers recognizing the overall benefits of such programs in addition to the financial savings that result after the programs become operational. A number of the states reviewed have programs where technical assistance was provided, or start-up costs were defrayed by pilot program grants or demonstration projects initiated by federal, state, regional or local government agencies.

4.3.1 Funding Programs in Virginia

Public funding of direct costs for implementation of teleworking programs in Virginia is limited to a pilot program which includes reimbursement of lease costs and consultant/technical assistance expenses. It reimburses a variable percentage of the lease expense for equipment, telework center space, technical assistance for setting up programs and installing equipment, and provides training for teleworkers and supervisors through the Telework!Va program (www.teleworkva.org). Telework!Va is a component of Governor Jim Gilmore's Innovative Progress initiatives. This pilot program is administered by the Commonwealth of Virginia's Department of Rail and Public Transportation (DRPT) and the Metropolitan Washington Council of Governments (MWCOG). The goal of the program is to encourage businesses to initiate new teleworking activities and requires a willingness to start a long-term program, invest in the planning and staff resources required to sustain a program, and commit to an implementation schedule with appropriate milestones of two years or less. Priority is given to new program starts although existing program expansion requests may be considered on a case-by-case basis (www.teleworkva.org). In the first three months, preliminary approval has been given to approximately 30 applicants, and contracts are being established. DRPT also provides support for the Telework Resource Center, which is administered by MWCOG.

4.3.2 National and International Case Studies

A comprehensive review of telework initiatives in the United States, Canada and Europe reveal significant interest in studying the impacts of increased use of teleworking as a viable workplace option. The states selected for inclusion in this review are cited because of their willingness to support research in this growing effort, and a summary of international activities is also provided to illustrate the global nature of telework initiatives. While not specifically cited here, numerous private national and international telework associations report similar activities in other states and countries to a greater or lesser degree, indicating these states are indicative of national and global trends toward an increase in public and private sector telework initiatives. This is to be expected as teleworking moves beyond the realm of being a transportation demand management option and becomes a more readily accepted business strategy that is used by corporations with national and international operations. A summary of these teleworking programs is provided in Table 24, and more detailed information is provided next for these domestic and international examples.

Table 24
Selected National and International Teleworking Programs

Region	Program	Purpose	Sources of Funding	Incentive Programs	Contact Information
Virginia	Telework!Va	Provides financial incentives to businesses for starting or expanding telework initiatives up to $35,000 over two years.	State	Includes technical assistance, equipment lease costs and training	VDRPT, Rick Clawson, (804) 786-7858, rclawson@drpt.state.va.us
	Ridefinders	Richmond Area carpooling clearinghouse	Federal, State and Local	Free referral services and transit info	rideshare@ridefinders.com
Virginia and Washington D.C.	Telework Resource Center - Commuter Connections	Provides information on commuting options, including teleworking. Coordinated Demonstration project studying eight teleworking programs in D.C. metro area.	Virginia, Maryland, Washington D.C. and MWCOG	Technical assistance; information about telecommuting.	MWCOG, 1-800-745-RIDE, www.mwcog.org
Arizona	AzTAC Arizona Telecommuting Advisory Council	Public/Private partnership for implementing pilot program in Maricopa County.	State	State & AT&T partnered to offer solutions to comply with air quality standards.	John Corbett, Telework Programs Admin, (602) 542-3637, adcorbej@ad.state.az.us
California	Telework Advisory Group (TAG)	To facilitate technical assistance in planning and implementing telework programs statewide.	State	Technical assistance	Linda Reiner, Telework Program Consultant, DPA (916) 327-9143, LindaReiner@dpa.ca.gov
Florida	State Employee Telecommuting Program	Provides technical assistance to state agencies and employees interested in telecommuting.	State	Technical assistance	Carolyn Johnson, DMS, HRM in Tallahassee.
Maryland	State Employee Teleworking Program	Provides technical assistance to state agencies and employees interested in telecommuting.	State	Technical assistance	
	Telework Partnership with Employees	MDOTs joint program for MDOT employees and private businesses interested in telework programs.	State, BMC & MWCOG	Technical assistance	Gil Weidenfeld, MDOT, (410) 865-1281, gweidenfeld@mdot.state.md
Washington	Commute Trip Reduction	Statewide program sponsored by WSDOT to reduce single-passenger trips	State	Grants and technical assistance	Brian Lagerberg, TDM Manager. (360) 705-7878, lagerbb@wsdot.wa.gov
U.S. - Federal	Flexiplace	Program to assist Federal employees to participate in flexible (alternative) workplace arrangements.	Federal Government	Technical assistance	Wendell Joice, GSA, (202) 273-4664, wendell.joice@gsa.gov
International	eWork 2000	Comprehensive report detailing telework program activities	n/a	Report of activities in 15 European countries, Japan and the US	www.eto.org.uk

4.3.2.1 National Case Studies

A review of telework activities in six states: Arizona, California, Florida, Maryland, Oregon, and Washington, identified significant increases in interest and participation among both public and private sector employers for teleworking initiatives. These states were selected for analysis because of their participation, support and/or reporting of teleworking pilot programs or other similar initiatives. In all these cases, the state legislatures and/or executive branches (through Executive Order) have mandated some form of teleworking program be piloted or established, and that a central administrative state agency be charged with overall implementation responsibility. This central agency then distributes or delegates that authority to other individual state agencies for actual program management.

4.3.2.1.1 Arizona

The State of Arizona Department of Administration (ADOA) was mandated in the late 1980s to create and implement a telecommuting program that would require state agencies operating in Maricopa County to have 15 percent of their state employees participating in teleworking pilot programs. The state partnered with the Regional Public Transportation Authority to create the Arizona Telecommuting Advisory Council (AzTAC) as a public/private partnership for implementing future programs. The original goals of the program were to reduce traffic congestion, air pollution, and energy consumption as measured by surveys of vehicle miles driven and consumption of gasoline in the metro-Phoenix area. Additionally surveys on levels of stress and productivity were also used to demonstrate the effects of the newly implemented teleworking programs. However, after implementation, it was acknowledged that telecommuting was also a powerful management tool that increases employee productivity while reducing the cost of employee turnover.

As mentioned earlier, Arizona went on to join Oregon, Washington and California in forming the Telework Collaborative to combine their expertise and to develop additional telecommuting materials including a management briefing and stand-alone telecommuter/supervisor training package. To date, 71 state agencies in Arizona have implemented the telecommuting program with the state reaching the mandated 15 percent Maricopa County participation.

4.3.2.1.2 California

California started its telecommuting program in the early 1980s in response to pressures to comply with federal air quality mandates. In 1984, the State created a multi-agency policy steering committee composed of mid-level managers representing an array of state entities. It was originally created to advise the Department of General Services in planning, executing and evaluating a two-year statewide pilot telecommuting program. The pilot program resulted in the enactment of legislation creating the State Employee Telecommuting Program (Sections 14200-14203, California Government Code). Through a Memorandum of Understanding the telework unit was eventually transferred from Department of General Services to the Department of Personnel Administration (DPA).

Since that time, the DPA program has grown to include many voluntary participants who see the additional value in using teleworking as a business strategy. The Telework Advisory Group (TAG) was created to provide technical assistance in planning and implementing telework programs statewide. Although the TAG is a state government program, local government and public membership is welcome on a voluntary basis.

4.3.2.1.3 Florida

The Florida Department of Management Services (DMS) is the responsible state government administrative agency and dictates teleworking project implementation responsibility to the Division of Human Resources Management (HRM). This agency provides information to other state departments that oversee individual teleworking arrangements. DMS policy is to encourage voluntary participation of state employees in formal teleworking agreements that use its model policy and fall within the purview of Section 110.171 of the Florida Code. Florida makes a concerted effort to identify all the benefits of teleworking, as do all the other states reviewed here; however, Florida also stresses the advantages teleworking may have in assisting with the employment of individuals who may have special needs that fall under the Americans with Disabilities Act (ADA). The state notes that teleworking does not relieve an employer of the responsibility of making a workplace ADA compliant; however, teleworking provides a viable option for employees who may otherwise have difficulty with obstacles related to daily travel to and from a more traditional workplace.

4.3.2.1.4 Maryland

Maryland has implemented a comprehensive telework program for state employees that is administered by the Department of Budget and Management (DBM). This department provides extensive resources and manuals to all state agencies and the general public. Its commitment is clearly stated in the Agency Teleworking Implementation Manual, available from DBM:

> The state has recognized the changing nature of its workforce and has begun to focus on ways to increase productivity while improving the quality of employee work-life and morale. In addition, teleworking has proven to be an effective tool for promoting environmental conservation by decreasing traffic congestion and automobile related emissions. Overall, teleworking has many benefits. The State has recognized these benefits and has developed this program so that the state, as an employer, can lead the way to a cleaner environment through a more flexible and productive workplace. (Section C. Teleworking Benefits, page 5)

To further this goal, the state operates 14 remote telework centers, and has plans for 6 more. These are operated through joint ventures with agencies such as the Maryland National Guard.

The Maryland Department of Transportation (MDOT) provides outreach statewide through MDOT's Telework Partnership with Employers (TPE) which offers free professional telework consulting services to Maryland employers. Implementation of the TPE is a coordinated effort between MDOT, MWCOG and the Baltimore Metropolitan Council (BMC). The consultation services are provided to employers who meet certain criteria established by MDOT, including: a commitment of top-level management support, designation of a telework project coordinator, creation of an internal teleworking team to work with MDOT consultants, selection of a TPE consultant, and commitment of at least 10 to 50 new teleworkers who will telework for at least two days per month for a one-year period.

The Baltimore region was recently the focus of a study to determine baseline statistics for telecommuting in the Baltimore commutershed. This study revealed that for the 17 percent of employers in the region that have formal teleworking programs, approximately 3.6 percent of the workforce telecommute (TPE Report Summary). The study reported that these teleworkers saved an average of 28 miles of commuting distance each way by teleworking three days per week. The study also found that more than a third of the employees surveyed who work for firms that currently do not have formal teleworking programs are interested in telecommuting.

4.3.2.1.5 Oregon

The State of Oregon's Office of Energy "actively promotes telework in Oregon, because it conserves fuel, relieves traffic congestion, and improves air quality - and because it makes good business sense" (www.energy.state.or.us/telework/telehm.html). Mandated by the State Legislature, Senate Bill 775, the Office of Energy is charged with overseeing the implementation of teleworking initiatives so that all state agencies may comply with the legislature's requirement "to encourage state agencies to allow employees to telecommute when there are opportunities for improved employee performance, reduced commuting miles or agency savings." Additionally, Executive Order 98-02 requires the Oregon Department of Transportation to take the lead in "promoting, coordinating and monitoring" the implementation of EO 98-02 and provide consultation, information resources and advice to other state agencies in the metro-Portland "Tri-County" area so that state agencies will be in compliance with the state's Employee Commute Options (ECO) rules.

These ECO rules were passed in 1992 by the Oregon Legislature to "help protect the health of the Portland-area residents from air pollution and to ensure compliance with the federal Clean Air Act", and apply to all businesses that employ more than 50 employees and public agencies operating in the Tri-County area. The ECO rules are enforced by the Oregon Department of Environmental Quality and require employers "to develop strategies to reduce the number of commute trips by their employees who drive alone to work" (www.energy.state.or.us/telework/telehm.html). In its efforts to encourage compliance with these rules and support the practice of teleworking among private sector employers, the state provides a Business Energy Tax Credit for private sector teleworking projects. The tax credit is intended to "encourage investments in energy conservation, recycling, renewable energy resources and less-polluting transportation fuels." The tax credit is 35 percent of the eligible project costs, taken over five years.

4.3.2.1.6 Washington

The Washington State Department of Transportation (WSDOT) is the primary government agency behind a statewide telework program called Commute Trip Reduction (CTR) that helps employees find transportation options that work for them. The goals of the CTR Program are to reduce traffic congestion, air pollution, and fuel consumption through employer-based programs that reduce the number of drive-alone trips. The Washington State Legislature passed the CTR Law in 1993, incorporating it into the Washington Clean Air Act as RCW 70.94.521-551. To date, more than 1,100 employment locations in Washington have participated in the program.

The CTR program is supported and staffed by WSDOT personnel and directed by a 22-member task force composed of members from state, regional, and local governments, academia, and the private sector. Washington State University's Cooperative Extension Energy Program published an extensive report by Rick Kunkle, *Perspectives on Successful Telework Initiatives,* in April 2000. It highlights all of the previously mentioned benefits of teleworking programs and goes on to encourage public sector support (in the form of sound public policy initiatives) of private sector initiatives and the use of competitive, best practice organization strategies for both public and private sector agencies. These practices include telework programs in the context of changing and improving work processes (Kunkle).

Additionally, WSU case studies with public and private sector subjects (KCTS Public Television, Washington Mutual Financial Services, and the City of Redmond) revealed how telework strategies were complemented by compressed work weeks and flextime programs to achieve the goals set forth by the state's CTR Program.

4.3.2.2 International Case Studies

Canada and Europe show a similar increase in teleworking activities to those reported above concerning the United States (and those states that were targeted for analysis within this study). It is worth noting that teleworking in Europe has workplace and work-type issues of significance. The issues of commuting and providing an alternative to the traditional workplace arrangement for employees are supplemented by a significant focus on the types of employment opportunities available to members of the working society in European countries. The reports on teleworking initiatives focus on how employers may increase the productivity of their workforce while simultaneously changing the nature of the workforce to respond to the changes being observed in an economy in transition from the "traditional manufacturing" to one more dependent upon "information technology." In short, the European focus appears to be directed at both improving worker productivity from the standpoint of reducing commuting, but also at the changing nature of the type of work in which their employees are engaged.

A review of the practices and policies governing teleworking initiatives in Canada reveal similar priorities to those state programs reviewed in this study. These include improving worker productivity, reducing commuting miles traveled, and contributing to the development of a sustainable society. A notable difference is the specific reference to employee rights and the involvement of union representatives in the development of telework agreements.

For illustrative purposes, a reference is made in Table 24 to the *eWork 2000* report, which provides a summary of international teleworking activity. This report provides a detailed analysis of 15 European countries, the United States, and Japan and is entitled: *eWork 2000: Status Report on New Ways to Work in the Information Society* (http://www.eto.org.uk.).

4.4 Performance Measures for Teleworking

The categories of performance measures for teleworking programs expands as the number of teleworkers increase, as new management techniques are deployed, as new programs are instituted at the state and federal level, and as communities are altered by an increased presence of workers. New studies on the benefits of teleworking, either as an individual activity or a combined flex-work program, are released almost monthly and research delves further into measuring the performance of teleworking activities. The results of many of these studies have been included in earlier sections of this report highlighting the benefits of teleworking programs.

This section has been subdivided to discuss performance measures in each of four categories. The categories are the teleworker, the company, government programs, and the community. Empirical data supporting the first two categories is becoming increasingly available, and information on government programs is also growing as local, regional and federal initiatives seek to resolve transportation issues with alternative work solutions. The community impacts of teleworking programs have not been explored enough to document, although a summary of some of the suggested measurement activities has been included. A very recent study released by the National Work/Life Measurement Project provided additional insight into the possible teleworker and company performance measures but concluded that further study into the potentials and pitfalls of teleworking in the new economy was necessary before any solid conclusions could be drawn (Pruchno, 2000). The critical point of all of the literature to date is that teleworking can be successful with proper and consistent management. This applies to programs instituted within each of the four categories that follow.

4.4.1 Teleworker Performance Measures

A number of performance measures related to the teleworkers themselves have been developed and studied to assess the success of teleworking programs. Much of the information gathered for this group has been collected by individual companies, research organizations, and teleworker advocacy groups who wish to highlight changes in worker satisfaction and productivity for workers taking part in various programs. There is a growing list of measures that outline worker performance.

The literature for teleworker performance measures sometimes relies heavily on teleworker programs aimed at increasing the availability of parents with children who are home or even adult children with aging parents. Some of the studies assess telecommuting as a transportation or time control measure and measure the relationship between the teleworker and the management team. It is important to realize the distinction in that the conclusions drawn in any given report may be specific to either workers with family responsibilities or who have chosen to work at home for reasons related to travel. The measurement of the success or failure of these programs at the telecommuter level needs to be categorized by the type of arrangement for the teleworker.

A representative list of some of the measures cited for this group include the following:

- Number of sick days taken
- Number of hours influenced by weather
- Number of productive hours per week
- Number of assignments completed on time
- Ratings on customer satisfaction report
- Promotion equity among telecommuters and office workers
- Management assessment of worker performance

4.4.2 Company Performance Measures

The relationship of a company to its management and the teleworkers is one with increasing documentation. Numerous reports issued in the last few years outline the positive and negative effects of various teleworking programs. Two new programs in Northern Virginia (Telework!Va and ECommute) provide financial benefit to the companies for participating in teleworking programs as an incentive to reduce traffic congestion and emissions.

Proper planning, strong communication, and involved management are critical to ensuring the success of company teleworking programs. Documented policies, expectations, and procedures lead to positive results when measuring performance. When properly instituted, a teleworking program can lead to measurable increases in a number of worker productivity categories. The number of measures of success of a company teleworking program are growing as managers seek the best ways to document the performance of their workers. A short list of some of the more common items used to assess company performance at the worker level include:

- Worker retention rates
- Increases in worker productivity
- Number/percentage of personnel teleworking
- Measured management issues (resentment, quality of work, morale)

Companies have begun to assess the success of telework programs to determine whether future efforts at expanding the programs are desirable. Some of the success stories are easily documented. A few of those examples are highlighted below:

- Bank of America began using teleworking as a way to improve family friendliness and flexibility while also improving recruitment and retention. The company is working toward expanding its program after noted increases in productivity and morale and reductions in absenteeism.
- IBM continues to expand its teleworking program, even as the total number of teleworkers for the company has increased to more than 80,000 worldwide.
- Merrill Lynch and Boeing both show appreciable cost savings from turnover reductions through teleworking programs. Both companies have trained management to focus on productivity rather than time spent on the job.

As mentioned, there are also company performance measures that relate to costs of teleworking programs. Office space needs and communication and technology requirements for teleworkers may have positive or slightly negative effects on the company bottom line. In addition, government agencies have begun to create alternative programs that can provide financial incentives to companies to promote teleworking within their organizations. Specific to Virginia are the ECommute program, with oversight provided by the National Environmental Policy Institute, and the state-sponsored Telework!Va program, which provides incentives to companies or individuals to cover the cost of technology needs for telecommuters.

Measuring the success of teleworking programs is critical to defining the benefits to the companies that take part. Some cost-related performance measures include the following:

- Cost savings or losses (real estate, technology costs, etc.)
- Emissions credits (Northern Virginia)
- Tax credits

4.4.3 Program Performance Measures

Various measures of the success of institutional teleworking programs have been developed as community leaders attempt to implement teleworking programs. Teleworking programs are being developed to combat the increases in traffic and the coincident effects of vehicle emissions on an aging transportation infrastructure. As an example, the Northern Virginia region may face the prospect of losing federal transportation funds due to air quality conformity issues associated with increasing vehicle emissions. Therefore government leaders are working to measure the success of teleworking programs and their effect on travel patterns, vehicle miles traveled, and emissions. Some implications are quantified below.

- In the Phoenix metropolitan area 93,800 people work at home at least one day per week. Surveys have shown that this reduces daily VMT by 900,400 miles per day and reduces emissions by more than 32,000 pounds per day. (Corbet, 2000)

- Washington State has found that the average telecommuter in the Seattle accounts for 36 fewer miles per day in daily travel and 50-70 percent reductions in pollutant emissions. (Van Horn, 2000)

The performance measures for these programs should yield quantifiable results due to the fairly stringent reporting requirements. There are a number of performance measures that have been identified in legislation, press releases, or on the Internet that will be used in the near term to measure the success of these programs. These measures include:

- Total number of teleworkers
- Number of teleworkers still in program after a year
- Telework days or telework hours
- Percentage of companies with teleworking programs
- Total amount of emissions credits generated by ECommute program
- Calculated reductions in overall VMT due to teleworking programs
- Average travel time savings

Practically all of the states that assess the success of their telework programs use VMT and resulting emissions reductions estimates as a way to measure the success of their demand management program. Transportation agencies will measure the success of their programs against the results of efforts to use teleworking as a travel demand measure.

4.4.4 Community Performance Measures

The effect of telecommuting on a community is not supported at this time by any statistical information, but there are some examples of expected outcomes from widely available telecommuting programs. Most of these are specifically related to the time savings associated with not having to commute to an office on a daily basis. It is theorized that communities with higher levels of telecommuting will exhibit higher levels of community involvement as free time is increased. A few performance measures have been discussed that seek to measure the impact of telecommuting on various communities. These include:

- Number of telecommuters
- Hours spent with family
- Hours available for community activities
- Crime rate (home burglary, etc.)
- Reduction in traffic accidents
- Increases in employment rates for persons with disabilities

5. CONCLUSION

The study has shown that there are many potential benefits associated with teleworking. These benefits include decreased congestion costs, improved air quality, more flexible work environments that lead to increased productivity, reduced turnover and absenteeism, and cost savings to organizations implementing teleworking. Although savings may appear small, for a large urban area they can be the difference between regulatory compliance and conformity. Furthermore, savings can be significant for organizations and individuals. The biggest potential impediment related to expanded teleworking is still resistance from managers.

Congestion Costs

There is no doubt that teleworking reduces work trips and also the number of total trips on any given day. The roadway congestion impacts for nine urban areas in which 80 percent of Virginia residents live and work were studied. Two surveys showed that on average approximately 8 percent of the workforce telework 1.5 days per week, with a greater incidence of teleworking in the larger urban areas. It was estimated that in the larger urban areas, vehicle miles traveled (VMT) is reduced by 0.5 to 2.25 percent due to current telework participation. Increased teleworking can result in decreased traffic congestion related costs. For example if an additional 5 percent of the workforce telework, annual congestion costs are estimated to decrease by $5 million in Hampton Roads and $13 million in Northern Virginia.

Air Quality

Vehicle emission reductions due to teleworking were estimated for five of the nine urban areas, as these five areas were, or are, problematic under new rules promulgated by the EPA. Vehicle emission reductions were estimated to be of the same order as the VMT reductions. Although these reductions are small in absolute terms, they are very important in relation to conformity adherence efforts and ultimately federal funding for these five urban areas.

Improved Work Environment

Various performance measures to evaluate the impacts of teleworking were reviewed. Most of the information in the literature pertains to performance measures used for employees and employers. Generally, teleworking had a positive impact on worker productivity, turnover rates and absenteeism.

Cost Savings

One performance measure that is typically considered is the financial impact of teleworking. This again can be viewed from different perspectives, with the most common being from the perspective of the employer. Two hypothetical analyses were performed to demonstrate the net benefits attainable from home-based or telecenter-based teleworking. Value is derived due to reduced costs associated with real estate (due to sharing of office space), turnover and absenteeism, and productivity gains.

Public Sector Initiatives

Various states have provided limited support for teleworking programs. Oregon established the Telework Collaborative, which now has five member states. The Telework Collaborative provides support to individuals, businesses, and government agencies in establishing effective teleworking programs, and also develops training material. Virginia has started an aggressive program called Telework!Va, which provides support to firms with 20 employees or more, for establishing new programs, or continuing with existing programs. This program is currently targeted on the Northern Virginia urban area, which has both the highest levels of congestion and teleworking in the Commonwealth.

Summary

Teleworking provides a viable alternative to working at a central office location. The results of the research performed for this report show that benefits in costs, productivity, congestion, and air quality can be achieved through a comprehensive program of teleworking. Aspects that are critical to the success of a teleworking program include adequate resources for managing the program, a training program for both managers and employees, and marketing efforts to publicize the program. Most states with a defined teleworking program have a specific group or department managing the telework activities in the State. Typically, this group or department provides information on the benefits of teleworking to the individual, business or community, administers incentive programs, and provides management training materials needed to ensure the success of programs at all levels.

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Appendix A

2000 Appropriations Act, Item 506-6

The Secretary of Transportation, the Secretary of Technology, and the Secretary of Finance shall conduct a study of the potential benefits of teleworking to the Commonwealth of Virginia. Such study shall be reported to the Governor and the Chairmen of the Senate Finance Committee and House Appropriations Committee by November 1, 2001. The study shall include the following: 1) the definition of teleworking; 2) costs of teleworking to employers and to government; 3) the impact of teleworking on congestion; 4) the applicability of teleworking in all regions of the state; 5) performance measures that can adequately and appropriately gauge the benefits of teleworking to the employee and employer as well as congestion relief; 6) alternatives for encouraging the use of teleworking in Virginia.

Appendix B
Roadway System Performance for Existing Conditions in Urban Areas in Virginia
Calculation Worksheets

CHARLOTTESVILLE

VDOT Telework Study
Roadway Information for Congestion
2000 Base Conditions (rev. 9/25/01)

ROADWAY	Classification	# Lanes	Rd Seg	ADT (2000)	Posted SL	ADT/Lane	Daily VMT	Ln-Miles	ADT/Lane	Cong level
Interstate/Freeway										
I-64	Urban Interstate	4	0.17	29,000	65	7,250	4,930	0.68	7,250	Uncongested
RT 29/250 Bypass	Urban Freeway	4	0.35	35,000	55	8,750	12,250	1.4	8,750	Uncongested
RT 250 Bypass	Urban Freeway	4	0.6	38,000	55	9,500	22,800	2.4	9,500	Uncongested
Total Interstate/Freeway							**39,980**	**4.48**	**8,924**	

	Uncongested	% Type of Congestion on Congested Arterials (=100%) Moderate	Heavy	Severe	Extreme
VMT	100%	0	0	0	0
Lane/Miles	100%	0	0	0	0

ROADWAY	Classification	# Lanes	Rd Seg	ADT (2000)	Posted SL	ADT/Lane	Daily VMT	Ln-Miles	ADT/Lane	Cong level
Principal Arterials										
Rt 29 Bus (Fontaine Ave.)	Urban Princ. Art.	2	0.42	13,000	35	6,500	5,460	0.84	6,500	Moderate
Rt 29 Bus (Emmet St.)	Urban Princ. Art.	4	0.45	24,000	40	6,000	10,800	1.8	6,000	Moderate
Rte 250e (University)	Urban Princ. Art.	2	0.4	17,000	25	8,500	6,800	0.8	8,500	Heavy
Rte 250e (University)	Urban Princ. Art.	2	0.19	15,000	25	7,500	2,850	0.38	7,500	Heavy
Rte 250 (High St E)	Urban Princ. Art.	2	0.23	12,000	25	6,000	2,760	0.46	6,000	Moderate
Rte 250 (High St E)	Urban Princ. Art.	2	0.21	10,000	25	5,000	2,100	0.42	5,000	Uncongested
Rte 250 (High St E)	Urban Princ. Art.	2	0.45	19,000	25	9,500	8,550	0.9	9,500	Severe
Rte 250w BUS(Grady Ave)	Urban Princ. Art.	2	0.57	4,900	25	2,450	2,793	1.14	2,450	Uncongested
Total Arterials							**42,113**	**6.74**	**6,248**	

	Uncongested	% Type of Congestion on Congested Arterials (=100%) Moderate	Heavy	Severe	Extreme
VMT	12%	51%	26%	23%	0
Lane/Miles	23%	60%	23%	17%	0

CONGESTION CALCULATOR - CHARLOTTESVILLE, VA

INVENTORY MEASURES

2000 Base Conditions (rev. 9/25/01)

Urban Area Information	
Population (000)	160
Urban Area (square miles)	1,177
Population Density	136
Freeway	
Daily VMT (000)	833
Lane-miles	91
VMT/Lane-mile	9,154
Incident to Recurring Delay Ratio	2.1
Percent of Pk Pd Travel in Cong. ****	21
Percent Moderate	0
Percent Heavy	0
Percent Severe	0
Percent Extreme	0
Percent of Ln-miles that are Cong.	0
Percent Moderate	0
Percent Heavy	0
Percent Severe	0
Percent Extreme	0
Principal Arterial Streets	
Daily VMT (000)	1,729
Lane-miles	283
VMT/Lane-mile	6,110
Incident to Recurring Delay Ratio	1.1
Percent of Pk Pd Travel in Cong. ****	27
Percent Moderate	51
Percent Heavy	26
Percent Severe	23
Percent Extreme	0
Percent of Ln-miles that are Cong.	77
Percent Moderate	60
Percent Heavy	23
Percent Severe	17
Percent Extreme	0
Roadway System	
Daily VMT (000)	4,462
Total Road Miles (centerline)	1,647
Percent of Daily Travel During Congested Time	15
Cost Components	
Value of Time ($/hour)	12.40
Truck Operating Cost ($/mile)	2.85
Fuel Cost ($/gallon)	1.07

*** (as seen on website)

Fwy Percent of Pk Pd Travel in Cong	6
PAS Percent of Pk Pd Travel in Cong	8
ROADWAY SYSTEM PERFORMANCE	
Travel Rate Index	1.09
Travel Time Index	1.11
Percent of Daily Travel in Congestion	4
Annual Hours of Delay	
Total (1000 Person-hours)	889
Freeway	
Recurring Person-hours (000)	0
Incident Person-hours (000)	0
Principal Arterial Street	
Recurring Person-hours (000)	423
Incident Person-hours (000)	466
Annual Delay per Capita (person-hours)	6
Annual Excess Fuel Consumed	
Total (million gallons)	1
Fuel consumed per capita (gallons)	6
Annual Congestion Cost	
Total ($million)	14
Cost per Capita ($)	85
Average Peak Period Travel Speed	
Freeway System (mph)	51
Prin Arterial Street System (mph)	34
Roadway Congestion Index	0.86

	CONSTANTS	
Freeway Speed	Uncongested	60
	Moderate	45
	Heavy	38
	Severe	35
	Extreme	32
PAS Speed	Uncongested	35
	Moderate	30
	Heavy	27
	Severe	23
	Extreme	21
Vehicle occupancy		1.25
Pct of passenger-vehicles		0.95
Pct of commercial vehicles		0.05
Number of Annual Workdays		250

CHARLOTTESVILLE

VDOT Telework Study
Roadway Information for Congestion
Medium teleworking - 7.5% (rev. 9/25/01)
Estimated VMT Reduction 0.9948

ROADWAY	Classification	# Lanes	Rd Seg	ADT (2000)	Posted SL	ADT/Lane	Daily VMT	Reduced VMT	Ln-Miles	Red. ADT/Lane	Cong level
Interstate/Freeway											
I-64	Urban Interstate	4	0.17	29,000	65	7,250	4,930	4,904	0.68	7,212	Uncongested
RT 29/250 Bypass	Urban Freeway	4	0.35	35,000	55	8,750	12,250	12,186	1.4	8,705	Uncongested
RT 250 Bypass	Urban Freeway	4	0.6	38,000	55	9,500	22,800	22,681	2.4	9,451	Uncongested
Total Interstate/Freeway							**39,980**	**39,772**	**4.48**	**8,878**	

		% Type of Congestion on Congested Arterials (=100%)			
	Uncongested	**Moderate**	**Heavy**	**Severe**	**Extreme**
VMT	100%	0	0	0	0
Lane/Miles	100%	0	0	0	0

ROADWAY	Classification	# Lanes	Rd Seg	ADT (2000)	Posted SL	ADT/Lane	Daily VMT	Reduced VMT	Ln-Miles	Red. ADT/Lane	Cong level
Principal Arterials											
Rt 29 Bus (Fontaine Ave.)	Urban Princ. Art.	2	0.42	13,000	35	6,500	5,460	5,432	0.84	6,466	Moderate
Rt 29 Bus (Emmet St.)	Urban Princ. Art.	4	0.45	24,000	40	6,000	10,800	10,744	1.8	5,969	Moderate
Rte 250e (University)	Urban Princ. Art.	2	0.4	17,000	25	8,500	6,800	6,765	0.8	8,456	Heavy
Rte 250e (University)	Urban Princ. Art.	2	0.19	15,000	25	7,500	2,850	2,835	0.38	7,461	Heavy
Rte 250 (High St E)	Urban Princ. Art.	2	0.23	12,000	25	6,000	2,760	2,746	0.46	5,969	Moderate
Rte 250 (High St E)	Urban Princ. Art.	2	0.21	10,000	25	5,000	2,100	2,089	0.42	4,974	Uncongested
Rte 250 (High St E)	Urban Princ. Art.	2	0.45	19,000	25	9,500	8,550	8,506	0.9	9,451	Severe
Rte 250w BUS(Grady Ave)	Urban Princ. Art.	2	0.57	4,900	25	2,450	2,793	2,778	1.14	2,437	Uncongested
Total Arterials							**42,113**	**41,894**	**6.74**	**6,216**	

		% Type of Congestion on Congested Arterials (=100%)			
	Uncongested	**Moderate**	**Heavy**	**Severe**	**Extreme**
VMT	12%	51%	26%	23%	0
Lane/Miles	23%	60%	23%	17%	0

CONGESTION CALCULATOR - CHARLOTTESVILLE, VA
INVENTORY MEASURES
Medium teleworking - 7.5%(rev. 9/25/01)

Urban Area Information	
Population (000)	160
Urban Area (square miles)	1,177
Population Density	136
Freeway	
Daily VMT (000)	829
Lane-miles	91
VMT/Lane-mile	9,106
Incident to Recurring Delay Ratio	2.1
Percent of Pk Pd Travel in Cong. ****	21
Percent Moderate	0
Percent Heavy	0
Percent Severe	0
Percent Extreme	0
Percent of Ln-miles that are Cong.	0
Percent Moderate	0
Percent Heavy	0
Percent Severe	0
Percent Extreme	0
Principal Arterial Streets	
Daily VMT (000)	1,720
Lane-miles	283
VMT/Lane-mile	6,078
Incident to Recurring Delay Ratio	1.1
Percent of Pk Pd Travel in Cong. ****	27
Percent Moderate	51
Percent Heavy	26
Percent Severe	23
Percent Extreme	0
Percent of Ln-miles that are Cong.	77
Percent Moderate	60
Percent Heavy	23
Percent Severe	17
Percent Extreme	0
Roadway System	
Daily VMT (000)	4,439
Total Road Miles (centerline)	1,647
Percent of Daily Travel During Congested Time	15
Cost Components	
Value of Time ($/hour)	12.40
Truck Operating Cost ($/mile)	2.85
Fuel Cost ($/gallon)	1.07

*** (as seen on website)	
Fwy Percent of Pk Pd Travel in Cong	6
PAS Percent of Pk Pd Travel in Cong	8
ROADWAY SYSTEM PERFORMANCE	
Travel Rate Index	1.09
Travel Time Index	1.11
Percent of Daily Travel in Congestion	4
Annual Hours of Delay	
Total (1000 Person-hours)	884
Freeway	
Recurring Person-hours (000)	0
Incident Person-hours (000)	0
Principal Arterial Street	
Recurring Person-hours (000)	421
Incident Person-hours (000)	463
Annual Delay per Capita (person-hours)	6
Annual Excess Fuel Consumed	
Total (million gallons)	1
Fuel consumed per capita (gallons)	6
Annual Congestion Cost	
Total ($million)	14
Cost per Capita ($)	85
Average Peak Period Travel Speed	
Freeway System (mph)	51
Prin Arterial Street System (mph)	34
Roadway Congestion Index	0.85

CONSTANTS

Freeway Speed	Uncongested	60
	Moderate	45
	Heavy	38
	Severe	35
	Extreme	32
PAS Speed	Uncongested	35
	Moderate	30
	Heavy	27
	Severe	23
	Extreme	21
Vehicle occupancy		1.25
Pct of passenger-vehicles		0.95
Pct of commercial vehicles		0.05
Number of Annual Workdays		250

CHARLOTTESVILLE

VDOT Telework Study
Roadway Information for Congestion
High teleworking - 10% (rev. 9/25/01)
Estimated VMT Reduction 0.9896

ROADWAY	Classification	# Lanes	Rd Seg	ADT (2000)	Posted SL	ADT/Lane	Daily VMT	Reduced VMT	Ln-Miles	Red. ADT/Lane	Cong level
Interstate/Freeway											
I-64	Urban Interstate	4	0.17	29,000	65	7,250	4,930	4,879	0.68	7,175	Uncongested
RT 29/250 Bypass	Urban Freeway	4	0.35	35,000	55	8,750	12,250	12,123	1.4	8,659	Uncongested
RT 250 Bypass	Urban Freeway	4	0.6	38,000	55	9,500	22,800	22,563	2.4	9,401	Uncongested
Total Interstate/Freeway							**39,980**	**39,564**	**4.48**	**8,831**	

	Uncongested	% Type of Congestion on Congested Arterials (=100%) Moderate	Heavy	Severe	Extreme
VMT	100%	0	0	0	0
Lane/Miles	100%	0	0	0	0

ROADWAY	Classification	# Lanes	Rd Seg	ADT (2000)	Posted SL	ADT/Lane	Daily VMT	Reduced VMT	Ln-Miles	Red. ADT/Lane	Cong level
Principal Arterials											
Rt 29 Bus (Fontaine Ave.)	Urban Princ. Art.	2	0.42	13,000	35	6,500	5,460	5,403	0.84	6,432	Moderate
Rt 29 Bus (Emmet St.)	Urban Princ. Art.	4	0.45	24,000	40	6,000	10,800	10,688	1.8	5,938	Moderate
Rte 250e (University)	Urban Princ. Art.	2	0.4	17,000	25	8,500	6,800	6,729	0.8	8,412	Heavy
Rte 250e (University)	Urban Princ. Art.	2	0.19	15,000	25	7,500	2,850	2,820	0.38	7,422	Heavy
Rte 250 (High St E)	Urban Princ. Art.	2	0.23	12,000	25	6,000	2,760	2,731	0.46	5,938	Moderate
Rte 250 (High St E)	Urban Princ. Art.	2	0.21	10,000	25	5,000	2,100	2,078	0.42	4,948	Uncongested
Rte 250 (High St E)	Urban Princ. Art.	2	0.45	19,000	25	9,500	8,550	8,461	0.9	9,401	Severe
Rte 250w BUS(Grady Ave)	Urban Princ. Art.	2	0.57	4,900	25	2,450	2,793	2,764	1.14	2,425	Uncongested
Total Arterials							**42,113**	**41,675**	**6.74**	**6,183**	

	Uncongested	% Type of Congestion on Congested Arterials (=100%) Moderate	Heavy	Severe	Extreme
VMT	12%	51%	26%	23%	0
Lane/Miles	23%	60%	23%	17%	0

CONGESTION CALCULATOR - CHARLOTTESVILLE, VA
INVENTORY MEASURES
High teleworking - 10%(rev. 9/25/01)

Urban Area Information	
Population (000)	160
Urban Area (square miles)	1,177
Population Density	136
Freeway	
Daily VMT (000)	824
Lane-miles	91
VMT/Lane-mile	9,059
Incident to Recurring Delay Ratio	2.1
Percent of Pk Pd Travel in Cong. ****	21
Percent Moderate	0
Percent Heavy	0
Percent Severe	0
Percent Extreme	0
Percent of Ln-miles that are Cong.	0
Percent Moderate	0
Percent Heavy	0
Percent Severe	0
Percent Extreme	0
Principal Arterial Streets	
Daily VMT (000)	1,711
Lane-miles	283
VMT/Lane-mile	6,046
Incident to Recurring Delay Ratio	1.1
Percent of Pk Pd Travel in Cong. ****	27
Percent Moderate	51
Percent Heavy	26
Percent Severe	23
Percent Extreme	0
Percent of Ln-miles that are Cong.	77
Percent Moderate	60
Percent Heavy	23
Percent Severe	17
Percent Extreme	0
Roadway System	
Daily VMT (000)	4,416
Total Road Miles (centerline)	1,647
Percent of Daily Travel During Congested Time	15
Cost Components	
Value of Time ($/hour)	12.40
Truck Operating Cost ($/mile)	2.85
Fuel Cost ($/gallon)	1.07

*** (as seen on website)

Fwy Percent of Pk Pd Travel in Cong	6
PAS Percent of Pk Pd Travel in Cong	8
ROADWAY SYSTEM PERFORMANCE	
Travel Rate Index	1.09
Travel Time Index	1.11
Percent of Daily Travel in Congestion	4
Annual Hours of Delay	
Total (1000 Person-hours)	880
Freeway	
Recurring Person-hours (000)	0
Incident Person-hours (000)	0
Principal Arterial Street	
Recurring Person-hours (000)	419
Incident Person-hours (000)	461
Annual Delay per Capita (person-hours)	6
Annual Excess Fuel Consumed	
Total (million gallons)	1
Fuel consumed per capita (gallons)	6
Annual Congestion Cost	
Total ($million)	13
Cost per Capita ($)	84
Average Peak Period Travel Speed	
Freeway System (mph)	51
Prin Arterial Street System (mph)	34
Roadway Congestion Index	0.85

CONSTANTS

Freeway Speed: Uncongested, Moderate, Heavy, Severe, Extreme
PAS Speed: Uncongested, Moderate, Heavy, Severe, Extreme
Vehicle occupancy
Pct of passenger-vehicles
Pct of commercial vehicles
Number of Annual Workdays

DANVILLE

VDOT Telework Study
Roadway Information for Congestion
2000 Base Conditions (rev. 9/25/01)

ROADWAY	Classification	# Lanes	Rd Seg	ADT (2000)	Posted SL	ADT/Lane	Daily VMT	Ln-Miles	ADT/Lane	Cong level
Interstate/Freeway										
NONE IN DANVILLE										

Principal Arterials										
Rte 29 Bus(W. Main St.)	Urban Princ. Art.	4	1.78	13,000	45	3,250	23,140	7.12	3,250	Uncongested
Rte 29 Bus(W. Main St.)	Urban Princ. Art.	4	0.65	18,000	40	4,500	11,700	2.6	4,500	Uncongested
Rte 29 (Central Blvd)	Urban Princ. Art.	4	0.3	35,000	40	8,750	10,500	1.2	8,750	Severe
Rte 29 (Central Blvd)	Urban Princ. Art.	4	0.97	32,000	40	8,000	31,040	3.88	8,000	Heavy
Rte 29 (Piney Forest)	Urban Princ. Art.	4	0.98	28,000	40	7,000	27,440	3.92	7,000	Moderate
Rte 41 (Franklin Tpke)	Urban Princ. Art.	4	0.7	15,000	40	3,750	10,500	2.8	3,750	Uncongested
Rte 58 (Riverside Dr.)	Urban Princ. Art.	4	0.92	27,000	40	6,750	24,840	3.68	6,750	Moderate
Rte 58 (Riverside Dr.)	Urban Princ. Art.	4	0.24	33,000	40	8,250	7,920	0.96	8,250	Heavy
Rte 58 (Riverside Dr.)	Urban Princ. Art.	4	0.58	26,000	40	6,500	15,080	2.32	6,500	Moderate
Rte 86 (South Main)	Urban Princ. Art.	4	0.61	12,000	45	3,000	7,320	2.44	3,000	Uncongested
Rte 86 (South Main)	Urban Princ. Art.	2	1.11	9,800	45	4,900	10,878	2.22	4,900	Uncongested
Total Arterials							**180,358**	**33.14**	**5,442**	

		% Type of Congestion on Congested Arterials (=100%)			
	Uncongested	**Moderate**	**Heavy**	**Severe**	**Extreme**
VMT	35%	58%	33%	9%	0
Lane/Miles	52%	62%	30%	8%	0

CONGESTION CALCULATOR - DANVILLE, VA
INVENTORY MEASURES
2000 Base Conditions (rev. 9/25/01)

Urban Area Information	
Population (000)	110
Urban Area (square miles)	1,022
Population Density	108
Freeway	
Daily VMT (000)	0
Lane-miles	0
VMT/Lane-mile	1,000
Incident to Recurring Delay Ratio	2.1
Percent of Pk Pd Travel in Cong. ****	21
Percent Moderate	0
Percent Heavy	0
Percent Severe	0
Percent Extreme	0
Percent of Ln-miles that are Cong.	0
Percent Moderate	0
Percent Heavy	0
Percent Severe	0
Percent Extreme	0
Principal Arterial Streets	
Daily VMT (000)	1,659
Lane-miles	402
VMT/Lane-mile	4,127
Incident to Recurring Delay Ratio	1.1
Percent of Pk Pd Travel in Cong. ****	27
Percent Moderate	58
Percent Heavy	33
Percent Severe	9
Percent Extreme	0
Percent of Ln-miles that are Cong.	48
Percent Moderate	62
Percent Heavy	30
Percent Severe	8
Percent Extreme	0
Roadway System	
Daily VMT (000)	2,683
Total Road Miles (centerline)	1,857
Percent of Daily Travel During Congested Time	15
Cost Components	
Value of Time ($/hour)	12.40
Truck Operating Cost ($/mile)	2.85
Fuel Cost ($/gallon)	1.07

*** (as seen on website)	
Fwy Percent of Pk Pd Travel in Cong	6
PAS Percent of Pk Pd Travel in Cong	8
ROADWAY SYSTEM PERFORMANCE	
Travel Rate Index	1.04
Travel Time Index	1.07
Percent of Daily Travel in Congestion	4
Annual Hours of Delay	
Total (1000 Person-hours)	710
Freeway	
Recurring Person-hours (000)	0
Incident Person-hours (000)	0
Principal Arterial Street	
Recurring Person-hours (000)	338
Incident Person-hours (000)	372
Annual Delay per Capita (person-hours)	6
Annual Excess Fuel Consumed	
Total (million gallons)	1
Fuel consumed per capita (gallons)	9
Annual Congestion Cost	
Total ($million)	12
Cost per Capita ($)	107
Average Peak Period Travel Speed	
Freeway System (mph)	51
Prin Arterial Street System (mph)	34
Roadway Congestion Index	0.75

	CONSTANTS	
Freeway Speed	Uncongested	60
	Moderate	45
	Heavy	38
	Severe	35
	Extreme	32
PAS Speed	Uncongested	35
	Moderate	30
	Heavy	27
	Severe	23
	Extreme	21
Vehicle occupancy		1.25
Pct of passenger-vehicles		0.95
Pct of commercial vehicles		0.05
Number of Annual Workdays		250

DANVILLE

VDOT Telework Study
Roadway Information for Congestion
Medium teleworking - 7.5% (rev. 9/25/01)
Estimated VMT Reduction 0.9951

ROADWAY	Classification	# Lanes	Rd Seg	ADT (2000)	Posted SL	ADT/Lane	Daily VMT	Reduced VMT	Ln-Miles	Red. ADT/Lane	Cong level
Interstate/Freeway											
NONE IN DANVILLE											

Principal Arterials											
Rte 29 Bus(W. Main St.)	Urban Princ. Art.	4	1.78	13,000	45	3,250	23,140	23,027	7.12	3,234	Uncongested
Rte 29 Bus(W. Main St.)	Urban Princ. Art.	4	0.65	18,000	40	4,500	11,700	11,643	2.6	4,478	Uncongested
Rte 29 (Central Blvd)	Urban Princ. Art.	4	0.3	35,000	40	8,750	10,500	10,449	1.2	8,707	Severe
Rte 29 (Central Blvd)	Urban Princ. Art.	4	0.97	32,000	40	8,000	31,040	30,888	3.88	7,961	Heavy
Rte 29 (Piney Forest)	Urban Princ. Art.	4	0.98	28,000	40	7,000	27,440	27,306	3.92	6,966	Moderate
Rte 41 (Franklin Tpke)	Urban Princ. Art.	4	0.7	15,000	40	3,750	10,500	10,449	2.8	3,732	Uncongested
Rte 58 (Riverside Dr.)	Urban Princ. Art.	4	0.92	27,000	40	6,750	24,840	24,718	3.68	6,717	Moderate
Rte 58 (Riverside Dr.)	Urban Princ. Art.	4	0.24	33,000	40	8,250	7,920	7,881	0.96	8,210	Heavy
Rte 58 (Riverside Dr.)	Urban Princ. Art.	4	0.58	26,000	40	6,500	15,080	15,006	2.32	6,468	Moderate
Rte 86 (South Main)	Urban Princ. Art.	4	0.61	12,000	45	3,000	7,320	7,284	2.44	2,985	Uncongested
Rte 86 (South Main)	Urban Princ. Art.	2	1.11	9,800	45	4,900	10,878	10,825	2.22	4,876	Uncongested
Total Arterials							**180,358**	**179,474**	**33.14**	**5,416**	

		% Type of Congestion on Congested Arterials (=100%)			
	Uncongested	**Moderate**	**Heavy**	**Severe**	**Extreme**
VMT	35%	58%	33%	9%	0
Lane/Miles	52%	62%	30%	8%	0

CONGESTION CALCULATOR - DANVILLE, VA
INVENTORY MEASURES
Medium teleworking - 7.5%(rev. 9/25/01)

Urban Area Information	
Population (000)	110
Urban Area (square miles)	1,022
Population Density	108
Freeway	
Daily VMT (000)	0
Lane-miles	0
VMT/Lane-mile	1,000
Incident to Recurring Delay Ratio	2.1
Percent of Pk Pd Travel in Cong. ****	21
Percent Moderate	0
Percent Heavy	0
Percent Severe	0
Percent Extreme	0
Percent of Ln-miles that are Cong.	0
Percent Moderate	0
Percent Heavy	0
Percent Severe	0
Percent Extreme	0
Principal Arterial Streets	
Daily VMT (000)	1,651
Lane-miles	402
VMT/Lane-mile	4,107
Incident to Recurring Delay Ratio	1.1
Percent of Pk Pd Travel in Cong. ****	27
Percent Moderate	58
Percent Heavy	33
Percent Severe	9
Percent Extreme	0
Percent of Ln-miles that are Cong.	48
Percent Moderate	62
Percent Heavy	30
Percent Severe	8
Percent Extreme	0
Roadway System	
Daily VMT (000)	2,669
Total Road Miles (centerline)	1,857
Percent of Daily Travel During Congested Time	15
Cost Components	
Value of Time ($/hour)	12.40
Truck Operating Cost ($/mile)	2.85
Fuel Cost ($/gallon)	1.07

*** (as seen on website)	
Fwy Percent of Pk Pd Travel in Cong	6
PAS Percent of Pk Pd Travel in Cong	8
ROADWAY SYSTEM PERFORMANCE	
Travel Rate Index	1.03
Travel Time Index	1.05
Percent of Daily Travel in Congestion	4
Annual Hours of Delay	
Total (1000 Person-hours)	504
Freeway	
Recurring Person-hours (000)	0
Incident Person-hours (000)	0
Principal Arterial Street	
Recurring Person-hours (000)	240
Incident Person-hours (000)	264
Annual Delay per Capita (person-hours)	5
Annual Excess Fuel Consumed	
Total (million gallons)	1
Fuel consumed per capita (gallons)	7
Annual Congestion Cost	
Total ($million)	8
Cost per Capita ($)	76
Average Peak Period Travel Speed	
Freeway System (mph)	54
Prin Arterial Street System (mph)	34
Roadway Congestion Index	0.75

	CONSTANTS	
Freeway Speed	Uncongested	60
	Moderate	45
	Heavy	38
	Severe	35
	Extreme	32
PAS Speed	Uncongested	35
	Moderate	30
	Heavy	27
	Severe	23
	Extreme	21
Vehicle occupancy		1.25
Pct of passenger-vehicles		0.95
Pct of commercial vehicles		0.05
Number of Annual Workdays		250

DANVILLE

VDOT Telework Study
Roadway Information for Congestion
High teleworking - 10% (rev. 9/25/01)
Estimated VMT Reduction 0.9903

ROADWAY	Classification	# Lanes	Rd Seg	ADT (2000)	Posted SL	ADT/Lane	Daily VMT	Reduced VMT	Ln-Miles	Red. ADT/Lane	Cong level
Interstate/Freeway											
NONE IN DANVILLE											

Principal Arterials											
Rte 29 Bus(W. Main St.)	Urban Princ. Art.	4	1.78	13,000	45	3,250	23,140	22,916	7.12	3,218	Uncongested
Rte 29 Bus(W. Main St.)	Urban Princ. Art.	4	0.65	18,000	40	4,500	11,700	11,587	2.6	4,456	Uncongested
Rte 29 (Central Blvd)	Urban Princ. Art.	4	0.3	35,000	40	8,750	10,500	10,398	1.2	8,665	Severe
Rte 29 (Central Blvd)	Urban Princ. Art.	4	0.97	32,000	40	8,000	31,040	30,739	3.88	7,922	Heavy
Rte 29 (Piney Forest)	Urban Princ. Art.	4	0.98	28,000	40	7,000	27,440	27,174	3.92	6,932	Moderate
Rte 41 (Franklin Tpke)	Urban Princ. Art.	4	0.7	15,000	40	3,750	10,500	10,398	2.8	3,714	Uncongested
Rte 58 (Riverside Dr.)	Urban Princ. Art.	4	0.92	27,000	40	6,750	24,840	24,599	3.68	6,685	Moderate
Rte 58 (Riverside Dr.)	Urban Princ. Art.	4	0.24	33,000	40	8,250	7,920	7,843	0.96	8,170	Heavy
Rte 58 (Riverside Dr.)	Urban Princ. Art.	4	0.58	26,000	40	6,500	15,080	14,934	2.32	6,437	Moderate
Rte 86 (South Main)	Urban Princ. Art.	4	0.61	12,000	45	3,000	7,320	7,249	2.44	2,971	Uncongested
Rte 86 (South Main)	Urban Princ. Art.	2	1.11	9,800	45	4,900	10,878	10,772	2.22	4,852	Uncongested
Total Arterials							**180,358**	**178,609**	**33.14**	**5,390**	

		% Type of Congestion on Congested Arterials (=100%)			
	Uncongested	**Moderate**	**Heavy**	**Severe**	**Extreme**
VMT	35%	58%	33%	9%	0
Lane/Miles	52%	62%	30%	8%	0

CONGESTION CALCULATOR - DANVILLE, VA
INVENTORY MEASURES
High teleworking - 10%(rev. 9/25/01)

Urban Area Information	
Population (000)	110
Urban Area (square miles)	1,022
Population Density	108
Freeway	
Daily VMT (000)	0
Lane-miles	0
VMT/Lane-mile	1,000
Incident to Recurring Delay Ratio	2.1
Percent of Pk Pd Travel in Cong. ****	21
Percent Moderate	0
Percent Heavy	0
Percent Severe	0
Percent Extreme	0
Percent of Ln-miles that are Cong.	0
Percent Moderate	0
Percent Heavy	0
Percent Severe	0
Percent Extreme	0
Principal Arterial Streets	
Daily VMT (000)	1,643
Lane-miles	402
VMT/Lane-mile	4,087
Incident to Recurring Delay Ratio	1.1
Percent of Pk Pd Travel in Cong. ****	27
Percent Moderate	58
Percent Heavy	33
Percent Severe	9
Percent Extreme	0
Percent of Ln-miles that are Cong.	48
Percent Moderate	62
Percent Heavy	30
Percent Severe	8
Percent Extreme	0
Roadway System	
Daily VMT (000)	2,657
Total Road Miles (centerline)	1,857
Percent of Daily Travel During Congested Time	15
Cost Components	
Value of Time ($/hour)	12.40
Truck Operating Cost ($/mile)	2.85
Fuel Cost ($/gallon)	1.07

*** (as seen on website)

Fwy Percent of Pk Pd Travel in Cong	6
PAS Percent of Pk Pd Travel in Cong	8
ROADWAY SYSTEM PERFORMANCE	
Travel Rate Index	1.03
Travel Time Index	1.05
Percent of Daily Travel in Congestion	4
Annual Hours of Delay	
Total (1000 Person-hours)	502
Freeway	
Recurring Person-hours (000)	0
Incident Person-hours (000)	0
Principal Arterial Street	
Recurring Person-hours (000)	239
Incident Person-hours (000)	263
Annual Delay per Capita (person-hours)	5
Annual Excess Fuel Consumed	
Total (million gallons)	1
Fuel consumed per capita (gallons)	7
Annual Congestion Cost	
Total ($million)	8
Cost per Capita ($)	75
Average Peak Period Travel Speed	
Freeway System (mph)	54
Prin Arterial Street System (mph)	34
Roadway Congestion Index	0.74

CONSTANTS

Freeway Speed	Uncongested	60
	Moderate	45
	Heavy	38
	Severe	35
	Extreme	32
PAS Speed	Uncongested	35
	Moderate	30
	Heavy	27
	Severe	23
	Extreme	21
Vehicle occupancy		1.25
Pct of passenger-vehicles		0.95
Pct of commercial vehicles		0.05
Number of Annual Workdays		250

FREDERICKSBURG

VDOT Telework Study
Roadway Information for Congestion
2000 Base Conditions (rev. 9/27/01)

ROADWAY	Classification	# Lanes	Rd Seg	ADT (2000)	Posted SL	ADT/Lane	Daily VMT	Ln-Miles	ADT/Lane	Cong level
Interstate/Freeway										
Route 95 (Fredericksburg)	Urban Interstate	6	1.61	104,000	n/a	17,333	167,440	9.66	17,333	Moderate
Route 95 (Fredericksburg)	Urban Interstate	6	1.76	137,000	n/a	22,833	241,120	10.56	22,833	Severe
Route 95 (Spotsylvania)	Urban Interstate	6	2.07	72,000	65	12,000	149,040	12.42	12,000	Uncongested
Total Interstate/Freeway							**557,600**	**32.64**	**17,083**	

		% Type of Congestion on Congested Arterials (=100%)			
	Uncongested	Moderate	Heavy	Severe	Extreme
VMT	27%	41%	0	59%	0
Lane/Miles	38%	48%	0	52%	0

ROADWAY	Classification	# Lanes	Rd Seg	ADT (2000)	Posted SL	ADT/Lane	Daily VMT	Ln-Miles	ADT/Lane	Cong level
Principal Arterials										
Route 1(Jefferson Davis)	Urban Princ. Art.	4	1.97	31,000	35	7,750	61,070	7.88	7,750	Heavy
Route 1(Jefferson Davis)	Urban Princ. Art.	4	0.4	26,000	35	6,500	10,400	1.6	6,500	Moderate
Rte 3 BUS (Williams St)	Urban Princ. Art.	4	0.38	29,000	n/a	7,250	11,020	1.52	7,250	Heavy
Route 3 (Spotsylvania)	Urban Princ. Art.	4	4.66	24,000	45	6,000	111,840	18.64	6,000	Moderate
Route 208	Urban Princ. Art.	4	3.05	31,000	45	7,750	94,550	12.2	7,750	Heavy
Route 208	Urban Princ. Art.	4	3.53	16,000	45	4,000	56,480	14.12	4,000	Uncongested
Total Arterials							**345,360**	**55.96**	**6,172**	

		% Type of Congestion on Congested Arterials (=100%)			
	Uncongested	Moderate	Heavy	Severe	Extreme
VMT	16%	42%	58%	0	0
Lane/Miles	33%	48%	52%	0	0

CONGESTION CALCULATOR - FREDERICKSBURG, VA
INVENTORY MEASURES
2000 Base Conditions (rev. 9/27/01)

Urban Area Information	
Population (000)	241
Urban Area (square miles)	1,335
Population Density	181
Freeway	
Daily VMT (000)	3,239
Lane-miles	188
VMT/Lane-mile	17,228
Incident to Recurring Delay Ratio	2.1
Percent of Pk Pd Travel in Cong. ****	21
Percent Moderate	41
Percent Heavy	0
Percent Severe	59
Percent Extreme	0
Percent of Ln-miles that are Cong.	62
Percent Moderate	48
Percent Heavy	0
Percent Severe	52
Percent Extreme	0
Principal Arterial Streets	
Daily VMT (000)	2,098
Lane-miles	354
VMT/Lane-mile	5,923
Incident to Recurring Delay Ratio	1.1
Percent of Pk Pd Travel in Cong. ****	27
Percent Moderate	42
Percent Heavy	58
Percent Severe	0
Percent Extreme	0
Percent of Ln-miles that are Cong.	67
Percent Moderate	48
Percent Heavy	52
Percent Severe	0
Percent Extreme	0
Roadway System	
Daily VMT (000)	7,782
Total Road Miles (centerline)	1,939
Percent of Daily Travel During Congested Time	40
Cost Components	
Value of Time ($/hour)	12.40
Truck Operating Cost ($/mile)	2.85
Fuel Cost ($/gallon)	1.07

*** (as seen on website)

Fwy Percent of Pk Pd Travel in Cong	17
PAS Percent of Pk Pd Travel in Cong	22
ROADWAY SYSTEM PERFORMANCE	
Travel Rate Index	1.07
Travel Time Index	1.12
Percent of Daily Travel in Congestion	9
Annual Hours of Delay	
Total (1000 Person-hours)	4087
Freeway	
Recurring Person-hours (000)	929
Incident Person-hours (000)	1951
Principal Arterial Street	
Recurring Person-hours (000)	575
Incident Person-hours (000)	632
Annual Delay per Capita (person-hours)	17
Annual Excess Fuel Consumed	
Total (million gallons)	6
Fuel consumed per capita (gallons)	27
Annual Congestion Cost	
Total ($million)	71
Cost per Capita ($)	294
Average Peak Period Travel Speed	
Freeway System (mph)	56
Prin Arterial Street System (mph)	33
Roadway Congestion Index	1.20

CONSTANTS

Freeway Speed	Uncongested	60
	Moderate	45
	Heavy	38
	Severe	35
	Extreme	32
PAS Speed	Uncongested	35
	Moderate	30
	Heavy	27
	Severe	23
	Extreme	21
Vehicle occupancy		1.25
Pct of passenger-vehicles		0.95
Pct of commercial vehicles		0.05
Number of Annual Workdays		250

FREDERICKSBURG

VDOT Telework Study
Roadway Information for Congestion
Medium teleworking - 7.5% (rev. 9/27/01)
Estimated VMT Reduction 0.9875

ROADWAY	Classification	# Lanes	Rd Seg	ADT (2000)	Posted SL	ADT/Lane	Daily VMT	Reduced VMT	Ln-Miles	Red. ADT/Lane	Cong level
Interstate/Freeway											
Route 95 (Fredericksburg)	Urban Interstate	6	1.61	104,000	n/a	17,333	167,440	165,347	9.66	17,117	Moderate
Route 95 (Fredericksburg)	Urban Interstate	6	1.76	137,000	n/a	22,833	241,120	238,106	10.56	22,548	Severe
Route 95 (Spotsylvania)	Urban Interstate	6	2.07	72,000	65	12,000	149,040	147,177	12.42	11,850	Uncongested
Total Interstate/Freeway							**557,600**	**550,630**	**32.64**	**16,870**	

		% Type of Congestion on Congested Arterials (=100%)			
	Uncongested	Moderate	Heavy	Severe	Extreme
VMT	27%	41%	0	59%	0
Lane/Miles	38%	48%	0	52%	0

ROADWAY	Classification	# Lanes	Rd Seg	ADT (2000)	Posted SL	ADT/Lane	Daily VMT	Reduced VMT	Ln-Miles	Red. ADT/Lane	Cong level
Principal Arterials											
Route 1(Jefferson Davis)	Urban Princ. Art.	4	1.97	31,000	35	7,750	61,070	60,307	7.88	7,750	Heavy
Route 1(Jefferson Davis)	Urban Princ. Art.	4	0.4	26,000	35	6,500	10,400	10,270	1.6	6,500	Moderate
Rte 3 BUS (Williams St)	Urban Princ. Art.	4	0.38	29,000	n/a	7,250	11,020	10,882	1.52	7,250	Heavy
Route 3 (Spotsylvania)	Urban Princ. Art.	4	4.66	24,000	45	6,000	111,840	110,442	18.64	6,000	Moderate
Route 208	Urban Princ. Art.	4	3.05	31,000	45	7,750	94,550	93,368	12.2	7,750	Heavy
Route 208	Urban Princ. Art.	4	3.53	16,000	45	4,000	56,480	55,774	14.12	4,000	Uncongested
Total Arterials							**345,360**	**341,043**	**55.96**	**6,094**	

		% Type of Congestion on Congested Arterials (=100%)			
	Uncongested	Moderate	Heavy	Severe	Extreme
VMT	16%	42%	58%	0	0
Lane/Miles	33%	48%	52%	0	0

CONGESTION CALCULATOR - FREDERICKSBURG, VA
INVENTORY MEASURES
Medium teleworking - 7.5%(rev. 9/27/01)

Urban Area Information	
Population (000)	241
Urban Area (square miles)	1,335
Population Density	181
Freeway	
Daily VMT (000)	3,198
Lane-miles	188
VMT/Lane-mile	17,013
Incident to Recurring Delay Ratio	2.1
Percent of Pk Pd Travel in Cong. ****	21
Percent Moderate	41
Percent Heavy	0
Percent Severe	59
Percent Extreme	0
Percent of Ln-miles that are Cong.	62
Percent Moderate	48
Percent Heavy	0
Percent Severe	52
Percent Extreme	0
Principal Arterial Streets	
Daily VMT (000)	2,072
Lane-miles	354
VMT/Lane-mile	5,849
Incident to Recurring Delay Ratio	1.1
Percent of Pk Pd Travel in Cong. ****	27
Percent Moderate	42
Percent Heavy	58
Percent Severe	0
Percent Extreme	0
Percent of Ln-miles that are Cong.	67
Percent Moderate	48
Percent Heavy	52
Percent Severe	0
Percent Extreme	0
Roadway System	
Daily VMT (000)	7,685
Total Road Miles (centerline)	1,939
Percent of Daily Travel During Congested Time	40
Cost Components	
Value of Time ($/hour)	12.40
Truck Operating Cost ($/mile)	2.85
Fuel Cost ($/gallon)	1.07

*** (as seen on website)

Fwy Percent of Pk Pd Travel in Cong	17
PAS Percent of Pk Pd Travel in Cong	22
ROADWAY SYSTEM PERFORMANCE	
Travel Rate Index	1.06
Travel Time Index	1.12
Percent of Daily Travel in Congestion	9
Annual Hours of Delay	
Total (1000 Person-hours)	3951
Freeway	
Recurring Person-hours (000)	898
Incident Person-hours (000)	1886
Principal Arterial Street	
Recurring Person-hours (000)	556
Incident Person-hours (000)	611
Annual Delay per Capita (person-hours)	16
Annual Excess Fuel Consumed	
Total (million gallons)	6
Fuel consumed per capita (gallons)	26
Annual Congestion Cost	
Total ($million)	69
Cost per Capita ($)	284
Average Peak Period Travel Speed	
Freeway System (mph)	56
Prin Arterial Street System (mph)	33
Roadway Congestion Index	1.18

CONSTANTS

Freeway Speed	Uncongested	60
	Moderate	45
	Heavy	38
	Severe	35
	Extreme	32
PAS Speed	Uncongested	35
	Moderate	30
	Heavy	27
	Severe	23
	Extreme	21
Vehicle occupancy		1.25
Pct of passenger-vehicles		0.95
Pct of commercial vehicles		0.05
Number of Annual Workdays		250

FREDERICKSBURG

VDOT Telework Study
Roadway Information for Congestion
High teleworking - 10% (rev. 9/27/01)
Estimated VMT Reduction 0.975

ROADWAY	Classification	# Lanes	Rd Seg	ADT (2000)	Posted SL	ADT/Lane	Daily VMT	Reduced VMT	Ln-Miles	Red. ADT/Lane	Cong level
Interstate/Freeway											
Route 95 (Fredericksburg)	Urban Interstate	6	1.61	104,000	n/a	17,333	167,440	163,254	9.66	16,900	Moderate
Route 95 (Fredericksburg)	Urban Interstate	6	1.76	137,000	n/a	22,833	241,120	235,092	10.56	22,263	Severe
Route 95 (Spotsylvania)	Urban Interstate	6	2.07	72,000	65	12,000	149,040	145,314	12.42	11,700	Uncongested
Total Interstate/Freeway							**557,600**	**543,660**	**32.64**	**16,656**	

		% Type of Congestion on Congested Arterials (=100%)			
	Uncongested	**Moderate**	**Heavy**	**Severe**	**Extreme**
VMT	27%	41%	0	59%	0
Lane/Miles	38%	48%	0	52%	0

Principal Arterials											
Route 1(Jefferson Davis)	Urban Princ. Art.	4	1.97	31,000	35	7,750	61,070	59,543	7.88	7,750	Heavy
Route 1(Jefferson Davis)	Urban Princ. Art.	4	0.4	26,000	35	6,500	10,400	10,140	1.6	6,500	Moderate
Rte 3 BUS (Williams St)	Urban Princ. Art.	4	0.38	29,000	n/a	7,250	11,020	10,745	1.52	7,250	Heavy
Route 3 (Spotsylvania)	Urban Princ. Art.	4	4.66	24,000	45	6,000	111,840	109,044	18.64	6,000	Moderate
Route 208	Urban Princ. Art.	4	3.05	31,000	45	7,750	94,550	92,186	12.2	7,750	Heavy
Route 208	Urban Princ. Art.	4	3.53	16,000	45	4,000	56,480	55,068	14.12	4,000	Uncongested
Total Arterials							**345,360**	**336,726**	**55.96**	**6,017**	

		% Type of Congestion on Congested Arterials (=100%)			
	Uncongested	**Moderate**	**Heavy**	**Severe**	**Extreme**
VMT	16%	42%	58%	0	0
Lane/Miles	33%	48%	52%	0	0

CONGESTION CALCULATOR - FREDERICKSBURG, VA
INVENTORY MEASURES
High teleworking - 10%(rev. 9/27/01)

Urban Area Information	
Population (000)	241
Urban Area (square miles)	1,335
Population Density	181
Freeway	
Daily VMT (000)	3,158
Lane-miles	188
VMT/Lane-mile	16,797
Incident to Recurring Delay Ratio	2.1
Percent of Pk Pd Travel in Cong. ****	21
Percent Moderate	41
Percent Heavy	0
Percent Severe	59
Percent Extreme	0
Percent of Ln-miles that are Cong.	62
Percent Moderate	48
Percent Heavy	0
Percent Severe	52
Percent Extreme	0
Principal Arterial Streets	
Daily VMT (000)	2,046
Lane-miles	354
VMT/Lane-mile	5,775
Incident to Recurring Delay Ratio	1.1
Percent of Pk Pd Travel in Cong. ****	27
Percent Moderate	42
Percent Heavy	58
Percent Severe	0
Percent Extreme	0
Percent of Ln-miles that are Cong.	67
Percent Moderate	48
Percent Heavy	52
Percent Severe	0
Percent Extreme	0
Roadway System	
Daily VMT (000)	7,588
Total Road Miles (centerline)	1,939
Percent of Daily Travel During Congested Time	40
Cost Components	
Value of Time ($/hour)	12.40
Truck Operating Cost ($/mile)	2.85
Fuel Cost ($/gallon)	1.07

*** (as seen on website)

Fwy Percent of Pk Pd Travel in Cong	17
PAS Percent of Pk Pd Travel in Cong	22
ROADWAY SYSTEM PERFORMANCE	
Travel Rate Index	1.06
Travel Time Index	1.12
Percent of Daily Travel in Congestion	9
Annual Hours of Delay	
Total (1000 Person-hours)	3901
Freeway	
Recurring Person-hours (000)	887
Incident Person-hours (000)	1862
Principal Arterial Street	
Recurring Person-hours (000)	549
Incident Person-hours (000)	603
Annual Delay per Capita (person-hours)	16
Annual Excess Fuel Consumed	
Total (million gallons)	6
Fuel consumed per capita (gallons)	25
Annual Congestion Cost	
Total ($million)	68
Cost per Capita ($)	281
Average Peak Period Travel Speed	
Freeway System (mph)	56
Prin Arterial Street System (mph)	33
Roadway Congestion Index	1.17

CONSTANTS

Freeway Speed	Uncongested	60
	Moderate	45
	Heavy	38
	Severe	35
	Extreme	32
PAS Speed	Uncongested	35
	Moderate	30
	Heavy	27
	Severe	23
	Extreme	21
Vehicle occupancy		1.25
Pct of passenger-vehicles		0.95
Pct of commercial vehicles		0.05
Number of Annual Workdays		250

HARRISONBURG

VDOT Telework Study
Roadway Information for Congestion
2000 Base Conditions (rev. 9/25/01)

ROADWAY	Classification	# Lanes	Rd Seg	ADT (2000)	Posted SL	ADT/Lane	Daily VMT	Ln-Miles	ADT/Lane	Cong level
Interstate/Freeway										
Rte 81	Rural Interstate	4	3.33	43,000	65	10,750	143,190	13.32	10,750	Uncongested
Rte 81	Rural Interstate	4	1.6	42,000	65	10,500	67,200	6.4	10,500	Uncongested
Total Interstate/Freeway							210,390	19.72	10,669	

		% Type of Congestion on Congested Arterials (=100%)			
	Uncongested	Moderate	Heavy	Severe	Extreme
VMT	100%	0	0	0	0
Lane/Miles	100%	0	0	0	0

ROADWAY	Classification	# Lanes	Rd Seg	ADT (2000)	Posted SL	ADT/Lane	Daily VMT	Ln-Miles	ADT/Lane	Cong level
Principal Arterials										
Rte 33 (W. Market St.)	Urban Princ. Art.	2	0.61	9,300	25	4,650	5,673	1.22	4,650	Uncongested
Rte 42 (S. High St.)	Urban Princ. Art.	4	0.4	21,000	35	5,250	8,400	1.6	5,250	Uncongested
Rte 42 (VA Ave.)	Urban Princ. Art.	2	0.44	9,800	35	4,900	4,312	0.88	4,900	Uncongested
Total Arterials							18,385	3.70	4,969	

		% Type of Congestion on Congested Arterials (=100%)			
	Uncongested	Moderate	Heavy	Severe	Extreme
VMT	100%	0	0	0	0
Lane/Miles	100%	0	0	0	0

CONGESTION CALCULATOR - HARRISONBURG, VA
INVENTORY MEASURES
2000 Base Conditions (rev. 9/25/01)

Urban Area Information	
Population (000)	40
Urban Area (square miles)	11
Population Density	3,588
Freeway	
Daily VMT (000)	283
Lane-miles	26
VMT/Lane-mile	10,884
Incident to Recurring Delay Ratio	2.1
Percent of Pk Pd Travel in Cong. ****	21
Percent Moderate	0
Percent Heavy	0
Percent Severe	0
Percent Extreme	0
Percent of Ln-miles that are Cong.	0
Percent Moderate	0
Percent Heavy	0
Percent Severe	0
Percent Extreme	0
Principal Arterial Streets	
Daily VMT (000)	240
Lane-miles	34
VMT/Lane-mile	7,059
Incident to Recurring Delay Ratio	1.1
Percent of Pk Pd Travel in Cong. ****	27
Percent Moderate	0
Percent Heavy	0
Percent Severe	0
Percent Extreme	0
Percent of Ln-miles that are Cong.	0
Percent Moderate	0
Percent Heavy	0
Percent Severe	0
Percent Extreme	0
Roadway System	
Daily VMT (000)	797
Total Road Miles (centerline)	134
Percent of Daily Travel During Congested Time	21
Cost Components	
Value of Time ($/hour)	12.40
Truck Operating Cost ($/mile)	2.85
Fuel Cost ($/gallon)	1.07

*** (as seen on website)

Fwy Percent of Pk Pd Travel in Cong	9
PAS Percent of Pk Pd Travel in Cong	11
ROADWAY SYSTEM PERFORMANCE	
Travel Rate Index	1.20
Travel Time Index	1.20
Percent of Daily Travel in Congestion	5
Annual Hours of Delay	
Total (1000 Person-hours)	0
Freeway	
Recurring Person-hours (000)	0
Incident Person-hours (000)	0
Principal Arterial Street	
Recurring Person-hours (000)	0
Incident Person-hours (000)	0
Annual Delay per Capita (person-hours)	0
Annual Excess Fuel Consumed	
Total (million gallons)	0
Fuel consumed per capita (gallons)	0
Annual Congestion Cost	
Total ($million)	0
Cost per Capita ($)	0
Average Peak Period Travel Speed	
Freeway System (mph)	51
Prin Arterial Street System (mph)	28
Roadway Congestion Index	0.90

CONSTANTS

Freeway Speed	Uncongested	60
	Moderate	45
	Heavy	38
	Severe	35
	Extreme	32
PAS Speed	Uncongested	35
	Moderate	30
	Heavy	27
	Severe	23
	Extreme	21
Vehicle occupancy		1.25
Pct of passenger-vehicles		0.95
Pct of commercial vehicles		0.05
Number of Annual Workdays		250

HARRISONBURG

VDOT Telework Study
Roadway Information for Congestion
Medium teleworking - 7.5% (rev. 9/25/01)
Estimated VMT Reduction 0.993

ROADWAY	Classification	# Lanes	Rd Seg	ADT (2000)	Posted SL	ADT/Lane	Daily VMT	Reduced VMT	Ln-Miles	Red. ADT/Lane	Cong level
Interstate/Freeway											
Rte 81	Rural Interstate	4	3.33	43,000	65	10,750	143,190	142,188	13.32	10,675	Uncongested
Rte 81	Rural Interstate	4	1.6	42,000	65	10,500	67,200	66,730	6.4	10,427	Uncongested
Total Interstate/Freeway							**210,390**	**208,917**	**19.72**	**10,594**	

	Uncongested	% Type of Congestion on Congested Arterials (=100%) Moderate	Heavy	Severe	Extreme
VMT	100%	0	0	0	0
Lane/Miles	100%	0	0	0	0

ROADWAY	Classification	# Lanes	Rd Seg	ADT (2000)	Posted SL	ADT/Lane	Daily VMT	Reduced VMT	Ln-Miles	Red. ADT/Lane	Cong level
Principal Arterials											
Rte 33 (W. Market St.)	Urban Princ. Art.	2	0.61	9,300	25	4,650	5,673	5,633	1.22	4,617	Uncongested
Rte 42 (S. High St.)	Urban Princ. Art.	4	0.4	21,000	35	5,250	8,400	8,341	1.6	5,213	Uncongested
Rte 42 (VA Ave.)	Urban Princ. Art.	2	0.44	9,800	35	4,900	4,312	4,282	0.88	4,866	Uncongested
Total Arterials							**18,385**	**18,256**	**3.70**	**4,934**	

	Uncongested	% Type of Congestion on Congested Arterials (=100%) Moderate	Heavy	Severe	Extreme
VMT	100%	0	0	0	0
Lane/Miles	100%	0	0	0	0

CONGESTION CALCULATOR - HARRISONBURG, VA
INVENTORY MEASURES
Medium teleworking - 7.5%(rev. 9/25/01)

Urban Area Information	
Population (000)	40
Urban Area (square miles)	11
Population Density	3,588
Freeway	
Daily VMT (000)	281
Lane-miles	26
VMT/Lane-mile	10,808
Incident to Recurring Delay Ratio	2.1
Percent of Pk Pd Travel in Cong. ****	21
Percent Moderate	0
Percent Heavy	0
Percent Severe	0
Percent Extreme	0
Percent of Ln-miles that are Cong.	0
Percent Moderate	0
Percent Heavy	0
Percent Severe	0
Percent Extreme	0
Principal Arterial Streets	
Daily VMT (000)	238
Lane-miles	34
VMT/Lane-mile	7,009
Incident to Recurring Delay Ratio	1.1
Percent of Pk Pd Travel in Cong. ****	27
Percent Moderate	0
Percent Heavy	0
Percent Severe	0
Percent Extreme	0
Percent of Ln-miles that are Cong.	0
Percent Moderate	0
Percent Heavy	0
Percent Severe	0
Percent Extreme	0
Roadway System	
Daily VMT (000)	791
Total Road Miles (centerline)	134
Percent of Daily Travel During Congested Time	21
Cost Components	
Value of Time ($/hour)	12.40
Truck Operating Cost ($/mile)	2.85
Fuel Cost ($/gallon)	1.07

*** (as seen on website)	
Fwy Percent of Pk Pd Travel in Cong	9
PAS Percent of Pk Pd Travel in Cong	11
ROADWAY SYSTEM PERFORMANCE	
Travel Rate Index	1.21
Travel Time Index	1.21
Percent of Daily Travel in Congestion	5
Annual Hours of Delay	
Total (1000 Person-hours)	0
Freeway	
Recurring Person-hours (000)	0
Incident Person-hours (000)	0
Principal Arterial Street	
Recurring Person-hours (000)	0
Incident Person-hours (000)	0
Annual Delay per Capita (person-hours)	0
Annual Excess Fuel Consumed	
Total (million gallons)	0
Fuel consumed per capita (gallons)	0
Annual Congestion Cost	
Total ($million)	0
Cost per Capita ($)	0
Average Peak Period Travel Speed	
Freeway System (mph)	51
Prin Arterial Street System (mph)	28
Roadway Congestion Index	0.90

	CONSTANTS	
Freeway Speed	Uncongested	60
	Moderate	45
	Heavy	38
	Severe	35
	Extreme	32
PAS Speed	Uncongested	35
	Moderate	30
	Heavy	27
	Severe	23
	Extreme	21
Vehicle occupancy		1.25
Pct of passenger-vehicles		0.95
Pct of commercial vehicles		0.05
Number of Annual Workdays		250

HARRISONBURG

VDOT Telework Study
Roadway Information for Congestion
High teleworking - 10% (rev. 9/25/01)
Estimated VMT Reduction 0.986

ROADWAY	Classification	# Lanes	Rd Seg	ADT (2000)	Posted SL	ADT/Lane	Daily VMT	Reduced VMT	Ln-Miles	Red. ADT/Lane	Cong level
Interstate/Freeway											
Rte 81	Rural Interstate	4	3.33	43,000	65	10,750	143,190	141,185	13.32	10,600	Uncongested
Rte 81	Rural Interstate	4	1.6	42,000	65	10,500	67,200	66,259	6.4	10,353	Uncongested
Total Interstate/Freeway							**210,390**	**207,445**	**19.72**	**10,520**	

	Uncongested	% Type of Congestion on Congested Arterials (=100%) Moderate	Heavy	Severe	Extreme
VMT	100%	0	0	0	0
Lane/Miles	100%	0	0	0	0

ROADWAY	Classification	# Lanes	Rd Seg	ADT (2000)	Posted SL	ADT/Lane	Daily VMT	Reduced VMT	Ln-Miles	Red. ADT/Lane	Cong level
Principal Arterials											
Rte 33 (W. Market St.)	Urban Princ. Art.	2	0.61	9,300	25	4,650	5,673	5,594	1.22	4,585	Uncongested
Rte 42 (S. High St.)	Urban Princ. Art.	4	0.4	21,000	35	5,250	8,400	8,282	1.6	5,177	Uncongested
Rte 42 (VA Ave.)	Urban Princ. Art.	2	0.44	9,800	35	4,900	4,312	4,252	0.88	4,831	Uncongested
Total Arterials							**18,385**	**18,128**	**3.70**	**4,899**	

	Uncongested	% Type of Congestion on Congested Arterials (=100%) Moderate	Heavy	Severe	Extreme
VMT	100%	0	0	0	0
Lane/Miles	100%	0	0	0	0

CONGESTION CALCULATOR - HARRISONBURG, VA
INVENTORY MEASURES
High teleworking - 10%(rev. 9/25/01)

Urban Area Information	
Population (000)	40
Urban Area (square miles)	11
Population Density	3,588
Freeway	
Daily VMT (000)	279
Lane-miles	26
VMT/Lane-mile	10,732
Incident to Recurring Delay Ratio	2.1
Percent of Pk Pd Travel in Cong. ****	21
Percent Moderate	0
Percent Heavy	0
Percent Severe	0
Percent Extreme	0
Percent of Ln-miles that are Cong.	0
Percent Moderate	0
Percent Heavy	0
Percent Severe	0
Percent Extreme	0
Principal Arterial Streets	
Daily VMT (000)	237
Lane-miles	34
VMT/Lane-mile	6,960
Incident to Recurring Delay Ratio	1.1
Percent of Pk Pd Travel in Cong. ****	27
Percent Moderate	0
Percent Heavy	0
Percent Severe	0
Percent Extreme	0
Percent of Ln-miles that are Cong.	0
Percent Moderate	0
Percent Heavy	0
Percent Severe	0
Percent Extreme	0
Roadway System	
Daily VMT (000)	786
Total Road Miles (centerline)	134
Percent of Daily Travel During Congested Time	21
Cost Components	
Value of Time ($/hour)	12.40
Truck Operating Cost ($/mile)	2.85
Fuel Cost ($/gallon)	1.07

*** (as seen on website)

Fwy Percent of Pk Pd Travel in Cong	9
PAS Percent of Pk Pd Travel in Cong	11
ROADWAY SYSTEM PERFORMANCE	
Travel Rate Index	1.21
Travel Time Index	1.21
Percent of Daily Travel in Congestion	5
Annual Hours of Delay	
Total (1000 Person-hours)	0
Freeway	
Recurring Person-hours (000)	0
Incident Person-hours (000)	0
Principal Arterial Street	
Recurring Person-hours (000)	0
Incident Person-hours (000)	0
Annual Delay per Capita (person-hours)	0
Annual Excess Fuel Consumed	
Total (million gallons)	0
Fuel consumed per capita (gallons)	0
Annual Congestion Cost	
Total ($million)	0
Cost per Capita ($)	0
Average Peak Period Travel Speed	
Freeway System (mph)	51
Prin Arterial Street System (mph)	28
Roadway Congestion Index	0.89

CONSTANTS

Freeway Speed	Uncongested	60
	Moderate	45
	Heavy	38
	Severe	35
	Extreme	32
PAS Speed	Uncongested	35
	Moderate	30
	Heavy	27
	Severe	23
	Extreme	21
Vehicle occupancy		1.25
Pct of passenger-vehicles		0.95
Pct of commercial vehicles		0.05
Number of Annual Workdays		250

LYNCHBURG

VDOT Telework Study
Roadway Information for Congestion
2000 Base Conditions (rev. 9/25/01)

ROADWAY	Classification	# Lanes	Rd Seg	ADT (2000)	Posted SL	ADT/Lane	Daily VMT	Ln-Miles	VMT/LnMi	Cong level
Interstate/Freeway										
Rte 29 (Lynchburg Exp)	Urban Freeway	4	1.37	44,000	55	11,000	60,280	5.48	11,000	Uncongested
Rte 501(Lynchburg Exp)	Urban Freeway	2	3.4	12,000	55	6,000	40,800	6.8	6,000	Uncongested
Total Interstate/Freeway							**101,080**	**12.28**	**8,231**	

		% Type of Congestion on Congested Arterials (=100%)			
	Uncongested	**Moderate**	**Heavy**	**Severe**	**Extreme**
VMT	100%	0	0	0	0
Lane/Miles	100%	0	0	0	0

Principal Arterials										
Rte 29 (Wards Road)	Urban Princ. Art.	4	1.74	31,000	45	7,750	53,940	6.96	7,750	Heavy
Rte 29 Bus (Wards Rd)	Urban Princ. Art.	2	0.76	17,000	35	8,500	12,920	1.52	8,500	Heavy
Rte 29 Bus (5th St)	Urban Princ. Art.	2	0.7	16,000	30	8,000	11,200	1.4	8,000	Heavy
Total Arterials							**78,060**	**9.88**	**7,901**	

		% Type of Congestion on Congested Arterials (=100%)			
	Uncongested	**Moderate**	**Heavy**	**Severe**	**Extreme**
VMT	20%	0	100%	0	0
Lane/Miles	31%	0	100%	0	0

CONGESTION CALCULATOR - LYNCHBURG, VA
INVENTORY MEASURES
2000 Base Conditions (rev. 9/25/01)

Urban Area Information	
Population (000)	215
Urban Area (square miles)	1,812
Population Density	119
Freeway	
Daily VMT (000)	481
Lane-miles	57
VMT/Lane-mile	8,439
Incident to Recurring Delay Ratio	2.1
Percent of Pk Pd Travel in Cong. ****	21
Percent Moderate	0
Percent Heavy	0
Percent Severe	0
Percent Extreme	0
Percent of Ln-miles that are Cong.	0
Percent Moderate	0
Percent Heavy	0
Percent Severe	0
Percent Extreme	0
Principal Arterial Streets	
Daily VMT (000)	2,999
Lane-miles	752
VMT/Lane-mile	3,988
Incident to Recurring Delay Ratio	1.1
Percent of Pk Pd Travel in Cong. ****	27
Percent Moderate	0
Percent Heavy	100
Percent Severe	0
Percent Extreme	0
Percent of Ln-miles that are Cong.	69
Percent Moderate	0
Percent Heavy	100
Percent Severe	0
Percent Extreme	0
Roadway System	
Daily VMT (000)	5,145
Total Road Miles (centerline)	2,822
Percent of Daily Travel During Congested Time	15
Cost Components	
Value of Time ($/hour)	12.40
Truck Operating Cost ($/mile)	2.85
Fuel Cost ($/gallon)	1.07

*** (as seen on website)

Fwy Percent of Pk Pd Travel in Cong	6
PAS Percent of Pk Pd Travel in Cong	8
ROADWAY SYSTEM PERFORMANCE	
Travel Rate Index	1.04
Travel Time Index	1.06
Percent of Daily Travel in Congestion	4
Annual Hours of Delay	
Total (1000 Person-hours)	1035
Freeway	
Recurring Person-hours (000)	0
Incident Person-hours (000)	0
Principal Arterial Street	
Recurring Person-hours (000)	493
Incident Person-hours (000)	542
Annual Delay per Capita (person-hours)	5
Annual Excess Fuel Consumed	
Total (million gallons)	1
Fuel consumed per capita (gallons)	6
Annual Congestion Cost	
Total ($million)	16
Cost per Capita ($)	77
Average Peak Period Travel Speed	
Freeway System (mph)	54
Prin Arterial Street System (mph)	34
Roadway Congestion Index	0.69

	CONSTANTS	
Freeway Speed	Uncongested	60
	Moderate	45
	Heavy	38
	Severe	35
	Extreme	32
PAS Speed	Uncongested	35
	Moderate	30
	Heavy	27
	Severe	23
	Extreme	21
Vehicle occupancy		1.25
Pct of passenger-vehicles		0.95
Pct of commercial vehicles		0.05
Number of Annual Workdays		250

LYNCHBURG

VDOT Telework Study
Roadway Information for Congestion
Medium teleworking - 7.5% (rev. 9/25/01)
Estimated VMT Reduction 0.9945

ROADWAY	Classification	# Lanes	Rd Seg	ADT (2000)	Posted SL	ADT/Lane	Daily VMT	Reduced VMT	Ln-Miles	Red. ADT/Lane	Cong level
Interstate/Freeway											
Rte 29 (Lynchburg Exp)	Urban Freeway	4	1.37	44,000	55	11,000	60,280	59,948	5.48	10,940	Uncongested
Rte 501(Lynchburg Exp)	Urban Freeway	2	3.4	12,000	55	6,000	40,800	40,576	6.8	5,967	Uncongested
Total Interstate/Freeway							**101,080**	**100,524**	**12.28**	**8,186**	

		% Type of Congestion on Congested Arterials (=100%)			
	Uncongested	Moderate	Heavy	Severe	Extreme
VMT	100%	0	0	0	0
Lane/Miles	100%	0	0	0	0

ROADWAY	Classification	# Lanes	Rd Seg	ADT (2000)	Posted SL	ADT/Lane	Daily VMT	Reduced VMT	Ln-Miles	Red. ADT/Lane	Cong level
Principal Arterials											
Rte 29 (Wards Road)	Urban Princ. Art.	4	1.74	31,000	45	7,750	53,940	53,643	6.96	7,707	Heavy
Rte 29 Bus (Wards Rd)	Urban Princ. Art.	2	0.76	17,000	35	8,500	12,920	12,849	1.52	8,453	Heavy
Rte 29 Bus (5th St)	Urban Princ. Art.	2	0.7	16,000	30	8,000	11,200	11,138	1.4	7,956	Heavy
Total Arterials							**78,060**	**77,631**	**9.88**	**7,857**	

		% Type of Congestion on Congested Arterials (=100%)			
	Uncongested	Moderate	Heavy	Severe	Extreme
VMT	20%	0	100%	0	0
Lane/Miles	31%	0	100%	0	0

CONGESTION CALCULATOR - LYNCHBURG, VA
INVENTORY MEASURES
Medium teleworking - 7.5%(rev. 9/25/01)

Urban Area Information	
Population (000)	215
Urban Area (square miles)	1,812
Population Density	119
Freeway	
Daily VMT (000)	478
Lane-miles	57
VMT/Lane-mile	8,392
Incident to Recurring Delay Ratio	2.1
Percent of Pk Pd Travel in Cong. ****	21
Percent Moderate	0
Percent Heavy	0
Percent Severe	0
Percent Extreme	0
Percent of Ln-miles that are Cong.	0
Percent Moderate	0
Percent Heavy	0
Percent Severe	0
Percent Extreme	0
Principal Arterial Streets	
Daily VMT (000)	2,983
Lane-miles	752
VMT/Lane-mile	3,966
Incident to Recurring Delay Ratio	1.1
Percent of Pk Pd Travel in Cong. ****	27
Percent Moderate	0
Percent Heavy	100
Percent Severe	0
Percent Extreme	0
Percent of Ln-miles that are Cong.	69
Percent Moderate	0
Percent Heavy	100
Percent Severe	0
Percent Extreme	0
Roadway System	
Daily VMT (000)	5,117
Total Road Miles (centerline)	2,822
Percent of Daily Travel During Congested Time	15
Cost Components	
Value of Time ($/hour)	12.40
Truck Operating Cost ($/mile)	2.85
Fuel Cost ($/gallon)	1.07

*** (as seen on website)

Fwy Percent of Pk Pd Travel in Cong	6
PAS Percent of Pk Pd Travel in Cong	8
ROADWAY SYSTEM PERFORMANCE	
Travel Rate Index	1.04
Travel Time Index	1.06
Percent of Daily Travel in Congestion	4
Annual Hours of Delay	
Total (1000 Person-hours)	1029
Freeway	
Recurring Person-hours (000)	0
Incident Person-hours (000)	0
Principal Arterial Street	
Recurring Person-hours (000)	490
Incident Person-hours (000)	539
Annual Delay per Capita (person-hours)	5
Annual Excess Fuel Consumed	
Total (million gallons)	1
Fuel consumed per capita (gallons)	6
Annual Congestion Cost	
Total ($million)	16
Cost per Capita ($)	76
Average Peak Period Travel Speed	
Freeway System (mph)	54
Prin Arterial Street System (mph)	34
Roadway Congestion Index	0.69

CONSTANTS

Freeway Speed	Uncongested	60
	Moderate	45
	Heavy	38
	Severe	35
	Extreme	32
PAS Speed	Uncongested	35
	Moderate	30
	Heavy	27
	Severe	23
	Extreme	21
Vehicle occupancy		1.25
Pct of passenger-vehicles		0.95
Pct of commercial vehicles		0.05
Number of Annual Workdays		250

LYNCHBURG

VDOT Telework Study
Roadway Information for Congestion
High teleworking - 10% (rev. 9/25/01)
Estimated VMT Reduction 0.9891

ROADWAY	Classification	# Lanes	Rd Seg	ADT (2000)	Posted SL	ADT/Lane	Daily VMT	Reduced VMT	Ln-Miles	Red. ADT/Lane	Cong level
Interstate/Freeway											
Rte 29 (Lynchburg Exp)	Urban Freeway	4	1.37	44,000	55	11,000	60,280	59,623	5.48	10,880	Uncongested
Rte 501(Lynchburg Exp)	Urban Freeway	2	3.4	12,000	55	6,000	40,800	40,355	6.8	5,935	Uncongested
Total Interstate/Freeway							**101,080**	**99,978**	**12.28**	**8,142**	

		% Type of Congestion on Congested Arterials (=100%)			
	Uncongested	Moderate	Heavy	Severe	Extreme
VMT	100%	0	0	0	0
Lane/Miles	100%	0	0	0	0

ROADWAY	Classification	# Lanes	Rd Seg	ADT (2000)	Posted SL	ADT/Lane	Daily VMT	Reduced VMT	Ln-Miles	Red. ADT/Lane	Cong level
Principal Arterials											
Rte 29 (Wards Road)	Urban Princ. Art.	4	1.74	31,000	45	7,750	53,940	53,352	6.96	7,666	Heavy
Rte 29 Bus (Wards Rd)	Urban Princ. Art.	2	0.76	17,000	35	8,500	12,920	12,779	1.52	8,407	Heavy
Rte 29 Bus (5th St)	Urban Princ. Art.	2	0.7	16,000	30	8,000	11,200	11,078	1.4	7,913	Heavy
Total Arterials							**78,060**	**77,209**	**9.88**	**7,815**	

		% Type of Congestion on Congested Arterials (=100%)			
	Uncongested	Moderate	Heavy	Severe	Extreme
VMT	20%	0	100%	0	0
Lane/Miles	31%	0	100%	0	0

CONGESTION CALCULATOR - LYNCHBURG, VA
INVENTORY MEASURES
High teleworking - 10%(rev. 9/25/01)

Urban Area Information	
Population (000)	215
Urban Area (square miles)	1,812
Population Density	119
Freeway	
Daily VMT (000)	476
Lane-miles	57
VMT/Lane-mile	8,347
Incident to Recurring Delay Ratio	2.1
Percent of Pk Pd Travel in Cong. ****	21
Percent Moderate	0
Percent Heavy	0
Percent Severe	0
Percent Extreme	0
Percent of Ln-miles that are Cong.	0
Percent Moderate	0
Percent Heavy	0
Percent Severe	0
Percent Extreme	0
Principal Arterial Streets	
Daily VMT (000)	2,966
Lane-miles	752
VMT/Lane-mile	3,945
Incident to Recurring Delay Ratio	1.1
Percent of Pk Pd Travel in Cong. ****	27
Percent Moderate	0
Percent Heavy	100
Percent Severe	0
Percent Extreme	0
Percent of Ln-miles that are Cong.	69
Percent Moderate	0
Percent Heavy	100
Percent Severe	0
Percent Extreme	0
Roadway System	
Daily VMT (000)	5,089
Total Road Miles (centerline)	2,822
Percent of Daily Travel During Congested Time	15
Cost Components	
Value of Time ($/hour)	12.40
Truck Operating Cost ($/mile)	2.85
Fuel Cost ($/gallon)	1.07

*** (as seen on website)

Fwy Percent of Pk Pd Travel in Cong	6
PAS Percent of Pk Pd Travel in Cong	8
ROADWAY SYSTEM PERFORMANCE	
Travel Rate Index	1.04
Travel Time Index	1.06
Percent of Daily Travel in Congestion	4
Annual Hours of Delay	
Total (1000 Person-hours)	1023
Freeway	
Recurring Person-hours (000)	0
Incident Person-hours (000)	0
Principal Arterial Street	
Recurring Person-hours (000)	487
Incident Person-hours (000)	536
Annual Delay per Capita (person-hours)	5
Annual Excess Fuel Consumed	
Total (million gallons)	1
Fuel consumed per capita (gallons)	6
Annual Congestion Cost	
Total ($million)	16
Cost per Capita ($)	76
Average Peak Period Travel Speed	
Freeway System (mph)	54
Prin Arterial Street System (mph)	34
Roadway Congestion Index	0.68

CONSTANTS

Freeway Speed	Uncongested	60
	Moderate	45
	Heavy	38
	Severe	35
	Extreme	32
PAS Speed	Uncongested	35
	Moderate	30
	Heavy	27
	Severe	23
	Extreme	21
Vehicle occupancy		1.25
Pct of passenger-vehicles		0.95
Pct of commercial vehicles		0.05
Number of Annual Workdays		250

NORTHERN VIRGINIA

VDOT Telework Study
Roadway Information for Congestion
2000 Base Conditions (rev. 9/25/01)

JURIS.	ROADWAY	Classification	# Lanes	Rd Seg	ADT (2000)	Posted SL	ADT/Lane	Daily VMT	Ln-Miles	ADT/Lane	Cong level
Interstate/Freeway											
Arlington	I-66(US 29 -US 29 @20th)	Urban Interstate	6	1.05	105,000	n/a	17,500	110,250	6.3	17,500	Moderate
Fairfax	I-66(Rte 29 E-Rte 28)	Urban Interstate	8	0.83	116,000	55	14,500	96,280	6.64	14,500	Uncongested
Fairfax	I-66(Rte 243 - I-495)	Urban Interstate	8	3.62	169,000	55	21,125	611,780	28.96	21,125	Severe
Fairfax	I-95 (Conv Rte 642-Ramp)	Urban Interstate	6	1.9	167,000	55	27,833	317,300	11.4	27,833	Extreme
Alexandria	I-95 (WCL Alex - Rte 1)	Urban Interstate	8	0.37	137,000	55	17,125	50,690	2.96	17,125	Moderate
Arlington	I-395(Conv Rte 120 - Rte 27)	Urban Interstate	8	1.2	154,000	55	19,250	184,800	9.6	19,250	Heavy
Fairfax	I-395(Conv I-95 - WCL Alex)	Urban Interstate	6	2.64	174,000	55	29,000	459,360	15.84	29,000	Extreme
Fairfax	I-495 (Rte 50 - I-66)	Urban Interstate	8	0.76	239,000	55	29,875	181,640	6.08	29,875	Extreme
Fairfax	I-495 (I-66 - SR 7)	Urban Interstate	8	1.82	180,000	55	22,500	327,600	14.56	22,500	Severe
Total Interstate/Freeway							**198,708**	**2,339,700**	**102.34**	**22,862**	

		% Type of Congestion on Congested Arterials (=100%)			
	Uncongested	**Moderate**	**Heavy**	**Severe**	**Extreme**
VMT	4%	7%	8%	42%	43%
Lane/Miles	6%	10%	10%	45%	35%

JURIS.	ROADWAY	Classification	# Lanes	Rd Seg	ADT (2000)	Posted SL	ADT/Lane	Daily VMT	Ln-Miles	ADT/Lane	Cong level
Principal Arterials											
Fairfax	Rte 1(I-95 - SR 242)	Urban Princ Art	4	1.44	38,000	50	9,500	54,720	5.76	9,500	Severe
Alexandria	Rte 1(SCL Alex - Wilkes)	Urban Princ Art	4	0.66	52,000	45	13,000	34,320	2.64	13,000	Extreme
Fairfax	Rte 7(Rte 193 - Rte 743)	Urban Princ Art	4	3.75	57,000	55	14,250	213,750	15.00	14,250	Extreme
Fairfax	Rte 29(Rte 28-Rte29-2953)	Urban Princ Art	4	3.11	32,000	45	8,000	99,520	12.44	8,000	Heavy
Falls Church	Rte 29(Rte 7 - Great Falls)	Urban Princ Art	4	0.18	30,000	30	7,500	5,400	0.72	7,500	Heavy
Arlington	Rte 123(Frfx CL - Wash DC)	Urban Princ Art	2	0.4	13,000	35	6,500	5,200	0.8	6,500	Moderate
Fairfax	Rte 236(SR 376 - I-495)	Urban Princ Art	4	0.89	51,000	45	12,750	45,390	3.56	12,750	Extreme
Fairfax	Rte 267(Rte 674 - Rte 7)	Urban Princ Art	6	3.47	122,000	55	20,333	423,340	20.82	20,333	Extreme
Loudon	Rte 267(Fairfax CL - Rte 28)	Rural Princ Art	4	1.23	74,000	55	18,500	91,020	4.92	18,500	Extreme
Fairfax	Rte 7100(Rte 6819-Rte608)	Urban Princ Art	4	1.07	24,282	45	6,071	25,982	4.28	6,071	Moderate
Total Arterials							**116,404**	**998,642**	**70.94**	**14,077**	

		% Type of Congestion on Congested Arterials (=100%)			
	Uncongested	**Moderate**	**Heavy**	**Severe**	**Extreme**
VMT	0	3%	10%	6%	81%
Lane/Miles	0	7%	19%	8%	66%

CONGESTION CALCULATOR - NORTHERN VIRGINIA
INVENTORY MEASURES
2000 Base Conditions (rev. 9/25/01)

Urban Area Information	
Population (000)	2,011
Urban Area (square miles)	3,479
Population Density	578
Freeway	
Daily VMT (000)	15,130
Lane-miles	679
VMT/Lane-mile	22,283
Incident to Recurring Delay Ratio	2.1
Percent of Pk Pd Travel in Cong. ****	78
Percent Moderate	7
Percent Heavy	8
Percent Severe	42
Percent Extreme	43
Percent of Ln-miles that are Cong.	94
Percent Moderate	10
Percent Heavy	10
Percent Severe	45
Percent Extreme	35
Principal Arterial Streets	
Daily VMT (000)	17,610
Lane-miles	1,226
VMT/Lane-mile	14,364
Incident to Recurring Delay Ratio	1.1
Percent of Pk Pd Travel in Cong. ****	83
Percent Moderate	3
Percent Heavy	10
Percent Severe	6
Percent Extreme	81
Percent of Ln-miles that are Cong.	87
Percent Moderate	7
Percent Heavy	19
Percent Severe	8
Percent Extreme	66
Roadway System	
Daily VMT (000)	47,282
Total Road Miles (centerline)	7,406
Percent of Daily Travel During Congested Time	40
Cost Components	
Value of Time ($/hour)	12.40
Truck Operating Cost ($/mile)	2.85
Fuel Cost ($/gallon)	1.07

*** (as seen on website)	
Fwy Percent of Pk Pd Travel in Cong	62
PAS Percent of Pk Pd Travel in Cong	66
ROADWAY SYSTEM PERFORMANCE	
Travel Rate Index	1.47
Travel Time Index	1.99
Percent of Daily Travel in Congestion	32
Annual Hours of Delay	
Total (1000 Person-hours)	154094
Freeway	
Recurring Person-hours (000)	22924
Incident Person-hours (000)	48141
Principal Arterial Street	
Recurring Person-hours (000)	39538
Incident Person-hours (000)	43491
Annual Delay per Capita (person-hours)	77
Annual Excess Fuel Consumed	
Total (million gallons)	217
Fuel consumed per capita (gallons)	108
Annual Congestion Cost	
Total ($million)	2533
Cost per Capita ($)	1259
Average Peak Period Travel Speed	
Freeway System (mph)	40
Prin Arterial Street System (mph)	24
Roadway Congestion Index	1.91

CONSTANTS

Freeway Speed	Uncongested	60
	Moderate	45
	Heavy	38
	Severe	35
	Extreme	32
PAS Speed	Uncongested	35
	Moderate	30
	Heavy	27
	Severe	23
	Extreme	21
Vehicle occupancy		1.25
Pct of passenger-vehicles		0.95
Pct of commercial vehicles		0.05
Number of Annual Workdays		250

NORTHERN VIRGINIA

VDOT Telework Study
Roadway Information for Congestion
Medium teleworking - 20% (rev. 9/27/01)
Estimated VMT Reduction 0.9896

JURIS.	ROADWAY	Classification	# Lanes	Rd Seg	ADT (2000)	Posted SL	ADT/Lane	Daily VMT	Reduced VMT	Ln-Miles	Red. ADT/Lane
Interstate/Freeway											
Arlington	I-66(US 29 -US 29 @20th)	Urban Interstate	6	1.05	105,000	n/a	17,500	110,250	109,103	6.3	17,318
Fairfax	I-66(Rte 29 E-Rte 28)	Urban Interstate	8	0.83	116,000	55	14,500	96,280	95,279	6.64	14,349
Fairfax	I-66(Rte 243 - I-495)	Urban Interstate	8	3.62	169,000	55	21,125	611,780	605,417	28.96	20,905
Fairfax	I-95 (Conv Rte 642-Ramp)	Urban Interstate	6	1.9	167,000	55	27,833	317,300	314,000	11.4	27,544
Alexandria	I-95 (WCL Alex - Rte 1)	Urban Interstate	8	0.37	137,000	55	17,125	50,690	50,163	2.96	16,947
Arlington	I-395(Conv Rte 120 - Rte 27)	Urban Interstate	8	1.2	154,000	55	19,250	184,800	182,878	9.6	19,050
Fairfax	I-395(Conv I-95 - WCL Alex)	Urban Interstate	6	2.64	174,000	55	29,000	459,360	454,583	15.84	28,698
Fairfax	I-495 (Rte 50 - I-66)	Urban Interstate	8	0.76	239,000	55	29,875	181,640	179,751	6.08	29,564
Fairfax	I-495 (I-66 - SR 7)	Urban Interstate	8	1.82	180,000	55	22,500	327,600	324,193	14.56	22,266
Total Interstate/Freeway							**198,708**	**2,339,700**	**2,315,367**	**102.34**	**22,624**

		% Type of Congestion on Congested Arterials (=100%)			
	Uncongested	**Moderate**	**Heavy**	**Severe**	**Extreme**
VMT	4%	7%	8%	42%	43%
Lane/Miles	6%	10%	10%	45%	35%

JURIS.	ROADWAY	Classification	# Lanes	Rd Seg	ADT (2000)	Posted SL	ADT/Lane	Daily VMT	Reduced VMT	Ln-Miles	Red. ADT/Lane
Principal Arterials											
Fairfax	Rte 1(I-95 - SR 242)	Urban Princ Art	4	1.44	38,000	50	9,500	54,720	54,151	5.76	9,401
Alexandria	Rte 1(SCL Alex - Wilkes)	Urban Princ Art	4	0.66	52,000	45	13,000	34,320	33,963	2.64	12,865
Fairfax	Rte 7(Rte 193 - Rte 743)	Urban Princ Art	4	3.75	57,000	55	14,250	213,750	211,527	15.00	14,102
Fairfax	Rte 29(Rte 28-Rte29-2953)	Urban Princ Art	4	3.11	32,000	45	8,000	99,520	98,485	12.44	7,917
Falls Church	Rte 29(Rte 7 - Great Falls)	Urban Princ Art	4	0.18	30,000	30	7,500	5,400	5,344	0.72	7,422
Arlington	Rte 123(Frfx CL - Wash DC)	Urban Princ Art	2	0.4	13,000	35	6,500	5,200	5,146	0.8	6,432
Fairfax	Rte 236(SR 376 - I-495)	Urban Princ Art	4	0.89	51,000	45	12,750	45,390	44,918	3.56	12,617
Fairfax	Rte 267(Rte 674 - Rte 7)	Urban Princ Art	6	3.47	122,000	55	20,333	423,340	418,937	20.82	20,122
Loudon	Rte 267(Fairfax CL - Rte 28)	Rural Princ Art	4	1.23	74,000	55	18,500	91,020	90,073	4.92	18,308
Fairfax	Rte 7100(Rte 6819-Rte608)	Urban Princ Art	4	1.07	24,282	45	6,071	25,982	25,712	4.28	6,007
Total Arterials							**116,404**	**998,642**	**988,256**	**70.94**	**13,931**

		% Type of Congestion on Congested Arterials (=100%)			
	Uncongested	**Moderate**	**Heavy**	**Severe**	**Extreme**
VMT	0	3%	10%	6%	81%
Lane/Miles	0	7%	19%	8%	66%

CONGESTION CALCULATOR - NORTHERN VIRGINIA
INVENTORY MEASURES
Medium teleworking - 20%(rev. 9/27/01)

Urban Area Information	
Population (000)	2,011
Urban Area (square miles)	3,479
Population Density	578
Freeway	
Daily VMT (000)	14,973
Lane-miles	679
VMT/Lane-mile	22,052
Incident to Recurring Delay Ratio	2.1
Percent of Pk Pd Travel in Cong. ****	78
Percent Moderate	7
Percent Heavy	8
Percent Severe	42
Percent Extreme	43
Percent of Ln-miles that are Cong.	94
Percent Moderate	10
Percent Heavy	10
Percent Severe	45
Percent Extreme	35
Principal Arterial Streets	
Daily VMT (000)	17,427
Lane-miles	1,226
VMT/Lane-mile	14,214
Incident to Recurring Delay Ratio	1.1
Percent of Pk Pd Travel in Cong. ****	83
Percent Moderate	3
Percent Heavy	10
Percent Severe	6
Percent Extreme	81
Percent of Ln-miles that are Cong.	87
Percent Moderate	7
Percent Heavy	19
Percent Severe	8
Percent Extreme	66
Roadway System	
Daily VMT (000)	46,790
Total Road Miles (centerline)	7,406
Percent of Daily Travel During Congested Time	40
Cost Components	
Value of Time ($/hour)	12.40
Truck Operating Cost ($/mile)	2.85
Fuel Cost ($/gallon)	1.07

*** (as seen on website)

Fwy Percent of Pk Pd Travel in Cong	62
PAS Percent of Pk Pd Travel in Cong	66
ROADWAY SYSTEM PERFORMANCE	
Travel Rate Index	1.47
Travel Time Index	1.99
Percent of Daily Travel in Congestion	32
Annual Hours of Delay	
Total (1000 Person-hours)	152491
Freeway	
Recurring Person-hours (000)	22686
Incident Person-hours (000)	47640
Principal Arterial Street	
Recurring Person-hours (000)	39126
Incident Person-hours (000)	43039
Annual Delay per Capita (person-hours)	76
Annual Excess Fuel Consumed	
Total (million gallons)	215
Fuel consumed per capita (gallons)	107
Annual Congestion Cost	
Total ($million)	2507
Cost per Capita ($)	1246
Average Peak Period Travel Speed	
Freeway System (mph)	40
Prin Arterial Street System (mph)	24
Roadway Congestion Index	1.89

CONSTANTS

Freeway Speed	Uncongested	60
	Moderate	45
	Heavy	38
	Severe	35
	Extreme	32
PAS Speed	Uncongested	35
	Moderate	30
	Heavy	27
	Severe	23
	Extreme	21
Vehicle occupancy		1.25
Pct of passenger-vehicles		0.95
Pct of commercial vehicles		0.05
Number of Annual Workdays		250

NORTHERN VIRGINIA

VDOT Telework Study
Roadway Information for Congestion
High teleworking - 25% (rev. 9/27/01)
Estimated VMT Reduction 0.9792

JURIS.	ROADWAY	Classification	# Lanes	Rd Seg	ADT (2000)	Posted SL	ADT/Lane	Daily VMT	Reduced VMT	Ln-Miles	Red. ADT/Lane
Interstate/Freeway											
Arlington	I-66(US 29 -US 29 @20th)	Urban Interstate	6	1.05	105,000	n/a	17,500	110,250	107,957	6.3	17,136
Fairfax	I-66(Rte 29 E-Rte 28)	Urban Interstate	8	0.83	116,000	55	14,500	96,280	94,277	6.64	14,198
Fairfax	I-66(Rte 243 - I-495)	Urban Interstate	8	3.62	169,000	55	21,125	611,780	599,055	28.96	20,686
Fairfax	I-95 (Conv Rte 642-Ramp)	Urban Interstate	6	1.9	167,000	55	27,833	317,300	310,700	11.4	27,254
Alexandria	I-95 (WCL Alex - Rte 1)	Urban Interstate	8	0.37	137,000	55	17,125	50,690	49,636	2.96	16,769
Arlington	I-395(Conv Rte 120 - Rte 27)	Urban Interstate	8	1.2	154,000	55	19,250	184,800	180,956	9.6	18,850
Fairfax	I-395(Conv I-95 - WCL Alex)	Urban Interstate	6	2.64	174,000	55	29,000	459,360	449,805	15.84	28,397
Fairfax	I-495 (Rte 50 - I-66)	Urban Interstate	8	0.76	239,000	55	29,875	181,640	177,862	6.08	29,254
Fairfax	I-495 (I-66 - SR 7)	Urban Interstate	8	1.82	180,000	55	22,500	327,600	320,786	14.56	22,032
Total Interstate/Freeway							**198,708**	**2,339,700**	**2,291,034**	**102.34**	**22,386**

		% Type of Congestion on Congested Arterials (=100%)			
	Uncongested	**Moderate**	**Heavy**	**Severe**	**Extreme**
VMT	4%	7%	8%	42%	43%
Lane/Miles	6%	10%	10%	45%	35%

JURIS.	ROADWAY	Classification	# Lanes	Rd Seg	ADT (2000)	Posted SL	ADT/Lane	Daily VMT	Reduced VMT	Ln-Miles	Red. ADT/Lane
Principal Arterials											
Fairfax	Rte 1(I-95 - SR 242)	Urban Princ Art	4	1.44	38,000	50	9,500	54,720	53,582	5.76	9,302
Alexandria	Rte 1(SCL Alex - Wilkes)	Urban Princ Art	4	0.66	52,000	45	13,000	34,320	33,606	2.64	12,730
Fairfax	Rte 7(Rte 193 - Rte 743)	Urban Princ Art	4	3.75	57,000	55	14,250	213,750	209,304	15.00	13,954
Fairfax	Rte 29(Rte 28-Rte29-2953)	Urban Princ Art	4	3.11	32,000	45	8,000	99,520	97,450	12.44	7,834
Falls Church	Rte 29(Rte 7 - Great Falls)	Urban Princ Art	4	0.18	30,000	30	7,500	5,400	5,288	0.72	7,344
Arlington	Rte 123(Frfx CL - Wash DC)	Urban Princ Art	2	0.4	13,000	35	6,500	5,200	5,092	0.8	6,365
Fairfax	Rte 236(SR 376 - I-495)	Urban Princ Art	4	0.89	51,000	45	12,750	45,390	44,446	3.56	12,485
Fairfax	Rte 267(Rte 674 - Rte 7)	Urban Princ Art	6	3.47	122,000	55	20,333	423,340	414,535	20.82	19,910
Loudon	Rte 267(Fairfax CL - Rte 28)	Rural Princ Art	4	1.23	74,000	55	18,500	91,020	89,127	4.92	18,115
Fairfax	Rte 7100(Rte 6819-Rte608)	Urban Princ Art	4	1.07	24,282	45	6,071	25,982	25,441	4.28	5,944
Total Arterials							**116,404**	**998,642**	**977,870**	**70.94**	**13,784**

		% Type of Congestion on Congested Arterials (=100%)			
	Uncongested	**Moderate**	**Heavy**	**Severe**	**Extreme**
VMT	0	3%	10%	6%	81%
Lane/Miles	0	7%	19%	8%	66%

CONGESTION CALCULATOR - NORTHERN VIRGINIA
INVENTORY MEASURES
High teleworking - 25%(rev. 9/27/01)

Urban Area Information	
Population (000)	2,011
Urban Area (square miles)	3,479
Population Density	578
Freeway	
Daily VMT (000)	14,816
Lane-miles	679
VMT/Lane-mile	21,820
Incident to Recurring Delay Ratio	2.1
Percent of Pk Pd Travel in Cong. ****	78
Percent Moderate	7
Percent Heavy	8
Percent Severe	42
Percent Extreme	43
Percent of Ln-miles that are Cong.	94
Percent Moderate	10
Percent Heavy	10
Percent Severe	45
Percent Extreme	35
Principal Arterial Streets	
Daily VMT (000)	17,244
Lane-miles	1,226
VMT/Lane-mile	14,065
Incident to Recurring Delay Ratio	1.1
Percent of Pk Pd Travel in Cong. ****	83
Percent Moderate	3
Percent Heavy	10
Percent Severe	6
Percent Extreme	81
Percent of Ln-miles that are Cong.	87
Percent Moderate	7
Percent Heavy	19
Percent Severe	8
Percent Extreme	66
Roadway System	
Daily VMT (000)	46,298
Total Road Miles (centerline)	7,406
Percent of Daily Travel During Congested Time	40
Cost Components	
Value of Time ($/hour)	12.40
Truck Operating Cost ($/mile)	2.85
Fuel Cost ($/gallon)	1.07

*** (as seen on website)	
Fwy Percent of Pk Pd Travel in Cong	62
PAS Percent of Pk Pd Travel in Cong	66
ROADWAY SYSTEM PERFORMANCE	
Travel Rate Index	1.47
Travel Time Index	1.99
Percent of Daily Travel in Congestion	32
Annual Hours of Delay	
Total (1000 Person-hours)	150888
Freeway	
Recurring Person-hours (000)	22447
Incident Person-hours (000)	47139
Principal Arterial Street	
Recurring Person-hours (000)	38715
Incident Person-hours (000)	42587
Annual Delay per Capita (person-hours)	75
Annual Excess Fuel Consumed	
Total (million gallons)	212
Fuel consumed per capita (gallons)	106
Annual Congestion Cost	
Total ($million)	2480
Cost per Capita ($)	1233
Average Peak Period Travel Speed	
Freeway System (mph)	40
Prin Arterial Street System (mph)	24
Roadway Congestion Index	1.87

	CONSTANTS	
Freeway	Uncongested	60
Speed	Moderate	45
	Heavy	38
	Severe	35
	Extreme	32
PAS	Uncongested	35
Speed	Moderate	30
	Heavy	27
	Severe	23
	Extreme	21
Vehicle occupancy		1.25
Pct of passenger-vehicles		0.95
Pct of commercial vehicles		0.05
Number of Annual Workdays		250

RICHMOND

VDOT Telework Study
Roadway Information for Congestion
2000 Base Conditions (rev. 9/25/01)

JURIS.	ROADWAY	Classification	# Lanes	Rd Seg	ADT (2000)	Posted SL	ADT/Lane	Daily VMT	Ln-Miles	ADT/Lane	Cong level
Interstate/Freeway											
Henrico	I-64(Glenside-Staples Mill)	Urban Interstate	6	2.03	103,000	55	17,167	209,090	12.18	17,167	Moderate
	I-64(Laburnum-Airport)	Urban Interstate	6	2.14	66,000	55	11,000	141,240	12.84	11,000	Uncongested
Henrico	I-95 (NCL Richmond-Brook)	Urban Interstate	6	0.91	94,000	55	15,667	85,540	5.46	15,667	Moderate
0	I-95 (Brook Rd-Chamberln)	Urban Interstate	6	0.3	86,000	55	14,333	25,800	1.8	14,333	Uncongested
Hanover	I-295(Rte 42-615-Rte 369)	Urban Interstate	8	2.6	70,000	65	8,750	182,000	20.8	8,750	Uncongested
Richmond	I-195(SR197-NCLRichmond)	Urban Interstate	6	0.65	76,000	n/a	12,667	49,400	3.9	12,667	Uncongested
Chesterfield	Rte 288(Rte 360-Rte 76)	Urban Freeway	4	3.04	22,000	n/a	5,500	66,880	12.16	5,500	Uncongested
Total Interstate/Freeway							**85,083**	**759,950**	**69.14**	**10,991**	

		% Type of Congestion on Congested Arterials (=100%)			
	Uncongested	**Moderate**	**Heavy**	**Severe**	**Extreme**
VMT	52%	100%	0	0	0
Lane/Miles	66%	100%	0	0	0

JURIS.	ROADWAY	Classification	# Lanes	Rd Seg	ADT (2000)	Posted SL	ADT/Lane	Daily VMT	Ln-Miles	ADT/Lane	Cong level
Principal Arterials											
Chesterfield	Rte 60(Rte 678-WCL Rich)	Urban Princ Art	6	1.3	53,000	n/a	8,833	68,900	7.8	8,833	Severe
Chesterfield	Rte 76(Rte 60-Rte 20-686)	Urban Princ Art	4	2.42	46,000	n/a	11,500	111,320	9.68	11,500	Extreme
Chesterfield	Rte 147(Rte 711-Rte 678)	Urban Princ Art	4	3.08	41,000	45	10,250	126,280	12.32	10,250	Extreme
Richmond	Rte 150(Forest Hill-Rte 147)	Urban Princ Art	4	1.56	37,000	45	9,250	57,720	6.24	9,250	Severe
Total Arterials								**364,220**	**36.04**	**10,106**	

		% Type of Congestion on Congested Arterials (=100%)			
	Uncongested	**Moderate**	**Heavy**	**Severe**	**Extreme**
VMT	0	0	0	35%	65%
Lane/Miles	0	0	0	39%	61%

CONGESTION CALCULATOR - RICHMOND, VA
INVENTORY MEASURES
2000 Base Conditions (rev. 9/25/01)

Urban Area Information	
Population (000)	997
Urban Area (square miles)	3,000
Population Density	332
Freeway	
Daily VMT (000)	11,505
Lane-miles	1,058
VMT/Lane-mile	10,874
Incident to Recurring Delay Ratio	2.1
Percent of Pk Pd Travel in Cong. ****	46
Percent Moderate	100
Percent Heavy	0
Percent Severe	0
Percent Extreme	0
Percent of Ln-miles that are Cong.	34
Percent Moderate	100
Percent Heavy	0
Percent Severe	0
Percent Extreme	0
Principal Arterial Streets	
Daily VMT (000)	10,135
Lane-miles	982
VMT/Lane-mile	10,321
Incident to Recurring Delay Ratio	1.1
Percent of Pk Pd Travel in Cong. ****	46
Percent Moderate	0
Percent Heavy	0
Percent Severe	35
Percent Extreme	65
Percent of Ln-miles that are Cong.	100
Percent Moderate	0
Percent Heavy	0
Percent Severe	39
Percent Extreme	61
Roadway System	
Daily VMT (000)	24,438
Total Road Miles (centerline)	6,068
Percent of Daily Travel During Congested Time	23
Cost Components	
Value of Time ($/hour)	12.40
Truck Operating Cost ($/mile)	2.85
Fuel Cost ($/gallon)	1.07

*** (as seen on website)

Fwy Percent of Pk Pd Travel in Cong	21
PAS Percent of Pk Pd Travel in Cong	21
ROADWAY SYSTEM PERFORMANCE	
Travel Rate Index	1.14
Travel Time Index	1.27
Percent of Daily Travel in Congestion	11
Annual Hours of Delay	
Total (1000 Person-hours)	35400
Freeway	
Recurring Person-hours (000)	3951
Incident Person-hours (000)	8297
Principal Arterial Street	
Recurring Person-hours (000)	11025
Incident Person-hours (000)	12127
Annual Delay per Capita (person-hours)	36
Annual Excess Fuel Consumed	
Total (million gallons)	56
Fuel consumed per capita (gallons)	56
Annual Congestion Cost	
Total ($million)	614
Cost per Capita ($)	616
Average Peak Period Travel Speed	
Freeway System (mph)	54
Prin Arterial Street System (mph)	30
Roadway Congestion Index	1.06

	CONSTANTS	
Freeway Speed	Uncongested	60
	Moderate	45
	Heavy	38
	Severe	35
	Extreme	32
PAS Speed	Uncongested	35
	Moderate	30
	Heavy	27
	Severe	23
	Extreme	21
Vehicle occupancy		1.25
Pct of passenger-vehicles		0.95
Pct of commercial vehicles		0.05
Number of Annual Workdays		250

RICHMOND

VDOT Telework Study
Roadway Information for Congestion
Medium teleworking - 10% (rev. 9/25/01)
Estimated VMT Reduction 0.9849

JURIS.	ROADWAY	Classification	# Lanes	Rd Seg	ADT (2000)	Posted SL	ADT/Lane	Daily VMT	Reduced VMT	Ln-Miles	Red. ADT/Lane
Interstate/Freeway											
Henrico	I-64(Glenside-Staples Mill)	Urban Interstate	6	2.03	103,000	55	17,167	209,090	205,933	12.18	16,907
	I-64(Laburnum-Airport)	Urban Interstate	6	2.14	66,000	55	11,000	141,240	139,107	12.84	10,834
Henrico	I-95 (NCL Richmond-Brook)	Urban Interstate	6	0.91	94,000	55	15,667	85,540	84,248	5.46	15,430
0	I-95 (Brook Rd-Chamberln)	Urban Interstate	6	0.3	86,000	55	14,333	25,800	25,410	1.8	14,117
Hanover	I-295(Rte 42-615-Rte 369)	Urban Interstate	8	2.6	70,000	65	8,750	182,000	179,252	20.8	8,618
Richmond	I-195(SR197-NCLRichmond)	Urban Interstate	6	0.65	76,000	n/a	12,667	49,400	48,654	3.9	12,475
Chesterfield	Rte 288(Rte 360-Rte 76)	Urban Freeway	4	3.04	22,000	n/a	5,500	66,880	65,870	12.16	5,417
Total Interstate/Freeway							**85,083**	**759,950**	**748,475**	**69.14**	**10,825**

		% Type of Congestion on Congested Arterials (=100%)			
	Uncongested	Moderate	Heavy	Severe	Extreme
VMT	52%	100%	0	0	0
Lane/Miles	66%	100%	0	0	0

JURIS.	ROADWAY	Classification	# Lanes	Rd Seg	ADT (2000)	Posted SL	ADT/Lane	Daily VMT	Reduced VMT	Ln-Miles	Red. ADT/Lane
Principal Arterials											
Chesterfield	Rte 60(Rte 678-WCL Rich)	Urban Princ Art	6	1.3	53,000	n/a	8,833	68,900	67,860	7.8	8,700
Chesterfield	Rte 76(Rte 60-Rte 20-686)	Urban Princ Art	4	2.42	46,000	n/a	11,500	111,320	109,639	9.68	11,326
Chesterfield	Rte 147(Rte 711-Rte 678)	Urban Princ Art	4	3.08	41,000	45	10,250	126,280	124,373	12.32	10,095
Richmond	Rte 150(Forest Hill-Rte 147)	Urban Princ Art	4	1.56	37,000	45	9,250	57,720	56,848	6.24	9,110
Total Arterials								**364,220**	**358,720**	**36.04**	**9,953**

		% Type of Congestion on Congested Arterials (=100%)			
	Uncongested	Moderate	Heavy	Severe	Extreme
VMT	0	0	0	35%	65%
Lane/Miles	0	0	0	39%	61%

CONGESTION CALCULATOR - RICHMOND, VA
INVENTORY MEASURES
Medium teleworking - 10%(rev. 9/25/01)

Urban Area Information	
Population (000)	997
Urban Area (square miles)	3,000
Population Density	332
Freeway	
Daily VMT (000)	11,331
Lane-miles	1,058
VMT/Lane-mile	10,710
Incident to Recurring Delay Ratio	2.1
Percent of Pk Pd Travel in Cong. ****	46
Percent Moderate	100
Percent Heavy	0
Percent Severe	0
Percent Extreme	0
Percent of Ln-miles that are Cong.	34
Percent Moderate	100
Percent Heavy	0
Percent Severe	0
Percent Extreme	0
Principal Arterial Streets	
Daily VMT (000)	9,982
Lane-miles	982
VMT/Lane-mile	10,165
Incident to Recurring Delay Ratio	1.1
Percent of Pk Pd Travel in Cong. ****	46
Percent Moderate	0
Percent Heavy	0
Percent Severe	35
Percent Extreme	65
Percent of Ln-miles that are Cong.	100
Percent Moderate	0
Percent Heavy	0
Percent Severe	39
Percent Extreme	61
Roadway System	
Daily VMT (000)	24,069
Total Road Miles (centerline)	6,068
Percent of Daily Travel During Congested Time	23
Cost Components	
Value of Time ($/hour)	12.40
Truck Operating Cost ($/mile)	2.85
Fuel Cost ($/gallon)	1.07

*** (as seen on website)

Fwy Percent of Pk Pd Travel in Cong	21
PAS Percent of Pk Pd Travel in Cong	21
ROADWAY SYSTEM PERFORMANCE	
Travel Rate Index	1.14
Travel Time Index	1.26
Percent of Daily Travel in Congestion	11
Annual Hours of Delay	
Total (1000 Person-hours)	34054
Freeway	
Recurring Person-hours (000)	3801
Incident Person-hours (000)	7981
Principal Arterial Street	
Recurring Person-hours (000)	10606
Incident Person-hours (000)	11666
Annual Delay per Capita (person-hours)	34
Annual Excess Fuel Consumed	
Total (million gallons)	54
Fuel consumed per capita (gallons)	54
Annual Congestion Cost	
Total ($million)	591
Cost per Capita ($)	593
Average Peak Period Travel Speed	
Freeway System (mph)	54
Prin Arterial Street System (mph)	30
Roadway Congestion Index	1.04

CONSTANTS

Freeway Speed	Uncongested	60
	Moderate	45
	Heavy	38
	Severe	35
	Extreme	32
PAS Speed	Uncongested	35
	Moderate	30
	Heavy	27
	Severe	23
	Extreme	21
Vehicle occupancy		1.25
Pct of passenger-vehicles		0.95
Pct of commercial vehicles		0.05
Number of Annual Workdays		250

RICHMOND

VDOT Telework Study
Roadway Information for Congestion
High teleworking - 12.5% (rev. 9/25/01)
Estimated VMT Reduction 0.9698

JURIS.	ROADWAY	Classification	# Lanes	Rd Seg	ADT (2000)	Posted SL	ADT/Lane	Daily VMT	Reduced VMT	Ln-Miles	Red. ADT/Lane
Interstate/Freeway											
Henrico	I-64(Glenside-Staples Mill)	Urban Interstate	6	2.03	103,000	55	17,167	209,090	202,775	12.18	16,648
	I-64(Laburnum-Airport)	Urban Interstate	6	2.14	66,000	55	11,000	141,240	136,975	12.84	10,668
Henrico	I-95 (NCL Richmond-Brook)	Urban Interstate	6	0.91	94,000	55	15,667	85,540	82,957	5.46	15,194
0	I-95 (Brook Rd-Chamberln)	Urban Interstate	6	0.3	86,000	55	14,333	25,800	25,021	1.8	13,900
Hanover	I-295(Rte 42-615-Rte 369)	Urban Interstate	8	2.6	70,000	65	8,750	182,000	176,504	20.8	8,486
Richmond	I-195(SR197-NCLRichmond)	Urban Interstate	6	0.65	76,000	n/a	12,667	49,400	47,908	3.9	12,284
Chesterfield	Rte 288(Rte 360-Rte 76)	Urban Freeway	4	3.04	22,000	n/a	5,500	66,880	64,860	12.16	5,334
Total Interstate/Freeway							**85,083**	**759,950**	**737,000**	**69.14**	**10,660**

	Uncongested	% Type of Congestion on Congested Arterials (=100%) Moderate	Heavy	Severe	Extreme
VMT	52%	100%	0	0	0
Lane/Miles	66%	100%	0	0	0

JURIS.	ROADWAY	Classification	# Lanes	Rd Seg	ADT (2000)	Posted SL	ADT/Lane	Daily VMT	Reduced VMT	Ln-Miles	Red. ADT/Lane
Principal Arterials											
Chesterfield	Rte 60(Rte 678-WCL Rich)	Urban Princ Art	6	1.3	53,000	n/a	8,833	68,900	66,819	7.8	8,567
Chesterfield	Rte 76(Rte 60-Rte 20-686)	Urban Princ Art	4	2.42	46,000	n/a	11,500	111,320	107,958	9.68	11,153
Chesterfield	Rte 147(Rte 711-Rte 678)	Urban Princ Art	4	3.08	41,000	45	10,250	126,280	122,466	12.32	9,940
Richmond	Rte 150(Forest Hill-Rte 147)	Urban Princ Art	4	1.56	37,000	45	9,250	57,720	55,977	6.24	8,971
Total Arterials								**364,220**	**353,221**	**36.04**	**9,801**

	Uncongested	% Type of Congestion on Congested Arterials (=100%) Moderate	Heavy	Severe	Extreme
VMT	0	0	0	69%	31%
Lane/Miles	0	0	0	73%	27%

CONGESTION CALCULATOR - RICHMOND, VA
INVENTORY MEASURES
High teleworking - 12.5%(rev. 9/25/01)

Urban Area Information	
Population (000)	997
Urban Area (square miles)	3,000
Population Density	332
Freeway	
Daily VMT (000)	11,157
Lane-miles	1,058
VMT/Lane-mile	10,546
Incident to Recurring Delay Ratio	2.1
Percent of Pk Pd Travel in Cong. ****	46
Percent Moderate	100
Percent Heavy	0
Percent Severe	0
Percent Extreme	0
Percent of Ln-miles that are Cong.	34
Percent Moderate	100
Percent Heavy	0
Percent Severe	0
Percent Extreme	0
Principal Arterial Streets	
Daily VMT (000)	9,829
Lane-miles	982
VMT/Lane-mile	10,009
Incident to Recurring Delay Ratio	1.1
Percent of Pk Pd Travel in Cong. ****	46
Percent Moderate	0
Percent Heavy	0
Percent Severe	69
Percent Extreme	31
Percent of Ln-miles that are Cong.	100
Percent Moderate	0
Percent Heavy	0
Percent Severe	73
Percent Extreme	27
Roadway System	
Daily VMT (000)	23,700
Total Road Miles (centerline)	6,068
Percent of Daily Travel During Congested Time	23
Cost Components	
Value of Time ($/hour)	12.40
Truck Operating Cost ($/mile)	2.85
Fuel Cost ($/gallon)	1.07

*** (as seen on website)

Fwy Percent of Pk Pd Travel in Cong	21
PAS Percent of Pk Pd Travel in Cong	21
ROADWAY SYSTEM PERFORMANCE	
Travel Rate Index	1.13
Travel Time Index	1.25
Percent of Daily Travel in Congestion	11
Annual Hours of Delay	
Total (1000 Person-hours)	31021
Freeway	
Recurring Person-hours (000)	3653
Incident Person-hours (000)	7672
Principal Arterial Street	
Recurring Person-hours (000)	9379
Incident Person-hours (000)	10317
Annual Delay per Capita (person-hours)	31
Annual Excess Fuel Consumed	
Total (million gallons)	49
Fuel consumed per capita (gallons)	49
Annual Congestion Cost	
Total ($million)	540
Cost per Capita ($)	541
Average Peak Period Travel Speed	
Freeway System (mph)	54
Prin Arterial Street System (mph)	30
Roadway Congestion Index	1.03

CONSTANTS

Freeway Speed	Uncongested	60
	Moderate	45
	Heavy	38
	Severe	35
	Extreme	32
PAS Speed	Uncongested	35
	Moderate	30
	Heavy	27
	Severe	23
	Extreme	21
Vehicle occupancy		1.25
Pct of passenger-vehicles		0.95
Pct of commercial vehicles		0.05
Number of Annual Workdays		250

ROANOKE

VDOT Telework Study
Roadway Information for Congestion
2000 Base Conditions (rev. 9/25/01)

ROADWAY	Classification	# Lanes	Rd Seg	ADT (2000)	Posted SL	ADT/Lane	Daily VMT	Ln-Miles	ADT/Lane	Cong level
Interstate/Freeway										
Rte 81 (Rte 311-SR 419)	Urban Interstate	4	1.64	58,000	65	14,500	95,120	6.56	14,500	Uncongested
Rte 581 (Orange-Hershbgr)	Urban Interstate	6	2.79	61,000	55	10,167	170,190	16.74	10,167	Uncongested
Rte 81(SCLSalem-SR 112)	Urban Interstate	4	0.2	47,000	65	11,750	9,400	0.8	11,750	Uncongested
Total Interstate/Freeway							**274,710**	**24.1**	**11,399**	

		% Type of Congestion on Congested Arterials (=100%)			
	Uncongested	Moderate	Heavy	Severe	Extreme
VMT	68%	0	0	0	0
Lane/Miles	75%	0	0	0	0

Principal Arterials										
Rte 419(Rte 221-SCL Slm)	Urban Princ. Art.	4	3.16	35,000	35	8,750	110,600	12.64	8,750	Severe
Rte 11(WCL Rnk-Edgewd)	Urban Princ. Art.	4	1.35	23,000	35	5,750	31,050	5.4	5,750	Moderate
Rte 11(Edgewd-Grandin)	Urban Princ. Art.	2	1.03	12,000	30	6,000	12,360	2.06	6,000	Moderate
Rte 220 (Rte 419-Wonju)	Urban Princ. Art.	6	1.84	46,000	55	7,667	84,640	11.04	7,667	Heavy
Rte 220 (Wonju-Elm Ave)	Urban Princ. Art.	6	1.71	61,000	55	10,167	104,310	10.26	10,167	Extreme
Total Arterials							**342,960**	**41.40**	**8,284**	

		% Type of Congestion on Congested Arterials (=100%)			
	Uncongested	Moderate	Heavy	Severe	Extreme
VMT	0	13%	25%	32%	30%
Lane/Miles	0	18%	27%	30%	25%

CONGESTION CALCULATOR - ROANOKE
INVENTORY MEASURES
2000 Base Conditions (rev. 9/25/01)

Urban Area Information	
Population (000)	236
Urban Area (square miles)	854
Population Density	276
Freeway	
Daily VMT (000)	2,255
Lane-miles	207
VMT/Lane-mile	10,894
Incident to Recurring Delay Ratio	2.1
Percent of Pk Pd Travel in Cong. ****	21
Percent Moderate	0
Percent Heavy	0
Percent Severe	0
Percent Extreme	0
Percent of Ln-miles that are Cong.	100
Percent Moderate	0
Percent Heavy	0
Percent Severe	0
Percent Extreme	0
Principal Arterial Streets	
Daily VMT (000)	2,672
Lane-miles	313
VMT/Lane-mile	8,537
Incident to Recurring Delay Ratio	1.1
Percent of Pk Pd Travel in Cong. ****	27
Percent Moderate	13
Percent Heavy	25
Percent Severe	32
Percent Extreme	30
Percent of Ln-miles that are Cong.	100
Percent Moderate	18
Percent Heavy	27
Percent Severe	30
Percent Extreme	25
Roadway System	
Daily VMT (000)	6,832
Total Road Miles (centerline)	1,810
Percent of Daily Travel During Congested Time	15
Cost Components	
Value of Time ($/hour)	12.40
Truck Operating Cost ($/mile)	2.85
Fuel Cost ($/gallon)	1.07

*** (as seen on website)

Fwy Percent of Pk Pd Travel in Cong	6
PAS Percent of Pk Pd Travel in Cong	8
ROADWAY SYSTEM PERFORMANCE	
Travel Rate Index	1.13
Travel Time Index	1.16
Percent of Daily Travel in Congestion	4
Annual Hours of Delay	
Total (1000 Person-hours)	2566
Freeway	
Recurring Person-hours (000)	0
Incident Person-hours (000)	0
Principal Arterial Street	
Recurring Person-hours (000)	1222
Incident Person-hours (000)	1344
Annual Delay per Capita (person-hours)	11
Annual Excess Fuel Consumed	
Total (million gallons)	2.00
Fuel consumed per capita (gallons)	10
Annual Congestion Cost	
Total ($million)	37
Cost per Capita ($)	157
Average Peak Period Travel Speed	
Freeway System (mph)	50
Prin Arterial Street System (mph)	33
Roadway Congestion Index	1.02

CONSTANTS

Freeway Speed	Uncongested	60
	Moderate	45
	Heavy	38
	Severe	35
	Extreme	32
PAS Speed	Uncongested	35
	Moderate	30
	Heavy	27
	Severe	23
	Extreme	21
Vehicle occupancy		1.25
Pct of passenger-vehicles		0.95
Pct of commercial vehicles		0.05
Number of Annual Workdays		250

ROANOKE

VDOT Telework Study
Roadway Information for Congestion
Medium teleworking - 7.5% (rev. 9/25/01)
Estimated VMT Reduction 0.9941

ROADWAY	Classification	# Lanes	Rd Seg	ADT (2000)	Posted SL	ADT/Lane	Daily VMT	Reduced VMT	Ln-Miles	Red. ADT/Lane	Cong level
Interstate/Freeway											
Rte 81 (Rte 311-SR 419)	Urban Interstate	4	1.64	58,000	65	14,500	95,120	94,559	6.56	14,414	Uncongested
Rte 581 (Orange-Hershbgr)	Urban Interstate	6	2.79	61,000	55	10,167	170,190	169,186	16.74	10,107	Uncongested
Rte 81(SCLSalem-SR 112)	Urban Interstate	4	0.2	47,000	65	11,750	9,400	9,345	0.8	11,681	Uncongested
Total Interstate/Freeway							**274,710**	**273,089**	**24.1**	**11,332**	

		% Type of Congestion on Congested Arterials (=100%)			
	Uncongested	Moderate	Heavy	Severe	Extreme
VMT	68%	0	0	0	0
Lane/Miles	75%	0	0	0	0

Principal Arterials											
Rte 419(Rte 221-SCL Slm)	Urban Princ. Art.	4	3.16	35,000	35	8,750	110,600	109,947	12.64	8,698	Severe
Rte 11(WCL Rnk-Edgewd)	Urban Princ. Art.	4	1.35	23,000	35	5,750	31,050	30,867	5.4	5,716	Moderate
Rte 11(Edgewd-Grandin)	Urban Princ. Art.	2	1.03	12,000	30	6,000	12,360	12,287	2.06	5,965	Moderate
Rte 220 (Rte 419-Wonju)	Urban Princ. Art.	6	1.84	46,000	55	7,667	84,640	84,141	11.04	7,621	Heavy
Rte 220 (Wonju-Elm Ave)	Urban Princ. Art.	6	1.71	61,000	55	10,167	104,310	103,695	10.26	10,107	Extreme
Total Arterials							**342,960**	**340,937**	**41.40**	**8,235**	

		% Type of Congestion on Congested Arterials (=100%)			
	Uncongested	Moderate	Heavy	Severe	Extreme
VMT	0	13%	25%	32%	30%
Lane/Miles	0	18%	27%	30%	25%

CONGESTION CALCULATOR - ROANOKE
INVENTORY MEASURES
Medium teleworking - 7.5%(rev. 9/25/01)

Urban Area Information	
Population (000)	236
Urban Area (square miles)	854
Population Density	276
Freeway	
Daily VMT (000)	2,242
Lane-miles	207
VMT/Lane-mile	10,829
Incident to Recurring Delay Ratio	2.1
Percent of Pk Pd Travel in Cong. ****	21
Percent Moderate	0
Percent Heavy	0
Percent Severe	0
Percent Extreme	0
Percent of Ln-miles that are Cong.	100
Percent Moderate	0
Percent Heavy	0
Percent Severe	0
Percent Extreme	0
Principal Arterial Streets	
Daily VMT (000)	2,656
Lane-miles	313
VMT/Lane-mile	8,486
Incident to Recurring Delay Ratio	1.1
Percent of Pk Pd Travel in Cong. ****	27
Percent Moderate	13
Percent Heavy	25
Percent Severe	32
Percent Extreme	30
Percent of Ln-miles that are Cong.	100
Percent Moderate	18
Percent Heavy	27
Percent Severe	30
Percent Extreme	25
Roadway System	
Daily VMT (000)	6,792
Total Road Miles (centerline)	1,810
Percent of Daily Travel During Congested Time	15
Cost Components	
Value of Time ($/hour)	12.40
Truck Operating Cost ($/mile)	2.85
Fuel Cost ($/gallon)	1.07

*** (as seen on website)	
Fwy Percent of Pk Pd Travel in Cong	6
PAS Percent of Pk Pd Travel in Cong	8
ROADWAY SYSTEM PERFORMANCE	
Travel Rate Index	1.13
Travel Time Index	1.16
Percent of Daily Travel in Congestion	4
Annual Hours of Delay	
Total (1000 Person-hours)	2551
Freeway	
Recurring Person-hours (000)	0
Incident Person-hours (000)	0
Principal Arterial Street	
Recurring Person-hours (000)	1215
Incident Person-hours (000)	1336
Annual Delay per Capita (person-hours)	11
Annual Excess Fuel Consumed	
Total (million gallons)	2.00
Fuel consumed per capita (gallons)	10
Annual Congestion Cost	
Total ($million)	37
Cost per Capita ($)	156
Average Peak Period Travel Speed	
Freeway System (mph)	50
Prin Arterial Street System (mph)	33
Roadway Congestion Index	1.02

	CONSTANTS	
Freeway Speed	Uncongested	60
	Moderate	45
	Heavy	38
	Severe	35
	Extreme	32
PAS Speed	Uncongested	35
	Moderate	30
	Heavy	27
	Severe	23
	Extreme	21
Vehicle occupancy		1.25
Pct of passenger-vehicles		0.95
Pct of commercial vehicles		0.05
Number of Annual Workdays		250

ROANOKE

VDOT Telework Study
Roadway Information for Congestion
High teleworking - 10% (rev. 9/25/01)
Estimated VMT Reduction 0.9881

ROADWAY	Classification	# Lanes	Rd Seg	ADT (2000)	Posted SL	ADT/Lane	Daily VMT	Reduced VMT	Ln-Miles	Red. ADT/Lane	Cong level
Interstate/Freeway											
Rte 81 (Rte 311-SR 419)	Urban Interstate	4	1.64	58,000	65	14,500	95,120	93,988	6.56	14,327	Uncongested
Rte 581 (Orange-Hershbgr)	Urban Interstate	6	2.79	61,000	55	10,167	170,190	168,165	16.74	10,046	Uncongested
Rte 81(SCLSalem-SR 112)	Urban Interstate	4	0.2	47,000	65	11,750	9,400	9,288	0.8	11,610	Uncongested
Total Interstate/Freeway							**274,710**	**271,441**	**24.1**	**11,263**	

		% Type of Congestion on Congested Arterials (=100%)			
	Uncongested	Moderate	Heavy	Severe	Extreme
VMT	68%	0	0	0	0
Lane/Miles	75%	0	0	0	0

Principal Arterials											
Rte 419(Rte 221-SCL Slm)	Urban Princ. Art.	4	3.16	35,000	35	8,750	110,600	109,284	12.64	8,646	Severe
Rte 11(WCL Rnk-Edgewd)	Urban Princ. Art.	4	1.35	23,000	35	5,750	31,050	30,681	5.4	5,682	Moderate
Rte 11(Edgewd-Grandin)	Urban Princ. Art.	2	1.03	12,000	30	6,000	12,360	12,213	2.06	5,929	Moderate
Rte 220 (Rte 419-Wonju)	Urban Princ. Art.	6	1.84	46,000	55	7,667	84,640	83,633	11.04	7,575	Heavy
Rte 220 (Wonju-Elm Ave)	Urban Princ. Art.	6	1.71	61,000	55	10,167	104,310	103,069	10.26	10,046	Extreme
Total Arterials							**342,960**	**338,879**	**41.40**	**8,185**	

		% Type of Congestion on Congested Arterials (=100%)			
	Uncongested	Moderate	Heavy	Severe	Extreme
VMT	0	13%	25%	32%	30%
Lane/Miles	0	18%	27%	30%	25%

CONGESTION CALCULATOR - ROANOKE
INVENTORY MEASURES
High teleworking - 10%(rev. 9/25/01)

Urban Area Information	
Population (000)	236
Urban Area (square miles)	854
Population Density	276
Freeway	
Daily VMT (000)	2,228
Lane-miles	207
VMT/Lane-mile	10,764
Incident to Recurring Delay Ratio	2.1
Percent of Pk Pd Travel in Cong. ****	21
Percent Moderate	0
Percent Heavy	0
Percent Severe	0
Percent Extreme	0
Percent of Ln-miles that are Cong.	100
Percent Moderate	0
Percent Heavy	0
Percent Severe	0
Percent Extreme	0
Principal Arterial Streets	
Daily VMT (000)	2,640
Lane-miles	313
VMT/Lane-mile	8,435
Incident to Recurring Delay Ratio	1.1
Percent of Pk Pd Travel in Cong. ****	27
Percent Moderate	13
Percent Heavy	25
Percent Severe	32
Percent Extreme	30
Percent of Ln-miles that are Cong.	100
Percent Moderate	18
Percent Heavy	27
Percent Severe	30
Percent Extreme	25
Roadway System	
Daily VMT (000)	6,751
Total Road Miles (centerline)	1,810
Percent of Daily Travel During Congested Time	15
Cost Components	
Value of Time ($/hour)	12.40
Truck Operating Cost ($/mile)	2.85
Fuel Cost ($/gallon)	1.07

*** (as seen on website)

Fwy Percent of Pk Pd Travel in Cong	6
PAS Percent of Pk Pd Travel in Cong	8
ROADWAY SYSTEM PERFORMANCE	
Travel Rate Index	1.13
Travel Time Index	1.16
Percent of Daily Travel in Congestion	4
Annual Hours of Delay	
Total (1000 Person-hours)	2535
Freeway	
Recurring Person-hours (000)	0
Incident Person-hours (000)	0
Principal Arterial Street	
Recurring Person-hours (000)	1207
Incident Person-hours (000)	1328
Annual Delay per Capita (person-hours)	11
Annual Excess Fuel Consumed	
Total (million gallons)	2.00
Fuel consumed per capita (gallons)	10
Annual Congestion Cost	
Total ($million)	37
Cost per Capita ($)	155
Average Peak Period Travel Speed	
Freeway System (mph)	50
Prin Arterial Street System (mph)	33
Roadway Congestion Index	1.01

	CONSTANTS	
Freeway Speed	Uncongested	60
	Moderate	45
	Heavy	38
	Severe	35
	Extreme	32
PAS Speed	Uncongested	35
	Moderate	30
	Heavy	27
	Severe	23
	Extreme	21
Vehicle occupancy		1.25
Pct of passenger-vehicles		0.95
Pct of commercial vehicles		0.05
Number of Annual Workdays		250

HAMPTON ROADS

VDOT Telework Study
Roadway Information for Congestion
2000 Base Conditions (rev. 9/25/01)

JURIS.	ROADWAY	Classification	# Lanes	Rd Seg	ADT (2000)	Posted SL	ADT/Lane	Daily VMT	Ln-Miles	ADT/Lane	Cong level
Interstate/Freeway											
	I-64(GW Hwy-Military Hwy)	Urban Interstate	4	1.46	58,000	55	14,500	84,680	5.84	14,500	Uncongested
Portsmouth	I-264(Fred Blvd-Deep Creek)	Urban Interstate	6	0.55	67,000	55	11,167	36,850	3.3	11,167	Uncongested
Hampton	I-64(Magruder-Mercury)	Urban Interstate	6	0.55	131,000	55	21,833	72,050	3.3	21,833	Severe
	I-64(Mercury - I-664)	Urban Interstate	6	0.3	131,000	55	21,833	39,300	1.8	21,833	Severe
	I-664(Powhatan - I-64)	Urban Interstate	6	1.13	68,000	55	11,333	76,840	6.78	11,333	Uncongested
Norfolk	I-64(Bay Ave - New Gate)	Urban Interstate	4	1.09	91,000	55	22,750	99,190	4.36	22,750	Severe
Newport News	I-64(JC Morris-Hampton CL)	Urban Interstate	6	1.06	135,000	55	22,500	143,100	6.36	22,500	Severe
Total Interstate/Freeway								**552,010**	**31.74**	**17,392**	

	Uncongested	% Type of Congestion on Congested Arterials (=100%) Moderate	Heavy	Severe	Extreme
VMT	36%	0	0	100%	0
Lane/Miles	50%	0	0	100%	0

JURIS.	ROADWAY	Classification	# Lanes	Rd Seg	ADT (2000)	Posted SL	ADT/Lane	Daily VMT	Ln-Miles	ADT/Lane	Cong level
Principal Arterials											
Chesapeake	Rte 13 (Allison-Greenbriar)	Urban Princ. Art.	4	0.41	33,000	45	8,250	13,530	1.64	8,250	Heavy
	Rte 17(WCL Prts-Chrchlnd)	Urban Princ. Art.	4	0.69	27,000	45	6,750	18,630	2.76	6,750	Moderate
Portsmouth	Rte 17(I-264 - Turnpike Rd)	Urban Princ. Art.	4	0.35	47,000	40	11,750	16,450	1.4	11,750	Extreme
	Rte 165(SR166/US13 - I-64)	Urban Princ. Art.	4	0.62	45,000	45	11,250	27,900	2.48	11,250	Extreme
Total Arterials								**76,510**	**8.28**	**9,240**	

	Uncongested	% Type of Congestion on Congested Arterials (=100%) Moderate	Heavy	Severe	Extreme
VMT	0	24%	18%	0	58%
Lane/Miles	0	33%	20%	0	47%

CONGESTION CALCULATOR - HAMPTON ROADS, VIRGINIA
INVENTORY MEASURES
2000 Base Conditions (rev. 9/25/01)

Urban Area Information	
Population (000)	1,551
Urban Area (square miles)	2,087
Population Density	743
Freeway	
Daily VMT (000)	10,316
Lane-miles	582
VMT/Lane-mile	17,724
Incident to Recurring Delay Ratio	2.1
Percent of Pk Pd Travel in Cong. ****	46
Percent Moderate	0
Percent Heavy	0
Percent Severe	100
Percent Extreme	0
Percent of Ln-miles that are Cong.	50
Percent Moderate	0
Percent Heavy	0
Percent Severe	100
Percent Extreme	0
Principal Arterial Streets	
Daily VMT (000)	14,626
Lane-miles	1,418
VMT/Lane-mile	10,314
Incident to Recurring Delay Ratio	1.1
Percent of Pk Pd Travel in Cong. ****	46
Percent Moderate	24
Percent Heavy	18
Percent Severe	0
Percent Extreme	58
Percent of Ln-miles that are Cong.	100
Percent Moderate	33
Percent Heavy	20
Percent Severe	0
Percent Extreme	47
Roadway System	
Daily VMT (000)	34,560
Total Road Miles (centerline)	6,163
Percent of Daily Travel During Congested Time	23
Cost Components	
Value of Time ($/hour)	12.40
Truck Operating Cost ($/mile)	2.85
Fuel Cost ($/gallon)	1.07

*** (as seen on website)

Fwy Percent of Pk Pd Travel in Cong	21
PAS Percent of Pk Pd Travel in Cong	21
ROADWAY SYSTEM PERFORMANCE	
Travel Rate Index	1.19
Travel Time Index	1.35
Percent of Daily Travel in Congestion	11
Annual Hours of Delay	
Total (1000 Person-hours)	57639
Freeway	
Recurring Person-hours (000)	8827
Incident Person-hours (000)	18536
Principal Arterial Street	
Recurring Person-hours (000)	14417
Incident Person-hours (000)	15859
Annual Delay per Capita (person-hours)	37
Annual Excess Fuel Consumed	
Total (million gallons)	83
Fuel consumed per capita (gallons)	53
Annual Congestion Cost	
Total ($million)	956
Cost per Capita ($)	616
Average Peak Period Travel Speed	
Freeway System (mph)	49
Prin Arterial Street System (mph)	30
Roadway Congestion Index	1.48

	CONSTANTS	
Freeway Speed	Uncongested	60
	Moderate	45
	Heavy	38
	Severe	35
	Extreme	32
PAS Speed	Uncongested	35
	Moderate	30
	Heavy	27
	Severe	23
	Extreme	21
Vehicle occupancy		1.25
Pct of passenger-vehicles		0.95
Pct of commercial vehicles		0.05
Number of Annual Workdays		250

HAMPTON ROADS

VDOT Telework Study
Roadway Information for Congestion
Medium teleworking - 10% (rev. 9/25/01)
Estimated VMT Reduction 0.9911

JURIS.	ROADWAY	Classification	# Lanes	Rd Seg	ADT (2000)	Posted SL	ADT/Lane	Daily VMT	Reduced VMT	Ln-Miles	Red. ADT/Lane
Interstate/Freeway											
	I-64(GW Hwy-Military Hwy)	Urban Interstate	4	1.46	58,000	55	14,500	84,680	83,926	5.84	14,371
Portsmouth	I-264(Fred Blvd-Deep Creek)	Urban Interstate	6	0.55	67,000	55	11,167	36,850	36,522	3.3	11,067
Hampton	I-64(Magruder-Mercury)	Urban Interstate	6	0.55	131,000	55	21,833	72,050	71,409	3.3	21,639
	I-64(Mercury - I-664)	Urban Interstate	6	0.3	131,000	55	21,833	39,300	38,950	1.8	21,639
	I-664(Powhatan - I-64)	Urban Interstate	6	1.13	68,000	55	11,333	76,840	76,156	6.78	11,232
Norfolk	I-64(Bay Ave - New Gate)	Urban Interstate	4	1.09	91,000	55	22,750	99,190	98,307	4.36	22,548
Newport News	I-64(JC Morris-Hampton CL)	Urban Interstate	6	1.06	135,000	55	22,500	143,100	141,826	6.36	22,300
Total Interstate/Freeway								**552,010**	**547,097**	**31.74**	**17,237**

		% Type of Congestion on Congested Arterials (=100%)			
	Uncongested	Moderate	Heavy	Severe	Extreme
VMT	36%	0	0	100%	0
Lane/Miles	50%	0	0	100%	0

JURIS.	ROADWAY	Classification	# Lanes	Rd Seg	ADT (2000)	Posted SL	ADT/Lane	Daily VMT	Reduced VMT	Ln-Miles	Red. ADT/Lane
Principal Arterials											
Chesapeake	Rte 13 (Allison-Greenbriar)	Urban Princ. Art.	4	0.41	33,000	45	8,250	13,530	13,410	1.64	8,177
	Rte 17(WCL Prts-Chrchlnd)	Urban Princ. Art.	4	0.69	27,000	45	6,750	18,630	18,464	2.76	6,690
Portsmouth	Rte 17(I-264 - Turnpike Rd)	Urban Princ. Art.	4	0.35	47,000	40	11,750	16,450	16,304	1.4	11,645
	Rte 165(SR166/US13 - I-64)	Urban Princ. Art.	4	0.62	45,000	45	11,250	27,900	27,652	2.48	11,150
Total Arterials								**76,510**	**75,829**	**8.28**	**9,158**

		% Type of Congestion on Congested Arterials (=100%)			
	Uncongested	Moderate	Heavy	Severe	Extreme
VMT	0	24%	18%	0	58%
Lane/Miles	0	33%	20%	0	47%

CONGESTION CALCULATOR - HAMPTON ROADS, VIRGINIA

INVENTORY MEASURES

Medium teleworking - 10%(rev. 9/25/01)

Urban Area Information	
Population (000)	1,551
Urban Area (square miles)	2,087
Population Density	743
Freeway	
Daily VMT (000)	10,224
Lane-miles	582
VMT/Lane-mile	17,567
Incident to Recurring Delay Ratio	2.1
Percent of Pk Pd Travel in Cong. ****	46
Percent Moderate	0
Percent Heavy	0
Percent Severe	100
Percent Extreme	0
Percent of Ln-miles that are Cong.	50
Percent Moderate	0
Percent Heavy	0
Percent Severe	100
Percent Extreme	0
Principal Arterial Streets	
Daily VMT (000)	14,496
Lane-miles	1,418
VMT/Lane-mile	10,223
Incident to Recurring Delay Ratio	1.1
Percent of Pk Pd Travel in Cong. ****	46
Percent Moderate	24
Percent Heavy	18
Percent Severe	0
Percent Extreme	58
Percent of Ln-miles that are Cong.	100
Percent Moderate	33
Percent Heavy	20
Percent Severe	0
Percent Extreme	47
Roadway System	
Daily VMT (000)	34,252
Total Road Miles (centerline)	6,163
Percent of Daily Travel During Congested Time	23
Cost Components	
Value of Time ($/hour)	12.40
Truck Operating Cost ($/mile)	2.85
Fuel Cost ($/gallon)	1.07

*** (as seen on website)

Fwy Percent of Pk Pd Travel in Cong	21
PAS Percent of Pk Pd Travel in Cong	21
ROADWAY SYSTEM PERFORMANCE	
Travel Rate Index	1.19
Travel Time Index	1.35
Percent of Daily Travel in Congestion	11
Annual Hours of Delay	
Total (1000 Person-hours)	57125
Freeway	
Recurring Person-hours (000)	8748
Incident Person-hours (000)	18371
Principal Arterial Street	
Recurring Person-hours (000)	14289
Incident Person-hours (000)	15717
Annual Delay per Capita (person-hours)	37
Annual Excess Fuel Consumed	
Total (million gallons)	82
Fuel consumed per capita (gallons)	53
Annual Congestion Cost	
Total ($million)	948
Cost per Capita ($)	611
Average Peak Period Travel Speed	
Freeway System (mph)	49
Prin Arterial Street System (mph)	30
Roadway Congestion Index	1.47

	CONSTANTS	
Freeway Speed	Uncongested	60
	Moderate	45
	Heavy	38
	Severe	35
	Extreme	32
PAS Speed	Uncongested	35
	Moderate	30
	Heavy	27
	Severe	23
	Extreme	21
Vehicle occupancy		1.25
Pct of passenger-vehicles		0.95
Pct of commercial vehicles		0.05
Number of Annual Workdays		250

HAMPTON ROADS

VDOT Telework Study
Roadway Information for Congestion
High teleworking - 12.5% (rev. 9/25/01)
Estimated VMT Reduction 0.9822

JURIS.	ROADWAY	Classification	# Lanes	Rd Seg	ADT (2000)	Posted SL	ADT/Lane	Daily VMT	Reduced VMT	Ln-Miles	Red. ADT/Lane
Interstate/Freeway											
	I-64(GW Hwy-Military Hwy)	Urban Interstate	4	1.46	58,000	55	14,500	84,680	83,173	5.84	14,242
Portsmouth	I-264(Fred Blvd-Deep Creek)	Urban Interstate	6	0.55	67,000	55	11,167	36,850	36,194	3.3	10,968
Hampton	I-64(Magruder-Mercury)	Urban Interstate	6	0.55	131,000	55	21,833	72,050	70,768	3.3	21,445
	I-64(Mercury - I-664)	Urban Interstate	6	0.3	131,000	55	21,833	39,300	38,600	1.8	21,445
	I-664(Powhatan - I-64)	Urban Interstate	6	1.13	68,000	55	11,333	76,840	75,472	6.78	11,132
Norfolk	I-64(Bay Ave - New Gate)	Urban Interstate	4	1.09	91,000	55	22,750	99,190	97,424	4.36	22,345
Newport News	I-64(JC Morris-Hampton CL)	Urban Interstate	6	1.06	135,000	55	22,500	143,100	140,553	6.36	22,100
Total Interstate/Freeway								**552,010**	**542,184**	**31.74**	**17,082**

		% Type of Congestion on Congested Arterials (=100%)			
	Uncongested	Moderate	Heavy	Severe	Extreme
VMT	36%	0	0	100%	0
Lane/Miles	50%	0	0	100%	0

JURIS.	ROADWAY	Classification	# Lanes	Rd Seg	ADT (2000)	Posted SL	ADT/Lane	Daily VMT	Reduced VMT	Ln-Miles	Red. ADT/Lane
Principal Arterials											
Chesapeake	Rte 13 (Allison-Greenbriar)	Urban Princ. Art.	4	0.41	33,000	45	8,250	13,530	13,289	1.64	8,103
	Rte 17(WCL Prts-Chrchlnd)	Urban Princ. Art.	4	0.69	27,000	45	6,750	18,630	18,298	2.76	6,630
Portsmouth	Rte 17(I-264 - Turnpike Rd)	Urban Princ. Art.	4	0.35	47,000	40	11,750	16,450	16,157	1.4	11,541
	Rte 165(SR166/US13 - I-64)	Urban Princ. Art.	4	0.62	45,000	45	11,250	27,900	27,403	2.48	11,050
Total Arterials								**76,510**	**75,148**	**8.28**	**9,076**

		% Type of Congestion on Congested Arterials (=100%)			
	Uncongested	Moderate	Heavy	Severe	Extreme
VMT	0	24%	18%	0	58%
Lane/Miles	0	33%	20%	0	47%

CONGESTION CALCULATOR - HAMPTON ROADS, VIRGINIA

INVENTORY MEASURES
High teleworking - 12.5%(rev. 9/25/01)

Urban Area Information	
Population (000)	1,551
Urban Area (square miles)	2,087
Population Density	743
Freeway	
Daily VMT (000)	10,132
Lane-miles	582
VMT/Lane-mile	17,409
Incident to Recurring Delay Ratio	2.1
Percent of Pk Pd Travel in Cong. ****	46
Percent Moderate	0
Percent Heavy	0
Percent Severe	100
Percent Extreme	0
Percent of Ln-miles that are Cong.	50
Percent Moderate	0
Percent Heavy	0
Percent Severe	100
Percent Extreme	0
Principal Arterial Streets	
Daily VMT (000)	14,365
Lane-miles	1,418
VMT/Lane-mile	10,131
Incident to Recurring Delay Ratio	1.1
Percent of Pk Pd Travel in Cong. ****	46
Percent Moderate	24
Percent Heavy	18
Percent Severe	0
Percent Extreme	58
Percent of Ln-miles that are Cong.	100
Percent Moderate	33
Percent Heavy	20
Percent Severe	0
Percent Extreme	47
Roadway System	
Daily VMT (000)	33,945
Total Road Miles (centerline)	6,163
Percent of Daily Travel During Congested Time	23
Cost Components	
Value of Time ($/hour)	12.40
Truck Operating Cost ($/mile)	2.85
Fuel Cost ($/gallon)	1.07

*** (as seen on website)

Fwy Percent of Pk Pd Travel in Cong	21
PAS Percent of Pk Pd Travel in Cong	21
ROADWAY SYSTEM PERFORMANCE	
Travel Rate Index	1.19
Travel Time Index	1.35
Percent of Daily Travel in Congestion	11
Annual Hours of Delay	
Total (1000 Person-hours)	56611
Freeway	
Recurring Person-hours (000)	8669
Incident Person-hours (000)	18206
Principal Arterial Street	
Recurring Person-hours (000)	14160
Incident Person-hours (000)	15576
Annual Delay per Capita (person-hours)	36
Annual Excess Fuel Consumed	
Total (million gallons)	81
Fuel consumed per capita (gallons)	52
Annual Congestion Cost	
Total ($million)	939
Cost per Capita ($)	605
Average Peak Period Travel Speed	
Freeway System (mph)	49
Prin Arterial Street System (mph)	30
Roadway Congestion Index	1.46

CONSTANTS

Freeway Speed	Uncongested	60
	Moderate	45
	Heavy	38
	Severe	35
	Extreme	32
PAS Speed	Uncongested	35
	Moderate	30
	Heavy	27
	Severe	23
	Extreme	21
Vehicle occupancy		1.25
Pct of passenger-vehicles		0.95
Pct of commercial vehicles		0.05
Number of Annual Workdays		250

Appendix C
GSA Cost per Person Model

In the *Workplace Evaluation Study*, GSA presents a model that expands the traditional method of evaluating real estate performance from the more narrowly defined cost per square foot analysis to one that considers telecommunications, information technology, furniture and alternative work environments. This model allows the user to analyze factors relating to quality, productivity and employee satisfaction and perform sensitivity analyses on various workplace scenarios, including home-based or telecenter-based telework. GSA defines the Cost per Person as "the sum of fully serviced real estate cost, telecommunications costs, information technology costs, furniture costs, and alternative work environment costs" (1999 GSA).

In a 1997 GSA study, *Office Space Review*, GSA discusses issues related to the need for expanding the traditional form of measuring real property performance. A subsequent 1998 *Government-wide Real Property Performance Measurement Study* provided the process for deriving seven real property performance measures including number of employees housed, total square feet, cost per square foot owned, vacancy rate, cost per square foot leased, cost per person and customer satisfaction. Performance data was gathered across federal agencies with real property authority and analyzed in order to estimate a baseline for each of the measures except for cost per person and customer satisfaction. These measures, which had not been measured extensively across either the public or private sector, were defined by limited published data and the agency's own internal analysis (1999 GSA).

The Cost per Person Model, which is available from GSA's Office of Real Property, is an Excel workbook consisting of the Cost per Person Model and a chart of representative rental rates in selected U.S. cities and sub-markets (1999 GSA). The Cost per Person model consists of five components. These components and their respective baseline assumptions are discussed below:

1. Real Estate: These costs are based on comparable market value.
2. Telecommunications: These costs were based on GSA cost data derived from knowledgeable sources within the agency.
3. Information Technology: These costs were based on GSA cost data derived from knowledgeable sources within the agency.
4. Workstation Furniture: These costs were based on GSA cost data derived from knowledgeable sources within the agency.
5. Alternative Work Environment: These costs were generated from assumptions on numbers of teleworkers, hoteling costs, and space per person which were based on policy guidance and adjusted as necessary.

The outputs for the baseline Cost per Person consist of a Total Annual Cost of the sum of the five components and a Cost per Person for the first year and years two and three are stated. The Base

Case for a typical federal agency located in Washington, DC generates a Cost per Person of $15,581 in year one and $10,929 in years two and three. This means that it will cost an organization the size of a federal agency (in this case 1,008 full time employees) located in Washington, DC over $15,000 to provide workspace for each employee in the first year and nearly $11,000 in the second and third years.

Table C-1 describes a hypothetical comparison of two office environments, the Traditional Office Environment where employees have individual work spaces at a main office and another called the "Innovative Office Environment," which accounts for home-based teleworking.

Table C-1
Average Cost per Person for Fiscal Year 1999
Southern California Company, Los Angeles, CA[1]

	Example A: Traditional Office Environment	Example B: Innovative Office Environment
No. of full-time employees	4,000	4,000
No. of workstations	4,000	3,000
No. of teleworkers	-	1,500
Full-time home workers	-	500
Part-time home workers	-	1,000
No. of shared workstations	-	500
Cost per Person (year 1)	**$13,343**	**$11,979**
Cost per Person (years 2-3)	**$8,689**	**$8,301**

[1]U.S. General Services Administration, *Workplace Evaluation Study*, 1999. In this study, GSA presents a comparative analysis of two hypothetical scenarios for "Southern California Company."

The assumptions used for modeling these two scenarios include:

1. Real Estate: A rental rate of $22.50 was assumed for Los Angeles, CA. A utilization rate of 230 rentable square feet per person was based on the GSA standard and adjusted to reflect the appropriate unit of measurement.
2. Telecommunications: Analog modems were assumed at a cost of $877 per workstation.
3. Information Technology: These costs include workstation and Local Area Network interface. The total annual IT cost per person is $3,337.
4. Workstation Furniture: These costs assumed system type design at a cost of $3,954 per workstation.
5. Alternative Work Environment: In the "Traditional Office Environment," the number of teleworkers was assumed to zero, generating no respective costs. In the "Alternative Office Environment," the number of teleworkers was assumed to be 1500 all home-based generating an annual cost of $5,259 per teleworker.

Comparing the two scenarios above, the Cost per Person associated with the Traditional Office scenario in the first year is approximately 11 percent more than that of the

Alternative Office scenario wherein home-based telework is used by a little over one-third of the agency's total office population. The Cost per Person associated with the Traditional Office scenario in the second and third years is approximately 5 percent more than that of the Alternative Office scenario. A full cost-benefit analysis would show cost increases every so many years to reflect necessary upgrades of obsolete computer equipment. It might also take into consideration the time value of money, inflation and depreciation.

Appendix D
Equipment and Information Technology Costs of Teleworking

TABLE D-1
Equipment and Information Technology Costs of Teleworking

EQUIPMENT		COSTS		
		High	Medium	Low
1.	Desktop Computer	$2,500	$1,500	$1,000
2.	Laptop Computer	$3,000	$2,000	$1,500
3.	Personal Digital Assistant	$600	$450	$200
4.	Modem (Dial up or DSL)	$150	$100	$50
5.	Digital Service Line	$250/month	$99/month	$50/month
6.	Internet Service (dial-up)	$30/month	$25/month	$15/month
7.	Wide-Area Network (set up and $2,000 per site)	$5,000	$3,000	$2,500
8.	Virtual Private Network	$500/month	$400/month	$250/month
9.	Electronic Mail Server	$150/month	$75/month	$25/month
10.	Basic Software (Word, Excel, Anti-Virus)	$600	$400	$250
11.	Space Mgmt Software (Hoteling 100 spaces)	$60,000 set up $21,600/year	$43,900 set up $16,200/year	$27,800 set up $10,800/year
12.	Printer	$1500	$650	$100
13.	Facsimile Machine	$650	$500	$250
14.	Cellular Phone Service	$200/month	$100/month	$50/month
15.	Voice Mail/ Answering Machine	$50/month	$35/month	$20/month
16.	Traveling Phone Service Centrix	$60/month plus $270 connection fee	$45/month plus $200 connection fee	$30/month plus $130 connection fee
17.	Long Distance Telecom Services	$100/month	$75/month	$50/month
18.	Video Conferencing site	Set up $20,000	Set up $15,000	Set up $10,000
19.	Conference Calling	$100/month	$75/month	$50/month
20.	Photo Copier	$1,500	$1,000	$500
21.	Scanner	$500	$300	$100