Public Decision Making for Land-Use and Transportation Planning

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Abstract - The often contentious debate of the US 101 corridor through Marin and Sonoma counties starting at San Francisco's Golden Gate Bridge provided the incentive to write this paper and to refine a decision structure that is suitable for addressing large publicly financed transportation projects with significant long-term socio-economic and ecological impacts upon a region. This decision structure goes beyond the traditional cost benefit (or with and without) analyses. It defines the system state that today's informed public would like to see two generations from now. This "horizon" state comprises a number of interrelated variables pertaining not only to transportation, but also to land-use and demography which in turn affects socio-economic and ecological outcomes. The first goal of this search for a desirable horizon state is to avoid the kind of major mistakes involving large-scale public systems that were made in good faith during the past two generations, for example, water developments in the Southwestern U.S. A related goal is to identify new paradigms which constitute elegant and sustainable solutions, mainly a network of towns that are relatively compact and have a match of deomography and the local economy, and thus eliminate the need for freeway expansion. Actual regional examples of the new paradigm are described and the techniques of visual preference and charrettes to inform and persuade the public are presented.

1. Introduction

This 1998 international conference of the System Dynamics Society is concerned with the dynamics of large-scale systems. Systems of this type are rarely of a purely technical, and hence highly predictable nature because humans are part of the system. They may be components of the system model (or *plant* in control-theoretic jargon) or of the decision-making process (*the controller* or *law of control*). The methodology of designing a controller which is able to move the system from its current state, $\mathbf{x}(0)$, to its horizon state, $\mathbf{x}(H)$, following an optimal trajectory, is well developed*. However, in systems containing humans, the objective function, the horizon state $\mathbf{x}(H)$ and the penalty of ending up in a terminal state different from $\mathbf{x}(H)$, is usually not obvious, nor necessarily the same for all the involved players. Moreover, there is generally not a single controller that executes the law of control associated with the objective function and the constraints, during the time period from $k = 0$ to $k = H$.

Regional and urban planning with respect to land use, transportation, economic development, demography, ecology, quality of life, and other attributes, is the subject of this paper. This subject illustrates the difficulties that result from the human element contained in both the plant and the controller. How do we link crime to other state and control variables? We think that slums are conducive to crime and that police patrols contain it. This is a plausible qualitative opinion which is hard to translate into a quantitative input - output relation. Next, the members of the community often have an entirely different (and sometimes inconsistent) vision of what a good city or region should be. Some like luxurious flats within walking distance of the opera, others like a 5 acre ranchette in the Hinterland. Last, there are the decision makers (the City Council or the Board of Supervisors) who need to be responsive to their electorate which generally includes special interests as

* The concept of a state and motion in the state space and its applicability to socio-economic systems is explained in Appendix A

well as followers of widely divergent ideologies. What one would like to see is a system in which a competent and steadfast single hand directs the state from $\mathbf{x}(0)$ to $\mathbf{x}(H)$. What one usually gets is a much more complex competitive situation, the dynamics of which are covered (and not particularly well at this time), by game theory.

However, regional and urban systems can be subjected to a useful and productive analysis based on the paradigms of control theory, system engineering and operations research. Urban Dynamics, by one of the founders of the System Dynamics Society, [1], is an early example in which the evolution of specific components of the urban state was simulated and where valuable and counter intuitive conclusions were reached.

In our paper we use the same paradigms, but focus on methodology rather than numerical output. We insist on the extreme importance of defining a horizon state $\mathbf{x}(H)$, that is both feasible and accepted by the community. Once this *anchor* state is known, the decisions required to get the city or region to that state are not all that difficult to figure out.

The need for defining $\mathbf{x}(H)$ when H is several generations from today, is philosophically unacceptable to some. Their argument is that the future is so uncertain that one should not even attempt to determine a reasonable course. Related to this anti-planning philosophy is the free-market laissez-faire ideology. Indeed, the decisions made by developers tend to be myopic and localized, the exact opposite of what Haussmann, the redevelopment czar of Paris during the period of 1850-1880, forced the developers to do. [2]

Haussmann's Paris is an example of the hierarchical decomposition which is necessary in the large-scale regional and urban systems that constitute the scope of this paper. Haussmann, a high-ranking government employee, was the strategist. He developed the master plan showing the location of the tree-lined boulevards, the parks and other elements of the public realm. He also imposed constraints, such as height limitation, roof coordination, alignment and style of the edifices to be sited along these boulevards. It is within the framework of this master plan and these and other constraints that private enterprise was unleashed and gave the world one of its greatest cities. It is unfortunate that Haussmann's achievement has, to a large extent, been adulterated by the unbridled and noisy auto traffic along the boulevards (of which many lost their trees to make way for parking) and the European version of edge cities and sprawl development outside the old gates (les portes).

Paris is one of many case studies that highlight the overriding importance of defining a horizon state $x(H)$. In the field of urban and regional development, the United States has more than its fair share of disasters, of which Los Angeles and San Jose are frequently cited examples. One would think that, by showing the residents of the greater Los Angeles in 1938 what this garden of Eden with its orange groves (hence Orange County) would look like and be like sixty years later, they might have stormed city hall. A thoroughly researched forecast of the state $\mathbf{x}(1998)$ including the freeways, the congestion, the air pollution and the hassles resulting from an inefficient and costly infrastructure would, one hopes, have triggered the search for a rather different horizon state $\mathbf{x}(H)$. This paper will outline what this state could have been today in the LA basin and hopefully will be along the US 101 corridor through Marin and Sonoma counties.

With the benefit of hindsight, we can now draw a long list of large-scale systems that are fiascoes which could have been prevented if the unintended consequences had been researched before any concrete was poured and if the true costs (including the full palette of subsidies and externalized costs) over time had been disclosed right from the beginning. The award-winning book, "Cadillac Desert" [3], is a compelling example. It describes the history of water development in the Southwestern US after World War I. Aquatic life, including a thriving salmon industry, has been largely destroyed; the Colorado River has zero flow, more or less, when it crosses the border into Mexico; and California has floods which are largely man-made.

There is much similarity between the auto-based transportation system and the immense freeway and arterial infrastructure that it requires, and the unwise water development, of the Cadillac Desert. In both cases, the initial small-scale projects spawned powerful industries and the unintended consequences could be ignored at the beginning of the process. We will show in this paper that the various costs associated with *automobility* (the term is due to [4]) are at least equal to the federal tax load of about 1.7 trillion (T$) dollars and we refer the reader to the long list of additional non-economic costs, such as death and injuries, sprawl, uglification and pollution. In both cases, it is appropriate to ask if the community might not be better off if the explosive evolution of these systems had been recognized early and limited to their unquestioned advantages, such as civilized enjoyment of the scenery along country roads. Another large-scale system that may be running amok is that of the media. The process which pays for the staggering expense of the programs relies on income from advertisements. It seems that close to half of these ads hawk automobility products and services. In addition, the feedback signals provided by the Nielsen ratings promote programs of dubious quality.

What should be the state $\mathbf{x}(H)$ pertaining to this system be in a generation or two?

The principal points made in our paper are summarized as follows:

The evolution of large-scale socio-economic systems should be constrained by a horizon condition or *state*. It should not consist of a sequence of myopic actions. Much of the methodology of decision analysis requires that a second boundary condition, that is, the horizon state or the penalty for not reaching it, be defined. This methodology is not what caused Soviet style planning to fail. It is completely consistent with democratic governance because it involves a well-informed public in defining the horizon state and it relies to a large extent on private enterprise to accomplish the desired evolution from the given initial to the specified horizon state. This is not command and control, but a democratic approach based on policy analysis. It makes it possible for well informed citizens to *channel* the activities of special interests in the right direction.

The application used throughout the paper is *automobility*, that is, a system for moving people and freight in a given region that is based mainly on freeways, highways and arterials. We demonstrate that this large-scale socio-economic system is incredibly expensive and we challenge those who claim that it is a *conditio sine qua non* of economic development and prosperity. Recognition of this largely avoidable cost is of particular importance to the LDC's[*] which have other overriding priorities.

The need for transporting people and goods within a region can be reduced significantly by adopting a regional urban structure that consists of well defined interconnected nodes within a network as opposed to the ubiquitous postwar sprawl pattern of development. This *neo-traditional* regional urban structure is spelled out in the Ahwahnee Principles of Appendix B. In addition it is necessary to ensure that each node is relatively independent with respects to its demography and economy. The Supplementary Principles enunciated in the paper accomplish this increased independence.

The three points, namely horizon state, high and avoidable cost of automobility and relatively independent nodal communities are tied together as follows: the horizon state helps the citizens define an efficient and socially satisfying regional habitat; the high cost of automobility is reduced and the resulting savings allow the relatively independent nodes to be feasible and to prosper.

[*] Lesser Developed Countries

2. The US 101 Corridor: Status Report

The stimulus for this paper came from the controversial US 101 Corridor through Marin and Sonoma counties north of San Francisco's Golden Gate. Despite several expensive upgrades, this main artery between Healdsburg and San Francisco is congested much of the time. The Chambers of Commerce demand additional lanes and other improvements and forecast a stagnating local economy unless remedial action is taken promptly. Adding lanes to US 101 is very costly because many of the existing overpasses would have to be replaced. A new parallel freeway comparable to Interstate 280 through the San Francisco peninsula is not even discussed.

Neither the Federal nor the State Governments have taken a lead role in promoting and financing the proposed improvements. Their position is that a regional solution largely paid for by regional funds is the way to go. This practically means a local add-on to the state sales tax or to the gasoline tax.

There exists an unused track formerly owned by the Pacific Northwest Railroad (PNWRR) from Healdsburg to Larkspur from where there is ferry service to downtown San Francisco. This track was recently acquired by a consortium of public agencies. It could be used quickly and at a comparatively modest cost to start passenger rail service.

The Golden Gate Transit District also operates a fleet of commuter buses along US 101 from Healdsburg to downtown San Francisco. These buses are not significantly affected by congestion along those segments of US 101 that have high occupancy vehicle (HOV) lanes. However, about 40 percent of the highway does not have HOV lanes.

The cost[*] of completing the HOV lanes and of making some other highway improvements including some non-motorized, but excluding the addition of new lanes, *and* to start passenger service on the PNWRR track and improving bus service was estimated by the project consultant [5] at 841 M$. The breakdown of the estimate is 493 M$ for highway improvements and 348 M$ for transit capital improvement and operating subsidies.

Voter approval in both Marin and Sonoma counties is required before a sales tax can be levied. It remains up to the courts to decide if a 2/3 majority is necessary to satisfy a recent initiative or if a simple majority is adequate. It is clear from recent polls that more than 50 percent of the voters will be in favor of the compromise proposed by Calthorpe. However, if 2/3 is needed it is virtually certain that the project is dead. This compromise consists of some highway improvements

[*] Capital and 10 year net operating cost after farebox recovery

and the beginning of rail passenger service. Omission of rail service and increasing the scope of highway improvements, the position favored by the chambers of commerce and most business interests, would be rejected by more than 50 percent of the voters according to recent polls.

The positions advocated by the various factions and community leaders are summarized and critiqued below. It should be noted that their views may be influenced more by ideology and hearsay than by a thoughtful analysis of facts. However, people vote on the basis of their perceptions. Thus:

The Business as Usual View: The modern transportation system is based on freeways and individual automobile ownership.

But this solution is costly, unsustainable, and draws increasing opposition from the public.

The Dreamer's View: Let us emulate the Swiss by building electric rail everywhere and walk to and from the train or trolley station.

But many Californians have never been to Switzerland, nor ridden on a train anywhere. They will not relate to this dream.

The Micro-Economist's View: If you neglect the subsidies (the indirect costs) provided by the various levels of government and if you omit the externalized costs, the freeway-based system makes economic sense.

But the direct cost incurred by the owner of a car is at least 7000$ per year and that is usually after tax money. *

The Macro-Economist's View: The auto industry and the various suppliers of fuel, tires, etc. and the providers of insurance, financing and other services employ 1 in 5 Americans.

But these people could be retrained to perform other services.

The Business Person's View: An efficient, inexpensive and decongested freeway-based transportation system for people, employees and freight is generally an essential requirement.

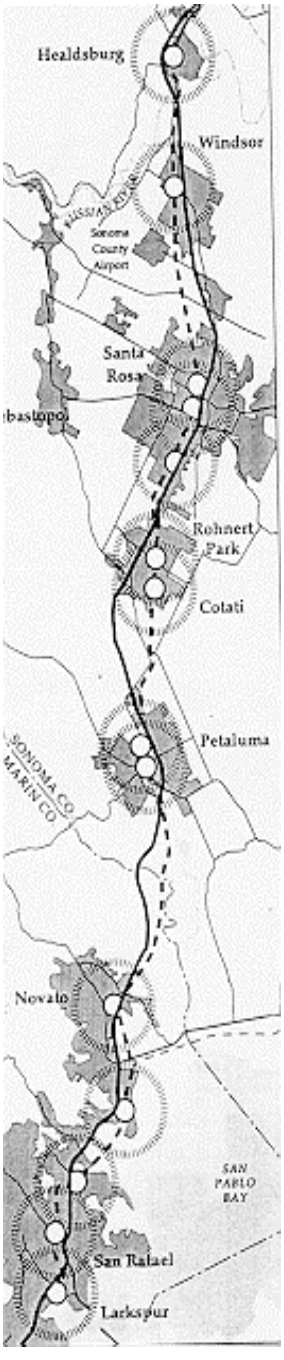

Fig. 1: The US 101 Corridor from Healdsburg to San Francisco. Note the Pacific Northwest railroad tracks and the Larkspur ferry terminal. Less than 60 percent of the corridor between San Francisco and Healdsburg has HOV lanes.
(Figure by courtesy of Calthorpe Associates.)

* This average cost has been calculated by various organizations including the California State Automobile Association.

But the single largest industry in California is tourism which generally opposes the destruction of scenery and nature that accompanies freeways, especially after they get lined by strip developments.

The Developer's View: We generally prefer to site new residential, business and shopping projects on agricultural properties that are accessible to the auto. We love to build bedroom communities.

But there is so much urban decay that development should be channeled into blighted urban areas, a planning technique referred to as "infill" which is generally shunned by conventional developers.

The Taxpayer's View: No new taxes!

But there are many services that the community needs and that can be provided more efficiently by local government than by individuals or private enterprise. Examples are the public realm, parks and greenways. The mistake to be avoided is to finance bad projects with your taxes and to justify such projects by saying that they create jobs.

The Anti-Growth View: We do not want freeways (nor trains) because they bring about undesired growth of people and development. We do not mind being called NIMBY's (not in my backyard).

But quality development in blighted communities would benefit the NIMBY's too by raising their property values and by providing useful amenities.

The Commuter's View: I am spending three or more hours per working day stuck in traffic. I enjoy the privacy of my car, but Government is responsible for outbuilding highway congestion.

But in the Eastern US, many commuters take the train, read a book, and do not seem to mind sitting next to strangers.

The Farmer's View: I inherited the family farm and I love agriculture; it is my way of life. I do not welcome development.

But older or unsuccessful farmers want to be able to sell their land to a developer and move to a condo in Palm Springs.

The Bank of America et al Point of View, [6] (paraphrased by these authors): Freeways and automobility are the principal cause of sprawl. Sprawl requires a very expensive and inefficient infrastructure which our cities and counties can no longer afford.

But I do not want to be forced into an infill development in which the existing infrastructure can be utilized. In addition, my property taxes, as a rule, do not reflect the true cost of my share of the infrastructure. Where is my incentive to stay close to the City core?

The Humanist's View: I want a society which does not ruin this world with noise, air and visual pollution and which aims to provide quality of life for all.

But global competitiveness is the name of the survival game.

In November 1998, the voters of the counties of Sonoma and Marin will, in all likelihood, be asked to accept or reject a sales tax increase of 0.5 percent lasting 10 years to pay for the rail and highway improvements recommended by Calthorpe. The range of opinions enumerated in the previous paragraphs suggests that the required majority may not be there. The real possibility of failure became evident when a recall effort aimed at ousting the no-growth majority of Windsor's City Council was overwhelmingly rejected by this bedroom community, the phenomenal growth of which was fueled by US 101.

In a 1996 public meeting called to discuss the need for addressing the congestion of US 101, the prestigious A and E firm Parsons Brinkerhof, presented slides of various sections of the highway including ramps and overpasses that would be needed in 2020 if the business-as-usual, including the freeway-only scenario, were adopted [7]. Images of the 20 lane monstrosity suggested to much of the audience that a different path was needed.

This different path, variously referred to as TOD (transit oriented development), neotraditional town planning, is inspired by the Ahwahnee Principles of Appendix B. These principles are augmented by the socio-economic Supplementary Principles developed in section 9 of this paper.

3. Public Decision-Making (as is)

The subject of primary interest is regional land use and transportation planning in the context of the US 101 corridor as well as numerous similar situations elsewhere in the United States and the world at large. The discussion will summarize the methodology used by urban and regional planners. However, the terminology and ways of thinking of the system engineer will be introduced for the purpose of illuminating this subject from a different and perhaps more thought-provoking direction.

The With/Without Analysis

Considering that the cost of alleviating congestion along the 101 Corridor will be at least one billion, there certainly is sufficient justification to do a thorough examination of the alternatives and to subject these alternatives to a cost/benefit or a with/without analysis. The methodolgy consists of creating two evolution scenarios over typically a 20 or 30 year period and to calculate the discounted sum of the net costs, that is, actual capital and operating cost incurred, and of the benefits realized. The first evolution scenario assumes *no project* and is therefore referred to as the *without* or *base* case. The second scenario assumes a precisely

defined project, such as widening US 101 and completing the HOV lanes. Comparison of these two scenarios provides the present worth of the stream of costs C and the benefits B that the *with* scenario incurs and yields, respectively, over the base case. The ration B/C is the magic number which decision makers use to justify or reject a project.

This rather standard approach to analyze the merits of a proposed major improvement of a large-scale system has numerous flaws. If the list of alternatives excludes a not-so-obvious innovation, then the wrong project may be chosen. Similarly, if the stream of costs excludes intangible or suspected but not officially accepted components (e.g. global warming) and if the stream of benefits excludes components that economists tend to reject because they are subjective (eg. aesthetics, quality of life or resilience), then again the wrong project may be chosen. Moreover, the driver is demand. The most common method for forecasting demand is to do a straight line extrapolation on a semi-log graph of past demand observations. This technique, of course, does not take into account unplanned external changes, perhaps a technical innovation such as the internet or drip irrigation, nor planned or mandated changes, such as cities in which most walk to work or agricultural systems in which crops are matched with soils and climates. It is this KISS for *keep it simple, stupid* doctrine that may well be the most appropriate solution to our congestion woes.

The following description of the planning methodolgies and realities in urban and regional contexts will confirm that the highly touted with/without or similar analyses may not be the way to go. These analyses tend to be focused on a specific project, such as widening of US 101, when in fact a more *integrated* approach which may include changes of life style is needed.

Land use planning usually takes place within the community, that is, a city or an unincorporated section in a county. By law, the community is required to create a *general plan* and to update it every 5 years.[*] This general plan is contained in a report the chapters of which address the following *elements*: population projections, land use, transportation, housing, safety, environmental impacts, economy. The planning period is typically twenty years. The authors of the plan are the city or county staff, often helped by outside consultants; a major contributor is (or should be) the public. The general public is usually represented by an appointed advisory committee. The final product is sanctioned by the City Council or the Board of Supervisors. Perhaps the most important by-product of the general plan is the *zoning code* which specifies what can be built on a given parcel and to what extent it can be subdivided.

The zoning code classifies the land as residential, light commercial, industrial, agricultural etc. The developers use this code as a basis for their projects. Transportation within the city consists almost exclusively of cars and trucks in most parts of the United States. The auto and truck traffic is a dependent variable, because it is determined by the land use that results form the general plan, the zoning code, the demography and the local economy.

Regions, which can cover a number of contiguous counties, are in general not required to create a general plan. Therefore the state variables that characterize the region, notably those related to the demography and the traffic are in fact dependent variables. They are determined by the land use, economy and demography of the cities and villages contained within the region.

System engineers are trained to design large-scale systems that optimize a stated objective function. Their question to regional and urban planners would be: What is your objective function and how do you go about optimizing it? The planners' answer is likely to be the general plan, the associated zoning code and the use permits which limit to some extent what businesses are allowed to do in the city. They will add that local politics, influenced by campaign finance obligations and pledges, can often override the general plan and that the advisory committee which helped create this plan in the first place was appointed by the city or county and therefore does not necessarily represent the community at large.

Accretion is the technical term which characterizes this non-optimal and not very predictable motion of a city's state. In addition, the motion of the states corresponding to the cities contained in a region is generally not well coordinated. Some planners, economists and ideologists, say that we need accretion, because it gives our cities their own specific character and charm and it allows the entrepreneurs to realize their dreams.

Policy analysis is the discipline that was evolved to optimize large-scale engineering-economic and socio-economic systems with respect to a stated objective function and constraints. If applied to a region, such as Sonoma and Marin, it would presumably discover better ways to use the land and to transport people and freight. The problem with this discipline is that it often restricts the freedom of action of entrenched special interests, although it could well promote the birth of new businesses. In the context of the 101 Corridor, there is little doubt that thoughtful policy analysis, if it had been done in, say 1960, would have predicted the sprawl and congestion that have been the result of a

[*] These are the requirements of the State of California. Other states and countries usually have a similar methodology.

generation of accretion. It might even have recommended partnerships between the government hierarchy (cities, counties, state and the Federal Highway Administration) and the special interests that would have created wealth and the good life, and avoided the unnecessary ecological and visual degradation of this prime residential and tourist area.

4. Automobility: Direct, Indirect and Other Costs.

'Automobility' is the term coined by Tengstrom in [4] to denote the way of life that came about when the automobile (and the truck) essentially replaced public transit and the regional railways after World War II in the United States. Since then, the private automobile (and the truck) have also become the dominant form of transportation in Europe, and that includes Switzerland with its exceptional rail and bus (Postauto) transportation system. Unless there is a major change in attitudes or regulation, the auto (and the truck) will also dominate transportation in the LDC's (the lesser developed countries) including the population giants, China and India [8].

Europe and many of the LDC's have public transportation and rail which, by US standards, is above average to excellent. Despite this and considering that gasoline may cost as much as $5/gallon because of taxation, people insist on using their cars under often appalling conditions of congestion. A fundamental question to be posed is: why would they want to spend a significant fraction of their income on an appliance that they really do not need, often cannot afford, and that is guaranteed to radically change their habitat and environment?

There are three principal reasons for this apparent irrational behavior on the part of the auto users:

- They are largely ignorant of the true costs of the auto (and truck).
- They desire to own and operate a heavy piece of machinery, to have privacy inside the machine, and to impress others with it. These are important psychological justifications.
- They really neither understand nor appreciate the long term impact upon the environment, the community and the best features of a traditional way of life.

Increasingly, lack of access and essential mobility to those who do not drive has become a major handicap, because quality public transit and compact walk-to-work habitats, are often not provided or discouraged.

Many car owners like to believe that the cost of driving is not much more than the cost of gasoline, which is affordable to most. They fail to include other direct costs, such as their capital, financing, insurance, ownership-related taxes, repair and maintenance, parking, tolls, and fines. What seems to be missing is an understanding of basic home economics and a willingness to accept the true costs, which is about $7000 per year for a rather modest car that is driven less than 16,000 kilometers. For most, the $7000 is an after-tax expense, which means that they need to earn $10,000 or more for the car alone.

In addition to these direct costs borne by the owner, there are significant indirect costs borne by the taxpayer (who may not drive) and intangible costs borne by the community. Indirect costs comprise subsidies to build and operate highways and parking lots, pay for the highway patrol and the judicial system. About 20 percent of the cost of educating a child in California is siphoned off by the institution of the school bus. The Economist reports that all of the indirect costs have been estimated to total 4 percent of the GDP in the European Union. This would amount to $300 billion plus per year in the US if the same figure of 4 percent were applicable as, we believe, it is.

The remaining costs are referred to as intangible because they are difficult to estimate. They include the loss of tourist income because tourists seek unspoiled scenery, loss of productive farm land, failure of traditional downtown business districts because malls offer free parking and often lower prices, the cost of mandatory free employee parking borne by the employers or the city which allows free or below-cost parking along its streets, the health consequences of air and noise pollution, and of stress when you are late for an appointment or when you just avoided a bad accident. And then there is the enormous intangible cost of time wasted in traffic jams. At the minimum wage of $5 an hour, this translates into a loss to the individual and/or his employer of at least another 20 billion $ per year. Related to this intangible cost is the additional travel time that people budget when they want to be absolutely sure to get to their destination, say a business appointment, on time. Finally, Hubbard states in [10] that oil prices are kept low in the US because of a number of subsidies that the Federal Government pays. One particularly significant subsidy is the US military presence in the key oil producing areas outside the US, such as the Gulf region, from which we import a dominant fraction of our oil needs. Hubbard estimates that the true cost of gasoline would double if the consumer had to pay directly for these subsidies at the pump, rather than indirectly in his Federal tax.

The intangible costs are paid by the individual and/or the community and should be viewed as an additional tax. In all fairness, one should deduct the economic benefits of access and mobility, that the system

returns to those who can afford a car and are allowed to drive. However, the system is exclusionary, because it makes access and mobility awkward or even impossible to adolescents, adults with certain disabilities, and those who cannot afford a car or simply do not drive.

There are over 140 million autos in the US. At $7000/year, the direct costs are one trillion* . Add the indirect costs of 0.3 trillion and forget about the intangible costs and benefits, the total is 1.3 trillion out of a GDP of 8 trillion. It is almost equal to the federal tax revenue. For most, the direct and indirect costs are the biggest expense after shelter and before health care, education and food.

Is 1.3 trillion a reasonable estimate of the direct and indirect (but not intangible) costs of automobility in the United States? Hubbard insists in [10] on the difficulties that economists have in allocating these indirect costs. How does one allocate the significant time the courts spend on the civil suits, criminal prosecutions and incarceration, among others for driving while intoxicated? However, we believe that 1.3 trillion is not an overstatement. The US News and World report [11] state that the true cost of gasoline should be $6.6/gallon to compensate the community fore the indirect and intangible costs. The resulting tax revenue would be about $5.0 x 200 10^9 gallons, that is, another trillion assuming an annual consumption of 200 billion gallons of fuel used by cars and trucks. In addition there is the direct cost of 1 trillion to the owner.

5. The Negawatts of Amory Lovins and their Transportation Equivalent.

In 1976 the Journal of Foreign Affairs published, "Energy Strategy: The Road Not Taken?" by Lovins. This paper influenced in a major way the energy conservation policies pursued by the Carter administration, by many foreign governments and by specific sectors of the economy, notably the electric utilities, the building industry, and various research and development organizations. The term "Negawatt" (NW), coined later by Lovins, [9] provides an easy summary of his work: If you can save a megawatt by using fluorescent, rather than the more common incandescent lights or by insulating your house, then your power company will not have to build and operate this megawatt of power plant capacity and you will not have to pay for it. The saved megawatt, of course, is the Negawatt.

It is significant that this technical paper appeared in Foreign Affairs. The Middle East war of 1974 and the oil embargo was a wake-up call for all those countries which depend heavily on imported oil and gas.

We suggest that regional transportation should look hard at an analogous quantity, namely the *Nega kilometer* (Nkm). The Nkm is similar to the NW in the sense that it is intended to be painless and to be a good deal for the individual as well as the community. Moreover, the rate structures in California and some other states were changed to reward those utilities that successfully promoted energy conservation. A similar reward structure can be developed in connection with Nkm's in order to get the private sector motivated.

It turns out that a group of prestigious urban planners got together in 1992 at the Ahwahnee Lodge in Yosemite National Park. The meeting was called by the Local Government Commission and the objective was to enunciate a recipe for better urban and regional planning. The resulting recipe became the Ahwahnee Principles of Appendix B. These principles advocate a return to traditional compact cities with a Main Street, parks, greenways and, perhaps most importantly, an urban growth boundary or greenbelt to prevent sprawl and discourage annexations. On a map, cities designed according to Ahwahnee would be nodes linked by branches of public transit, preferably rail-based, and roads rather than freeways. This vision is the exact opposite of the low density developments without a boundary nor a well defined center for shopping and community buildings and, most of the time, no convenient public transit, that became the rage after World War II. Andres Duany, one of the signators of the Ahwahnee Principles and co-author of [12], mentions Princetown, New Jersey, and Sonoma, California, as examples to be emulated. One of the authors (Peschon) is a resident of Sonoma. He generally agrees with Duany, but regrets that all but the center surrounding the historical plaza was built up after WWII in accordance with the usual sterile sprawl and strip development prescription. Regional bus transport exists, but is impractical. However, those who live in or near the historical section, can walk to many destinations and thus accumulate Nkm's. The best examples of towns that satisfy the Ahwahnee Principles, as well as the supplementary principles to be enunciated in section 9, are the hill towns of Tuscany and Provence. It may be that the fortification walls acting as urban growth boundaries plus legislation to preserve historical structures and districts explain why these thriving modernized medieval towns are food for thought and inspiration. Some will argue that Volterra or Siena are special cases that could not be duplicated in most other regions of the world. It is true that their well preserved historical buildings constitute an important tourist attraction. But, in addition, they have a thriving

* There actually are 200 million autos, of which we estimate 60 million to be under-used and therefore ignored in our calculation.

economy that is generally owned and operated by well trained local merchants, artisans and trades. The end result is a prosperous community without ghettos nor significant social conflicts. We assert that this model can be duplicated in, among others, North America and we propose the Ahwahnee and the Supplementary Principles as a road map to accomplish this even though there is no medieval architecture.

The Ahwahnee Principles, together with a recognition by community leaders and volunteers and a progressive legislature, that a change of course is necessary, were used by Portland, Oregon, and the surrounding region to create a model for regional development. The community leaders founded the NGO* 1000 Friends of Oregon [13]; the legislature allowed a regional governmental structure to be voted in to assure coordination and avoid competition between cities. The chief planning consultant was Calthorpe, also a signator of the Ahwahnee Principles. In the San Francisco Bay Area, the non-profit group Urban Ecology was funded by several foundations to create "Blueprint for a Sustainable Bay Area" [14] for the nine county region, which includes Marin and Sonoma. The recommendations not only address land-use and transportation, but also include economic development, demographic and quality-of-life issues.

If we accept that the production of Nkm's is indeed an important objective, then we must seek demographic diversity in each node of the network and avoid bedroom communities. However, each node must also have a diverse local economy which is matched to its demography. Single industry company towns should be avoided because of the boom-bust transients and the lack of demographic diversity that usually results.

The regions surrounding Stockholm and Helsinki experimented with satellite cities, such as Vallingby and Farsta near Stockholm and Tapiola near Helsinki. The design of these nodal cities dates back to before and shortly after WWII. The planners' intention was to limit the growth of the capitals by channeling additional development into small (under 50,000 population), compact and relatively self-contained habitats within 20 minutes or less by public transportation to the centers of the capitals. The result is a partial success. The concept of a self-contained habitat in which a local economy would provide employment and shopping failed and too many residents commute. Also, these satellites are everything but architectural landmarks, unlike Stockholm and Helsinki.

The same concept of satellite cities has been tried elsewhere including the United States. The post WWII projects of Reston and Columbia near Washington, DC were also intended to be relatively self-contained, but too many of their residents now commute. More recently, Laguna West near Sacramento, suffered the same fate: it attracted one major employer, Apple, the prospects of which are somewhat uncertain. These partial successes suggest that there should be more formal regional coordination of the type pioneered in Oregon to ensure that the existing and future nodal cities remain in fact relatively self contained and do not end up becoming bedroom communities. Competition among proximate cities for new employers and malls, together with access by freeways seem to put nascent nodal cities at a disadvantage.

Kilometers are not only accumulated by the private car, but also by trucks which range from the UPS style delivery vehicle to the 18 wheeler. In [15], the renowned urbanologist Jane Jacobs promotes the concept of relatively self-contained local economies. This, of course, is related to the desired diverse demography. It results in the Nkm's of freight because Sonoma residents can buy their bread from the Sonoma baker, who recently won first place in the International Bread Baking Competition in Paris, rather then truck it in from a baking factory in Minnesota.

The fact that automobility and the resulting kilometers provide 1 out of 5 Americans (or Europeans) with a job and therefore should be encouraged is a faux argument. Some of these people could become educators or work to improve the country's housing (a gargantuan task) provided that there is a plan that allows for a smooth occupational transition over a period of years.

6. Public Decision-Making (as it should be)

Forrester's Urban Dynamics [1] demonstrated that the evolution of a city could be represented by the familiar state transition equations

$$\mathbf{x}(k+1) = \mathbf{f}\left[\mathbf{x}(u),\ \mathbf{u}(k),\ \mathbf{v}(k)\right]$$

where: **x** = state, a vector of components x_i

u = control or decision, a vector of components u_j

v = perturbation, a vector of components v_m

k= discrete time, usually a year

He simulated the evolution of a subset of **x**, namely housing, economic development and work force skills for a section of Boston. He proved that the city's decision to create affordable housing would hurt the local economy because people with inferior skills would be attracted.

* Non governmental organization

We intend to use the concepts of control theory, system engineering and operations research somewhat differently. Our goal is to develop a framework for regional and urban decision making that utilizes these concepts as a *way of thinking* in addition to a way of simulating dynamics.

Perhaps the most important component of this way of thinking is the horizon state $\mathbf{x}(H)$, where the planning horizon H should be two or more generations in the future, say 2060. Public decisions are often purely reactive, that is $H = 0$, or short-term and therefore myopic, that is $H = 10$ to 20. Decision-makers do not want to look at $H = 60+$, because, they argue, external forces **v** cannot be predicted. Population growth that far ahead is cited as an example of this uncertainty. We counter this by saying that it is precisely under those conditions of uncertainty that we have to define our long-range vision $\mathbf{x}(H)$ and to gain a position that allows us to control our destiny.

One of the key components of $\mathbf{x}(H)$ is the footprint of the nodal city which is determined by the urban growth boundary (UGB). This footprint may be limited by geography, resources, the desires of the existing population and, increasingly, the preference for minimal traffic. A city of $10km^2$ with a population of 100,000 (40 per acre) was analyzed in [18] from the point of view of its transportation needs. These were modest compared to those of a standard low density layout. The transportation system relied largely on walking, light rail and cab. It was surprisingly inexpensive and, of course, non-exclusionary. This system was also very predictable, which is not at all the case for mainly private car based traffic. This excellent predictability results for the following reasons:

- public transit has a much greater (by a factor of 20 or more) capacity measured in people per hour and per lane (or track) than a car based system.
- the need to use motorized transport is greatly reduced because many origin-destination points are within walking or cycling distance.

What if the UGB turns out to be too constraining in, say 2010? The answer should generally be, "Add a new nodal city to your regional network and do not upset a carefully planned $\mathbf{x}(H)$."

The state $\mathbf{x}(H)$ has numerous components in addition to footprint and population size. Ideally, it should be a place where people are prosperous, have a good life, enjoy each other's company and do not have to worry about crime and pollution. These attributes translate into other state variables, such as the infrastructure state, the economic development state, the education and skill states, and the city's financial state. This last state variable largely determines whether the state $\mathbf{x}(H)$, as well as intermediate states $\mathbf{x}(k)$ are feasible. If the income from taxes and fees is insufficient to provide infrastructure, vocational education, crime prevention and other social services, the city will do a "Bridgeport".* A reduced state model of a city is described and its evolution is optimized in [16].

The feasibility condition of $\mathbf{x}(H)$ is crucial. The visionaries must demonstrate that the interaction between these state variables leads to a stable equilibrium. The Ahwahnee Principles augmented by the Supplementary Principles of Section 9 ensure that major inefficiencies, social anomalies, and outside influences have been addressed and that the city's revenues are adequate to take care of the parks, enforce ordinances and participate in economic development and culture. These two sets of principles also ensure that the increasingly important constraint of *sustainability* is respected, again because the city and the region are efficient in their use of resources and innovative in their disposal of effluents and wastes.

Assuming that the community has been able to define a feasible $\mathbf{x}(H)$ what process should it use to move from its current state $\mathbf{x}(0)$ toward $\mathbf{x}(H)$? In other words, how does it pick the control sequence $\mathbf{u}(0), \mathbf{u}(1)\ldots\mathbf{u}(H-1)$ to get there without too much wasted motion? In [16], the optimizer contained within Excel was used to find the best sequence $\mathbf{u}(k)$. In actuality, one would focus on the first decision $\mathbf{u}(0)$, then estimate the state $\mathbf{x}(1)$ at time $k = 1$ and focus on the next decision $\mathbf{u}(1)$. This focusing can be done with the help of a standard spread sheet product such as Excel *and/or* with a commitment by the community to implement the Ahwahnee and Supplementary Principles as expeditiously as allowed by prudent budgetary practice. These principles should prevent the inefficiencies resulting from the construction of roads and buildings that are inconsistent with $\mathbf{x}(H)$ and therefore will be torn down before the end of their useful life.

This planning methodology constitutes in effect a control system which is designed to reach a target state $\mathbf{x}(H)$ at time H. The motion from $\mathbf{x}(0)$ to $\mathbf{x}(H)$ can be optimized with respect to a stated objective, for instance minimum discounted cost, and subject to various constraints, for instance maximum debt by the city. A mathematical optimization would require models

* Bridgeport is the name of a city in the wealthy State of Connecticut which had to file for bankruptcy when the middle class emigrated because of too much crime and too few services. Bridgeport exemplifies an urban downward spiral.

for the state transition equation which can be developed when socio-economic variables are involved as was demonstrated by Forrester in [1]. The Ahwahnee and Supplemental Principles act as a *law of control*

$$\mathbf{u} = \mathbf{g}\left[\mathbf{x}(k), k; \mathbf{x}(H)\right]$$

which will normally get the current state $\mathbf{x}(k)$ to $\mathbf{x}(H)$ if $\mathbf{x}(H)$ is a feasible state. This non-optimal process has the additional advantage of being understood by the community whose continued support is a condition of success. A somewhat simplistic way of looking at the law of control is that it compares the current state $\mathbf{x}(k)$ to $\mathbf{x}(H)$ and generates a correction $\mathbf{u}(k)$ designed to reduce the difference between $\mathbf{x}(k)$ and $\mathbf{x}(H)$.

The methodology presumes that the city constitutes a steadfast decision maker that does not deviate from its goal, namely $\mathbf{x}(H)$ during the transition. In actuality, the decisions and votes of the council, are influenced by a variety of special interests ranging from corporations to seniors. Nevertheless, the methodology has great value as a policy analysis tool: It can be used to show the community what is doable if a unified front can be built. Let us not forget that activists, foundations and NGO's have succeeded in giving us environmental protection laws that hurt some special interests (but benefit others), in reducing the consumption of tobacco products and in virtually banning land mines.

In addition to a consensus by the community to evolve toward $\mathbf{x}(H)$, it is necessary to enlist the help of the special interests that could derail the community's plan in a number of ways including campaign finance pledges, recalls, and carefully packaged partial truths. The community is usually in a position where it can assist many of these special interests in return for their support. In section 8 below, we give the wish list of a world class electronics manufacturer to support our notion that partnerships between local government and many, though perhaps not all, special interests can be devised.

How realistic is the stipulation $\mathbf{x}(H)$ at a time when regulations and stipulations are frequently attacked? It would seem that the evolution of a city or a region should be approached to some extent like the design of a complex piece of technology, such as the new Boeing 777. The 777 project team began by defining its objective $\mathbf{x}(H)$ consisting of the airliner's specifications as well as the production and marketing structures. Imagine the chaos that would result from an open-ended sequence of additions to and changes of the airframe.

Las Vegas and New Orleans are examples of cities that did not evolve to become major convention centers by chance. There was a horizon state with which many might disagree, but the objective was accomplished.

7. Charrettes, Visual Preference Exercises and Sim City.

Local government should (and usually does) take the initiative in formulating the mandated general plan and zoning code. This makes sense because the city's or county's staff has the required expertise and land use data base. The community's opinion is solicited. However, the city (or county) retain considerable power in shaping the community's opinion. In the context of this paper, the all-important horizon state, $\mathbf{x}(H)$, should be defined by a collaboration of staff and community with staff providing much of the leadership.

The *charrette*, is one methodology that has proven to be highly effective in educating the members (staff and citizens) of this collaboration. The methodology consists of structured sessions in which professional urban planners work with community representatives to create a future snapshot of the city's land-use, transportation and other attributes. Ref. [12] gives remarkably detailed outputs of this exercise. The desired end result is a feasible layout that also articulates the community's real desires and therefore is likely to be realized. The charrette effectively demonstrates to the participants the reality that compromises must be made, otherwise the plan is not feasible. Example: You cannot have a city with low traffic if you allow residential development in the hills beyond the periphery. A shortcoming of the charrette is its focus on the land-use/transportation bipole and its lack of explicit consideration of the economic development/taxation and demography/land value bipoles.[*]

The *visual preference* methodology, [17], constitutes another effective way of eliciting the real desires of the community and of enlisting their support for the resulting plan. It uses computer aided design and imaging to display what a section of town would end up looking like if a specific zoning map or landscaping plan were adopted. You would be amazed what a row of mature trees could do to beautify a sterile urban arterial.

Sim City 2000 is the popular computer game in which the player acts as the city administrator. The state contained in the forward simulation includes components for urban planning, traffic, economic development, taxation, demographics, land-value, crime, disasters and

[*] In [18], a bipole is defined as a subsystem the variables of which have strong connections

more. The simulation is accompanied by eye (and ear) catching displays. If the city administrator's plan is poorly coordinated in time and space, the residents (the Sims) vote with their feet and the city does a Bridgeport. We used Sim City 2000 in [18] to analyze the impact upon traffic, air pollution, cost and wasted time of each of six rather different land-use strategies of a 100,000 people city. We concluded that a new version (referred to as Sim City 2001) with greater attention to the real world and more convincing relations between variables would give city staff an extremely powerful tool for analyzing the short and long term consequences intended (as well as unintended), of the administrator's and the community's decisions. Sim City 2001 remains to be written. It should be kept in mind, however, that Sim City 2000 assumes virtually no interaction within and beyond the surrounding region. That assumption just does not hold up in bedroom communities like Windsor or anomalies like Palo Alto which has a population of 60,000 and employs 70,000.

The one-acre *tile* is the segmentation used in Sim City 2000. Thus, 25,000 tiles would be needed in a city of $100km^2$. Each tile might have to be characterized by 10 state variables. The resulting simulator would consist of 250,000 state variables. This seems impractical. The approach of [1] in which the segmentation covers much larger areas together with efficient techniques to aggregate the attributes within each segment, for example the number of square meters of commercial floor space, would lead to a much more usable urban analyzer and *what if?* interlocutor.

A serious weakness of Sim City 2000 and other available analysis methods pertains to the modeling of the auto traffic that would result 10 or 20 years from now after major modifications in land use, demography, traffic regulations, (such as pedestrian zones), were implemented in accordance with the Ahwahnee (or similar) principles. Traffic models that are based on a near future extrapolation of the current observed situation are accurate enough. That is not generally so when a long term prediction in the presence of major changes of the rules is desired. However, we found in [18] that in a city designed in accordance with the Ahwahnee Principles, and with frequent public transit service, traffic is no longer an issue, simply because the redesigned city does not generate much traffic nor facilitate cruising. Two of the authors grew up in Europe right after World War II. Their recollection is that there was very little auto-traffic because most of the auto stock had been destroyed, and yet the cities functioned quite well. Life in some countries, notably France and the Benelux trio, was rather pleasant and there was no pressure yet to widen the boulevards and to install urban freeways, partly because a good public transport infrastructure was in place.

The Supplementary Principles of Section 9 similarly simplify the interconnected models of the bipoles demography/land value and economic development/ taxation. The reason for this is that diversity of the population throughout the city and diversity of the local economy are stated objectives which should be reached before 2060. If the demography is fairly homogenous (most belong to the middle class) and the economy is not dependent on one or two employers, this pair of bipoles can also be represented by a few state variables each.

It would be very useful, we think, if staff could display to the community how the retained state variables would evolve over time and demonstrate that the horizon state $\mathbf{x}(H)$ would indeed be reachable and stable. This horizon state, we repeat, should constitute a match of the demography and the local economy.

This same simulator could also be used to explore the dynamics of the current socio-economic *vogue* which comprises globalization and downsizing, and rejects import replacement and wage standards. Some opponents with impeccable credentials argue that the resulting horizon state is unstable because the impoverished population will not have enough money to support a consumerist economy.

Finally, there is the land value half of the demography bipole. It needs to be included in the simulator because of its dominant impact upon the spending power of the people after they paid their rent or mortgage. We do not know of an interactive simulation complemented by an effective display that addresses these issues and demonstrates to the community that the postulates of Jacobs and of these authors, are indeed right on target.

8. Controllability.

The mayor of Los Angeles was recently asked what he could do about crime in the city. His answer was "Nothing". This response underlines the lack of control under which local governments are expected to function.

As was pointed out earlier, regional as well as urban traffic is largely the result of the urban state, specifically the imbalance between the demography of a city (or a sector of a city) and its employment, shopping and educational destinations. It is clear that over-investment in freeways and arterials, coupled with subsidized automobility, compound this imbalance. The saying goes, "If you build, they will come" and that explains sprawl.

Therefore, one way to control the imbalance between demography and destinations is to expand

freeways, arterials and free parking lots with great reluctance and to make sure that the users bear the *true* cost, as will be the case if and when congestion pricing schemes are installed. This same reluctance to build and subsidize should also apply to public transit, especially new subways, which are incredibly expensive.

Local governments have considerable power to regulate land-use by referring to the general plan and the zoning code which they helped shape in the first place. They can also regulate to some extent the type and size of businesses that are welcome in the city. In the event of a controversy, typically when a McDonald or a Walmart propose to install golden arches or a big box, the city council may find it prudent to put approval or rejection on the ballot. The same prudence often applies when an urban growth boundary or aesthetic constraints on structures are an issue. In the latter case, the opponents argue that aesthetics are subjective and therefore should not be regulated. The same argument is used when the city's architectural consultant wants to impose stylistic uniformity, height limitations or alignment of buildings along the sidewalk.

Yet, the amount of control that local government has in the socio-economic arena is generally even less than is the case in the land use arena for the following reasons:

- State or federal law usually bans regulation in those cases when an individual's rights or the interplay of market forces is restricted.*
- The case that a community can benefit from socio-economic control remains to be made in specific instances.

The controversial subject of rent control is used to illustrate the issue. The argument in favor is that rapid increases in demand will not and should not force tenants to move out and, perhaps, become long-distance commuters. The argument against is that rent control discourages investors from increasing the rental housing stock which, in due time, would force rents down to the point where the investor has an adequate, but not exorbitant, rate of return on his investment. An adequate ROI plus *stable* rents can be and have been obtained in intelligently managed rent control situations.

A related example is the explosive increase in industrial and residential land costs in much of the Silicon Valley, notably Palo Alto, population: 60,000; employment: 70,000. In addition to the long distance commute, there is an undesirable erosion of demographic diversity and a flight of many businesses to lower-cost locations as far away as New Mexico. The demographic trend is toward retired trades persons who bought their home in 1960 for $15,000 and attorneys under pressure to bill a bone crushing 2400 hours/ year.

On the other hand, cities and counties must try to entice employers to locate a plant or an outlet in their territory. Quality employers use a checklist to rank proposed locations. Attributes that usually appear on the checklist of a high technology national or international employer are:

- availability of a skilled and loyal labor force
- proximity of a university or college for employee training and continuing education
- desirable area to live; this includes recreation, public transportation, local environmental controls, prosperity
- property taxes, corporate and individual income taxes, sales and other taxes
- housing; preferably nearby and affordable
- schools; their evaluation includes scores, college entrance statistics,
teacher salaries, sources of funds
- health services
- transportation infrastructure, including walkways and bicycle paths
- utilities and communications
- police and fire protection

If the city wants to attract quality employers, it will have to satisfy this or similar wish lists. This requires good long-range planning, community commitment and money. Discretionary funds are often scarce with the result that the city must beg the state or federal governments for grants. This reduces the amount of control it has in shaping its economic development and its demography.

The cost of land for both residential and business uses has a major impact on a city's demography and the employers that it may try to attract. Yet, it would seem that the city is not in a strong position to effect land costs since the market is supposed to do so in a market economy. That, however, is not completely true. If there is a will, there is a way. With community support, the city can permit the construction of multi-story, quality condominium and apartment complexes in or near high-priced residential areas to achieve demographic diversity and contain housing costs. Similarly, it can significantly lower the costs of industrial real estate by allowing compact multi-story structures and by waiving the requirement for large, complimentary employee parking lots. These cost-control actions, which are very consistent with the Ahwahnee Principles, become especially important when an urban growth boundary has been adopted, because it limits the amount of developable land and tends to inflate the land prices within the UGB.

The subject of controllability as defined in control theory is not well understood in the urban and

* The state capital of Vermont, Montpelier, did not want an international fast food operator to occupy a historic building in the town center. Their only legal basis for rejecting the application was parking and traffic impacts, not maintenance of the downtown character.

regional context. However, the subject is of great psychological and political importance, as evidenced by the Federalist Papers of 1789. Related to controllability is resilience, that is, how well does a city or region cope with disasters ranging from ice storms to economic recessions? There is considerable evidence that communities and regions that have installed defensive systems and are ready and able to act when a disaster hits are less vulnerable than those which rely on assistance from the outside. In other words, the mayor should have the authority and the budget to rid his city of drugs.

The Ahwahnee Principles and these authors favor a regional network of relatively self-contained traditional compact communities or nodes. This vision is difficult to realize unless there is forceful regional coordination. In the absence of such coordination, the nodal cities will compete with one another (and with the County) to attract employers and outlets. Usually the city that is able to offer the largest subsidies to the interested employer or outlet wins. Regional coordination with clout can help direct the interested employer or outlet to the node where they are most needed according to the self-containment objective. Some economists will argue that this additional layer of control interferes with market forces. The answer is that the subsidies offered by the most affluent cities constitute a distortion of the market which the regional government should regulate and attenuate through regional revenue sharing to avoid the downward spiral epitomized by Bridgeport and to prevent excessive internodal travel demand.

9. Supplementary Principles.

The scope of the Ahwahnee Principles is primarily land-use and transportation within a city and a region. These principles do not focus on the other two bipoles, namely economic development/taxation and demography/land value described in [18]. The purpose of the supplementary principles to be enunciated below is to address these two subsystems in the context of a regional habitat. Thus:

Economic Development: The city creates the conditions sought by stable and profitable businesses, that is, an educated work force, no crime or addictions, local markets and partnership relations with the city which is prepared to be a launch customer for innovative goods and services. The economic development should be *diverse*, not dependent on natural resource depletion, and matched to the city's population. Corporations that overcut timber and import much of their work force are unwelcome, especially when they dominate the local economy. The city should take a pro-active role in encouraging and permitting investments that benefit the community at large. It should review critically the proposals of special interests and only permit those that provide significant net benefits to the community.

Taxation: The city has the right to impose specific taxes and fees for the purpose of financing and facilitating its transition toward the community approved horizon state. Examples of such taxes are gate fees, substantial parking fees and employment taxes on commuters.

Transparency, Use of Funds and Verity of Costs: The city must divulge the origin and use of funds in an annual report which also states the true costs of the improvements that it finances and the services that it provides. Subsidies and externalized costs are permitted, provided that they are disclosed and justified.

Demography: The city should help create a diverse demography which also ought to be matched to the city's economy. Sections of town that are reserved for the ultra-successful, the beginners and those in between should make way for developments in which the full spectrum of the population lives in the same general vicinity. The resulting diverse habitat creates a sense of community and effectively counters crime and hopelessness. The city, in effect, becomes Oldenburg's Third Place [19].

Efficiency: The city, as well as the region, should avoid inefficient technologies, investments and management processes and attitudes, even when some other government entity pays. Examples of such inefficiency are regional economic developments that invite traffic and require state and federal investments in new highways, military bases and welfare due to lack of skills or adequate job opportunities, and child care.

Domestic financial Management, Savings and Local Investments: The city should take a pro-active role in educating the citizens to live efficiently, save, organize their retirement income, and invest prudently in local business, and replace their credit cards by debit cards

Subsidiarity:[*] The city should seek control of its own destiny within a framework of constraints imposed by superior government. These constraints should not be overly binding. The city should also seek fair pro rata reimbursement under the form of discretionary grants in return for taxes its citizens and corporations are paying to superior levels of government.

Solidarity, Import Replacement and Residency Requirements: The community should take a pro-active role in educating the citizens to give preferential treatment to locally produced goods and services, and in hiring employees who are residents of the city.

The Environment: The city should maintain expertise in predicting the numerous, complex and long-term impacts of planning and use permit decisions that affect the environment. Job creation should not be an

[*] Subsidiarity is defined as control at the lowest level of a hierarchy.

excuse to abuse the environment, especially when the damage is expensive or impossible to repair.

Regional Coordination: The cities that constitute the nodes of a natural regional network should coordinate expansion plans in order to reduce the need for excessive transportation of people and freight along the branches of the network. Tax revenue sharing and other forms of collaboration should be developed to counter the blackmail that existing and potential future businesses frequently employ to obtain favors from competing individual cities (and counties.)

As with the Ahwahnee Principles, the opinion of a well-informed and briefed citizenry should be sought whenever significant decisions in the socio-economic arena need to be made. The principles together with simulations should be used by staff to inform and brief the citizenry.

10. Concluding Comments.

Robert Louis Stevenson posed a very important problem when he wrote:

"The world is so full
of a number of things,
I'm sure we should all be
as happy as kings."

There are a number of reasons, some due to our own ineptitude, why most of us do not live like kings. The point of this paper is that automobility and the associated roadway and parking infrastructures are so incredibly expensive in direct, indirect, and intangible costs that there is not enough left to allow us to live like kings. In addition to the expense, there is pollution and hassle.

The thrust of this paper is not to attack the automobile, which is a marvelous invention, but to *redirect* its use toward the good life, that is exploration and recreation, on a network of tree-lined country roads. Is this redirection possible? We believe so. The center piece of our redirection strategy is the Negakilometer which requires the development of a multigenerational strategy aimed at regional networks with compact urban nodes and abandonment of the sprawl and accretion that evolved after World War II.

Such regional networks not only allow cost effective public transit and freight transportation (which sprawl does not), but also has a range of benefits that are not directly related to transportation, namely a sense of community and moderation of the income and race related social polarization and fragmentation that plagues our inner cities and rural ghettos.

These social and quality-of-life related advantages are real. Those of us who were born prior to 1950 remember the compact neighborhoods where people knew each other and where truants were reported to their parents by an informal network of friends and neighbors.

We estimated that the tangible costs of our auto based transportation system is comparable to the size of our federal budget, about 1.7 trillion. Much of this money could be re-deployed. Our private and public expenditures are not prioritized well. By reducing our private and public contributions to automobility, we could finance the efficient nodal network and have money left over for more recreation and education.

There are many that oppose the regional network with compact urban nodes and diverse demographics and economies. Obvious opponents are those who manufacture, sell, service, finance and insure automobility and build highways and freeways. Additional opposition comes from those who believe in the economy of scale of large plants, tall office towers and big boxes. However, we are beginning to see attention-catching examples, (e.g. electrical power generation), in which the economy of scale argument was proven to be very wrong, once the increased resilience of dispersed generation and the opportunity for cogeneration was factored in.

Then there are those who argue that high technology solutions are just around the corner, for instance electric vehicles and the Automated Highway System, (AHS). Our counter is that these solutions will probably help somewhat but will not be affordable and effective remedies for the US and, perhaps more importantly, the LDC's* whose appetite for motorization has become a cause for global concern. Tele-commuting, of course, is with us and provides a useful partial solution for human interactivity, somewhat like the telephone.

An important suggestion of this paper is the dynamic programming way of thinking, notably the definition of a bi-generational horizon state, $\mathbf{x}(H)$, the development of laws of control which entice the various factions of the community to move the state forward in the right direction and, of course, the *principle of optimality* which says that trying to save too much money and pain in the short term will cost more money and pain in the long-term. The resulting optimum split between short and long term investment needs by the community should help settle the ideological dispute between the proponents of spending and those in favor of reducing local taxes.

The key to a successful transition from the current state to the horizon state is to define a horizon state which meets the following conditions:

* Lesser Developed Countries

- It is feasible, that is, internally consistent and reachable.

- It has the backing of the majority of the community.

- It needs to be scrutinized and, if necessary, updated periodically.

There exists a vast body of knowledge which describes the kind of horizon state that makes sense to a city and, by extension, to a region. The Ahwahnee Principles augmented by the Supplementary Principles, point the community in the right direction. The charrette, visual preference and simulation techniques, including games such as the existing Sim City 2000 and the hoped for Sim City 2001 are needed to understand all the implications of the chosen $\mathbf{x}(H)$ and create community consensus and steadfast support to realize it. The charrettes and visual preference techniques are well established. Simulations and interactive games, especially in the context of identifying the winning $\mathbf{x}(H)$ and enlisting community interest, understanding and support remain to be developed.

Can the transition from the inefficient and costly habitats and lifestyles to a state based on nodal compact and relatively independent cities be realized within our political structures? We believe that it can. It is quite possible that the initiative will not originate in an OECD country because of inertia and vested interests. Jaime Lerner, former mayor of Curitiba, inventor of a brilliant bus-based transportation system in this 1.4 million people city [20], and now Governor of the State of Parana, Brazil, comes to mind. It is certainly encouraging to note that more and more of our elected representatives want to phase out most subsidies and charge each user for the true prorated cost for the amenities and services that he demands. Trading user fees for subsidies and reducing taxes in the process would seem to be a politically acceptable strategy toward realizing efficient habitats and life styles.

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Appendix A

The state $\mathbf{x}$ and motion in the state space $\mathbf{x}(k)$.

Those readers who are repelled by algebraic symbols such as $\mathbf{x}$ should reflect on this paragraph only. The state $\mathbf{x}$ is a list of all those pertinent attributes of a city (or any other large-scale system) that cannot be changed by the stroke of a pen, but require time and effort. The area covered by parks and the incidence of

violence are examples taken from that list. Ordinances and taxation schemes, on the other hand, are decision variables, and they can be changed or created by the stroke of a pen. Getting the urban state to make a soft landing at or near the specified horizon condition is a control problem similar to that of delivering a happy NYSE together with near-full employment and no inflation, or of adjusting the horizontal and vertical positions and velocities, and the attitude angle, of a jet liner so that it lands without a jolt.

The dynamics of physical systems are described by differential equations, such as Newton's relation between a force F which accelerates a mass m at the rate a

$$F = ma \qquad (1)$$

Let the scalars x_1 be the distance of mass m from a given starting point $x_1(0)$ and x_2 be in velocity. Then (1) can be rewritten as two first order differential equations

$$\dot{x} = x_2$$

$$\dot{x} = \frac{F}{m} \qquad (2)$$

The solution of (2) provides the answers and $x_1(t)$ and $x_2(t)$ where t is continuous time $x_1(k)$ and $x_2(k)$ where k is discrete time.

Poincaré pointed out that the trajectory formed by a point of coordinates x_1 and x_2 in the x_1, x_2 plane as a function of t (or k) might be more instructive than the traditional plots of x_1 and x_2 versus t (or k).

The idea of a trajectory associated with the variables $x_i(t)$ can be extended to systems of greater complexity, that is $n > 2$. The resulting column of scalars $x_1, \ldots, x_i, \ldots x_n$ is a vector **x** called the state. The motion or trajectory of **x** as a function of t (or k) is described by a set of n differential (or difference) equations similar to (2), but more numerous and involving more variables.

The force F in (2) can be the result of a deliberate decision u, a perturbation v, or both. Thus the trajectory in the x_1, x_2 plane depends on the forces u and/or v. In the higher dimensional case of **x**, the decisions and perturbations are also vectors **u** and **v**.

In physical systems, the components of **x** are usually related to a form of energy. In (2), the velocity of the mass m is related to the kinetic energy

$$\frac{m(x_2)^2}{2}$$

This observation suggests that a state variable cannot change quickly, unlike the decision or perturbation variables.

Differential (and difference) equations can also be used to describe the dynamics of economic and socio-economic systems. For example, the state x of a bank account is related to deposits u_1, withdrawals u_2 and interest i per unit time by

$$x(k+1) = x(k)\,(1+i) + u_1(k) - u_2(k) \qquad (3)$$

Note that the bank account state also has inertia: it takes time and effort to increase the asset represented by the account.

A very important example of social dynamics is demography. Let x_i be the number of people of age i in a community and k be measured in years.

A very important example of social dynamics is demography. Let $x_i(k)$ be the number of people of age i in a community in the current or a future year k. If we limit the age to 100 years, we can define a vector $\mathbf{x}(k)$ of 100 components, one for each age i.

It is straightforward to relate next year's demographic state $\mathbf{x}(k+1)$ to this years state $\mathbf{x}(k)$ provided that we know (or can estimate) the following deomographic forces:

$B(k)$ = number of births in year k, a sealar

$\mathbf{I}(k)$ = net immigration into the city (or the region) in year k. $\mathbf{I}(k)$ is a vector of 100 components

$\mathbf{D}(k)$ = deaths in year k, another vector

In order for a city to be described adequately for the purpose of a future specification $\mathbf{x}(H)$ and its planned motion (or trajectory) from the current state to the horizon state $\mathbf{x}(H)$, a number of state variables pertaining to land-use, transportation, city assets, economy and demography need to be defined, together with a decision variables $\mathbf{u}(k)$ pertaining to new housing, infrastructure and economic development,

taxation, education, cultural activities, etc. That was accomplished to a large extent in Sim City 2000.

Appendix B (included by permission)

AHWAHNEE PRINCIPLES
for Resource-Efficient Communities

Existing patterns of urban and suburban development seriously impair our quality of life. These symptoms are: more congestion and air pollution resulting from our increased dependence on automobiles, the loss of precious open space, the need for costly improvements to roads and public services, the inequitable distribution of economic resources and the loss of a sense of community. By drawing upon the best from the past and the present, we can, first, infill existing communities and, second, plan new communities that will more successfully serve the needs of those who live and work within them. Such planning should adhere to these fundamental principles:

Community Principles

1. All planning should be in the form of complete and integrated communities containing housing, shops, work places, schools, parks and civic facilities essential to the daily life of the residents.

2. Community size should be designed so that housing, jobs, daily needs and other activities are within easy walking distance of each other.

3. As many activities as possible should be located within easy walking distance of transit stops.

4. A community should contain a diversity of housing types to enable citizens from a wide range of economic levels and age groups to live within its boundaries.

5. Businesses within the community should provide a range of job types for the community's residents.

6. The location and character of the community should be consistent with a larger transit network.

7. The community should have a center focus that combines commercial, civic, cultural and recreational uses.

8. The community should contain an ample supply of specialized open space in the form of squares, greens and parks whose frequent use is encouraged through placement and design.

9. Public spaces should be designed to encourage the attention and presence of people at all hours of the day and night.

10. Both community or cluster of communities should have a well defined edge, such as agricultural greenbelts or wildlife corridors, permanently protected from development.

11. Streets, pedestrian paths and bike paths should contribute to a system of fully-connected and interesting routes to all destinations. Their design should encourage pedestrian and bicycle use by being small and spatially defined by buildings, trees and lighting; and by discouraging high speed traffic.

12. Wherever possible, the natural terrain, drainage, and vegetation of the community should be preserved with superior examples contained within parks or geenbelts.

13. The community design should help conserve resources and minimize waste.

14. Communities should provide for the efficient use of water through the use of natural drainage, drought tolerant landscaping and recycling.

15. The street orientation, the placement of buildings and the use of shading should contribute to the energy efficiency of the community.

Regional Principles

1. The regional land-use planning structure should be integrated within a larger transportation network built around transit rather than freeways.

2. Regions should be bounded by and provide a continuous system of greenbelt/wildlife corridors to be determined by natural conditions.

3. Regional institutions and services (government, stadiums, museums, etc.) should be located in the urban core.

4. Materials and methods of construction should be specific to the region, exhibiting continuity of history and culture and compatibility with the climate to encourage the development of local character and community identity.

Implementation Strategy

1. The general plan should be updated to incorporate the above principles.

2. Rather than allowing piecemeal development, local governments should take charge of the planning process. General plans should designate where new growth, infill or redevelopment will be allowed to occur.

3. Prior to any development, a specific plan should be prepared based on these planning principles. With the adoption of specific plans, complying projects could proceed with minimal delay.

4. Plans should be developed through an open process and participants in the process should be provided visual models of all planning proposals.

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