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JERRY FRANK

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VIRTUAL TRANSPORTATION AS A SOLUTION TO URBAN TRANSPORTATION PROBLEMS: A CRITICAL ANALYSIS OF THE POTENTIAL OF TELECOMMUTING AS A WORK TRIP REDUCTION STRATEGY

Introduction

Transportation in urban space has become increasingly difficult. The automobile, the dominant transportation mode choice, is restricting the movement of people during peak demand periods. The rising levels of traffic congestion caused by overloaded road transportation infrastructure, is evidence of this crisis. The mass utilization of the automobile has had a lasting effect on society, the economy and the environment¹. Policy makers have planned and implemented numerous strategies to attempt to solve the problem of congestion and environmental degradation. The least supported solution, virtual transportation shows the most promise in eliminating or reducing urban transportation problems. The development of a global information economy and recent advancements in technology make virtual transportation a viable solution to the peak demand problem.

Virtual transportation has the potential to reduce traffic congestion and the associated environmental impacts by reducing the generation of work trips or by altering their spatial and temporal components. A clear understanding of the root of the transportation problem will explain why many of the contemporary proposed solutions are ineffective. The success of the transfer from physical to virtual transportation largely relies on how well implementation strategies are designed. Virtual transportation will have massive repercussions on society. Public policy issues and societal impacts will need to be mediated. Virtual transportation, although in its infancy, has shown results that support theoretical expectations.

The Urban Transportation Problem

Mode Choice

The philosophy of travelling to work was born in the industrial revolution when masses of people left the home for the factory. The

James A. Buczynski

spheres of work and home were separated. Social practices prescribe the precise timing and locations of events that confine human movement to set rhythms between activity sites². The invention and introduction of the Trolley car increased the spatial separation between home and work by allowing families to settle further from their place of employment. Trolley lines shaped the development of the city.

The automobile was a catalyst for the rise of a suburban culture in North America. Cities decentralized after World War II as widespread automobile ownership brought great increases in personal mobility, further increasing the distance between home and work. Land use policies and the baby boom fuelled the massive suburbanization that took place. Land use planning departments sought to safeguard property values by separating land uses. Suburban housing patterns resulted in large distances between places, making automobile mobility a necessity. Public investment in automobile infrastructure, namely expressways (1945-1970), opened up new land for development, decreased commute times to work and stimulated the economy. Refitting the urban environment to accommodate the car required a vast capital expenditure which translated into jobs and business activity³. Human settlements became auto-centric with urban design, urban infrastructure and policy making all catering to the car⁴. Auto-centric land use patterns make public transit logistically and economically infeasible.

The growth in automobiles has surpassed the growth of the population. Today, 70% of freeways have become congested to some degree as freeway capacity is surpassed, causing the length of time to commute to work to drastically increase⁵. The ever expanding urban periphery has increased the average number of vehicle miles travelled (VMT). The automobile meets up to 90% of all travel requirements⁶. Freeways were designed to move people between the periphery and the central business district or manufacturing regions. The rise of the information economy and municipal policy decisions have deconcentrated jobs across the urban space. The radial orientation of freeway networks is out of synchronization with the demand of intra-urban flows. In summary, the Post-Industrial metropolis is faced with inherent structural transportation problems that can only be solved by reducing the amount of travel demand serviced by the automobile.

Travel Demand

Transportation is a by-product of trying to accomplish some non-transport activity. Work trip travel demand is a derived demand. Home is

at one end of 80% of all trips made each day in the city. Work trips account for up to 50% of all intraurban trips⁷. Traffic congestion results from the peaking of travel demands during rush hours. Rush hour periods are between 6:00am to 9:00am and 3:00pm to 6:00pm. Standardized work hours are the culprit for this double peaking phenomenon. The absolute magnitude of the peak travel demand is increasing rapidly and is a function of three variables: activity accessibility, automobile ownership and labour-force participation.

Auto-centric urban design and spatially constricted automobile travel create concentrated travel flows. Transportation planners did not accurately forecast the future demand that would be placed on the freeway networks. People are willing to travel long distances to access economic activities. The utility of affordable housing surpasses the disutility of long commute times and distances. The length of trips measured in distance, time and cost, has been found to increase as city size increases and density decreases. Hence, the length of peak demand periods increase.

The growth in automobile ownership (population of cars) has outpaced the growth in human population in cities. Motor vehicle registrations in Canada increased by over three million from 1980 to 1992 or an average annual increment of 2.6 percent⁸. Expressways became congested as design capacity was surpassed.

Transportation planners designing the urban freeway network did not forecast the impact on demand caused by the growth in female labour-force participation. This growth was fed by the woman's movement, the development of a consumer society and the changing composition of the household. Peak travel demands soared.

Environmental Impacts

The automobile is responsible for a multitude of negative environmental impacts. The automobile pollutes the environment, murders and injures million of people and causes damage to property, consumes vast reserves of energy and occupies inordinate amounts of space. Advances in technology which mediate the impacts of the automobile are negated by the increases in its population.

The internal combustion engine consumes energy stored in petroleum and emits pollutants. Fossil fuel reserves are being depleted. Internal combustion engines that are fuelled by diesel fuel release particulates into the atmosphere. These particulates are a known carcinogen. The main pollutants emitted from automobiles propelled by the internal combustion engine are: Carbon Monoxide, Carbon Dioxide,

Volatile organic Compounds and Nitrous Oxides. Congestion and increases in vehicle miles travelled only magnifies the magnitude of the emissions outputted by an automobile during a work trip.

Automobile infrastructure consumes vast quantities of space and phenomenal quantities of natural resources. Roadways partition or destroy neighbourhoods, farmland and wildlife habitat. Automobiles generate large amounts of noise pollution. The production of cars and auto infrastructure consume large amounts of finite resources and their disposal generates vast quantities of waste. Clearly, a new transportation system is required that is environmentally sustainable and does not restrict freedom of movement.

Potential Solutions to the Urban Transportation Problem

The government and the market possess the power to develop an environmentally friendly urban transportation system that can efficiently handle travel flows. The government can mandate change or provide incentives for change. The market reacts to both government regulation and consumer demand with the aim of continually maximizing profits. The market drives our consumer society. The solution to the urban transportation problem will require a balance between government intervention and market forces. Proposed solutions to the causes and effects of single modal choice, unevenly distributed travel demand and finite automobile transportation infrastructure are:

- 1> Technologically fixing the automobile
- 2> Increasing the capacity of auto infrastructure
- 3> Changing the transportation modal split

Technological Fix

The most strongly advocated solution to the environmental problems of the automobile is technologically taming the emissions produced by the automobile. The removal of lead from fuel has solved the lead pollution problems of the automobile. The amounts of carbon monoxide emitted by the automobile has been largely tamed by the introduction of the two and three way catalytic converter. The catalytic converter does not perform its role until it reaches a high temperature, making it relatively useless on short errand trips. In addition, carbon monoxide emissions are replaced by higher carbon dioxide emissions,

which is a greenhouse gas. The ongoing evolution of more and more fuel efficient internal combustion engines has led to a reduction in energy depletion per vehicle and an increase in nitrous oxides emitted. However, most pollution reduction brought about by technological improvements has been offset by the explosive growth in the size of the automobile population. The development of an electric propulsion motor will solve the pollution shortcomings of the internal combustion engine. The electric vehicle solves only one part of the urban transportation problem, pollution. The large problems of congestion, land consumption and people and property damage are not resolved.

Increasing the Capacity of Automobile Infrastructure

The urban transportation problem of congestion can be solved by increasing automobile infrastructure capacity. The flows on a network can be increased in two ways: increase the physical dimensions of the network links or improve network link efficiency. The unusual level of affluence that facilitated the mass highway construction era does not exist today. Governments have already accumulated massive deficits and tax-payers are not willing to incur the costs associated with building more highways. The civil liberties movement and the current environmental conservation movement provide formidable obstacles to solving the problem of congestion with this solution. Increasing capacity only improves the utility of the car and with time, congestion will reappear as more demand is placed on the transportation network link.

Network link efficiency can be improved by the use of traffic management technology. Intelligent Vehicle Highway systems (IVHS) is the solution currently supported by the highway engineering community as the Interstate Highway Construction Program has been largely completed⁹. The end of the cold war has left defence contractors without a future so they are supporting IVHS as an avenue for future profits. IVHS is a short term solution to congestion that will not be ready for introduction for decades. Development has just begun. The pursuit of this solution is purely influenced by politics. Augmenting capacity will only solve the problem in the short term. The problem to solve is how to manage continually increasing unevenly distributed flows of people across increasing distances. The solution lies in changing the modal split and reducing the number of work trips generated.

Changing the Modal Split

In theory the urban transportation problem may be solved by

changing the modal split of work trip demand. Government mandates and incentives could be used to change people's behaviour by making modes other than the automobile more attractive and decreasing the utility of single occupancy automobile travel. The alternate travel modes are: high occupancy vehicles (car pooling), public transit and virtual transportation (telecommuting).

Government mandates and incentives to change the travel behaviour of people have been ineffective, expensive and frustrating. The dispersion of economic activities across urban space in combination with residential land use patterns make public transit an unviable option. Park and ride schemes make trunk travel by public transit possible but congest local areas and fail to solve the problem of reaching the work destination from the nearest transit stop. Public transit is also very expensive to build and maintain. Peaking demand requires a large fleet which is under used most of the day and night. Virtual transportation is a simple solution that is inexpensive, requires little government intervention and drastically reduces emissions.

The Virtual Transportation Solution

Virtual transportation has the potential to solve the urban transportation crisis within a short period of time with little cost to employees and employers and can be implemented with little government incentives and mandates and at a reasonable cost. The solution attacks the root of the problem: the temporally concentrated generation of work trips across ever increasing distances and their modal split. The emergence of a global information economy and recent advancements in technology make virtual transportation an inevitable solution to the urban transportation crisis.

Virtual Transportation Defined

The concept of virtual transportation assumes many names and associated definitions. Telecommuting and teleworking are the two most common labels of the phenomenon. Virtual transportation is still in its infancy, which results in definitions changing as information technology evolves and new applications for the technology are discovered. For the purpose of this paper, virtual transportation (telecommuting) will be

defined as:

"a philosophy of allowing an employee to perform required tasks full-time or part-time from his/her choice of location by using information technology".¹⁰

Telecommuting removes or reduces the geographic constraints of time and space. Virtual transportation will reverse the work-location trends of the 19th century industrial revolution a systematic reappraisal of the spatial organization of economic institutions.¹¹ Information technology is ready today to make virtual transportation possible.

Information Technology

A full review of all of the present and prospective developments in Information Technology is beyond the scope of this paper. A brief review of some of the key technologies is included to demonstrate the feasibility of telecommuting today. The adoption of evolving information technology has accelerated due to increased power, user friendliness, dependability, exposure and the decreased cost of the technology.¹²

The backbone of information technology infrastructure are the communication networks. They are comparable to freeways and road systems. There is a hierarchical ordering of communication flows. Telephone, Cable TV (coaxial cable) and wireless are three possible interactive telecommunication mediums. The key network for telecommuting currently under development is the ISDN - Integrated Services Digital Network. ISDN will enable data in any format (voice, data, images, music and video) to travel on the same cables. The carrying capacity of a network is measured by the bandwidth of its cables and the type of switches. The telephone line with twisted copper cable has a very low carrying capacity and is a constraint to connecting the home to ISDN. Cable TV coaxial cable has 100 times the carrying capacity of the phone line. However, current infrastructure is not point to point and two way. Expensive upgrading will be required if the cable TV network is to be used as a communication corridor. Fiber optics are the superhighways of the telecommunications network. They carry 10000 times the capacity of the copper telephone line due to their broad bandwidth.¹³ Satellite corridors are faster than coaxial cable and less than fiber optics. The recent substantial enhancements in transfer capacity of communication networks have been the result of the introduction of digital switching (versus

analogue) data compression technologies and fibre optic trunk lines. Digital switching has increased the ability of service providers to manage data streams. Service providers hope to have a fully digital trunk network shortly.¹⁴

The weakest link in telecommunication infrastructure is the absence of a complete fibre optic network. The integrated services digital network is the only medium that can handle the anticipated flows of data and transmit them at a reasonable speed. The cost of replacing copper telephone cables is prohibitively expensive due to the decentralized low density residential pattern of contemporary cities. Virtual commuters have different demands for services. Many economic activities could be transferred to the home without the need for ISDN services. The construction of neighbourhood telecommunication centres (teleports) will make telecommuting possible in the short term for those economic activities that require full time or periodic ISDN services, without the massive expenditure of upgrading the whole network immediately. Cellular technology may be another solution. Currently it is not sufficiently developed to access its potential as a communications network.

Telecommunication Centres

Telecommunication centres are a solution to many of the problems limiting the introduction of telecommuting. In theory, they would be structured in the form of a community office. They would be evenly distributed across urban residential space and the size of each 'teleport' would differ according to local demand. They would be equipped with all the office equipment, amenities and information technology required to perform any information economy activity. Hardware would include: personal computers with fax-modems and video-phones and a variety of software, audio telephones with numerous services (call forwarding, waiting, voice mail), photocopiers, scanners and video-conference equipment. A single fibre optic highway could support 20 000 telecommuters. Gann¹⁵ has hypothesized a 'teleport' for 1000 telecommuters would require: 1000 computers, 200 fax terminals, 200 ISDN circuits, 200 data only circuits, and 10 video conference suites.

The strength in the theory of telecommunication centres lies in their ability to supplement the amenities available in the home at an easily accessible location and a short distance away. The problematic part of the idea lies in financing. Who should pay to build and operate these facilities:

municipal government, federal government, Industry or the users? A combination of sources is required. Ideally they should be controlled by a government body to ensure equal access. Financing could include usage tolls paid by employers, a reasonable membership fee for employees and heavy subsidization by fuel taxes or even road pricing. Road pricing would be an excellent way to generate the capital required for the initial construction of facilities.

Telecommuting Explained

Coordination between business and government is necessary to make the transition to virtual commuting smooth. The success of the transfer from physical to virtual transportation largely relies on correctly selecting economic activities that are telecommunicable given the technology available at the specific period in time. Telecommuting will require time and creativity to implement. The information workforce will need time to adjust and social impacts will need to be mediated.

Business and government will receive benefits from the adoption of telecommuting. The reduction in work trip generation and the reduction in its temporal and spatial components will solve the urban transportation problem. The reduction of temporally concentrated demand on freeway networks will eliminate congestion and reduce emissions. The reorganization of society by telecommuting will make any locality, region or country that much more competitive in the global information economy. The province of New Brunswick was first in Canada to fully digitize its communication networks and as a result has been successful in attracting high technology and information based employment. Economic growth can only benefit the people and business. Telecommuting has been demonstrated to decrease the costs of production by lowering capital expenditure (land) and increasing worker productivity. Virtual transportation also has the ability to increase worker satisfaction. Table 1 demonstrates the potential of telecommuting to both satisfy employers and employees. The idea of the neighbourhood telecommunications centre would solve the majority of problems for both employers and employees. The centre is located close to home and open 24 hours a day. Video phone technology will remove the feeling of disconnectedness with colleagues but will bring personal attire to the forefront again. The teleport in theory will create a closer sense of community and maintain a sense of corporate culture. Unfortunately, not all workers are eligible telecommuters.

TABLE 1 ADVANTAGES AND DISADVANTAGES OF TELECOMMUTING¹⁶**The Individual Employee****ADVANTAGES**

- Less commuting time and costs (monetary and physical)
- Flexible work schedule and more time for home and family
- Ability to plant roots in a community and work in a wider catchment area
- Employment opportunities for the disabled
- More effective use of face to face contact
- Increased job satisfaction

DISADVANTAGES

- Isolation - lack of interaction with co-workers
- Potential of gaining experience from peers is reduced
- Chances for personal promotion are reduced with horizontal organizational structure
- Less political power within the organization
- Danger of exploitation -work during leisure hours to make deadline
- Loss of contract status, benefits?
- Pressures of family and work in the same sphere

The Employer**ADVANTAGES**

- Time and space advantages of telecommuting in a global market
- Early birds or night owls can work when they are most productive
- Higher productivity (25% average)
- Lower facility/amenity costs
- Easier to recruit staff - contract staff for rushes.
 - wider catchment area to recruit staff
- Compliance with local commuting reduction regulations
- Reduced labour militancy

DISADVANTAGES

- incompatibility with current work ethos, corporate identity
- Greater demand to supervise and monitor progress
- Technical problems of transporting or transferring work.
- Cost of setting up telecommuting eg. training
- Security of information
- Loss of productivity in transition period

The majority of current information production and processing positions are telecommunicatable. The actual potential population differs substantially within the literature. Estimates range from ten percent to seventy five percent. Quantifying the number of present telecommuters has also been problematic given the variety of defining parameters. The population has been measured as between 10 000 and 10 000 000 in the United States. The key determinants for evaluating the potential

transferability of an economic activity to a remote site are:

- 1> The degree that the activity is information based
- 2> The amount of physical interaction required by the activity
- 3> The measurability of output

Table 2 illustrates some of the many positions that can be performed from a remote site using information technology. Clerical and professional occupations are the simplest to transfer to remote sites.

TABLE 2 EXAMPLES OF JOBS WITH TELECOMMUTING POTENTIAL¹⁷

Accountant	Journalist
Applications programmer	Lawyer
Architect	Market analyst
Auditor	Purchasing manager
CAD/CAM engineer	Realtor
Civil engineer	Statistician
Data entry clerk	Stock broker

Virtual transportation has the potential to solve the urban transportation problem by reducing the number of work trips generated and the magnitude of their spatial and temporal components. The development of a network of telecommunication centres, one within each neighbourhood would solve many of the problems associated with using one's home as an economic activity location. The full adoption of telecommuting may take up to ten years. Gradually, air quality would improve and congestion would become a memory of the past.

Virtual Transportation Performance Appraisal

Virtual transportation presently exists more powerfully as an ideological construct than as a reality. The phenomenon is in its infancy. There have been few published empirical studies verifying the theoretical trip reduction impacts of telecommuting. Moreover, it is not captured in any comprehensive statistical databases. An empirical study by Lund and Mokhtarian in 1994 and one by Mokhtarian, Handy and Solomon in 1995 show results that correlate with trip reduction potentials associated with virtual transportation.¹⁸ The total amount of vehicle miles travelled, peak period trips, energy consumption and emissions decrease significantly. In addition, there appears to be no new generation of non-work trips now

that the automobile is liberated from its work trip duties. Very small reductions in single occupancy vehicles have been found to result in exponential decreases in congestion.¹⁹ There appears to be no empirical data published on the impact on the temporal and spatial components of work trips by telecommunications centres, in an urban region. The true long term impacts of telecommuting remain unknown and many hypotheses are simply extrapolations from limited short term empirical studies.

Substantial case histories and anecdotal evidence suggests that telecommuting leads to gains in work productivity and job satisfaction.²⁰ A limited empirical study by DuBrin reveals the same results. The reoccurring themes that emerge from case studies of pilot projects are a strong resistance from management to changing work structures and a fear by workers of forced adoption of telecommuting which eventually leads to exploitation. Voluntary programs show disappointing participation rates. If telecommuting is to solve the urban transportation problem, government intervention is required to stimulate employers and employees to switch over from physical commuting to virtual commuting and legislation needs to be amended to protect workers from exploitation.

Public Policy Issues

Government legislation is required to maintain affordable and universal access to the networks of the informational economy. Information technology is very difficult to control. The cost of upgrading the information economy should be borne by the service carriers since they stand to profit. The only way to ensure equity in a telecommunicating workforce is for a government body to control price stability and service quality.

Zoning regulations and employment legislation need to be amended to address the potential problems of implementing telecommuting on a large scale. Current zoning practices and lease agreements forbid many economic activities from locating within the home. Many white collar occupations do not present the kinds of problems the codes were designed to control. Employment legislation currently contains few provisions to protect the telecommuter. Telecommuting provides the opportunity to employers to exploit workers by shifting the costs of information technology to employees, forcing employees to work for less pay, demanding unreasonable production schedules and cutting employee benefits. Regulatory protection is

necessary. Income tax regulations discourage the use of the home as a location of work. Business deductions are difficult to claim.

Societal Impacts

Virtual commuting has the potential to improve the quality of life of society. However, it may also generate negative impacts on the city. Improvements to the quality of life were summarized in Table 1. Potential negative impacts to the city include local traffic congestion, further decentralization of the city and creating a central business district real estate crisis. The introduction of telecommunication centres into the residential landscape may congest the roadways of neighbourhoods. Telecommuting enables employees to locate anywhere telecommunication networks service. Wilderness and rural regions would be theoretically threatened should service be provided to these regions. Urban planning decisions motivated by maximizing development could be a serious threat to the remaining fragile ecosystems untouched by development.²¹ Telecommuting will decrease the need for commercial space by a magnitude never witnessed before. A substantial portion of the wealth of our capitalist society lies in real estate, especially commercial real estate. A vacancy crisis would fuel a large resistance by property owners against the mass introduction of telecommuting. Creative uses must be found for vacant commercial space to avoid the development of urban wastelands within the city.

Conclusion

The form of a city dictates what kind of transportation system is feasible. However, transport itself is a determinant of the shape that a city assumes. The relation between the two is a complex blend of cause and effect.²² The most advocated solutions to the current urban transportation problem fail to address this relationship. The cause of the problem is temporally concentrated transportation demand. Physical transportation is not feasible given the urban landscape of a contemporary city. Virtual transportation is the mode of travel of the future. Telecommuting ignores time and space. The infrastructure of this transportation consumes negligible amounts of space and is environmentally sustainable. Telecommuting may restore the sense of place and community that was taken away by the automobile.

The introduction of road pricing could be used as a revenue generating mechanism to build a network of telecommunication centres. Road pricing would provide a strong incentive to commuters to substitute physical travel with virtual travel. Telecommunication centres could be accessed with small, environmentally friendly neighbourhood electric vehicles.²³ Society would not have to relinquish the tradition of auto mobility.

The real power of the telecommunicating phenomenon lies in its creative applications. Virtual shopping and virtual training are examples. The acceptance of telecommuting by society is evident in the strong demand for remote access to graduate university programs. People want the convenience of remote access across any distance. Time is a finite resource in people's lives, it should not be wasted travelling. The automobile changed the world, virtual transportation will do the same.

Notes

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