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Cover photos, clockwise from centre:

- Joseph Kott and John Eells, Palo Alto CA USA (Anuj Aggarwal)
- Munich, Germany- green corridor adjacent to an arterial (Michelle DeRobertis)
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Dr. Joachim und Hanna Schmidt
Stiftung für Umwelt und Verkehr

"We are grateful for the financial support of the journal from the Dr Joachim und Hanna Schmidt Stiftung fuer Umwelt und Verkehr, Hamburg, Germany"

http://www.dr-schmidt-stiftung.de/28-0-Aktuelle+Projekte.html

Dr Joseph Kott (Joe)

This is a special issue of this journal to celebrate the life and work of Joe Kott. Joe died in Oakland, California on 14th February 2019 at the very early age of 71, depriving us of many more years of sharply focused messages, insights and policy suggestions around urban design, streets and sustainable transport. His contribution was significant on a global scale and remarkable for its fusion of research, teaching and the practical application of professional and personal skills working within council and local government. He served as Chief Transportation Officer for the City of Palo Alto in California (1999-2005).
In addition to a busy life teaching, researching and actually doing the practical work involved in designing and implementing sustainable transport solutions in Palo Alto he co-founded the non-profit organisation, "Transportation Choices for Sustainable Communities" (TCSC). TCSC is still very active in pursuing the wider issues of transport, urban design, sustainability and community viability and we are very fortunate indeed that Joe found time to embed his work and insights into a continuing research, policy and advocacy presence in this field.

Joe's clear thinking about sustainable transport, pedestrians and streets is present in his many publications referred to in this special issue. His 2016 article in this journal (volume 21, number 4) sums up many of the themes we have taken up over 25 years of publication and we are delighted that we had an opportunity to publish.

John Whitelegg
Editor

Guest editor introduction

This special issue is to celebrate and share the contributions of Joseph Kott in advancing new ideas and approaches to improving urban transportation. Joe was a socially-minded entrepreneur of the first order, who brought high standards and deep values to all of his work. He was the rare individual who had risen to the top of his profession, and then used that vantage point to chart and pursue new directions for both himself and his field.

I, Michelle, first met Joe twenty years ago when, as a consultant, I worked on several innovative transportation studies under his direction at the City of Palo Alto. We stayed in touch due to our mutual interest in reducing automobile dependency and improving traffic safety. In 2011, I was honored to be asked, along with John Eells, to help him co-found the non-profit Transportation Choices for Sustainable Communities. As a Bay Area transportation professional, I, Rick, knew Joe by reputation for decades. I really got to know him after 2014 when Joe and his fellow principals offered me the privilege of joining them at Transportation Choices for Sustainable Communities.

Despite Joe's unexpected and too-early passing, we along with the other remaining principals at Transportation Choices are committed to continuing both the organization that he started and the ideals it represents. All of the topics included in this issue have Joe's fingerprints on them, and indeed one of our current projects discussed herein, Green Streets, emanated from Joe's PhD dissertation. Our work both individually and with Transportation Choices will help ensure that Joe's ideals continue to be realized.

With this in mind, this issue is dedicated to Dr. Joseph Kott.

Michelle DeRobertis and Richard W. Lee
Guest Editors

A Future for Pedestrian Streets in America?
Joseph Kott

Abstract:
This paper reviews the literature on the history of pedestrianized streets in the USA and evaluates factors that have contributed to their success or failure. The aim of the paper is to elicit lessons learned from the history of pedestrian streets around the nation so as to inform contemporary urban planning policy.

Influences on Bicycle and Pedestrian Travel: An Interdisciplinary Review of the Literature
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Abstract:
There are a multitude of influences on the incidence of walking and cycling as modes of transport as well as recreation ranging from the built environment to socio-economic and cultural factors. This article surveys the interdisciplinary research worldwide, finding a surprising complexity in the influences on cycling and walking. Understanding these influences is a key to promoting their use for shorter distance trips within urban areas.

From Complete Streets to Complete, Green, and Sustainable Streets: A Review of the Green Streets Literature
Christopher Ferrell, John Eells, Joseph Kott, Richard Lee, Frank Arellano and Reyhane Hosseinzade

Abstract:
Cities, counties and other transportation-focused agencies are increasingly looking to sustainable streets to accommodate and balance the transportation needs of increasing populations and their mobility needs. A relatively new concept, sustainable streets include two, more mature components: complete streets and green streets improvements within the public right-of-way. While distinct, the two street concepts (complete streets and green streets) share similarities. This article explores common elements of green street and complete street definitions from the research literature, followed by a more focused review of green street types, and their social and environmental benefits.

Keywords: Green Streets, Complete Streets, Sustainable Streets, Green Infrastructure, Transportation Planning, Transportation Engineering, Environmental Engineering

Global Inspiration for U.S. Transport Innovation
Michelle DeRobertis and Beth Thomas

Abstract:
Americans have received inspiration from abroad for sustainable and innovative transportation solutions ranging from bicycle transport innovations to bus rapid transit. How and why this is so is a story of successful globalization. This paper highlights the cities and countries of origin for several key transportation strategies and designs and describes the early adopters in the USA that led to their now common use and acceptance. It also describes several new practices that may also become ubiquitous.

Keywords: sustainable transport, technology transfer, global diffusion of best practices, transportation history.

Cars and Cities: Looking Back on Jacobs and Buchanan 55 years Later
Michelle DeRobertis

Abstract:
Jane Jacobs and Colin Buchanan provided some of the earliest warnings about the problems of cars in cities. This paper examines and presents their key points for a new generation of practitioners and others who might never have read the full works. It also looks back on what they missed and what we missed in interpreting their work.

Keywords: traffic restriction, livable streets, cars and cities, tragedy of the commons, adverse impacts of cars, cities and public transit.

San Francisco TDM Ordinance: A tool for promoting sustainable transport

Charles R. Rivasplata

Abstract:
This paper examines the evolution and application of the San Francisco Transportation Demand Management (TDM) Ordinance, an act of municipal legislation that requires the creation of a TDM Programme in the buildings that developers intend to build or renovate in San Francisco. This Ordinance, adopted in 2017, details the transport requirements and responsibilities of developers in their commercial and residential buildings. Since 1979, the municipality has developed TDM measures for new projects; however, many developers or owners have chosen not to comply with these approval conditions. The Ordinance establishes the need to formulate a TDM Programme at the beginning of the application process, forcing each developer to choose a series of measures to develop a TDM Programme for its workers. Each Programme is expected to reduce the number of vehicle-kilometres travelled (VKT) generated by building projects. In principle, the municipality proposes to work with developers and owners to promote new travel options. With the adoption of the TDM Ordinance, the TDM Programme is applied to all kinds of buildings and changes in building use throughout San Francisco, except at certain state institutions and affordable housing projects. The application process and the delivery of legal rights must be carefully considered. Whilst it is still too early to effectively evaluate the new TDM Programme, in the best of cases, the Ordinance can generate sustainable transport options for tenants, employees, residents and visitors to a building, benefitting not only the neighbourhood, but also the city and the Bay Area.

Keywords: Travel Demand Management, Sustainability, Transportation Sustainability Program(me), San Francisco, Project Conditions.

Freedom to Drive and the Tragedy of the Commons of U.S. Cities: Reflections on Policy, Culture and Technology

Michelle DeRobertis, Richard W. Lee

Abstract:
This article reinterprets many of Garrett Hardin's "tragedy of the commons" arguments (1968) from the perspective that urban roadways are public "commons". Solutions to transportation problems have historically been dominated by technological solutions, and the discourse today has not changed, only the type of technology. Hardin, somewhat controversially, challenged humanity's freedom to breed; this article challenges our freedom to drive. This article proposes that, rather than technology, what is actually required are changes in human behavior and changes in national spending priorities toward investment in mass rapid transit.

Keywords: Traffic congestion, public transit, city policy, public policy, technical solutions, tragedy of the commons.

About Joseph Kott, PhD, AICP

Joseph Kott PhD, AICP was a transportation planning and management expert with a career spanning over five decades and five states in both the public and private sector as well as academia. A proud native of Detroit, he was extremely focussed on the role of transportation in creating vibrant livable communities.

After receiving a Masters of City Planning (MCP) at the University of North Carolina at Chapel Hill, Joe held positions with Orange County in Hillsborough, North Carolina and the North Carolina Department of Transportation in Raleigh. Joe then spent five years in Illinois before moving to Maine in 1988, where he was a planning consultant in Auburn, and then transportation planning and programs manager for the Greater Portland Council of Governments from 1992 to 1998. He began his teaching career at this time, becoming an adjunct professor at the University of Southern Maine in Portland, teaching graduate courses in both community transportation planning and community planning until 1997.

In 1998, Joe moved to California to be the transportation coordinator for Marin County in the San Francisco Bay Area. In 1999, he was recruited by the City of Palo Alto to be Chief Transportation Official, a position he held for almost seven years and where he cemented his reputation as a staunch supporter of sustainable transportation and an "out of the box" thinker. He practiced what he preached with his multimodal commute from Albany to Palo Alto (over 45 miles each way), riding his bike to the North Berkeley BART station, taking BART to downtown San Francisco, then biking one mile to the CalTrain station and finishing the trip on the train to his office in Palo Alto.

An avid believer in higher education and being well prepared to face the transportation challenges of the 21st century, Joe received two Masters degrees from Monash University, Melbourne, Australia in 2002 and 2004. Later, instead of thinking about early retirement, he began his PhD studies with the Curtin University Sustainability Policy Institute in Perth, Western Australia, receiving his doctorate in January 2012. His dissertation was titled Streets of Clay: Design and Assessment of Sustainable Urban and Suburban Streets, an extract of which this journal published in February 2016. During the early 2000s, Joe became visiting scholar, lecturer and/or adjunct professor at several universities including Stanford University, Sonoma State University, and the Presidio Graduate School. He was perhaps most well-known and loved as a longtime lecturer/ adjunct professor at San Jose State University both in the Urban and Regional Planning Department and at the Mineta Transportation Institute. He taught the introductory graduate seminar in urban planning history and theory, and courses in transportation and the environment, planning sustainable local transportation, and fundamentals of transportation management. Dr. Charles Rivasplata often co-taught the transportation courses in Urban and Regional Planning with him.

In 2011, Joe conceived of founding a 501(c)3 non-profit organization that would research and promote sustainable urban transportation planning and policy. He was a founding principal, along with John Eells and Michelle DeRobertis, of Transportation Choices for Sustainable Communities in Oakland. He subsequently recruited two more colleagues, Dr. Richard W. Lee, and Dr. Christopher Ferrell, currently Treasurer and Executive Director, respectively. Most of the Board Members were recruited by

Joe and many of the initiatives that Transportation Choices is involved emanated from him. It is fair to say that without Joe, Transportation Choices would not exist.

Paul Kott wrote that his father "was the kindest man I've ever known. He was also the most intelligent, thoughtful person I've ever met. His love was powerful, and that love was reflected in his values and actions. He made the world a better place, both professionally and personally, fighting for more livable cities and battling climate change and greenhouse gas emissions. He was truly interested in the lives and interests of others."

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Streets Ahead: A Perspective on The Urban Transportation Legacy of Dr Joseph Kott
Jeffrey Kenworthy

Dr Joseph Kott devoted his research and teaching to creating better cities for everyone by addressing perhaps the most intransigent of the problems we face in our urban world: how to lessen the grip of the automobile in shaping mobility patterns in cities and to bring a needed balance and sanity back to how we think about and plan our streets, especially our arterial roads, and more broadly, our communities. Far from being an anti-automobile fanatic, Joe came from a Michigan family with nearly a century of close ties to the automobile industry. By his own admission in his PhD dissertation (Kott, 2011), his research "is not however a jeremiad against the automobile" (p.9). Rather his work is about "a more sustainable balance of people, nature and automobiles in our cities. Arterial streets, like clay have the plasticity to be molded either to suit the current motor vehicle traffic dominance (in North American cities and worldwide) or to conform them to a new mold." (p.9).

These words have tremendous import and urgency, not only in the auto-dominated world in which Joe worked, but across the whole Asian region, Latin America, Africa, Eastern Europe and in every other place where the car is on the rise. Most urban fabrics in these rapidly developing regions co-evolved with very space efficient non-motorised transport and in many cases public transport systems and are not able to cope with the motorised onslaught of space consuming cars, trucks or even large fleets of motor cycles (e.g. Kenworthy, 2017; Jauregui-Fung et al, 2019). Despite these obvious facts and against all wisdom and prudence, the same traffic engineering principles, standards and indeed values, that were used to create unprecedented levels of automobile dependence in places like Los Angeles and Houston, by giving pre-eminence to the car, are being applied in situations that are entirely inappropriate and alien to them. Chinese cities, for example, up to the 1990s were models of non-motorised transportation, whereas today in many of them bicycle lanes are now traffic lanes, footpaths are set aside totally for parking and the cities are engulfed in health-threatening levels of pollution (Schiller and Kenworthy, 2018).

Roads occupy generally between 8% to 30% of the urban land area in cities, depending on the nature of the city. Whenever we walk outside our dwelling, a shop, our workplace, school or business, the street is the first environment that confronts us. Streets are the fabric that knits everything together in cities. They are the primary shapers of the public realm in cities. They can be horrible, polluted, dirty, noisy, dangerous and threatening on every level - traffic sewers - or they can be paragons of urban design and enjoyment incorporating green and attractive spaces, wide footpaths, active street frontages with eyes on the street and filled with the constant byplay of thousands of residents and visitors alike. If streets are beautiful places they help us to feel good about where we live, we feel we belong. They encourage social interaction in cities, they allow independent mobility of vulnerable members of society - the young and the old and those less physically-abled. The benefits of streets that provide for a range of mobility options including walking, cycling and public transport, all able to be undertaken in safety and dignity, have immeasurable social, environmental and economic benefits and few dis-benefits. In a scientific and objective sense, Joe's PhD dissertation work on transforming arterial streets into more sustainable environments and his subsequent teaching, writing and lecturing about this, took our knowledge on these matters to a new level of comprehensiveness and integration.

As Joe Kott's principal PhD supervisor, I can personally attest to the ground-breaking and monumental nature of what Joe produced. Assessing and comparing the "sustainability" of arterial roads is fraught with complexity and pitfalls. It involves a plethora of both physical, objective measures such as adjoining land uses, their architectural features, landscaping, urban design, noise, air pollution, transit services, walkability, amenity for bikes, speed of traffic and many more factors that need to be considered.

Of course, it also involves even more qualitative and perceptual aspects, which are contingent at least partly on peoples' personal opinions and preferences about the way a street should be to feel that it is comfortable, convenient, economically viable, functional from a traffic perspective, environmentally and socially inviting and so on. And of course, "people" are even more diverse and complex than the streets themselves and very difficult to plumb for their views. So, for example, those who run businesses along a street may have very different needs and perceptions to those that use the street as visitors or residents who live nearby. Joe's work definitively showed that there is no such thing as a "unitary public interest", but rather an almost endless array and diversity of public interests, the balancing of which challenges everyone in decision-making and policy positions on roads. In short, it is minefield and one that is extraordinarily difficult to navigate.

Joe launched into this challenging maelstrom of conflicting and complicated ideas undaunted, or at the very least, prepared to take it all on despite the obvious challenges that lay ahead. It was a complicated piece of work from the beginning. Even being able to compare a before and after situation along arterial roads to assess their relative "sustainability" was not possible because there were no "before and after" situations available for the same street. So, the first big obstacle was how to go about the work and create an acceptable surrogate before and after perspective. This was solved by choosing streets that were presently "untreated" with sustainability approaches (the before case) and comparing them to streets that Joe carefully demonstrated to be similar enough to represent similar situations, but which had been treated with programs to make them more sustainable and liveable (the after case).

As everyone can no doubt imagine, the literature review to establish the current state of knowledge about the almost endless array of matters that needed to be considered, was a monumental challenge for Joe. This came in two forms: firstly, reading all the literature and extracting the key findings and points in relation to his research questions and then synthesising and systematising all those results into a logical and readable "story". Naturally, Joe's own research then had to distinguish the state of the pre-existing knowledge from what his work was adding to that knowledge base. A truly yeoman effort was needed.

It is at this point in any such extraordinary endeavour when one realises that much more than intellect drives the work forward. It's impossible to separate the work to be done from the values of the individual doing the work and what drives them. There is a certain moral tenacity and dare I say goodness required in a person to stand up to the complex and demanding task of making cities better places for everyone. This is not, in my view, the case in the more narrow, self-seeking and ultimately self-defeating and destructive impulses involved in making streets only better for the car.

Travelling with Joe, mostly through cyberspace (due to his location in California and mine in Germany), along this fraught and maze-like endeavour, I was constantly amazed by his enthusiasm, persistence, meticulous attention to detail and willingness to take constructive feedback. A lesser person with less moral fortitude would not have been able endure this and come out the other end with their sanity intact. And here is the key for me to what made Joe so special in this field. We cannot separate the person Joe was from the nature of what he achieved. This work was a calling, not just an academic exercise and as such it placed the whole thing in what I consider to be a "higher realm", for want of a better phrase. Joe had the "head and the heart" in his work and it is this combination of intellect and passion that can achieve amazing things.

If I might be forgiven for indulging this perspective for a moment, I would like to share a personal story that at least for me confirms Joe's contribution in a way that is not just purely academic.

During Joe's PhD candidature, I was only once with him in person in the Bay Area and Joe and his wife Katherine were kind enough to have me stay with them during this short sojourn. Joe and I went for long on-site visits to all his case study and control streets, taking extensive photographs and discussing in great detail, his work plan and technical details of what he was attempting. His enthusiasm, intellectual rigour and hopeful, caring nature were always on display as we travelled this course.

Symbolically, it was also on this trip in 2008, when I was interviewed by Public Broadcasting Service (PBS) in the USA in Joe and Katherine's little garden about the tearing down of the Cheonggyecheong Freeway and the creation of the now famous 6 km green river boulevard there in Seoul, South Korea. Joe was part of that event, helping set up the space that was needed in their garden and he was excited about the topic and to be part of it in this way. The resulting 25-minute film, Seoul: The Stream of Consciousness broadcast by PBS in December of that year as part of the e2 series (PBS 2008), is one that I use in my teaching about traffic being a gas and not a liquid – expanding and contracting according to the space provided for it – not a liquid that maintains a constant volume.

Joe's work was all about making streets better places rather than passages, and that freeway demolition and river restoration in Seoul is probably the best example so far of the transformation of an intense road corridor (170,000 vehicles per day) from a passage to one of both place and passage, including cars on the remaining surface street above what is now a green river boulevard on the lower level.

Perhaps it is easy in hindsight to overplay the spiritual significance or symbolism of moments like these, but Joe's heart, his spiritual heart, was very deeply committed to making life better in cities through his work on transport. This spirituality and goodness was, I believe, what gave Joe the intellectual impetus and human energy to carry out his amazingly detailed work on streets in the Bay Area.

The fact that part of the film about this landmark road transformation demonstration project was made in Joe and Katherine's garden, an entirely extraordinary coincidence whichever way one cares to perceive it, is for me at least, an interesting spiritual confirmation of what Joe stood for in his labour and mission here with us.

Simply put, Joe was a superb human being. His intellectual capacity and skills and his tenacity at sticking to a task go without saying. But what I so loved about Joe was his genuine, care, compassion and spirituality. He really did have the "head and the heart" in generous measures of both. A beautiful soul which shone through everything he did and every life he touched.

I felt totally comfortable to speak with Joe about things of the heart and soul, things which go so much deeper than human intellect, things which are at the very core of our individual and collective being. From my perspective, Joe's spirituality infused everything he did and this is what I loved most about him. Joe in short was one of the finest human beings I have ever had the pleasure to know and the most gracious student I've ever supervised.

Of course, Joe's work was not limited to his PhD. His teaching and participation in public dialogues were critical to his life's endeavour. When one teaches, much more is communicated than intellectual matters. A good teacher conveys so much more, not necessarily in words, but in feelings and just "who they are". In simple terms, a fine teacher teaches goodness, pure and simple. Those students who have had the good fortune to be taught by Joe have received a far greater gift than mere human learning. They've also seen what it means to be upright, kind, gentle and deeply caring. And I believe there are many who would testify to that.

Joe's presence and work here with us is sorely missed but his legacy will live on.

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A Future for Pedestrian Streets in America?

Joseph Kott

Preface

This paper was presented by Dr. Kott at the Association of Collegiate Schools of Planning 2016 Annual Conference, in Portland, Oregon, USA on November 5, 2016. It illustrates Dr. Kott's interest in pedestrian-only streets, on which he was keenly eager to do additional research. His interest also included exploring the different niches that the many variations of pedestrian streets could occupy, i.e. truly car-free streets, pedestrian/transit-only malls and pedestrian-oriented streets. A draft abstract he wrote exploring this research idea is presented later in this journal.

Introduction

Americans who visit Europe are often struck by the many vibrant pedestrian malls and pedestrian friendly streets across the Atlantic. People walk these streets for utilitarian purposes or just to experience street liveliness. Healthful walking is integrated into their daily lives. Why aren't there more pedestrian malls and pedestrian-oriented streets in the United States? I posed this question once to a colleague, a distinguished and enlightened practitioner of new urbanist traffic engineering. His answer was simply that "those kinds of streets don't work here". His view is widely shared among my urban planning colleagues.

What has made some pedestrian streets around the country not only endure but prosper? On the other hand, why are a number of pedestrian malls being reopened to car traffic? In the 1960s and 1970s some 200 main streets or street precincts across the United States were closed to automobile traffic in an attempt to compete with the emerging regional shopping centers (Pojani, 2010). For the most part they failed and were eventually re-opened to automobile traffic (Robertson, 1990). Other pedestrianized streets have been notably successful, including Santa Monica's Third Street Promenade, Charlottesville's Downtown Mall, and Boulder's Pearl

Figure 1: Typical European Pedestrian Street, Marseille France
Photo by Michelle DeRobertis

Street Mall (Pojani, 2005; Bates, 2013). Some former pedestrian malls have simply re-opened to car traffic just as before pedestrianization. Others have been combined with public transit as shared-use streets (Robertson, 1990). One recent estimate is that 89% of formerly pedestrianized streets in the USA are now re-opened as before, shared with transit, or failing (Judge, 2013). Some of these pedestrian malls, for example the Fayetteville Street Mall in downtown Raleigh, North Carolina that I used to frequent as a young transportation planner with the North Carolina Department of Transportation, have been re-designed as pedestrian- oriented rather than car-free[1].

European pedestrianization of center city streets that helped inspire Americans to create downtown pedestrian malls has continued meanwhile, widening in some cases to car-free or "car restricted" city centers (Topp & Pharoah, 1994). Bordeaux, for example, has a strikingly successful network of car-free pedestrian streets. These are interlaced with pedestrian-oriented streets traversed by trams lines but also accessible by car[2]. At the same time as enthusiasm for pedestrianization has waned in the USA, practitioner and scholarly interest worldwide in the public health benefits of more walkable communities (U.S. Department of Health Service, 2015), public space and place-making (Newman and Jennings, 2008; Haas and Olsson, 2013) and reducing car dependence (Tumlin, 2012; Newman & Kenworthy, 2015) has risen. So too has interest in re-thinking street design (A. Jacobs, 1993; Kott, 2011; Schlossberg, Rowell, Amos, & Sanford, 2014; Kott, 2016; Sadik-Kahn and Solomonow, 2016).

A notable recent counter-point to the frequent past failure of pedestrianization, however, has been the success of Times Square and other pedestrian plazas in New York City (Sadik-Kahn and Solomonow, 2016). These highly visible examples could spark a revival of interest in pedestrianization in the rest of urban America. Trends such as the post-industrial re- urbanization of many U.S. central cities (Ehrenhalt, 2012; Bates, 2013) and the renaissance of public transportation (Newman and Kenworthy, 2015) in many U.S. cities are also indicators that pedestrianization may re-emerge as an urban strategy.

This paper reviews the literature on the history of pedestrianized streets in the USA and evaluates factors that have contributed to their success or failure. The aim is to elicit lessons learned from the history of pedestrian streets around the nation so as to inform contemporary urban planning policy.

Literature Review

Downtown retail sales in America fell from about a fifth to a twenty-fifth of those of entire metropolitan areas between 1954 and 1977 (Robertson, 1983) as a result of migration to the suburbs and powerful competition from suburban retail centers. This downward spiral led to a search for strategies that would stem or even reverse the loss of the urban retail base (Pojani, 2005). One such strategy was the pedestrian mall, a downtown answer to suburban retail threat. America's first pedestrian mall was opened in 1957 in Kalamazoo, Michigan, although a plan for an extensive pedestrian precinct in Fort Worth was drawn up the year before but never implemented (Bates, 2013). Despite the misgivings about pedestrianization expressed by the celebrated urbanist Jane Jacobs (1961), pedestrian malls spread nationwide over the next two decades.

This wave of pedestrianization was influenced by a parallel trend in pedestrian streets and precincts in Europe (Robertson, 1990; Bates, 2013). Pedestrianization had different outcomes on each continent, however. While retaining retail competitiveness was a motive for cities in both Europe and the USA to pedestrianize streets (Bates, 2013), the European experience was in the context of higher center city population density and better public transit (Pojani, 2005). In the USA, pedestrian malls were spreading just as both center city population density (Robertson, 1995; Newman & Kenworthy, 1999)

1. I was impressed by the attention to both urban design detail as well land use mix and density on the "new" Fayetteville Street during a visit there to speak at the 11th Annual North Carolina State University Urban Design Conference in 2014.
2. I visited these streets on a Friday afternoon in April, 2016 to see them thronged with people after the end of the French work week that Noontime.

and urban transit (Gordon, 1991) were in steep decline. The wave of pedestrianization was occurring just as many U.S. cities were hollowing out. The city streets enlivened by a variety of people on them at different times of the day that were so celebrated by Jane Jacobs (1961) were being transformed to nine to five environments ghostly after hours. They began to resemble suburban office parks but mixed with struggling retail uses.

The forensics on the fate of pedestrian malls in the USA is sobering. For most, the bill of indictment includes rising retail vacancy rates, falling retail variety, fewer pedestrians, lower commercial rents, and perceptions, if not always realities, of increased criminal activity (Pojani, 2010; Feehan & Becker, 2011; Judge, 2013). The survivors, some more successful than others, included downtowns with the pedestrian generation of a nearby college campus like Boulder CO, Ithaca NY, Burlington VT or Charlottesville VA (Pojani, 2010). The short list also comprises tourist destinations such as Santa Monica CA, the South Beach neighborhood of Miami Beach, and Cape May NJ (Pojani, 2010). Other successes include the shared transit and pedestrian malls of Denver, Minneapolis, and Portland (Robertson, 1995).

The overall failure of pedestrianization in the USA has been ascribed to a diverse set of causes. These include the outgoing tide of jobs and people that was already underway, ineffective management of the downtown retail mix, poor street maintenance, over-design, and a paucity of evening entertainment and special events (Robertson, 1990; Pojani, 2010; Feehan & Becker, 2011; Bates, 2013). Transportation causes identified include inadequate public transit, inconvenient automobile parking, and inconvenient automobile circulation (Pojani, 2010; Feehan & Becker, 2011; Bates, 2013) and lack of cross street visibility provided by car circulation on cross streets (Beyer, 2015).

Some of the literature on sustainable transportation that has emerged since the heyday of the pedestrian mall in the USA now envisions a much less automobile-dependent or "post- automobility" city (Tumlin, 2012; Newman & Kenworthy; 2015; Schawartz & Rosen, 2015; Zipori &

Figure 2: Nicolet Transit Mall, Minneapolis, Minnesota
Photo by Michelle DeRobertis

Cohen, 2015;). The hopes of this literature are predicated on increases in urban density and land use mix, walkability, and public transit availability. These same factors both support and result from pedestrianization in Europe (Pojani, 2010). This vision of American cities after the era of automobile dominance portends, explicitly or implicitly, new opportunities for pedestrianization.

Discussion

There are hard lessons to learn from the U.S. pedestrianization experience. The lessons all teach realism. At the same time, they also illuminate the way forward in creating pedestrian-oriented spaces in street rights of way. A new appreciation of the ecosystem of streets incorporates a continuum from vehicle-dominated space to streets solely for pedestrian movement and dwelling (Gunnarsson, 2007). While pedestrian streets, malls, and precincts will not solve complex urban problems per se, they do have a natural niche in this new ecology. The new context of re-urbanization of many U.S. cities means that the people and jobs coming to them are recreating the mix of street uses throughout the day that is the medium for lively street life. The priority given to safe, comfortable, and convenient pedestrian and bicycle circulation and the revival of urban public transit (Newman & Kenworthy, 2015) create an amenable transportation context for pedestrianization. A greater appreciation in detail for urban design qualities (Southworth, 2005; Clemente & Ewing & Ewing, 2013) and placemaking (Thomas, 2016) is available for use in transforming public rights of way. The conditions are in place for reconsideration of the pedestrian street.

What will increase probabilities for success in pedestrianization? A comprehensive approach to the pedestrian precinct and environs is essential. This includes an evaluation of the demographics, economic base, and use mix on and in the catchment area of a street or street precinct. Nearby residential population and jobs are two ingredients for success of pedestrian streets. Another is multi-modal access and circulation in the environs. An example of best practice in access and circulation is the successful Murray Street Mall that I used to visit while a doctoral student in Perth, Western Australia. This pedestrian precinct is seamlessly integrated with Perth's busiest passenger terminal, woven into the network of downtown footpaths, served at its portals by a circulator free shuttle bus, and flanked by structured parking for cars.

Optimizing car parking through optimal car parking supply that supports rather than hinders sustainable transportation, efficient pricing, shared parking, and location of both on-street and off-street parking, the staples of contemporary parking reform (Shoup, 2011), are also important for successful pedestrianization. A last important building block for successful pedestrian malls in the USA is space management, including the mix of uses on the street, street maintenance, lighting, amenities, and security, as well as special events (Weisbrod & Pollakowski, 1984). Re-purposing streets for pedestrian use requires special events to engender excitement and stimulate use. Street festivals, farmers markets, running and bicycling events, and one-day closures to car traffic are teaching today's Americans that streets can be re-purposed for enjoyment, if only for a day. Institutional arrangements, including public- private partnerships in managing street rights of way are a requirement for successful pedestrianization.

Conclusion

Pedestrianization has had a mixed, often disappointing, history in U.S. cities. The reasons for this are in the socio-economic trends affecting cities, as well as misapprehensions about the ingredients for creating successful pedestrian streets and malls. Both the socio-economics and the understanding of street ecosystems has changed in contemporary America. Re-urbanization of some of our cities, the revival of urban public transit, the recognition of how important pedestrian and bicycle modes of travel are to healthy, vibrant, and safe cities, and the new emphasis on placemaking are all amenable to well-considered pedestrianization schemes. The typology of streets in U.S. cities includes a range of pedestrian-oriented spaces, from pedestrian-oriented streets with limited car traffic on them, to shared pedestrian and transit malls, and then to pedestrian precincts (Robertson, 1990). Which of these street types find a sustainable niche and where in any given city depends on a comprehensive set of factors. Pedestrian malls do not have to be on the endangered street species list. Instead, they can be, under the right circumstances, a healthy species adaptable to a variety of urban environments. There is an opportunity and cautious hope for renewed academic and practitioner interest in the once moribund topic of pedestrianizing America's streets.

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Influences on Bicycle and Pedestrian Travel: An Interdisciplinary Review of the Literature

Joseph Kott

Preface

Joseph Kott wrote this article about eight years ago, but to our knowledge it was never published, and he had not listed it in his master resume. In the interest of allowing others to benefit from the extensive literature review that he had conducted, we are pleased to include this article in this journal highlighting his work and life.

Introduction

There is a rising interest in measures to induce more non-motorized travel. There are compelling reasons for encouraging more walking and cycling, especially in urban areas. These include the personal and public health benefits as well as the energy and space efficiency of these modes of travel. Overarching all is the impetus to reduce the carbon footprint of travel in cities and suburbs, thus lower greenhouse gas emissions. This article reviews the interdisciplinary literature regarding influences on bicycle and pedestrian travel, especially on, alongside, and across urban and suburban streets. This is the domain of the automobile and its attendant environmental impacts. Shifting travel away from the car to the bicycle or walking holds great promise in the effort to redeem community livability as well as lower the environmental cost of mobility in cities and suburbs.

Influences on walking and cycling.

The built environment is one of many influences on the decision to walk or bicycle. Saelens et al., (2003) reviewed research in the transportation, urban design, and planning literature on correlates of walking and cycling. They found that "communities with higher density, greater connectivity, and more land use mix" also had "higher rates of walking and cycling for utilitarian purposes" (Saelens et al., 2003, p. 80). There was a "similarity of findings across research designs and analytical methods" that "adds further to confidence in the results" (Saelens et al., 2003, p. 86).

Moudon and Lee (2003) prepared a synthesis of knowledge of walking, cycling, and the built environment, along with a behavioral model of walking or biking with three components: origin and destination, road characteristics, and characteristics of areas around origin and destination. They reviewed all instruments to audit physical environments for walking and cycling, whether for recreational or transportation purposes. They define an environmental audit instrument as "a tool used to inventory and assess physical environmental conditions associated with walking and bicycling" (Moudon and Lee, 2003, p. 21). Such audits use spatio-physical, spatio-behavioral, spatio-psychosocial, and policy-based variables. Walking and cycling conditions depend on three factors: interpersonal, environmental, and trip characteristic (purpose and length). All interact in complex ways to influence the decision about whether to walk or bike (Moudon & Lee, 2003, p. 22).

The immediate physical environment is particularly important to those traveling on foot or by bicycle. It is important to assess this environment in detail since pedestrians and cyclists "move relatively slowly through the environment and are afforded an intimate experience of the environment around them that affects where and how long they choose to walk or bike (Moudon & Lee, 2003, p. 23). The researchers also assert that "work remains to assemble objective data of environments at a grain or resolution fine enough to correspond to those sensed by walkers and bicyclists" and that the absence of detailed and accurate information is the most important research need regarding environmental influences on walking and bicycling (Moudon & Lee, 2003, p. 36).

Pikora, Giles-Corti, Bull, Jamrozik, and Donovan (2003) consulted the literature then interviewed experts in urban planning, local government, transport planning, public health, as well as advocates for pedestrians, cyclists, and people with disabilities. Their purposes were to conduct a Delphi study of the possible influences on walking and cycling and to determine the perceived relative importance of these influences. The authors classified four key themes in research on walking and cycling environments: functional, safety, aesthetic, and destination. Panelist interviews elicited personal safety, attractiveness, and the presence of destinations that gave the trip a purpose as the most important determinants of walking. The most important factors for cycling were route continuity and speed and volume of traffic (Pikora et al., 2003, p. 1698).

Some of the most important research on factors that influence the decision to walk or bicycle is summarized in Table 1. Built environment influences on the propensity to use non-motorized modes of travel that have been identified in this research include route quality, land use characteristics at both trip ends, bicycle and pedestrian friendly design, and street connectivity. While there is evidence that the built environment is an important influence, personal and household attributes, as well as the trip characteristics, are even more significant considerations in this decision. Interestingly, there is evidence that route preference considerations hold constant across nations.

Author(s)	Location and findings
Westerdijk (1990)	**Britain, Sweden, and The Netherlands**
	Pedestrian and cyclist route preference varied little across countries.
	The most important factors for pedestrians were distance and pleasantness of a route.
	The most important factors for cyclists were distance, pleasantness, and traffic safety of a route.
	There was evidence that these factors are traded off against each other in route choice decisions.
Cervero and Duncan (2003)	**San Francisco Bay Area**
	Propensity to walk and:
	jobs within one mile radius (+)
	walk friendly design at trip origin (+)
	walk friendly design at destination (+)
	land use mix at origin (+)
	land use mix at destination (+)
	Significant variables associated with propensity to bike:
	jobs within five-mile radius (+)
	retail/service job density within one mile radius (+)
	bike friendly design at origin (+)
	bike friendly design at destination (+)
	land use mix at origin (+)
	land use mix at destination (+)
	Personal and household attributes and trip characteristics were more important than the built environment in the propensity to walk or bike.
Dill (2004)	**Portland, OR Metropolitan Area**
	There was a .902 correlation between street network link density and intersection density
	A high degree of street connectivity gives walkers and cyclists a wide range of route choice.

Table 1: Notable Research on Factors Influencing the Decision to Bike or Walk

Why walk?

Why do we walk? How long are we willing to walk and for what purposes? Marchetti (1994) argues that from an anthropological perspective, humans are territorial and seek the shelter of the cave. These two characteristics are balanced through the parameter of mean travel time per day. This balance is struck at one hour per day "mean exposure time" moving from one place to another (Marchetti, 1994, p. 75). The radius of travel is set by multiplying travel time by speed of travel. For the cities, towns, and villages before about the year1800 that relied mainly on pedestrian travel, an hour round-trip at 2.5 kilometers per hour walking speed implied that the area of a settlement would have a radius of no more than 2.5 kilometers. There are no city walls of large ancient cities that exceed this limit (Marchetti, 1994, p. 77). While the city defined by the pedestrian has given way to the multimodal city whose radius is described by much faster modes of travel, walking remains ubiquitous in cities and the quality of the pedestrian environment is a key element of urban sustainability. Marchetti's concept of mean exposure time has an intuitive appeal, is helpful as a metaphor, but eludes empirical confirmation.

Newman (2003) argues for the re-emphasis on the essential role of walking in cities because advances in information technology and the knowledge economy depend both on electronic and in-person communication (p. 100). As a result, he argues, "the coffee shops and mixed use, dense urban environments of city centres and inner areas where the car is not dominant" are an essential part of a rising "global economy city" (Newman, 2003, p. 100). Moreover, our evolution and history as a species show that "we need to walk and we want to be part of walkable environments". In sum, "this is built into us and we need to build it into our cities" (Newman, 2003, p. 101). While Newman's argument is a hopeful one from the perspective of sustainable transport, information age cities could just as well impel people to spend more time in isolation, communing with their social networks through electronic means rather than in person over espresso drinks at coffee bars.

Alfonzo (2005) posits a hierarchy of walking needs, including "feasibility, accessibility, safety, comfort, and pleasurability" (p. 830). Feasibility, or practicality, is affected by an individual's physical condition and time constraints (Alfonzo, pp. 824-826). Accessibility comprises the variety and proximity of destinations as well as the connectivity between them (Alfonzo, 2005, pp. 826-827). Safety pertains to protection from threat of crime (Alfonzo, 2005, 827-828). Comfort relates to "a person's level of ease, convenience, and contentment"(Alfonzo, pp. 828-829). Pleasurability, in contrast, pertains to "the level of appeal that a setting provides with respect to a person's walking experience" (p. 829). He cautions, however, that the hierarchy of walking needs only applies to situations in which a choice to walk exists (Alfonzo, 2005, p. 831). This view is reasonable with the proviso that different individuals may make different trade-offs among components of a walking needs hierarchy. Accessibility may be most important to one person in choosing a walking route, for example, and aesthetic pleasure may trump access for another. Moreover, individuals may have different rates of marginal substitution along the walking needs hierarchy depending on trip purpose.

Shay, Spoon and Khattak (2003) surveyed the literature on walkable environments and walking behavior, described what constitutes a walkable environment, and summarized research on walking for both utilitarian and non-utilitarian purposes, as well as on pedestrian safety (p. 2). They assert that while "walkability is gaining prominence in the professional discourse of public health, planning, policy, and engineering", to date there was "little agreement as to what truly defines a walkable environment" (Shay et al., 2003, p. 3). Nevertheless, they identify a short list of consensus variables that belong to a walkable environment: "mixed land uses, destinations within walking distance, presence of pedestrian supports such as sidewalks, and good connectivity of roads and pedestrian networks" (Shay et al., 2003, p. 13). The authors observe that there the research on walking was far from complete, partly due to "the complex interactions between human behavior and environments with a rich variety of combinations and formulations of design and function" (Shay et al., 2003, p. 16). That research in walkability is nascent is a striking statement in context of walking being the oldest mode of human transport.

Untermann and Lewicki, (1984), early proponents of creating more walkable cities and towns, observed that "travel on foot allows people to meet and greet each other, to look at and become part of the neighborhood", thus offering "true accessibility to the life within our communities" (p. 25). In their view, "the secret of pedestrian improvement is to reduce the walk length with short cuts, to intensify activity, and to improve intermediate distance substitutes – bus, bicycle and taxi" (Untermann and Lewicki, 1984, p. 25). For Untermann and Lewicki, there are three categories of pedestrian improvements: safety improvements to reduce conflicts with cars; functional upgrades to extend the pedestrians physical limitations; and "pleasurable changes", which "are sensory and extend our psychological limits" (Untermann and Lewicki, 1984, p. 26). They list 10 important ways to better accommodate pedestrians:

- mixed land use;
- activity and people;
- window shopping opportunities;
- restaurants;
- unfolding views, diversity (of sights);
- nearby destinations;
- compact land uses;
- public transportation;
- shortcuts; and
- sidewalks (Untermann and Lewicki, 1984, p. 29).

Untermann and Lewicki emphasize that visual stimulation helps emphasize how much progress pedestrians make during their walk. Pedestrian furniture not only enhances the visual experience, but also reduces the apparent walk length (Untermann and Lewicki, 1984, p. 27). Pedestrian perceptions are also influenced by the relative speed of walking. Rapoport (1987) asserts the following:

> At driving speeds, the time available to obtain information is … greatly reduced. The need is thus for large-scale elements and infrequent broad and smooth rhythms. The pedestrian receives very different input – it is fine-grain, he can vary the rate, he can look around and stop to observe detail, he is aware of the environment all around him in all sense modalities. Motorists' perceptions are affected by the length of time each element is in view and also by the criticality of the task. The pedestrian has each element in view as long as he wishes and can satisfy his interest in it because of the low criticality of the task (p. 88).

Although this view has merit, it does understate the imperative in utilitarian walking, as well as in vigorous walking and jogging for exercise, of moving quickly from A to B.

Jaskiewicz (1999) proposed a variety of specific evaluation measures for assessment of the aesthetics, safety, and ease of use of the pedestrian environment. Enclosure better defines the street edge, puts "eyes on the street", and conveys a feeling of narrowness to motorists, thus inducing slower speeds and safer driving (Jaskiewizc, 1999, p. 3). Complexity of path network gives pedestrians more route choices and both building articulation and complexity of spaces adds interest to the walk (Jaskiewicz, 1999, pp. 4-5). Overhangs, awnings, and varied roof lines and shade trees add to the pedestrian sensory experience and well as provide protection against sun and rain. Buffers increase both actual and perceived safety by separating the pedestrian from moving traffic (Jaskiewicz, 1999, p. 6). Transparency provides a "smooth interface" between public and private realms (Jaskiewicz, 1999, p. 7). Physical components/condition elements, such as sidewalk design and condition, street design speed, pedestrian crossing treatments, etc. affect pedestrian safety and comfort (Jaskiewicz, 1999, pp. 7-8).

Southworth (2005) describes several criteria for the successful pedestrian network design for a walkable city: connectivity, linkage to other modes, fine-grained land use patterns, safety (traffic and crime), and path content (p. 246). The term path content comprises street design, visual interest, transparency, spatial definition, landscape, and overall explorability (Southworth, 2005, p. 247). In order to succeed, pedestrian environments must be "well supported by transit and situated within an accessible mix of land uses" (Southworth, 2005, p. 251). Southworth's urban design perspective rightly emphasizes the finer grain attributes of the street and its environs in supporting pedestrian activity. Nevertheless, this perspective does not give enough weight to two crucial elements that foster foot traffic: sufficient moving and gathering space for people and buffers between pedestrians and motor vehicle traffic.

Ewing, Handy, Brownson, and Clemente (2009) attempted to quantify urban design perceptual qualities pertinent to walking on commercial streets. They sampled streetscapes with a visual assessment survey of detailed physical features representing the following urban design qualities found in the literature: imageability, visual enclosure, human scale, transparency, and complexity (Ewing et al., 2009, p. 65). The authors observed that the conceptual framework for their study "considers the role of perceptions as they intervene (or mediate) between the physical features of the environment and walking behavior" (Ewing et al., 2009, p. 67).

These scenes were shown to a panel of ten urban design and urban planning experts whose ratings of the urban design qualities in each were used as dependent variables to estimate statistical models. Various aspects of the physical condition of the street were used as independent variables (Ewing et al., 2009, p. 71). Imageability was defined operationally as "the quality of a place that makes it distinct" (Ewing et al., 2009, p. 73). Enclosure was defined as "the degree to which streets … are visually defined by buildings, walls, trees, and other vertical elements" (Ewing et al., 2009, p. 75). Human scale was "the match between the physical elements of the street and the size and proportion of humans", as well as how these physical elements correspond to human walking speed (Ewing et al., 2009, p. 77). Transparency is defined as "the degree to which people can see or perceive what lies beyond the edge of the street" (Ewing et al, 2009, p. 78). Complexity is the quality of visual richness (Ewing et al., 2009, p. 81). The researchers found correlations of significant physical features to each design quality, as shown in Table 2.

Day, Boarnet, Alfonzo, and Forsyth (2006) developed the Irvine-Minnesota Inventory to Measure Built Environments to assess the land use, design, and traffic environments facing pedestrians. The researchers performed a literature search, convened

Quality	Most significant features
Imageability	Proportion, historic buildings (+)
	Major landscape features (+)
	Outdoor dining (+)
	Courtyards, plazas, parks (+)
Enclosure	Proportion sky across (-)
	Proportion sky ahead (-)
	Proportion street wall, same side (+)
	Proportion street wall, opposite side (+)
Human Scale	Proportion first floor with windows (+)
	Long sight lines (-)
	Urban designer used (+)
Transparency	Proportion first floor with windows (+)
	Proportion street wall, same side (+)
	Proportion active uses (+)
Complexity	Outdoor dining (+)
	Public art (+)

Table 2: Physical Features of Urban Design Qualities

Note: Adapted from "Measuring the Unmeasurable: Urban Design Qualities Related to Walkability," by R. Ewing, S. Handy, R. Brownson, and O. Clemente, 2009, Journal of Urban Design, 14, p. 72. Copyright 2009 by the Taylor & Francis Group.

focus groups, consulted an expert panel, and conducted field tests at 27 sites, mainly in Southern California (Day et al., 2006, p. 147). The Inventory comprises 162 items, grouped in four "domains": accessibility, pleasureability, perceived safety from traffic, and perceived safety from crime (Day et al., 2006, pp. 148-149). Table 3 displays the component variables in each of these domains.

The structure beneath the urban design and other qualities that attract pedestrians is the street network itself. Hillier, Penn, Hanson, Grajewski, and Xu (1993) studied the configuration of the urban street network as a generator of patterns of movement, where retail and other land uses are then located "to take advantage of the opportunities offered by the passing trade" (p. 29). The form of the street grid gives a location advantage to certain spaces, which are then filled by retail and other land uses. The more integrated the street system, the greater the effect. From a space syntax perspective, "it is not the local properties of a space that are important in the main but its configurational relations to the larger system" (Hillier et al., 1993, p. 29). As such, "urban systems configuration is the primary generator of pedestrian movement patterns" (Hillier et al., 1993, p. 31). They assert that "natural movement in a grid is the proportion of urban pedestrian movement determined by the grid itself" (Hillier et al., 1993, p. 32). Shops and other pedestrian attractors serve to multiply the natural movement effects (Hillier et al., 1993, p. 48). The researchers studied the relationship between street grid integration and pedestrian volumes in ten subareas of Kings Cross London and found strong correlations between volumes of moving and stationary adults and degree of integration of the street system (Hillier, et al, 1993, p. 46).

Despite its apparent empirical confirmation in the Kings Cross study, the space syntax explanation for pedestrian activity is far too abstract to apply at the level of an arterial street segment. The variations between streets in land use, streetscape and street front, right-of-way allocation, transport alternatives, access to gathering spaces, availability of vistas, provision for nature, and other influences on the choices to walk and to linger are too great to be accounted for within this framework. In this context, it is prudent to heed the warning of one researcher about "the reductionist tendency for viewing variables in isolation", which does not capture the "synergistic qualities of pedestrian environments" (Lamont, 2001, p. 32).

There has been extensive research in recent years on the correlates of walking. Owen, Humpel, Leslie, Bauman, and Sallis (2004) reviewed 18 cross-sectional studies regarding the "relationships of objectively assessed and perceived environmental attributes" for "exercise and recreational walking, walking to get to and from places, and total walking" (Owen et al., 2004, p. 67). The authors found that perceptions about traffic were associated with both recreational and utilitarian walking (Owen, et al, 2004, p.72). In addition, they found

Domain	Variable
Accessibility	Land use mix
	Density
	Street pattern
	Slope
	Integration of uses
Pleasurability	Aesthetic appeal
	Attractive destinations
Perceived safety from traffic	Beliefs about opportunities for injury
Perceived safety from crime	Beliefs about opportunities for crime victimization

Table 3: Walking Environment Assessment Domains

Note: Adapted from "The Irvine-Minnesota Inventory to Measure Built Environments: Development" by K. Day, M. Boarnet, M. Alfonzo, and A. Forsyth, 2006, American Journal of Preventive Medicine, 30, pp. 146-147. Copyright 2006 by the American College of Preventive Medicine & Association for Prevention Teaching and Research.

that accessibility of destinations, including stores and parks, were associated with walking for particular purposes (Owen et al., 2004, p. 68). Route aesthetic attributes were found to be associated with recreational walking in some studies, but no studies found such an association with utilitarian walking (Owen et al., 2004, p. 72). The researchers called for more reliable measures of these environmental characteristics (Owen et al., 2004, p. 74).

Tables 4, 5, and 6 summarize noteworthy contributions to the literature on correlates of walking. There is considerable evidence in this literature that trip distance, access to destinations, population density, sidewalks, amenities en route, and other physical characteristics of communities and streets are associated with an increased propensity to walk. Many common threads emerge through the extensive review of the literature on determinants of walking.

Author(s)	**Location and findings**
Ham, Mererra, and Lindley (2005)	2001 (US) National Household Travel Survey
	Walking trips accounted for 21.2% of all trips less than one mile in length.
	In urban areas 39.3% of trips one mile or less in length were on foot, compared to 14.0% in rural areas.
Marcus (2008)	2001 (US) National Household Travel Survey
	About 78% of respondents did not walk on their survey day, but for those who did the average walk trip time was 15 minutes.
	There was a comparatively strong correlation between population density and walking.
	Those who lived less than one mile from work walked twice as often as those who lived more than 10 miles from work.
Agrawal and Schiemek (2007)	2001 (US) National Household Travel Survey
	This study found that 40% of walk trips in the US were for shopping, errands, and personal business; 20% were for recreation, 16% for access to or egress from public transport, and 11% for school or work commuting.
	Almost 70% of walk trips were four blocks or less in length.
	Utilitarian, but not recreational, walk trips increased as population density rose.
Kruger, Ham, Berrigan, and Ballard-Barbus (2008)	2005 (US) National Health Survey
	Only 6% of US adults walked for transportation and 9% for recreational purposes for at least 30 minutes five or more days each week.

Table 4: Notable National-Level Research on Walking

Author(s)	Location and findings
Greenwald and Boarnet (2001)	Portland, OR Metropolitan Area
	Amount of walking and:
	Population density (+)
	Trip distance (-)
	Area walkability (+)
	Retail density (+)
Giles-Corti and Donovan (2003)	Perth, Western Australia Metropolitan Area
	There were individual, social, environmental, and physical influences on the amount of walking.
	Those living on a street with a sidewalk or shop on it were 75% morelikely to achieve recommended amounts of walking than those who did not.
	Those who lived on a street with trees and without ma-jor traffic were 50%more likely to achieve recommended amounts of walking than those who did not.
Moudon et al. (2006)	King County (Seattle)
	Amount of walking and:
	Residential population density (+)
	Smaller street blocks (+)
	Proximity to food and daily retail stores (+)
	Proximity to eating and drinking establishments (+)
Forsyth, Hearst, Oakes and Schmitz (2008)	Minneapolis - St. Paul, MN Metropolitan Area
	There was more utilitarian, but less recreational, walking in higher density areas.
	Amount of walking and:
	Sidewalks (+)
	Street lights (+)
	Traffic calming measures (+)
	Connected street patterns (+)
Rodriguez, Aytur, For-syth, Oakes and Clifton (2008)	Minneapolis - St. Paul Metropolitan Area and Montgomery County, MD
	Amount of walking and:
	Population density (+)
	Access to destinations (+)
	Perceived difficulty in retail area parking (+)
	Ease of walking to transit stop, utilitarian walking (-)

Table 5: Notable Metropolitan Area Research on Walking

Author(s)	Location and findings
Lamont (2001)	Oakland, Albany, Berkeley, and Walnut Creek, CA
	Walking frequency was most influenced (inversely) by distance, age, student status, and neighborhood walk-ability.
	There was evidence of residential self-selection for the option of walking, even if individuals did not actually walk more after relocation.
Landis, Vattikuti, Otten-berg, McLeod, and Gut-tenplan (2001)	Pensacola, FL
	Study participants rated street segments.
	Amount of lateral separation from moving motor vehi-cletraffic had the highest positive association with sense ofpedestrian safety and comfort.
	Sense of walking safety and comfort and:
	Motor vehicle volume (-)
	Motor vehicle speed (-)
	# of through motor vehicle lanes (-)
	Width of outside lane (+)
	Width of shoulder or bike lane (+)
	Presence of sidewalk (+)
	Width of sidewalk (+)
	Width of buffer between street and sidewalk (+)
	Trees and other barriers between street and sidewalk (+)
	On-street parking (+)
Craig, Brownson, Cragg, and Dunn (2002)	22 neighborhoods in Quebec, Ontario, and New Bruns-wick
	The neighborhood physical environment was positivel-yassociated with propensity to walk to work.
	This relationship held true even while controlling for edu-cation, income, and degree of urbanization.
Brown, Werner, Am-burgey, and Szalay (2007)	Salt lake City, UT
	Student raters used the Minnesota-Irvine Environmental Audit Instrument.
	The best rated routes had traffic safety, a pleasant social milieu, goodaesthetics, and a diversity of destinations.
Wells and Yang (2008)	Southeastern US (various locations)
	This was a study of pre- and post-move walking of lower income women.
	Respondents walked more in neighborhoods with few or no culs-de-sac.
	Unexpectedly, land use mix was associated with less walking.

Table 6: Notable Local-Level Research on Correlates of Walking

Why bike?

While walking may be the most important non-motorized mode of travel, the higher speed and therefore greater range of bicycling gives it more potential as an alternative to the automobile for many trips. What factors induce people to choose bicycling as a mode of travel? How important is the physical environment to this decision? There is a growing literature on this subject, much of which is applicable to the study of determinants or correlates of cycling on arterial streets.

Landis, Vattikuti, and Brannick (1997) developed a statistically calibrated model to predict the suitability or quality of non-central business district urban collector or arterial streets (excluding central business districts) for cycling (p. 119). The researchers used ratings provided by about 150 cyclists who rode a 27-kilometer course with a variety of street sections in the Tampa, Florida metropolitan area. Statistically significant variables in a linear regression model that explained about three-quarters of the variation in street section ratings given by the study participants included pavement surface condition, motor vehicle speed, and outside lane motor vehicle volume.

Harkey, Reinfurt, Knuiman, Stewart, and Sorton (1998) used ratings of over 200 study participants in Olympia, Washington, Austin, Texas, and Chapel Hill, North Carolina who viewed video clips of street sections to predict cycling comfort level (p. 53). Their statistical model, which included these variables and adjustment factors, explained 83% of the variation in "Bicycle Compatibility Index" scores:

- bicycle lane or paved shoulder present (+);
- width of bicycle lane or shoulder (+);
- width of curb lane (+);
- residential development along roadside (+);
- vehicle volumes (-);
- vehicle speeds (-);
- on-street parking (-);
- curb lane truck volumes (-);
- vehicle right turn volumes (-); and
- parking time limit (+) (Harkey et al, 1998, pp. 53-54).

Macbeth (1999) studied the effect of adding 40 km of bicycle lanes on Toronto streets from 1993 to 1998, often as part of conversion of the street cross-section from two lanes in each direction to one in each direction with a left turn lane at signalized intersections (pp. 38-39). He notes that while motor vehicle traffic volumes are not affected by the installation of bicycle lanes, bicycle usage rises by varying amounts. In the case of Toronto, bicycle volumes rose from 4% to 42%, depending on street section, with an average rise of 24% after installation of bicycle lanes (Macbeth, 1999, p. 39). This study did not attempt to differentiate among street segments by land use, street network characteristics, population density, or other likely influences on bicycling demand.

Krizek (2006) conducted a stated preference survey to model the preferences of cyclists for on-street compared to off-street cycling facilities in Minneapolis-St. Paul. The researcher showed video clips of various bicycle facility types to 167 randomly selected University of Minnesota staff to elicit data for a model that predicted the odds of preferring a given facility type over others assuming equal travel time (Krizek, 2006, p. 312). He found that "the effect of travel time is negative, showing that people prefer shorter trips" (Krizek, 2006, p. 312). For a 20-minute bicycle ride, however, an on-street bicycle lane is worth an extra 16.3 minutes, the absence of on-street parking an additional .9 minutes, and an off-road bicycle path the addition of 5.2 minutes to the trip (Krizek, 2006, p. 313). The odds were also greater that the respondents would choose a more time-consuming route in summer than in winter in order to ride a preferred facility type and that neither income nor sex were significant influences on route decisions (Kirzek, 2006, p. 312). This study is notable for its sophistication in identifying the marginal value in time of the trade-offs by cyclists making route choices based on facility type and season.

Pucher, Dill, and Handy (2010) reviewed 139 studies, both peer reviewed and otherwise, on the effects of various policy interventions on cycling demand. They concluded after review of this literature and evaluating 15 case studies of cities in Europe and the United States, that public policy can be effective in stimulating increases in bicycle use. This happens, however, only when a comprehensive, integrated approach is taken. Elements of such an approach are bicycle infrastructure, education and marketing to encourage bicycle use, land use planning that supports cycling, and automobile use restrictions (Pucher, et al., 2010, p. S122). Additional research on bicycle demand is summarized in Tables 7 and 8. In general, this research has confirmed that the presence of bicycle facilities and constraints on automobile use are both associated with increased bicycle demand. It is also clear from the review of bicycling determinants that there is not always universal consistency or agreement in the results. For example, some of the studies find little or no relationship between bike facilities and the level of cycling use and others find that traffic speed and volume of little consequence. The majority of studies, however, do report clear associations between such factors and cycling propensity. Overall, the literature points to considerable scope in further investigation in this area, especially at the street level.

Author(s)	Location and findings
Nelson and Allen (1997)	18 U.S. cities
	Each additional mile of bikeway provided was associated-with a 0.075% increase in bicycle share of work commuting.
Dill and Carr (2003)	35 U.S. cities
	Bicycle demand and:
	Bicycle lanes per square mile (+)
	Per capita spending on bicycle and pedestrian facilities (+)
	Number of vehicles per household (-)
Krizek and El-Geneidy (2005)	Minneapolis-St. Paul Metropolitan Area
	Neither on-street nor off-street bicycle facilities facilities had a statistically significant association with bicycle commuting.
Moudon et al. (2005)	King County (Seattle area), Washington
	Bicycle demand and:
	Actual nearness to trails (+)
	Perceived access to trails and bicycle (+)
	Traffic speed, traffic volume, number of lanes, topographical conditions, and block size were not significantly associated with likelihood of cycling.
Hunt and Abraham (2007)	Edmonton, Canada
	One minute of cycling in mixed traffic is as onerous as 4.1 minutes in a bike lane or 2.8 minutes on a bike path and the availability of bicycle parking was equivalent to 3.6 minutes of cycling in mixed traffic.
Dill (2009)	Portland, OR Metropolitan Area
	A total of 166 cyclists were fitted with pda devices having GPS tracking capabilities.
	One-half of cycling trips took place on bike paths or bicycle (traffic calming mixed use streets designated as bicycle routes), although only 8% of the combined street and bikeway network were of these facility types.
Winters, Brauer, Setton, and Teschke (2010)	Vancouver, BC Metropolitan Area
	Cycling probability increased with flatter terrain, higher intersection density, fewer highways or arterials, traffic calmed streets, more neighborhood commercial land uses, and higher population density.

Table 7: Notable North American Research on Bicycling Influences

Author(s)	Location and findings
Nankervis (1999)	Melbourne, Australia
	Bicycle demand and:
	Daily temperature (+)
	Daily wind speed (-)
	Daily rainfall (-)
	Rain was most serious deterrent to cycling, followed by cold.
Rietveld and Daniel (2004)	103 Dutch cities
	A fall in bicycle trip time by 10% was associated with a 3.4% rise in bicycle trip demand and a fall in .3 stops per kilometer is associated with a 4.9% increase in bicycle trip demand.
	Bicycle demand and:
	Price of car parking (+)
	Fewer hindrances en route (+)
	Fewer serious accidents (+)
	City size (-)
	Car ownership (-)
	Average slope of bicycle route (-)
Titse, Stroneggger, Janschitz, and Oja (2005)	Graz, Austria
	Bicycle demand and:
	Bicycle lane connectivity (+)
	Steep elevation (-)
	Perceived social support for cycling (+)
	The main barriers to cycling were physical discomfort and impracticality due to clothing or rain.
Wardman, Tight, and Page (2007)	UK (nationwide)
	Universal provision of bicycle lane network would increase bicycle mode share only from 5.8% to 9.0%.
	A £2 daily subsidy would increase the bicycle mode share to 10.9% and a £10 daily subsidy would increase the bicycle mode share to 28.0%.
Owen, N., et al. (2010)	Ghent, Belgium and Adelaide, Australia
	In Ghent, those who lived in more walkable neighborhoods were 2.5 times more like to cycle regularly for transport than those who did not.
	In Adelaide, those who lived in more walkable neighborhoods were 82% more likely to cycle regularly for transport

Table 8: Notable International Research on Bicycling Influences

As in the research on factors that may influence pedestrian demand, none of the studies on likely bicycle use determinants are both comprehensive in nature and focused on the street segment and its environs.

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From Complete Streets to Complete, Green, and Sustainable Streets: A Review of the Green Streets Literature

Christopher Ferrell, John Eells, Joseph Kott, Richard Lee, Frank Arellano and Reyhane Hosseinzade

Preface

A few years ago, I (Dr. Ferrell) was approached by Dr. Joseph Kott, the co-founder of Transportation Choices for Sustainable Communities (TCSC) and asked to join the organization. Two years later, Joe convinced me to become executive director, and at the time, I remember thinking that since he was leading our most prominent research project to-date (still in the proposal stage, at the time) working for the Mineta Transportation Institute and the California Department of Transportation (Caltrans) called "From Complete Streets to Complete, Green, and Sustainable Streets," I could handle the executive director role. A few weeks after the project's kickoff meeting, Joe unexpectedly passed away, leaving the project and TCSC in disarray and his friends and colleagues in a state of shocked grief. Mustering our resolve, the project team determined to fill Joe's shoes and carry on. Nevertheless, the work before us felt daunting, since the project's subject matter (green streets) was Joe's specialty and not ours. After struggling for several months, we were able to pick up the pieces and produce (in my opinion) a credible and useful green streets research literature review for Caltrans. That document was the seed from which this article sprouted and grew, and as with everything having to do with this project and TCSC in general, we would not be here, working together as colleagues and researching green streets, if it were not for Joe's generous, gregarious, and wise friendship. Our thanks also extend to our project clients, Caltrans and the Mineta Transportation Institute at San Jose State University, not only for their monetary support (always important!) but their encouragement for us to carry on after Joe's passing.

Introduction

Cities, counties and other transportation-focused agencies are increasingly looking to sustainable streets to accommodate and balance the transportation needs of increasing populations and their mobility needs (Shapard and Cole 2013). A relatively new concept, sustainable streets include two, more mature components: complete streets and green streets improvements within the public right-of-way (ROW).

According to the California Department of Transportation (Caltrans),

> A complete street is a transportation facility that is planned, designed, operated, and maintained to provide safe mobility for all users, including bicyclists, pedestrians, transit vehicles, truckers, and motorists, appropriate to the function and context of the facility. Every complete street looks different, according to its context, community preferences, the types of road users, and their needs.
> (Source: http://www.dot.ca.gov/trans-planning/ocp/complete-streets.html)

In the United States alone, approximately 25 percent of cities have some type of complete street policy in place (Carlson et al. 2015). Additionally, complete streets offer many benefits to promote physical activity, and make for better and safer drivers, transit users, and pedestrians (Carlson et al. 2015).

Green streets, as defined by the Environmental Protection Agency, are streets that incorporate different kinds of vegetation and permeable surfaces "...to slow, filter, and cleanse storm water run-off from impermeable surfaces" (EPA 2010). Unlike traditional streets, green streets retain runoff at the source rather than discharging runoff off-site (EPA 2018). As this concept has matured, green streets have come to offer other benefits as well, including improving water quality, absorbing carbon, and reducing urban heat island effects (EPA 2018; EPA 2016).

While distinct, the two street concepts (complete streets and green streets) share similarities. Church (2014) remarked that green streets and complete streets share elements that can be integrated with one another, yielding greater environmental and social benefits in the bargain. For example, participants in active transport modes (associated with complete streets) tend to be more aware of green streets infrastructure. In fact, these two categories are complementary and overlapping to such a degree that some have made the case that they should be thought of as part of as a single approach to building a more sustainable transportation system. For example, Sousa and Rosales (2010) state that green streets form part of a set of tools that are a component of complete streets.

This article explores common elements of green street and complete street definitions from the research literature, followed by a more focused review of green street types, and their social and environmental benefits.

Complete, Green and Sustainable Streets: Complementary and Evolving Concepts

This article's literature review effort found many complementary definitions for green and complete streets. Yusuf et al. (2001) defines complete streets as "streetscapes designed for safe and convenient walking, biking, and transit usage by all residents including children, the elderly, and the disabled." Carlson et al.'s (2015) definition states that a complete street "is not a single design but an approach that is safe for all people "regardless of age, ability or mode of transport." Elias (2011) and Kingsbury, Lowry and Dixon (2011) agree that complete street users are pedestrians, cyclists, and transit users. Elias (2011) emphasizes that complete streets shift away from auto-oriented users, while Kingsbury, Lowry, and Dixon (2011) denote that people that use streets as public space for socialization and social activities should also be included. Sousa and Rosales (2010) further refine the complete street concept by emphasizing a contextually complete street as "a multi-modal complete street reflecting the principles of context sensitivity and sustainability [where the] stakeholders and context define what is meant by 'complete.'" Similarly, Kingsbury, Lowry, and Dixon (2011) point out that the definition of complete streets can also vary depending on the street's location: urban versus rural.

Green streets slow, filter and cleanse stormwater runoff at the source while reducing heat island effects and carbon in the air through carbon sequestration. Green streets can incorporate "low impact development" (LIDs) including bioretention areas and bioswales, green roofs, and permeable road surface materials (Dietz 2007; Elkin 2008; Yang and Li 2013). These LID elements are designed to mimic natural hydrology to help filter pollutants out of stormwater runoff, reduce the rate of runoff, and facilitate the infiltration of water into the ground (Sousa and Rosales 2010; Caltrans 2013). Green streets can also include adding trees and other vegetation to remove carbon and other pollutants from the air and reduce stormwater runoff by capturing precipitation in tree canopies and absorbing stormwater pollutants in tree roots (Caltrans 2013).

Similarly, complete streets also share some of the same health benefits as green streets. For example, complete streets have been shown to encourage more active modes of transport such as walking and bicycling (reducing vehicular use) while contributing to a reduction in greenhouse gas (GHG) vehicular emissions (Tumlin 2012). Additionally, complete streets contribute to improving public health by facilitating outdoor physical achieved by making streets safer for children to pursue outdoor physical activities (Tumlin 2012).

Integrating the complementary methods of both complete and green streets may yield additional sustainability benefits to our transportation networks that would not be possible when one or the other approach is used alone (Sousa and Rosales 2010). For example, Church (2014) discusses how integrating green and complete streets elements into existing streets and sidewalks in Portland, Oregon yields sustainability benefits. Caltrans indicates in its Main Streets, California Guide (Caltrans 2013), sustainable streets can be designed to:

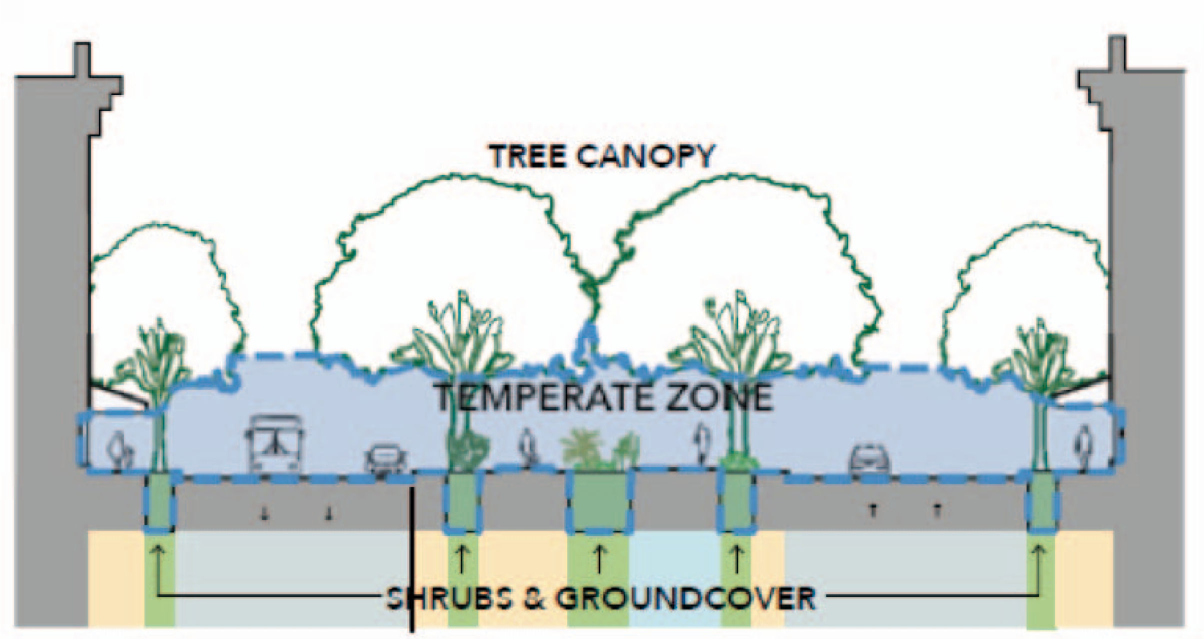

Figure 1: Sustainable Street Conceptual Diagram
Source: Taecker Planning & Design 2019.

- promote alternative travel modes that reduce pollution, greenhouse gas emissions, and fossil fuel consumption
- promote energy efficiency
- minimize detrimental impacts to air, water, and soil quality
- protect natural ecosystems
- conserve natural resources including water, soil and native vegetation
- enhance public health and quality of life.

Therefore, for the purpose of this literature review, combining elements of complete and green streets yields "sustainable streets." Since complete street intervention methods and outcomes are relatively well-known in the transportation planning and engineering professions, this literature review focuses specifically on *green streets*.

Green Streets: Ecological and Social Benefits

Both Yang and Li (2013), and Church (2015) note that green streets provide "sustainable stormwater facilities" that contribute towards a reduction of stormwater runoff by holding and infiltrating stormwater, reducing impacts to existing wastewater systems. Elkin (2008) notes that in addition to reducing stormwater runoff, they also contribute to a reduction in combined sewer overflows (CSO's) and sewer back-ups through a combined reduction in both peak flows and flow volume. The EPA recommends green streets techniques, in part, for their abilities to absorb carbon (sequestration) and reduce urban heat island effects (EPA 2018; EPA 2016). Church (2015) notes social benefits, including, "...access to nature and the opportunity to learn about the storm water management system." Dill et. al (2011) and Carlson et al. (2015) suggest through their research that green streets can contribute towards increased physical activity. Moreover, Takanabe, Nakamura, and Watanabe's (2002) study of urban populations in Tokyo found that walkable green street elements can enhance the longevity of elder citizens due to the quality of the physical environments, the space for taking a stroll, tree lined streets, the number of hours of sunlight at the residence, and less noise from automobiles and factories.

Green Street Types

Elkin (2008) notes that green streets are comprised of a mix of infrastructure treatments to address the unique characteristics of the urban realm. These elements are broken down into the following categories: curb extensions, vegetated planters, street trees, simple green streets, and low impact development (LID) (Elkin 2008). According to Elkin (2008) LID elements include bioretention facilities and permeable road surfaces.

Curb Extensions

Curb extensions are more expensive than Simple Green Streets at $30 per square foot ($344 per square meter) (Elkin 2008). Curb extensions typically are placed adjacent to the existing street curb in the parking lane, and typically feature adjustments for the installation of curb and gutter, narrow streets (to allow for emergency vehicle access), and accommodations for street parking needs (see Figure 2) (Elkin 2008). Curb extensions also provide the added benefit of improving pedestrian crossing conditions by shortening walking distances and improving sightlines (Elkin 2008).

Vegetated Planters

Vegetated planters, while more expensive than curb extensions, better accommodate existing parking demand in urban centers (Elkin 2008). Vegetated planters are fully integrated into the right-of-way through the use of a pedestrian and planter strip, thereby preserving existing street parking spaces (Elkin 2008). San Mateo County's Green Streets Design Guidelines note that planters are best suited for commercial streets (with space limitations); however, they are more expensive than bioswales (see description below) and are deemed appropriate for highly dense urban areas (San Mateo County 2009).

Street Trees

Planting street trees—either in planter strips or free-standing tree boxes—can be a particularly effective green street treatment since they:

- remove pollutants from the air, including carbon dioxide through carbon sequestration,
- reduce stormwater runoff by capturing precipitation in tree canopies and absorbing stormwater pollutants in tree roots (Caltrans 2013),
- reduce the urban heat island effect,
- improve the local economy, and
- improve urban aesthetics (Lukes and Kloss 2008).

While they have been a part of the urban designers' and developers' playbook for generations, street trees are often given little space to grow. Construction soils

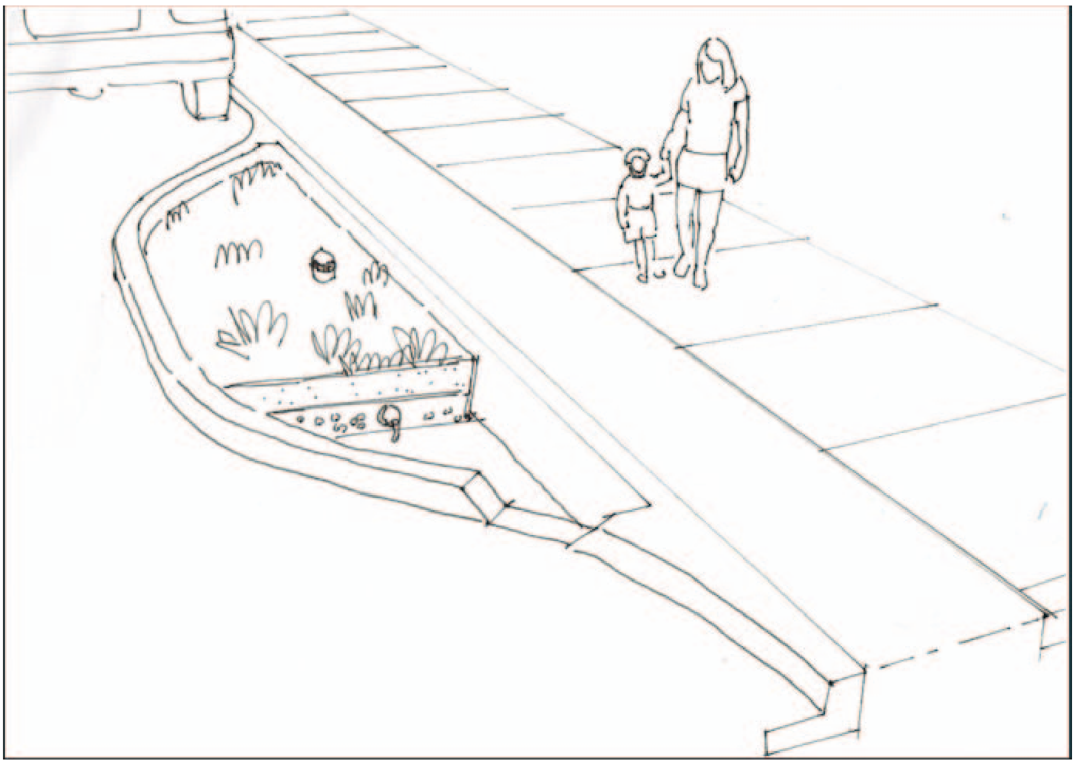

Figure 2: Curb Extension Design
Source: Taecker Planning & Design 2020.

around street trees are typically compacted, providing a barrier to root and tree growth, while undergrounded utilities through street tree planter soils further encroach on root space. In combination, these constraints to growth will lead to stunted trees with declining health and shorter lifespans.

Fortunately, street trees—and their benefits—can flourish by providing adequate soil volume (uncompacted) with a healthy soil mixture with uncovered or permeable surfaces. Green infrastructure advances that can help ensure these favorable conditions include root paths, structural soils, and "silva cells" (Lukes and Kloss 2008).

- *Root Paths:* Connect a small root tree volume area to a larger one nearby, effectively increasing the root growth potential of trees in otherwise limited planter areas.
- *Structural Soils:* Provide adequate tree root volume underneath sidewalks, plazas and other paved surfaces by excavating the root area and filling it with a mix of stone and soils that provides enough void space of healthy root growth and then covering the area with impermeable surfaces.
- *Silva Cells:* Like structural soils, provides adequate tree root volume and structural support for supporting paved and concrete surfaces above by installing "plastic milk crate-like frames" underneath (Lukes and Kloss 2008).

Simple Green Streets

Simple green streets are a low-cost facility designed to be placed within an existing 2.4-meter-wide (or wider) planter strip between curb and sidewalk (see Figure 3). It has a trapezoidal shape, with 4:1 side slopes and a 60-centimeter-wide flat bottom to promote infiltration. At $16 per square foot ($172 per square meter) this design has the advantage of being a low-cost alternative to more invasive curb extensions (see below) using bioswales and rain gardens that often require taking up on-street parking spaces or lanes of traffic (Elkin 2008). Since bike lanes are curb-adjacent, simple green street planters offer the possibility of retrofitting an existing street with both bicycle and green street facilities.

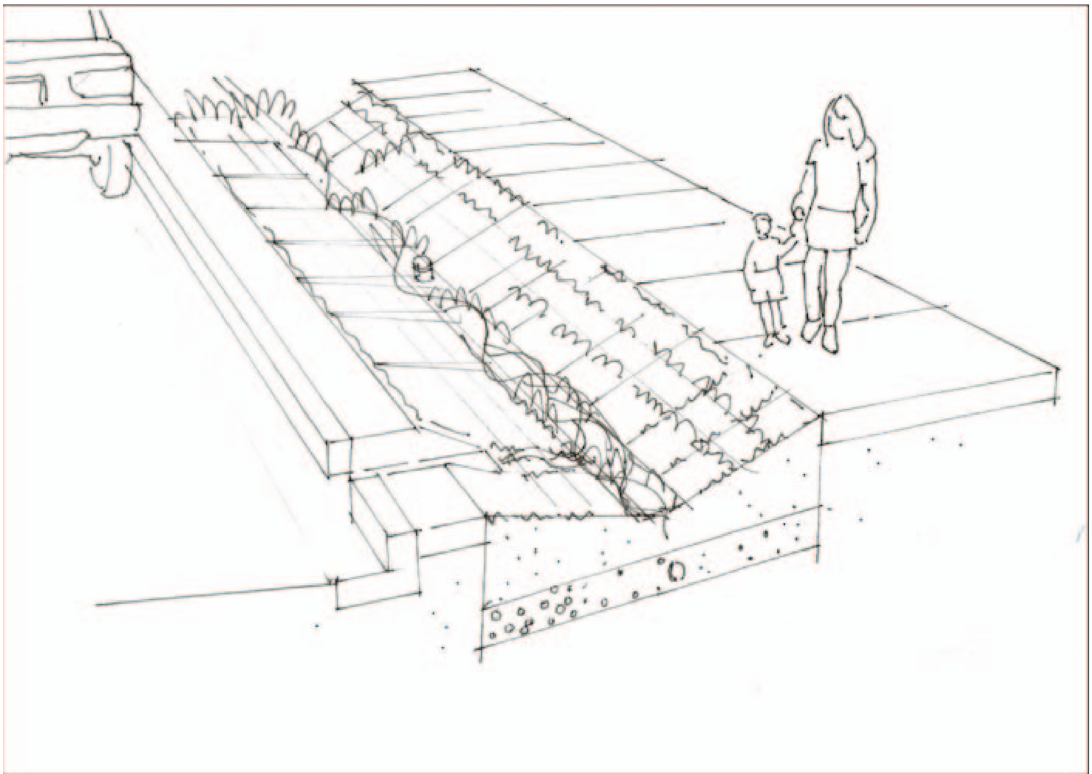

Figure 3: Portland, Oregon's Simple Green Street Design
Source: Taecker Planning & Design 2020 based on Elkin 2008.

Developed by City of Portland, Oregon staff, these inexpensive facilities are placed between the existing curb and sidewalk and can accommodate both ground infiltration along with tree planting. Part of a simple green street design also involves incorporating “check dams” as a way to “slow water and promote infiltration” (Elkin 2008).

Low Impact Development

LID elements include bioretention facilities and permeable road surfaces.

Bioretention Areas (Bioswales and Rain Gardens)

Bioretention areas or rain gardens (also referred to as bioswales) are ground depressions designed to collect stormwater runoff (Dietz 2007). Rain gardens can be used in areas of underutilized spaces in the public right-of-way in both residential or commercial areas (Elkin 2008; Dietz 2007). Ranging in size from roughly 46 to 650 square meters, rain gardens have the added benefit of improving pedestrian and vehicular traffic by shortening pedestrian crossing distances (if part of a curb extension), clarifying vehicular movements, decreasing surface runoff, providing on-site pollutant treatment, and feeding groundwater recharge (Elkin 2008; Dietz 2007). Although serving a similar function to that of rain gardens, bioswales are designed to carry larger quantities of runoff from impervious surfaces; thus, they use engineered soils, a linear design that is longer than it is wide, and a deeper design depth than rain gardens (Soils America). San Mateo Green Streets Design Guidelines note that rain gardens are best suited to residential areas, and left-over spaces created by medians/islands; however, they might prove difficult to install in urban areas where space restrictions may pose more of an issue. Bioswales, on the other hand, are best suited to residential and commercial streets (both on arterials and local streets) and within street medians. However, swales require long continuous spans which can be difficult to find under retrofit conditions. Swales may also prove difficult to integrate with other street elements such as lighting and may impact pedestrian circulation (San Mateo County 2009).

Permeable Road Surfaces

Dietz (2007) evaluated several types of permeable pavement surfaces such as concrete blocks (or grids), asphalt pavement, and concrete pavement. Concrete blocks or grids have voids or spaces to allow for surface run-off to infiltrate into the ground and are typically laid by hand (Dietz 2007). Research on concrete block installations indicate statistically significant reductions ($p<0.01$) in pollutant concentrations of metals (lead, zinc, and copper), total suspended solids (TSS), and total phosphorus (TP). The study also found runoff had completely infiltrated into the ground through permeable pavement surfaces (Dietz 2007). Testing of plastic grids, while relatively new, revealed similar results in terms of runoff reduction at 93 percent, with metal concentrations from run-off being reduced ($p<0.01$). Findings reviewed by Dietz (2007) of prior studies of pervious asphalt revealed that while similar trends in performance reductions of metal concentrations and other pollutants were observed, they did not perform as well as concrete blocks and grids, and plastic grids.

Testing of pollutants in groundwater from pervious concrete installations indicated some improvements to water quality, while run-off retention results revealed pervious concrete captured all run-off during storm events (5 cm or less) (Dietz 2007). San Mateo’s Green Streets Design Guidelines manual notes that permeable pavement is best suited to low-volume streets, reducing the need for other stormwater measures, especially in urban areas (San Mateo County 2009).

Permeable road surfaces can also reduce heat island effects by reflecting more solar radiation and generating more water evaporation and air circulation. These cooling pavements can also minimize the amount of pavement heat that is transferred to water bodies, thereby reducing the damage to aquatic ecosystems (Caltrans 2013).

Green Streets Key Findings and Design Considerations

This review of literature identified potentially important findings and design considerations for green streets performance with respect to vegetated planters, bioretention areas, traffic volumes, aesthetics, soil type, groundwater contamination, maintenance issues, construction costs, demographics and housing premiums.

Vegetated Planters and Code Requirements

Vegetated planters require specific techniques to mitigate the accumulation of debris and sediment (Elkin 2008). To design a new green street, it is necessary to meet the code requirements regarding the street width for emergency service vehicles. A street's design should provide a free flow of oversized vehicle traffic (e.g., a firetruck). The Uniform Fire Code requires that streets have a minimum 6.1 meters of unobstructed width; therefore, a street with parking on both sides would require a width of at least 10.4 meters (Lukes et al. 2008). Adding vegetated planters to existing narrow streets may require costly acquisition of additional right-of-way or taking on-street parking spaces for curb extensions to house them.

Bioretention Areas and Water Pollutants

A study by Davis et al. (2003) notes that bioretention works well at reducing metal concentrations in runoff (greater than 95%) of metals like lead (Pb), copper (Cu), and Zinc (Zn). However, bioretention areas tend to export more total phosphorus (TP) than they restrain posing a problem to downstream water sources; thus, alternative methods should be considered for areas where soils have a high phosphorus content (Dietz 2007). In terms of bacterial contamination, a study by Rusciano and Obrota (2005) found that fecal coliform (FC) concentrations in a bioretention area was reduced by 88 percent compared to pre-construction conditions (Dietz 2007). Additionally, from a temperature regulating perspective, bioretention areas could potentially serve to cool street surfaces (potentially reducing the impact of the Urban Heat Island effect [UHI]). For example, Hunt and Lord's (2006) study found that influent stormwater passing through a bioretention area decreased in temperature between 5 to 10 degrees Fahrenheit (Dietz 2007).

Another concern pertains to how well green infrastructure sites handle groundwater pollutants such as nutrients, petroleum residue, heavy metals, pathogens, and pesticides (Dietz 2007). Results from a study by Pitt et al. (1999) revealed that the risk of contamination is "low to moderate." As noted previously, fecal coliform (FC) may be present in ground water discharged from bioretention areas (Rusciano and Obropta 2005).

Traffic Volumes

Streets with higher traffic volumes tend to attract and collect more sediment in green street facilities compared to traditional streetscape designs (Elkin 2008). When considering "chaining" or connecting green street elements along a street, the first (uphill) facility will accumulate the most sediment; thus, it will require more space for sediment storage than the downstream facilities (Elkin 2008).

Aesthetics

Apostolaki, Jeffries, and Wild (2006) examined community acceptance of stormwater management practices by both the public and professionals in the U.K. and Greece. They identified aesthetics as a major factor swaying public opinion after the installation of these types of facilities. The authors found that the more aesthetically pleasing the resulting facility was, the less the number of concerns the public had and the greater the level of public acceptance it garnered.

Soil Type

Dietz (2007) suggests different soil types have varying effects on the drainage performance of pervious materials. For example, clay soils in bioretention areas tend to lower their water retention effectiveness. However, a study by Dreelin et al. (2006) found that by using a layer of thick, coarse aggregate, it is possible to install high performing bioretention areas at sites with clay soils (35 to 60%) (Dietz 2007).

Maintenance Issues

A review of the literature revealed several concerns over the installation and maintenance of green street elements such as bio-swales (bioretention areas) and culverts, including underperformance in runoff collection, safety, and public concerns about parking availability and litter.

Surface Clogging (Blockages)

Dietz (2007) notes concerns about porous pavements experiencing surface blockages over time and suggests maintenance programs using high-pressure washing or suction removal of debris should be developed to ensure the ongoing performance of stormwater runoff collection and infiltration. However, a study by Haslebach et al. (2006) found that clogging due to sediment (e.g., sand) did not significantly affect the overall performance of pervious surfaces, and they still continued to operate normally (up to 100-year simulated storm event) (Dietz 2007).

Safety and Litter

Apostolaki, Jeffries, and Wild (2006) noted concerns by the public in the U.K. over safety and litter impacts of stormwater management practices. Safety concerns included the potential for children to drown in ponds, and littering (associated with poor maintenance). While over 70 percent of residents expressed concerns over these issues, residents still preferred living near these facilities since they were perceived as less dangerous than living near a heavily trafficked road or next to a river.

Construction Costs

The literature pointed to two key findings concerning market rate construction costs. First, while the addition of complete street elements such as sidewalks and bicycle lanes can increase the overall cost of a project, they only increase the costs minimally when compared to market-rate construction costs (Shapard and Cole 2013). In Sheppard and Cole's study conducted in Charlotte, NC, they found the cost to build a three-lane street to be approximately $3 million per kilometer, while the addition of a bicycle lane and sidewalk could be accomplished for as little as 6.5 percent of the overall project cost. The authors also found this could be reduced by up to two percent (from 6.5% additional cost) through lane width reductions (e.g., reducing lane widths from 3.7 to 3.4 meters). Moreover, the cost of incorporating complete street elements can be mitigated by integrating existing curb and gutter placements (Shapard and Cole, 2013).

Demographics: Age, Gender, Car Ownership, Home Ownership and Income

A 2010 report by Dill et al. looked at incorporating demographics into the evaluation or performance of green streets in Portland, Oregon. The report found that younger, renting residents without cars were statistically more likely to walk more when living near green streets ($p<0.01$). Additionally, younger residents were more likely to have positive or favorable views concerning green streets than those 65 years of age and older. Takano, Nakamura, and Watanabe (2002) also looked at age and found that walkable green spaces positively influenced the longevity of urban senior citizens ($p<0.01$) based on a five-year cohort study.

Housing Premiums

Dill et al. (2011) used hedonic price regression analysis to determine if proximity to green streets (within 152 meters) measurably affects housing prices. This research found that the higher the number of nearby green street features, the higher the housing value.

Conclusions

This review of the literature began with a synthesis of the various green street definitions, while also placing these definitions within the context of similar definitions for complete streets and sustainable streets. In summary, complete streets + green streets = sustainable streets. Sustainable streets can be designed to:

- promote alternative travel modes that reduce pollution, greenhouse gas emissions, and fossil fuel consumption
- promote energy efficiency

- minimize detrimental impacts to air, water, and soil quality
- protect natural ecosystems
- conserve natural resources including water, soil and native vegetation
- enhance public health and quality of life.

In addition, sustainable streets help reduce stormwater runoff by holding and infiltrating stormwater, reducing impacts to existing wastewater systems. And finally, sustainable streets techniques absorb carbon and reduce urban heat island effects.

The review then turned to focus on green streets infrastructure types and their attributes, followed by an overview of the research findings for the benefits and costs of green streets infrastructure. In particular, planting street trees—either in planter strips or free-standing tree boxes—can be a particularly effective green street treatment since they remove pollutants from the air and reduce stormwater runoff. Similarly, simple green streets can be inexpensive facilities placed between the existing curb and sidewalk and can accommodate both ground infiltration along with tree planting. Bioretention areas, including rain gardens and bioswales, serve to collect stormwater runoff from impervious surfaces, thereby reducing the amount of stormwater entering conventional stormwater systems. Finally, permeable roadway surfaces such as concrete blocks have spaces to allow surface runoff to infiltrate into the ground, and thus reduce conventional stormwater volumes, and help filter out pollutants from groundwater.

The benefits and costs review yielded a variety of useful findings and design considerations for green streets infrastructure. These findings included the need to meet minimum street width code requirements for emergency vehicle access when designing a green street facility, the potential and limitations of bioretention facilities to reduce runoff and groundwater pollution, methods to reduce the construction costs of green streets installations, and some of the important maintenance challenges they can incur.

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Global Inspiration for U.S. Transport Innovation

Michelle DeRobertis and Beth Thomas

Preface

This paper was inspired by the abstract that Joseph Kott submitted for the 12th Annual Global Studies Conference, held in Krakow, Poland, in June 2019. The abstract was accepted but Joe's untimely death made it impossible for him to attend. Michelle DeRobertis prepared the presentation for this conference and presented it on June 27, 2019. Her attendance was made possible by Transportation Choices for Sustainable Communities. This paper is based on that Global Studies Conference presentation, providing many of the details that could not be included in a presentation. Needless to say, without Joe's articulation of the premise and his submittal of the abstract to be presented at the conference, this paper would never have been written.

1. Introduction

Americans have received inspiration from abroad for solutions to our pressing urban transport problems for decades. The purpose of this paper is to highlight some of these innovations and give credit to the pioneering cities, both those abroad where the idea was originally developed and those cities here in the USA where the strategy was first adopted. Of these strategies, some may no longer seem innovative as they are now adopted practice if not ubiquitous in the USA. Others, while present in the USA, can still be considered in their "infant" stages, in terms of both number of years since they have been in the USA and in terms of geographic acceptance. This paper also spotlights the role of institutions such as professional journals, public agencies (e.g., U.S. FHWA) and private organizations (e.g., ITE) in disseminating innovative practices to a global audience.

2. Strategies Well-adopted in the USA

The following strategies or designs were at one point in time considered major innovations in urban transportation. Now, in 2019, they have been widely adopted if not become standard practice across the USA. For each strategy, we will discuss its origin, what made it different / innovative, and where and how it first was implemented in the USA.

Bus Rapid Transit

Origin

The first major innovation to improving the utility of busses was the bus-only lane and, in rare cases, the busway, i.e., a bus-only roadway. The bus-only lane is considered the precursor to Bus Rapid Transit (BRT). The innovators and first adopters of bus-only lanes were:

Figure 1: Enclosed BRT station in Curitiba, Brazil.
Photo by Nicola DeRobertis-Theye, 2006

- Bologna, Italy, 1972
- Ottawa, Canada, 1973
- Curitiba, Brazil, 1974
- Pittsburgh, Pennsylvania, USA, 1977

Curitiba, Brazil (Figure1) is acknowledged to be the original developer of what is now called Bus Rapid Transit. In 1992, after having already implemented bus-only lanes, they adapted the operational concepts of light rail transit (LRT) and applied them to bus operations. These features significantly increased the capacity and travel speeds of the busses by: a) decreasing the dwell time (decreasing the time spent by passengers boarding and debarking), and b) increasing the travel speed between stops and stations.

Key Features
According to the Institute for Transportation & Development Policy (ITDP), BRT comprises several key distinctive features that are designed to help it operate as if it were light rail:

- Dedicated busway / bus lanes; this significantly decreases travel time between stops /stations, and increases average travel speeds.
- Reduced number of stops and stations such that station spacing is similar to LRT. This significantly increases average travel speeds.
- Off-board fare collection. With off-board fare collection, it is no longer necessary to pay the driver, eliminating passengers funneling single file onto

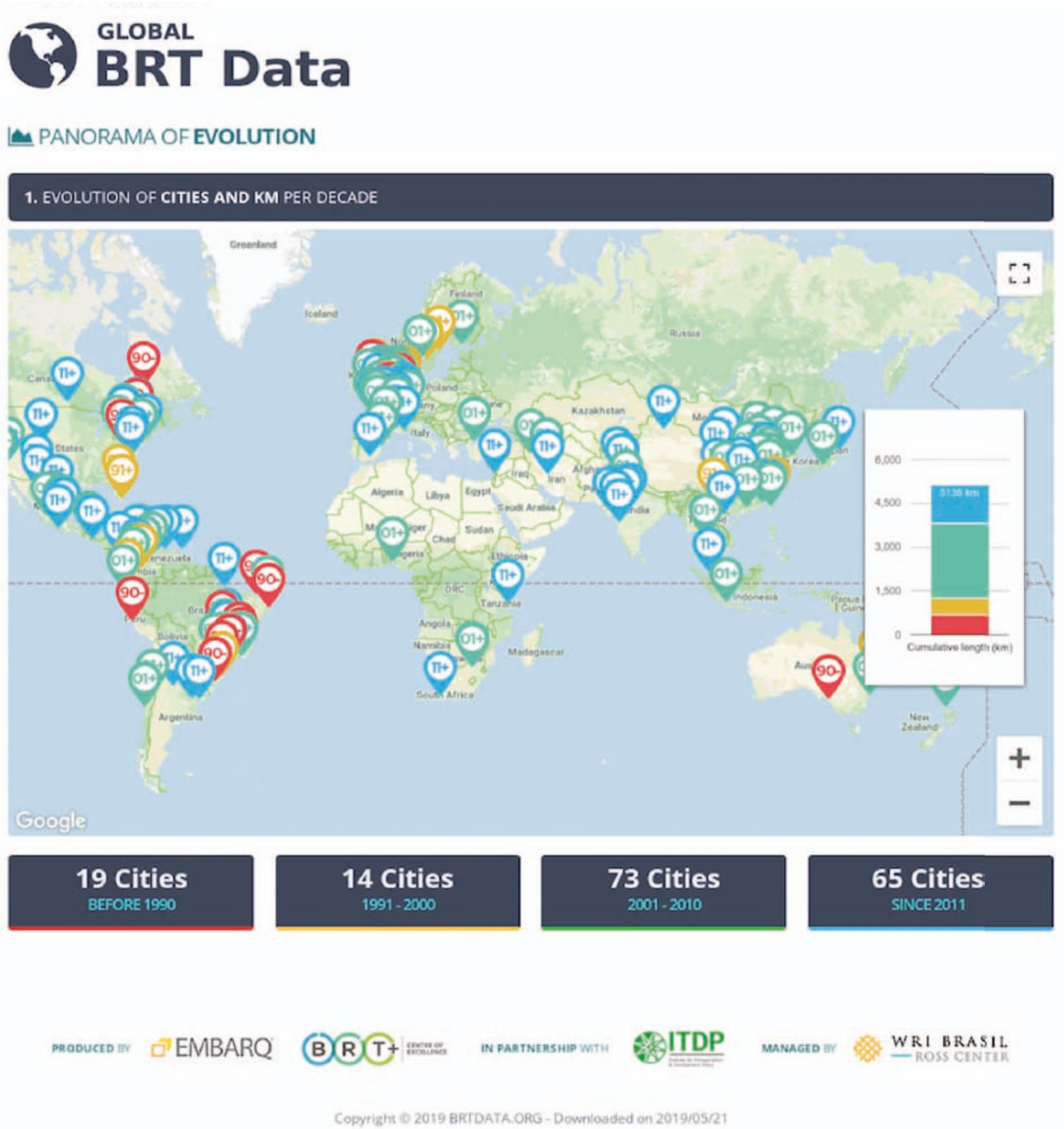

Figure 2: Global spread of BRT.
Source: BRTdata.org

the bus, often scrounging for payment, which significantly delays boarding. Fare enforcement is achieved by proof-of-payment inspectors or constructing enclosed "stations" which can only be entered by having a valid ticket. Typically passengers can both board and deboard by all doors on the BRT bus, just as they would a light rail or heavy rail train.

● Platform level boarding. This reduces the time it takes to board the bus; prior to this, busses often had three or four steps which increased the time it took for passengers to board, particularly for elderly patrons. Boarding wheelchair-bound passengers also took considerable time for the bus to kneel or deploy the wheelchair ramp.

● Intersection priority. This strategy reduces the time it takes for the BRT vehicles to traverse intersections by giving the BRT vehicles signal priority and, in some cases, reducing or eliminating the conflicting turning movements.

● Typically, the busses are redesigned not only to have a special "brand" and "look" but also to account for the possibility of boarding/deboarding by all doors, off-board fare collection, and platform-level boarding; in addition, doors may be provided on both sides of the busses to accommodate both median- and curb-side loading.

Global Spread and USA Introduction/Adoption

The relatively low construction cost of BRT compared to LRT and the significant improvement in quality of service over slow city busses resulted in BRT spreading rapidly across the entire world (Figure 2). As shown in Figure 2, 19 cities had some aspects of BRT before 1990, an additional 14 cities adopted BRT during the 1990s, an additional 73 from 2000 to 2010, and an additional 65 so far this decade.

In the USA, Pittsburgh was well positioned to adopt BRT since it had already implemented bus-only lanes, which were then converted to BRT in the 1990s. Other USA cities that were early adopters of BRT include:

- Las Vegas, Nevada, 2004
- Los angeles, California, 2005
- Eugene, Oregon, 2007
- Cleveland, Ohio, 2008

According to BRTdata.org, BRT is now operating in 13 American cities and there are a total of 26 current or planned BRT systems in the USA.

Figure 3: "Health Line" BRT on Euclid Street, Cleveland, Ohio.
Photo by Michelle DeRobertis, 2019

Roundabouts

Origin

While the traffic circle had been in use for decades, if not over a century, credit for inventing the modern roundabout is attributed to Frank Blackmore of the UK's Transport Research Laboratory. According to his obituary in The Times, London, June 14, 2008, during the 1960s, Mr. Blackmore experimented with various designs and affiliated policies and through an iterative process, he developed the elements of the modern roundabout. The first major change was the concept of yield on entry which became mandatory in the United Kingdom for all new roundabouts in November 1966. The first new modern roundabout was built in 1969 in Peterborough, UK. The roundabout specifications

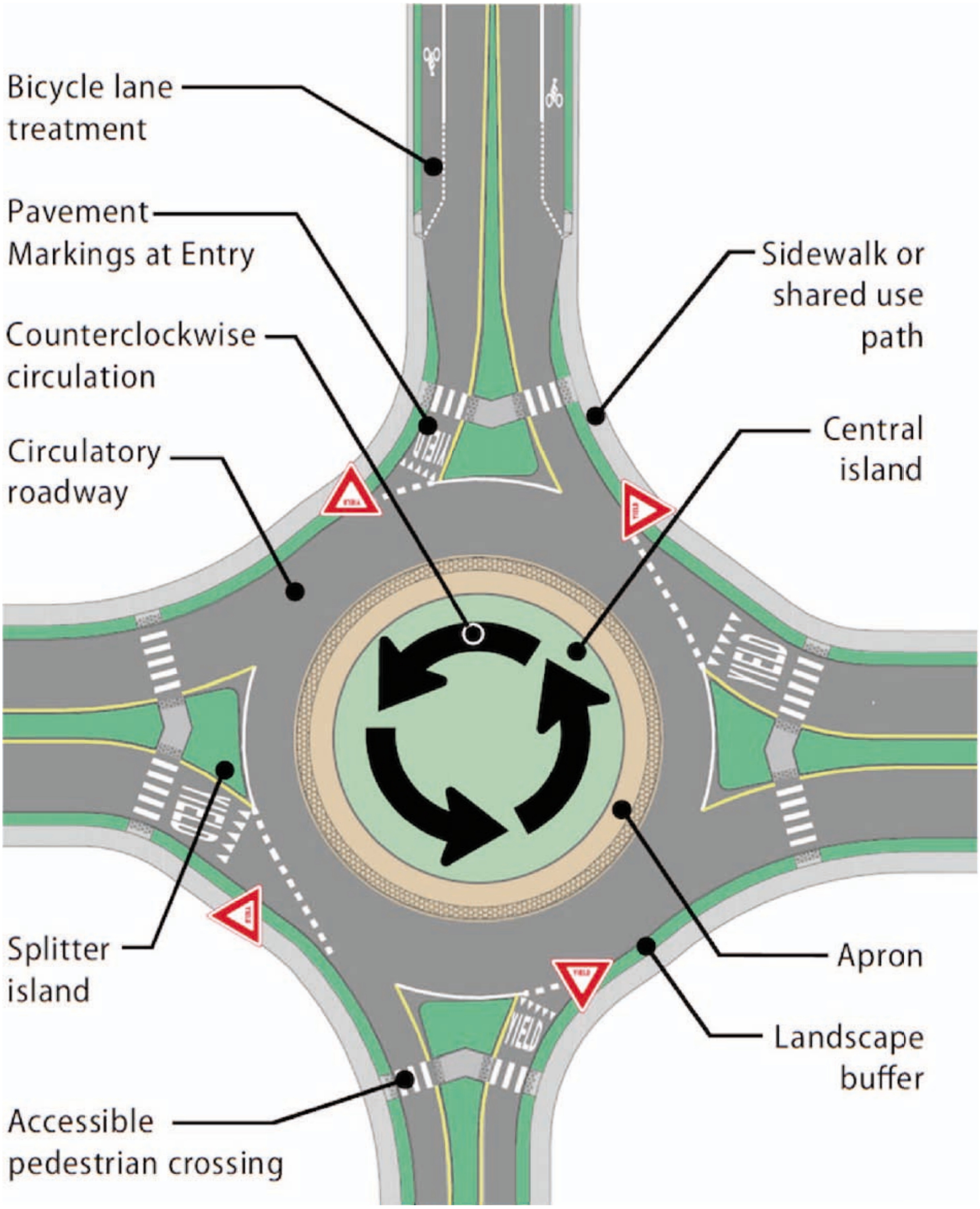

Figure 4: Modern Roundabout.
Image Source: U.S. FHWA, accessed at https://safety.fhwa.dot.gov/intersection/innovative/roundabouts/images/image001-lgr.png

were introduced into UK design manuals in 1975.

Key Features

1. Yield on entry to the roundabout. (With traffic circles, standard practice had been that vehicles could enter the circular roadway at will, thus jamming both the traffic circle and the approaches to the intersection.)
2. Much smaller diameter than the previous large traffic circles, as small as 2 m. (7 feet).
3. Use of paint to have a mountable ring so that large vehicles could also navigate the smaller roundabouts. (Modern roundabouts typically have a mountable "apron" to enable large trucks to traverse the roundabout.)
4. Splitter Island: Deflection and curvature in the approach to the roundabout which forces approaching vehicles to slow prior to entering and travelling through the roundabout, generally 25-40 kph (15-25 mph).

These features, illustrated in Figure 4, not only reduce delay and congestion, they significantly reduce traffic collisions, particularly fatal and serious injury crashes, compared to all-way stop and traffic signal control intersections. Thus roundabouts dramatically improve intersection safety, as documented by U.S. FHWA and others.

Global Spread and USA Introduction/ Adoption

France was an early adopter of the modern roundabout beginning in the 1970s. By 2010, France had more than 30,000 roundabouts. Melbourne, Australia also was an early adopter, implementing their first roundabout in 1978. This can be contrasted with Italy whose first modern roundabout was implemented in 1989 in Lecco.

The first modern roundabouts in the USA were completed in 1991 in Summerlin, Nevada and Gainesville, Florida. The U.S. Federal Highway Administration (U.S. FHWA) published guidance for developing roundabouts in March 2000 and they are now considered a proven safety countermeasure. Today the USA has roundabouts in every state, but some communities have embraced them more fervently than others. U.S. FHWA has continued to promote them and in 2015, published a seven-volume series "Accelerating Roundabout Implementation in the United States". Many American state departments of transportation have published their own roundabout guidelines as well.

Traffic Calming and Speed Humps

Origin - Traffic Calming

The intrusion of cars into primarily residential streets was articulated as a problem as early as 1963 by Colin Buchanan in Traffic in Towns: A Study of the Long Term Problems of Traffic in Urban Areas. The report stated that there was a need for two distinct kinds of areas or streets: one for the movement of through-traffic, and "environmental areas" where people live and work and thus where through-traffic should be discouraged or prohibited.

Simultaneously across the Atlantic, cities such as Berkeley, California and St. Louis, Missouri were attempting to manage the intrusion of cars in residential areas through barriers and diverters. As described by Sinemus (1979), Berkeley implemented its first set of barriers and diverters in 1965. Subsequently, in 1972, the City of Berkeley commissioned DeLeuw Cather & Company to do an extensive traffic engineering study to analyze whether and how to expand diverters citywide. The expansion of diverters and barriers was implemented in 1975.

Origin - Speed Humps

While barriers and diverters addressed the volume of traffic on city streets, there was a concern on both sides of the Atlantic about the speed of the traffic, particularly in residential areas. To address this issue, the UK's Transport and Road Research Laboratory (TRRL) researched other methods to control traffic in residential areas during the 1970s. Watts (1973) states that, after much experimentation with a variety of geometries, TRRL invented the speed hump—a 3.6 m (12-foot) elongated version of the speed bump. Several sources agree that speed humps were then installed experimentally in several communities in Britain as well as Toronto in the late 1970s (Appleyard, 1981, 299-300; Smith et al, 1980; and Sumner et al, 1978).

Key Features

- Physical change in the surface of the roadway causing vehicles to make a vertical deflection.
- No restrictions on the volume of traffic: drivers are free to make a choice to use road with speed humps or use other routes (if available).
- In U.S. practice, it is accompanied by a warning sign which advises 15 mph (25 kph) speed when crossing the speed hump (U.S. FHWA, Manual of Uniform Traffic Control Devices, Section 2C.29).

Global Spread and USA Introduction/ Adoption

As stated above, Toronto was one of the early communities to implement speed humps experimentally. By 1986, several locations in Australia had also implemented speed humps (ITE, 1986).

In the USA, the U.S. FHWA (1980) report State of the Art: Residential Traffic Management mentions speed humps but does not mention any USA implementations. In fact, they were so new that they were referred to as "undulations" to differentiate them from the more common, at the time, speed bump. A 1983 California Traffic Control Devices Committee (CTCDC) report stated that other names used for the device in these early days included sleeping policemen, road bump, road hump, speed bump, speed hump, type II bump, and class 12 speed bump (p. iii). The characteristics of undulations were discussed alongside those of old speed bumps, although differences between the two designs were made clear. According to the CTCDC report, all installations of the speed hump to-date, including in the UK, were experimental even though the UK TRRL had by that time developed guidelines for their physical dimensions and application.

According to an article in The Herald of Everett, Washington, USA, the first speed hump in the USA was implemented in St. Louis in 1979; the CTCDC report cites the City of Brea, California, as also having implemented a speed hump in 1979. The cities of Sacramento and San Jose, California were conducting experiments with various designs in 1979. Another of the early adopters in the USA was Thousand Oaks, California, which installed speed humps in September 1981 as a response to a request to reduce speeds on residential streets (Clement, 1983). According to the CTCDC report, in October 1981, four cities in California had speed humps: Brea, Sacramento, Santa Rosa and Thousand Oaks; by October 1982, 12 jurisdictions in California were using speed humps; and by July 1983, another 25 were interested in using them.

Due to their increased use and lack of official policy for their use, in April 1981, the State of California Traffic Control Devices Committee commissioned a research committee to "develop criteria for the use of these devices and provisions for their installation" (CTCDC, 1983). In October 1981, the research committee submitted its recommendations, which were primarily based on the experiences of Brea and Sacramento. There continued to be confusion about speed humps, so in December 1981, the CTCDC sent a survey to approximately 200 California agencies to ask about their experience with them as well as agency concerns about liability and safety. Of the 50 survey respondents, 23 remained strongly opposed to using them; therefore the Subcommittee on Pavement Undulations was reestablished to evaluate the various installations of speed humps and to "evaluate the liability associated with these devices and to prepare recommendations" for their use and application. The subcommittee concluded that speed humps are appropriate for use on public streets and provided recommendations as to their use, shape and positioning on the roadway (CTCDC, 1983).

By 1986, a survey of USA cities conducted by an Institute of Transportation Engineers (ITE) Technical Council revealed that 43 of 407 (10%) responding agencies had implemented speed humps and only 30% would consider using them. Nevertheless they increased in acceptability, and in 1993, ITE issued guidelines for both the design and application of speed humps. McCourt (1997) reported that a survey of 120 agencies revealed that 45 (38%) had installed speed humps and furthermore that they were the single most common traffic calming strategy used in neighborhood traffic management programs. Thus, in less than 20 years, from the end of the 1970s to the end of the 1990s, speed humps had gone from non-existent to experimental to spotty acceptance to virtually ubiquitous across both the USA and Europe.

Bike Lanes

Origin
Some of the first cycle (bike) lanes were developed in Esplanaden, Denmark in 1892. With the passage of Denmark's first Traffic Law in 1923, bicycle riders were formally allowed to use the striped shoulder of county roadways. The Traffic Law was revised in 1932 to make use of dedicated cycling infrastructure mandatory for cyclists where it existed. By the end of the 1930s, reliance on striped shoulders alone for cycling infrastructure had fallen out of favor, with the Danish Road Laboratory's Road Committee publishing standards in 1938 and 1940 concerning the circumstances under which striped cycle lanes versus physically separated cycle tracks (such as using a curb for separation) were appropriate, based in part on the traffic volume and number of cyclists per hour (Schønberg, 2009).

In The Netherlands, the first bicycle facility was a path constructed in Utrecht in 1885. Construction of additional bicycle paths and lanes followed to provide a place for people to cycle for recreational and utilitarian purposes without being disturbed by horses or pedestrians. But these facilities were not designed consistently, well connected, or even always necessary as bicyclists far outnumbered drivers of automobiles (Bicycle Dutch video, in City Clock Magazine, 2014). As the automobile gained in prominence in the 1950s and 1960s, cycling declined and the development of biking infrastructure did not keep up with roadway construction for serving cars and trucks (Carlton, 2012). As the number of cars in The Netherlands increased into the millions, the number of people riding bicycles who were struck and killed by drivers, including many children, increased dramatically, peaking at over 500 children per year killed while bicycling.

In response to the Dutch safety crisis, parents organized a campaign in 1972, aided by the oil shortage of 1973-74, called "Stop de kindermoord", which translates as "Stop the child murder" (Wagenbuur, 2013). This movement was preceded, but supported in principle, by national guidelines published in 1970 that called for separating modes of travel based on travel speed, required braking distance, vehicle maneuverability and visibility on the road. These principles of separation were further developed in national guidance for designing cycling infrastructure published in 1993 and titled "Tekenen voor de fiets", translated into English as "Sign up for the bike", which discussed the needs of cyclists and approaches for minimizing cycling stress. In 2006, the manual was updated as the CROW ""Ontwerpwijzer Fietsverkeer", translated into English as the "Design Manual for Bicycle Traffic", and incorporating many more design drawings (Tiemens, 2015). The 2006 manual and its 2017 edition include principles for separation of bicyclists from motor traffic based on speed and number of lanes, with on-road bicycle lanes adjacent to motor traffic deemed appropriate where the motor traffic speed is less than or equal to 30 kilometers per hour (about 20 mph) (U.S. FHWA). Bicycle lanes, along with cycle tracks and bike paths, have been developed throughout the Netherlands based on these general principles of separation and were often designed to provide a more direct route into the historic centers of towns and cities than the roadways for cars, which have been deprioritized for this access over the years since the late 1970s.

Key Features

- Dedicated on-street space for bicyclists to use, typically situated between a general-purpose lane (mixed traffic lane used by autos) and the curb.
- Bike lanes are typically separated from the adjacent motor traffic lane by a solid line, which, in the USA, is dashed where motor traffic merges into the bike lane to prepare to turn at an approaching intersection or where motor traffic crosses the bike lane to turn into a commercial driveway.
- Bike lanes typically have a bicycle symbol as a pavement legend to indicate their purpose.
- Bike lanes may have a colored surface for clearer delineation and greater visibility. They are typically colored blue

through intersections in Denmark and brick red in The Netherlands. Green is the designated color for bike lanes in the USA, but the use of color is optional and not employed in most locations.

Global Spread and USA Introduction/ Adoption

Bike lane development has spread to other European countries, Asia, Australia, South America, Canada, and the USA. The first bike lanes in Japan were installed beginning with the Road Traffic Act of 1971 (Japan Ministry of Land, Infrastructure, Transport and Tourism, undated). The first on-street bike lanes in Toronto, Canada, were installed in 1979 (Sharma, 2016). Bike lanes were developed more slowly in Australia, with the first one in Melbourne not being installed until the 1990s.

The first city in the USA to develop bike lanes along streets was Davis, California. As a small, topographically flat city with a compact central business district, Davis had more bicycling than neighboring cities even before the campus was greatly expanded in the 1960s in accordance with a master plan that called for a network of bike paths without motor vehicle access to the campus core. The Dutch influence on the City came by way of a UC Davis economics professor, Frank Child, and his wife, Eve, who had enjoyed bicycling regularly in The Netherlands while there on sabbatical. They and other residents formed the Citizens' Bicycle Study Group, which organized and petitioned in 1964 and 1965 to try to get the City to retrofit off-campus streets with bike lanes (Buehler and Handy, 2008). By 1966, the group had become influential enough to help get two bicycling-supportive candidates elected to the City Council. This tipped the balance of the Council to the point where the first bicycle lanes were approved in mid-1967. Around that time, a bill granting California cities the right to install bike lanes was passed (City of Davis).

The first on-street bike lane in Davis, and the first official one in the USA for that matter, was opened in July 1967 on 8th Street between Sycamore Lane and A Street. The creation of other bike lanes in Davis soon followed in the fall of 1967. One of these bike lanes, on Sycamore Lane between Russell Boulevard and West 8th Street, was placed between the parking lane and the curb, with concrete wheel stops used to keep drivers from parking in the bike lane. It was deemed a failure out of concern that bicyclists were not as visible to drivers turning at intersections compared to their visibility within bike lanes placed between the parking lane and the motor traffic lane. The Sycamore bike lane was converted to the latter configuration (City of Davis, 2019). Over the years, Davis greatly expanded its network both of off-street bike paths and on-street bike lanes. Due to this connectedness and the university presence, bicycling enjoys a high share of trips in Davis.

Other cities throughout California and the USA developed on-street bike lanes based on design standards developed in Davis, but with usually much more modest success in attracting bicyclists due to spread-out development, high motor traffic speeds in the lane adjacent to the bike lane, and a lack of civic commitment to developing a connected biking network. The model for bike lanes set by Davis, and subsequently codified into California law and set in State design standards and national design guidance, which unlike the Dutch and Danish models did not allow for physical protection of bike lanes from adjacent motor traffic even where motor speeds were high, may have actually delayed the USA in adopting bicycling in greater numbers. The development of physically protected bike lanes, also called cycle tracks, and their late adoption in the USA is described in the next section.

Cycle Tracks

Origin

The larger towns in Denmark began developing curb-separated cycle lanes, also called "cycle tracks," along local streets beginning in the 1920s. As described above on the origins of bike lanes, the Danish Road Laboratory published standards by the end of the 1930s concerning the circumstances under which physically separated cycle tracks were appropriate, as opposed to using only a painted stripe to separate cycle lanes from motor traffic. The tipping point was determined to be 100 bicycles per hour or 100 vehicles per hour on a given road segment. The results of the studies on cyclists' needs for separation from traffic were published in "Views on the Implementation of Bicycle Lanes, Bicycle Stripes and Pedestrian Paths" in 1938 and "Bicycle Lane Fixtures" in 1944 (Copenhagenize.com). The expansion of cycle tracks and bike paths outside the larger cities and on county roads followed suit.

In The Netherlands, cycle tracks and bike paths were developed within and between towns in the 1880s through the 1930s, but were not always well connected or designed consistently (Bicycle Dutch video, in City Clock Magazine, 2014). The above-described "Stop de Kindermoord" movement in The Netherlands combined with the 1973 oil crisis led Dutch planners to develop a network of cycle tracks within cities and towns throughout the country starting in the latter half of the 1970s (The Guardian, 2018). These were typically separated from motor traffic by a raised curb and colored brick red for visibility. Like in Denmark, principles for separation of bicyclists from motor traffic were developed based on cyclists' comfort, with motor traffic speed and number of lanes being considered the determinants of that comfort.

Key Features

- Dedicated on-street space for bicyclists to use, typically situated between a general-purpose lane (mixed traffic lane used by autos) and the curb.
- Cycle tracks are separated from the adjacent motor traffic lane by a vertical element.
  - > In Denmark, cycle tracks are usually at a raised elevation compared to the rest of the street, typically at an elevation intermediate between that of the street and that of the sidewalk;
  - > In The Netherlands, a raised curb is typically placed between a street-level cycle track and the adjacent motor traffic lane;
  - > Cycle tracks in Vancouver, Canada, and Seattle, Washington, USA have been protected from motor traffic through the use of planter boxes placed between the cycle track and the rest of the street;
  - > Cycle tracks in the USA are commonly protected from motor traffic by placing the parking lane between the cycle track and the rest of the street.
- Cycle tracks may be colored for extra delineation and visibility, along their entire course or only at locations of conflict with motor vehicles, such as where cycle tracks cross intersections and driveways.
  - > Cycle tracks in Denmark are typically colored blue through intersections;
  - > Cycle tracks in The Netherlands typically have a brick red color.
- Cycle tracks may be raised where they cross driveways and minor intersecting streets in order to slow motor vehicles as they cross the cycle track and emphasize the priority of the cyclists.
- At intersections, cycle tracks in The Netherlands are typically designed with raised corner islands to provide a designated place for cyclists to wait at a signal while positioned ahead and to the right of drivers waiting to turn right, in order to maximize visibility.
- Bicycle signals are commonly used in The Netherlands and Denmark in conjunction with, but separate from, pedestrian signals in order to direct the cyclists' movements; a common Danish and Dutch application is to separate the cyclist through-movement phase from the parallel right-turning vehicle phase.

Global Spread and USA Introduction/Adoption

Germany had a similar history to Denmark in terms of development of cycle paths through the 1930s and decline after World War II. Germany, however, has not kept pace with The Netherlands and Denmark in developing cycle tracks since the cycling infrastructure resurgence in those countries that started in the 1970s. The development of cycle tracks has also spread gradually over the last forty years to cities in other European countries, East Asia, South America, Australia, and Canada. Wide cycle tracks were, however, developed rapidly in Beijing, China, beginning in 1965 as a way to provide mass transportation at low government cost using the already very wide main roads (Lusk, 2012). Notably, Bogota, Colombia, became a leader among South American cities when, in 1999 under the leadership of Mayor Enrique Peñalosa, the City began building a network of cycle tracks and bike paths (Hidalgo, 2016). In the North American context, Montreal was an early adopter and, in 1985, the first city in North America to build a permanent cycle track (Bruntlett, 2014). Such infrastructure spread slowly to other Canadian cities, with Vancouver and Toronto not constructing their first ones until 2009 and 2013, respectively (BC Climate Action; CBS News, 2013).

The adoption of cycle tracks in the USA similarly progressed very slowly. More commonly known in the USA as protected or separated bike lanes, the first cycle track in the USA inspired by European cycle tracks was installed on Sycamore Lane in Davis, California in the late 1960s as a result of advocacy by UC Davis economics professor, Frank Child, and his wife, Eve, who had enjoyed using cycle tracks in The Netherlands while there on sabbatical. As described in the previous section on bike lanes, the Sycamore cycle track was protected from moving motor traffic by placing the parking lane between the traffic lane and the bikeway, and was bordered by concrete wheel stops to keep drivers from parking in the bikeway. The facility, however, was not well designed for handling conflicts with motor vehicles at intersections and driveways. For example, where the wheel stops ended at the approach to the intersection with Russell Boulevard, no pavement markings were employed to indicate to drivers the continuation of the bike lane to and through the intersection. Drivers were allowed to park all the way up to driveway entrances, blocking views of the cycle track for auto drivers trying to turn into a driveway. The Sycamore cycle track was deemed a failure and was converted to a bike lane on the outside of the parking lane, immediately adjacent to the motor traffic lane, the layout that became the conventional bike lane design in the USA (City of Davis).

The movement that led the way forward in adopting cycle tracks in the USA picked up momentum on the opposite coast. But before that, New York City had a false start with cycle tracks in 1980 when a barrier-protected bike lane was installed on 6th Avenue between Greenwich Village and Central Park. It was removed a few months later due to opposition from motorists over losing street space, combined with poor planning for litter removal and for prevention of incursion by street vendors and pedestrians (Cripps, 2015). After years of public advocacy for safer bikeways, however, in 2007 New York City, under the administration of Mayor Michael Bloomberg, installed its first cycle track, or separated bike lane, as a pilot project on 9th Avenue through Times Square intended not only to provide a safer place to bike, but to reclaim motor traffic space for use by people outside cars. The success of this project led the administration to develop subsequent cycle track projects, with design adjustments made to address operational problems, rather than outright removal of cycle tracks as had previously occurred in New York and other cities (Vega-Barachowitz, 2011).

In frustration with AASHTO over the limitations of its street design guidance, New York and other cities founded the National Association of City Transportation Officials (NACTO) in 1996. This organization became the vehicle for developing new national design guidance for bikeways, including cycle tracks / protected bikeways, through the release of the NACTO Urban Bikeway Design Guide. AASHTO is currently in the process of revising its bicycle facility guidance. In the meantime, in 2015 the U.S. FHWA and the State of California each issued design guidelines for separated bike lanes. In the years since the 9th Avenue protected bikeway and the first publication of the NACTO Urban Bikeway Design Guide, cycle tracks have been developed in many cities and towns across the USA and many more are in the planning and design stages.

3. Strategies Not Adopted Widely in the USA but Emerging

Woonerfs

Origin
In the late 1960s and early 1970s, cities in The Netherlands were having the same concerns as the UK and USA over traffic intrusion into residential neighborhoods. In particular, residents of many cities were becoming concerned about the growing trend of automobile crashes even on residential streets. The fact that children could no longer play safely outside even on resi-

dential streets was met with alarm; it was recognized that, being children, they could not dependably be told to just stay on the sidewalk. Safety concerns also extended to adults on sidewalks, since many adults also felt unsafe walking, even on residential streets.

In response, the woonerf evolved in the early 1970s over several years of experimentation by various communities. This was a new approach to dealing with traffic on residential streets which used both legal and physical changes to discourage but not prevent through-traffic from using certain streets. The national legislation establishing the woonerf was introduced in September 1976 (ANWB, 1980).

Key Features

The overarching goal of the woonerf is to be a place where the residential function clearly predominates; there may be other uses on the street, (churches, schools, even shops), but the area's residential function always prevails (ANWB, 1980). The key innovative features, established by national law, are:

- Changes the behavior of motor vehicles while in a woonerf.
  - First, pedestrian and children have equal or greater rights to the street space than traffic: pedestrians may use the full width of the road; there are no sidewalks.
  - Children may play in the street, although separate play areas where cars cannot access are also encouraged.
  - Cars are to drive no faster than a walking pace.
- Minimum design and furniture requirements help ensure the following.
  - A woonerf street is clearly distinguishable from a normal one.
  - Motorists modify their behavior in conformance with the new regulation.
  - Pedestrians are free to walk anywhere, as typically there are no sidewalks.

The Dutch Ministry emphasizes that the street redesign and the new regulations go hand in hand: the main purpose of the redesign and new laws is to make it difficult (as well as illegal) to drive quickly through the streets. This: a) dramatically reduces the amount of cut-through traffic, as there is no time advantage to doing so; and b) creates a safer environment more amenable to social activities than before.

Global Spread and USA Introduction/Adoption

Figure 5: Typical Woonerf sign used in many European countries

Many European countries soon followed the Dutch example and adopted the concept of residential precincts or streets with pedestrian priority, including Denmark in 1978, Austria in 1983, and Switzerland in 1984 (Schlabbach, 1997). One of the first was the state of Nordrhein-Westfalen, Germany, which established the concept in March 1977, and then the country of Germany adopted the concept of "Traffic Restraint Precincts" in 1980 (Schlabbach, 1997). Britain adopted a policy for "Home Zones". The standardized sign used in these and other countries is depicted in Figure 5.

In the USA, the concept of the woonerf—pedestrian priority residential streets—has been much slower to spread. While the woonerf has been described in many USA publications for decades[1], and indeed a few examples of woonerven appear to have been constructed in the USA[2], they have not been adopted or mainstreamed as they have been in Western Europe. Moreover, even though a few may have

1. These include two ITE publications, Traffic Safety Toolbox, Chapter 19 Designing for Pedestrians,1993 (ITE Publ. No. LP-279) and Residential Street Design and Traffic Control, 1989 (ISBN 0-13-775008-0).
2. The only USA case study appearing in a search of ITE publications for the keyword "woonerf" is from Boulder, Colorado in 1985: "The American Woonerf, Boulder's Experience". By Steven R. Jepsen, ITE Compendium of Technical Papers. 55th Annual Meeting, New Orleans,1985, 102-107.

been implemented, it is not known if any states have amended their vehicle codes to allow for the full impact of the strategy as did the Dutch, i.e., the concept of pedestrians having priority anywhere within the public street including children playing. The authors would encourage any USA or Canadian localities to share their knowledge and experience of case studies of implementing woonerfs, including any legal changes and physical design guidance.

Pedestrian-Only Streets

Origin
In some cities, certain neighborhoods have never allowed motorized vehicles and thus have always been pedestrian-only. While the reasons vary, including topographical constraints and the use of stairs (for example, parts of Perugia and Genova, Italy), or aquatic reasons (Venice), in other cities it is primarily due to the fact that their streets, and the buildings they provide access to, date back to medieval times and are extremely narrow, e.g. 2 to 4 meters (6.5 to 13 feet) from building-face to building-face, with buildings that are five or six stories high. Thus the use of cars is/was extremely difficult if not impossible. A classic example of such a pedestrian area is the Old City of Dubrovnik, Croatia. There are even isolated examples in the USA of historically pedestrian-only towns or large areas; the most true example is Mackinac Island in Michigan, where besides pedestrians, only horses and buggies are permitted; motorized vehicles were banned in 1898, almost as soon as they were invented.

While undoubtedly other motorized car bans were implemented in the early 20th century here and there across the world, the beginning of the second wave of car-free zones may have been in post-World

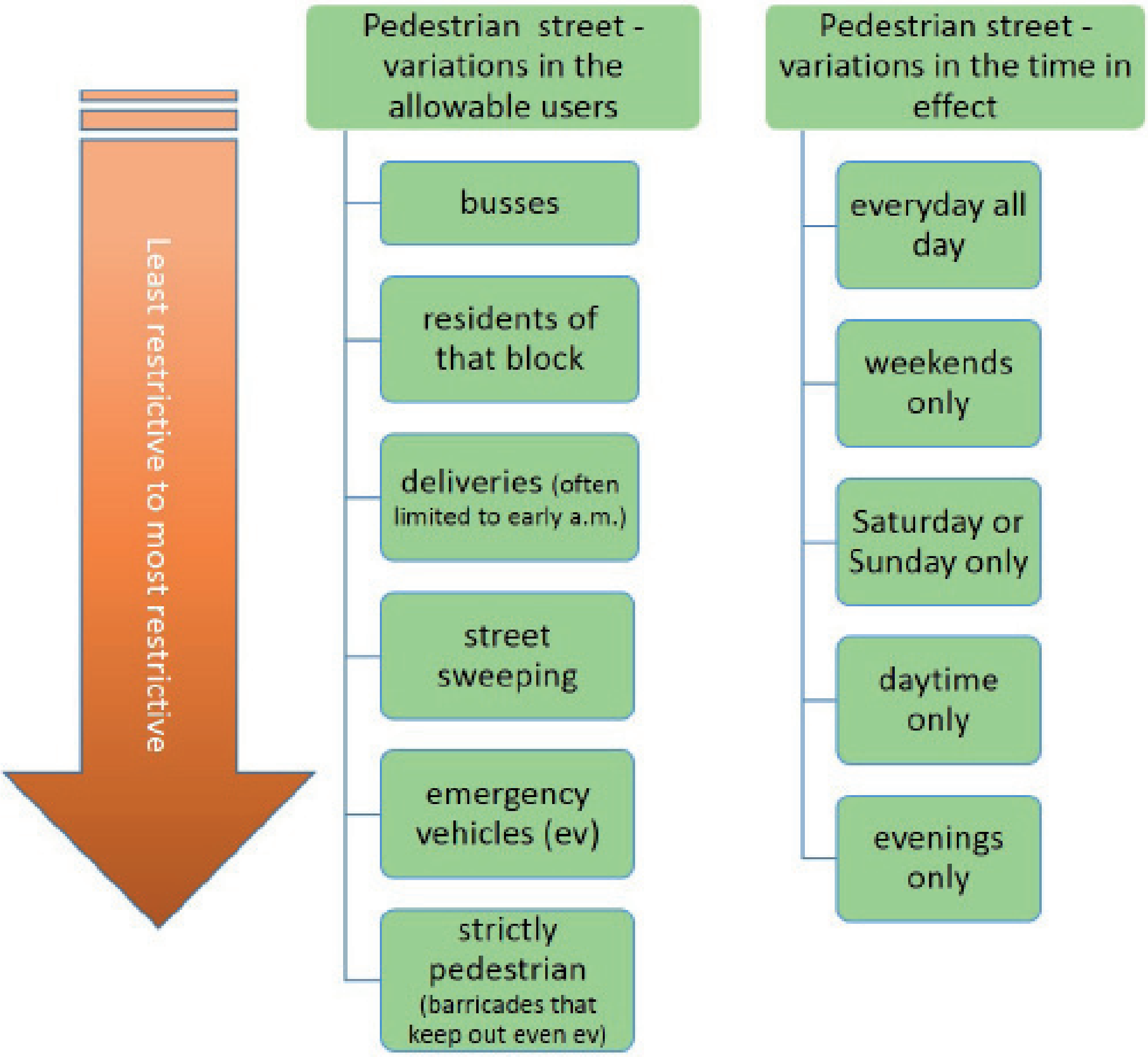

Figure 6: Pedestrian street variations.

War II Germany when bombed-out cities were rebuilding. The consensus of the literature appears to be that the concept of pedestrianizing an already-motorized street began and then spread widely in Germany. One source cites Cologne as one of the first when, after rebuilding their city center after World War II, they closed their main shopping street to motor traffic during the day by inserting posts in slots at either end of the streets; deliveries took place early in the early morning or at night (Buchanan, 1963, 174). R. Monheim (2002) cites Aachen which in the early 1950s pedestrianized some small lanes as well as closed the main shopping street in the afternoons (p. 187). Hass-Klau (1993) reported that, by 1955, 21 German cities already had at least one traffic-free street, typically less than a kilometer long, and by 1963 there were 63 cities with traffic-free streets (pp. 21-31). By the end of the 1960s, H. Monheim (2002) wrote that there were over 400 pedestrian zones in Germany (p.155). According to Hass-Klau (2015), today in Germany most towns with a population over 50,000 have a pedestrian area.

While a pedestrian street completely bans all motor vehicles, there can be many variations and exceptions in practice. The most common exception is to allow for early morning deliveries (as in Dubrovnik), which ostensibly does not change its function or ambiance as a pedestrian street. Other variations are to allow transit vehicles and/or to allow only the few residents who live on that block to have motorized access. There are also temporal variations, i.e., to be part-time (e.g., 10 a.m. to 6 p.m.) or to be weekend only. The 21st century variation is the Sunday Street. The many variations and exceptions that pedestrian areas can have are illustrated in Figure 6.

Global Spread and USA Introduction/ Adoption

Pedestrian-only streets have spread to virtually every country in Europe. In Italy, pedestrian streets began with the banning of cars in the piazzas. Siena was first in 1962 when it banned automobiles from Piazza del Campo (Maggi, 2016). Pedestrian streets are now common in most Italian cities (Figure 7) and also most large European cities including Marseilles, Vienna, and Budapest. They are not limited to major cities: according to Hass-Klau (2015), "nearly every British city has pedestrian streets although they vary substantially in size and design" (p. 43). In fact, these days, it is hard to imagine a medium or large European city without at least one main pedestrian commercial street if not an entire area of the city center.

USA adoption of pedestrian-only streets has been more uneven. Many USA cities in the 1960s and 1970s attempted to compete with the suburban shopping malls by constructing "downtown pedestrian malls" or other pedestrian or quasi-pedestrian zones such as transit malls (Robertson, 1994). But of the over 200 downtown pedestrian malls in the 1980s, there were only 30 left by the 1990s (West, 1995; in Pojani, 2010). Of those that remained, many were transit malls, that is, they are not completely pedestrianized, such as Nicolet Mall in Minneapolis, Minnesota and 16th Street Mall in Denver, Colorado. Many of the downtown pedestrian areas/ streets that were successful and survived until today have been in small towns, college towns or tourist towns such as Vail, Colorado; Boulder, Colorado; Aspen, Colorado and Burlington, Vermont. A few failing or failed downtown malls from the 1970s became successful after they were redeveloped, including Santa Monica, Santa Cruz, San Luis Obispo, and Pasadena, California (Pojani, 2010). In the last decade, there has been a revival of interest on the part of many cities across the USA, most notably New York, which in 2009 gradually closed Times Square to traffic, first temporarily, then permanently.

Congestion Pricing

Origin

Congestion pricing has many variations and thus has many names: cordon pricing, cordon tolls, area licensing schemes, congestion charge zones, road pricing, urban pricing. It could be a single toll or a time-based fee, but the adjective 'congestion" implies that the toll or fee varies by time of day / degree of congestion. It is differentiated from roadway or bridge tolls since it typically applies to an area rather than a single bridge or roadway segment.

Figure 7: Typical European pedestrian street (Turin, Italy).
Photo by Michelle DeRobertis

The main motivation for implementing said charges also varies from congestion reduction to revenue raising (Ieromonachou et al, 2006).

Singapore is acknowledged to have implemented the first modern road pricing system, an area-based user charge, whose aim was to reduce congestion (Eliasson and Lundberg, 2003; Evans et al, 2003). Singapore's motivation was the extreme congestion and the recognition of the futility of road capacity improvements in the central city (Geok, 1975).

Key features

The key features of congestion pricing are:

- Defining a cordoned area or borders within which the fee will be charged.
- Fees vary by time of day (static) or degree of congestion (dynamic).

Global Spread and USA Introduction/ Adoption

After Singapore, Norway cities are credited with pioneering area-based tolls to cross all city borders, (e.g., Bergen, Trondheim, and Oslo); the primary goal was to finance new infrastructure and public transport (Eliasson and Lundberg, 2003, p. 11). In 2006, Stockholm began charging for driving on certain roads with a charge that varies by time of day (Evans et al, 2003). London began planning a congestion charge zone in the 1990s which was finally implemented in 2003; its primary goal is congestion reduction (Lemoine, 2009). Congestion pricing has also spread to small cities such as Valletta, Malta (Carreno, 2007; Attard and Ison, 2008) and Znojno, Czech Republic (Maloula, 2007). Depending on the city, certain vehicles may be exempted from the fee; for example in Valletta, Malta, residents, motorcyclists, electric vehicles, and disabled persons working in Valletta are exempt.

Several U.S. cities have been researching and considering congestion pricing for years, most notably New York (Geberer, 2008). In 2019, two cities made progress: New York and San Francisco. In March 2019, the State of New York passed legislation that clears the way for the City of New York to implement congestion pricing. The funds will be used for public transportation; eighty percent of the revenue will be used to fund the subway and busses, and the Long Island Rail Road and the Metro-North Railroad will each receive ten percent (McKinley and Wang, 2019). Charging in lower Manhattan may begin as early as 2021 (Hu, 2019). In April 2019, the City and County of San Francisco issued an RFP for a "Downtown Congestion Pricing Study" to study how such a program could be structured in San Francisco.

4. How Did These Transfers of Ideas Happen?

There have been many means, both official and unofficial, that have aided in disseminating innovative practices to a global audience. These ranged from study tours to conferences to papers, now easily available in both print and electronically, and even the experience of individual Americans traveling or living abroad. The key players in spreading ideas have been:

- Government agencies and study tours
- Academic institutions, scholars and practitioners through conferences and papers
- Professional organizations such as ITE, (professional journals, conferences and study tours)
- Non-governmental organizations (NGOs),
- Private citizens, in the case of bike lanes spreading to Davis, CA

Below is a list of just a few of these study tours sponsored by USA organizations. Undoubtedly there are others based outside the USA or with ties on both sides of the Atlantic or Pacific. One such organization is the German Marshall Fund of the United States whose mission is to strengthen "transatlantic cooperation on regional, national, and global challenges and opportunities in the spirit of the Marshall Plan." (http://www.gmfus.org/about-gmf)

Institute of Transportation Engineers (ITE)

- 1994: Intelligent Transportation System (ITS) European Study Tour.
- 2014: ITE London Study Tour Sharing Innovative Solutions for Safe and Sustainable Transport Access and Choice for all Users.
- 2015: From Rapid Transit to Light Rail; in Sydney, Australia.

U.S. Federal Highway Administration (U.S. FHWA)

- 1994: For Pedestrian and Bicyclist Safety; in England, Germany, The Netherlands.
- 1995: Speed Management and Enforcement; in The Netherlands, Germany, Sweden, Australia.
- 2003: Signalized Intersection Safety; in Europe.
- 2008 Improving Safety and Mobility for Older Road Users; in Australia and Japan.
- 2010: Reducing Congestion & Increasing Funding Using Road Pricing; in Europe, Singapore.

Private foundations: W. Alton Jones Foundation

- 1990s: Bus Rapid Transit; in Curitiba, Brazil.

This latter tour is perhaps one of the most unusually financed, but certainly one of the most effective. It was sponsored by a private foundation, the W. Alton Jones Foundation (now Blue Moon). The ITDP credits this foundation with playing a key role in increasing the knowledge about BRT by providing funding to take top officials from several American cities to Curitiba, Brazil to see firsthand what BRT was and how it worked (Weinstock et al, 2011, pp. 15, 51). The foundation then actively promoted BRT as an alternate, more cost-effective solution to mass transit problems.

5. Conclusion

This paper provided a brief overview of some of the many innovative transportation strategies that originated outside the United States to address urban transport and safety problems that USA cities have adopted or are in the process of adopting. This is a story of successful globalization and illustrates the need to continue sharing information via professional, academic, cultural, student, and personal exchanges.

There are many other strategies and policies that this paper did not explore, some of which have begun to be adopted, such as Vision Zero (which originated in Sweden in 1997 and was adopted in New York City in 2014), which rejects the cost-benefit approach to traffic safety improvements: "it can never be ethically acceptable that people are killed or seriously injured when moving within the road transport system". Other strategies and policies that are widely adopted abroad that are not yet prevalent—or even present—in the USA (and indeed may be met with skepticism in many parts of the country), include 30 kph (<20 mph) zones that apply to every local street; city center low-emission zones; city center traffic-restricted zones, and metropolitan areawide public transportation authorities that provide seamless transit coordination between agencies.

It is essential that we as a society keep an open mind and ask questions about what might work better and to acknowledge that we Americans have much to learn from others. The responsibility is shared between professional transport planners and engineers, politicians and policy makers, and even citizens and the public to investigate, share information and explore new strategies and solutions. Going outside the comfort zone of the known, tried and true, is the only way progress has ever been made, whether it is new devices and technology, or seemingly going "back in time" to the adoption of car-free areas.

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Cars and Cities: Looking Back on Jacobs and Buchanan 55 years Later

Michelle DeRobertis

Preface

The premise and much of the text of this article are excerpted from my PhD dissertation entitled Towards an Assessment of Livability in the ZTL: Reversing the Tragedy of the Commons of the Historic City Center—The Case Study of Brescia (Italy). I would like to acknowledge the inspiration and support that Joe Kott provided both before and during my 3.5 years at the University of Brescia conducting this research. The main theme of how auto dependency has adversely impacted where we live and work was one that Joe and I often discussed together and that Joe took in a different direction in the research for his 2012 dissertation. My big regret is that I did not have an opportunity to share my findings with Joe or to hear his observations and keen insights about further analysis that could be conducted.

Introduction

In a 1968 article, Garrett Hardin used William Forster Lloyd's metaphor of the tragedy of the commons (Lloyd, 1833) to describe the problem of overpopulation. This phenomenon can be summarized as the inevitable degradation of the public pasture, or commons, that results when all are free to graze their livestock with no restrictions.

In the author's dissertation (DeRobertis 2019), the concept of the commons is applied to the problem of too many automobiles in city centers as follows. The city center is a community resource, particularly the historic city centers of most Italian towns. Due to the incursion of automobiles, Italian city centers were subjected to the same tragedy-of-the-commons phenomenon described by Hardin and Forster—its overuse degrades it for everybody. Specifically, in the context of the Italian city center, the streets' overuse by private automobiles meant that the city center had become unattractive and virtually unusable, and not only for the automobiles stuck in gridlock, but also for the main reasons a city exists—people and their daily activities.

The author's dissertation argues that three of Hardin's key points in assessing and reversing a tragedy of the commons are particularly relevant with respect to discussing cars and the Italian city center. These are (bold face italic type are the specific terms used by Hardin):

1. It is first necessary to ***recognize the problem*** that ***freedom in a commons brings ruin to all***.

This same concept is applicable to the freedom to drive: free access to city streets by any and all automobiles makes the Italian city center less attractive and less livable for everybody. Similarly, lack of restrictions on driving makes U.S. urban and suburban arterials overly congested, degrading their utility for all users. (DeRobertis and Lee, 2017).

2. A ***criterion of judgment and a system of weighting are needed*** to make the right decisions.

In the case of the Italian historic city center, a new system of judgment and evaluation was needed in which the access, movement and parking of cars were not the priority, people were, including their enjoyment of being in the city center. With respect to urban and suburban arterials, new judgment criteria have emerged in the form of Complete Streets, where the goal is to design for and safely accommodate all modes.

3. The solution is dependent on ***mutual coercion mutually agreed upon***.

By this Hardin meant that in order to instill responsibility over the public commons, it is not sufficient to rely on the people's conscience to do the right thing; rather social arrangements that elicit responsibility are needed. In modern times these social arrangements are laws and regulations which "coerce" people to do what is best for society, i.e. people and their needs. In the context of cars and cities, the adoption of rules and regulations is needed to keep the city center and city streets from being overused. In Italy, an example of the coercion of which Garrett Hardin speaks was the establishment of traffic-restricted zones (ZTL) (DeRobertis and Tira, 2016 and

Morici, 1994). Indeed, ZTL regulations have been adopted in over 350 Italian cities and towns with populations ranging from 1,000 to 2,500,000.

This paper will present a brief overview of early research works which dealt with the first of these three concepts: the recognition of the problem. It will focus however, on two of these early works, one by Jane Jacobs and the other by Colin Buchanan.

Recognition of the Problem of the Negative Impacts of Too Many Cars

Cities have been struggling with automobiles almost since cars were first invented. While indeed automobiles initially improved the ambiance and public health of cities by removing the stench and unsanitary conditions caused by horse manure, they quickly created their own problems. These problems were apparent and recognized by the 1950s, thus reports began to be commissioned and books written. For example, Tetlow and Goss (1968) wrote that by the 1950s, governments were attempting to address the congestion and parking problems by planning to add more capacity for automobiles. But, Tetlow and Goss continued:

> It has been forgotten that the centre is not primarily a place to which people and goods travel but in which people work, shop, meet their friends and visit restaurants, theatres and concerts. The pedestrian is not just a nuisance and a hindrance to traffic; his or her desire to move about on business, look into shop windows, or just stand and stare, is the prime reason why the city centre exists at all. (Tetlow and Goss, 1968, p. 187)

Muhlrad (2010) describes how in old dense cities, increased noise and pollution due to cars was discouraging both people from living there and others from going there for shopping or pleasure (p. 77).

One of the earliest comprehensive research studies, conducted in the late 1960s and published in 1970, was Street Livability Study, by Donald Appleyard which was commissioned by the Department of City Planning of the City and County of San Francisco, CA, USA. The purpose of this research was "to explore what it is like to live on streets with different kinds of traffic." This research documented how auto traffic indeed had become a problem, and identified exactly which types of problems by studying streets with varying levels of traffic volumes.

By 1975, the problem of urban traffic in Europe was so pervasive that the OECD (Organization for Economic Co-operation and Development) Environment Committee organized a conference in Paris entitled Better Towns with Less Traffic whose purpose was "to evaluate the possibilities and effects of policies for limiting motor traffic in urban areas such as are being applied by a growing number of towns in Member countries" (Eldin, 1975, p.1). Eldin stated four specific reasons for this conference, two of which were: 1) air pollution, noise, and accidents in light of both the high social costs that motor traffic has as well as its damaging effect on the quality of urban life; and 2) given the era's energy crisis, the need to reduce dependence on private cars as it is directly related to need to conserve energy.

Two other early works which recognized the adverse impacts of car intrusion in cities are still widely read and discussed today. The first is the seminal The Death and Life of Great American Cities by Jane Jacobs in 1961. More or less concurrently, across the ocean, Colin Buchanan was commissioned to write a report for the UK Minister of Transport, to study "the long term problem of traffic in towns" (Traffic in Towns 1963). How did these two authors describe the problem of cars and cities? From the perspective of 55 years hence, what did they miss and what did we miss in interpreting their work?

1. Jane Jacobs, The Death and Life of Great American Cities, 1961

Purpose: Jacobs begins her work by stating in the very first sentence that "This book is an attack on current city planning and rebuilding" (p. 3). Her purpose is to discuss "what principles of planning and practices in rebuilding can promote social and economic vitality and what practices and principles will deaden these attributes"

(p. 4). Jacobs also writes very early on that "Automobiles are conveniently tagged as the villains...but the destructive effects of automobiles are much less a cause than a symptom of our incompetence at city building" (p. 7). City planners "do not know what to do with automobiles in cities because they do not know how to plan for workable and vital cities anyway—with or without automobiles……How can you know what to try with traffic until you know how the city itself works, and what else it needs to do with its streets? You can't." (p. 7).

Philosophical Approach: Jacobs ties her main arguments to her premise that a successful city is one with an "intricate and close-grained diversity of uses" (p. 14) and that four conditions generated this diversity, all of which are necessary: mixed uses, small blocks, aged buildings (to create a variety of rents/prices which are essential to have a variety of uses) and concentration i.e. density. She believes that city planning should deliberately focus on inducing whichever of these four conditions doesn't exist. Much of the book is criticism of public housing projects and other large-scale urban redevelopment efforts that destroyed parts of cities and she provides numerous examples of how they violated one or more of these four conditions. Although good transportation, public or otherwise, was not one of the four essential conditions, she did acknowledge that good transportation… is "also a basic necessity" (p. 339-340) and, in fact, the book does devote an entire chapter to the discussion of automobiles, primarily the problems that they impose on cities.

Recognition of the Auto Problem: Despite the fact that Jacobs doesn't blame excessive auto use for city ills, but rather city design and redevelopment, she goes on to decry the adverse impacts of automobiles in an entire chapter. Thus, Chapter 18 is devoted to the problem of the automobile circa late 1950s to 1960, the lessons of which by now we have well-learned in hindsight: "too much dependence on private automobiles and city concentration of use are incompatible.... automobiles compete with other uses for space and convenience" (p. 349). In other words, cities can have density and diversity or cities can prioritize automobiles, but cities cannot have both. When a city does continue to allocate space to accommodate automobiles instead of city uses, she calls this detrimental effect the "erosion of cities". She maintains that cities cannot get the conditions they need for generating diversity (and become healthy lively cities) "if accommodations for huge numbers of cars gets first consideration" (p. 357) (such as wider streets, narrower sidewalks, more surface parking, longer blocks, one-way streets, or new expressways cutting through neighborhoods). Her solution was simple: rely on the natural "attrition of autos" that will result from implementing the conditions that help diversify cities (p. 363). Basically, by building the elements of diversity, Jacobs maintained that traffic will be slowly discouraged from using streets. The fact that such changes are (and should be) implemented "piecemeal", i.e. slowly, was considered a good thing as it does "not disrupt too many habits at once" (p. 369). In addition, given that trucks and busses have unique roles in city life, she stated that they should be treated differently from cars; measures to improve their efficiency (bus lanes, loading zones) would also contribute to the attrition of cars by increasing delay to automobiles (p. 365). Thus, Jacobs says, whenever there is a conflict between automobiles and these features (busses or one of the four elements of city diversity), the resolution should be in favor of the latter.

Observations and Critiques: While Jacobs very clearly articulates that strategies to accommodate automobiles such as large surface parking lots, blasting roadways through city parks, and narrowing sidewalks to widen streets are not only shortsighted and ugly but downright harmful to vibrant successful cities, she neglected to address or acknowledge two key aspects of the city-automobile problem.

Mass Transit as a Necessary Element of Cities: First, the *Death and Life of Great American Cities* ignores the role of good mass public transportation in contributing to the success, both economically and functionally, of large cities. This is particularly noteworthy since she stated outright that her analysis and observations only apply to "great" American cities, which almost by definition would have the best public transportation in the USA. "Towns, suburbs and even little cities are totally different organisms from great cities." (p. 16). It could be argued one of the reasons for both this difference between great cities and little cities and the reasons why dense, diverse, large cities are so lively and successful is the presence of mass transit. If a city is to have density or limit automobile use, and especially have density AND limit automobile use, it must have readily available alternative transportation, i.e. mass public transit. This includes street cars, subways and suburban commuter rail, as was indeed the case for the model "great" cities she highlighted: New York, Philadelphia, Boston, Chicago, Pittsburgh, and San Francisco, whose 1960 populations ranged from 600,000 to 7.8 million.

It is particularly interesting that Jacobs neglected to mention the key role of public transit given that much of her observations were about her own Greenwich Village street which was located very close to a major subway station served by seven subway lines, (Figure 1) which brought thousands of pedestrians to her neighborhood every hour (Marshall 2018). Given the amount of public transit capacity and ridership available to her street, her street perhaps had disproportionately low level of cars for the number of pedestrians and other lively city activities present compared to any other U.S. city. The contribution of the New York subway system to creating and maintaining this level of lively city activity was not acknowledged. So, to Jacobs' four necessary conditions, a fifth

Figure 1: Greenwich Village and the New York Subway System Circa 1965
(Source: John Kulpa, HNTB Corportation)

necessary element should be added: the presence of fast, frequent, reliable, affordable mass public transportation.

Adverse Impacts of the Use and Presence of Cars: Second, it is interesting to note that to Jacobs, the mere presence of too many cars was not considered in and of itself a major problem for city life and character, only the modifications to the cityscape (and to her four required conditions) that are made in order to facilitate and prioritize the use of these numerous automobiles. In fact, she outright states that the congestion resulting from not widening streets would be a good thing in that increased delay would discourage more car use. But the negative impacts of the presence of all these cars filling city streets—such as the noise, fumes, and crashes—were not acknowledged, as did Bruce Appleyard described previously; as did Colin Buchanan as will be described later, or as by Italian city officials discussed below.

Since the adverse aspect of too many automobiles on the streets of the Italian city center, where people reside, work, shop, and otherwise visit, was the focus of this author's dissertation, the applicability of Jacobs' four necessary conditions to Italian city centers will be explored. The Italian historic city center, for the most part, has all four of Jacobs' conditions of diversity: mixed uses, small blocks, age/variety of rents, and concentration/density. Even though many of the car-centric strategies prioritizing automobiles which Jacobs cited as eroding cities, such as widening streets, providing more surface parking, and creating longer blocks, were not implemented inside Italian historic city centers, the city centers still became overrun with cars and automobile presence on city center streets exceeded what was considered to be a "livable" level. Indeed, cars filled up all the available space, (even if it wasn't much space by U.S. standards), and created noisy, polluted resident- and pedestrian-unfriendly congested city centers (Figure 2, p.70). This was considered unacceptable and precipitated the development of and widespread adoption of the ZTL beginning in the mid 1960s (Morici, 1994). While Italian city center streets may have met Jacobs' criteria for those of lively, interesting, walkable cities, with people throughout the day, creating many chance encounters and other wonders of successful city streets (Jacobs p. 65, p. 154, p. 163), they also became downright unpleasant, crowded with cars, traffic noise and fumes, and became increasingly unsafe for pedestrians and bicyclists. Thus, Italian city center experience shows that the four conditions of diversity are not enough to make a pleasant, livable city. Even with the four conditions of diversity, without some measure of, as Hardin called it, coercion, the historic city center, although "successful" and certainly not dull, was still not a pleasant place to be. Because there were no controls on driving and few controls on parking, the historic city center streets were freely used by individuals for their own purposes and consequently the city center as a whole became choked and unpleasant—a tragedy of the commons.

Summary and Takeaway: Jacobs recognized that prioritizing the automobile by widening roads, providing more parking lots, and other car-centric measures would be detrimental to cities. Even so, Jacobs maintained the solution was to focus on the four city design conditions. This, she argued, would naturally result in a reduced presence of cars since even if it meant accepting traffic-congested city streets, this would serve as a deterrent to more traffic. She did not examine, let alone acknowledge, the adverse impacts of the mere presence of car-filled streets on city life and character, such as traffic noise, traffic fumes, and the visual intrusion cited by Buchanan. Indeed, Italian historic city centers seemed to have all four of Jacobs' required conditions yet still suffered from the negative impacts of the excess use of cars, which led to the development and implementation of the strategy known as ZTL—traffic-restricted zones. Lastly, Jacobs did not acknowledge the essential role that fast, frequent public transit has in creating a diverse vibrant city with a concentration of uses and functions. Indeed, her Greenwich Village street was often cited as an exemplary city street, but the reader never knew it was located near a subway station served by, not just one, but seven subway lines.

Figure 2: Piazza Duomo Brescia, Italy, before and after implementation of ZTL.

2. Colin Buchanan, Traffic In Towns, 1963

Purpose: The focus of Traffic in Towns (also known as the Buchanan Report) was, as the name implies, automobile traffic in urban areas. Already by 1960, traffic jams and congestion were such major problems in the United Kingdom that the Ministry of Transport commissioned this professional study. Its stated purpose was, given that significant population growth was forecasted for the next few decades, to "study the long term development of roads and traffic in urban areas and their influence on the urban environment" (p. 7). The study was to determine, whether for new towns or expansion of existing towns: "How can activities be arranged, buildings sited to enable use of motor vehicle to the best advantage?" (p. 31).

Philosophical Approach: The Buchanan group decided to study not just how to best to accommodate traffic but to do so in towns that "are worth living in":

> The overriding context in which the problems of urban traffic have to be considered is the need to create or re-create towns which in the broadest sense of the term **are worth living in**, and this means much more than the freedom to use motor vehicles. It is a mixture of all manner of things, convenience, variety of choice, contrast, architecture, history visible in the buildings – all more or less subtle qualities. Life in towns could no doubt be lived without any of them, but it would be a poorer and emptier life as a result. The town planner is in an unenviable position - blamed if opportunities are missed, accused if he tries to tell people what they should have. (p. 32, par. 66, emphasis added)

The report correctly forecasted that:

> ….potential increase in number of vehicles is so great that …. Either the utility of vehicles in towns will decline rapidly or the pleasantness and safety of surroundings will deteriorate catastrophically, in all probability both will happen together. (p. 7)

It also realized:

> …there could be no question of a simple 'solution' to the traffic problem. …… For the traffic problem is not so much a problem waiting for a solution as a **social situation** requiring to be dealt with by policies patiently applied over a period, and revised from time to time in the light of events. There is no straightforward or best solution. (p. 8, emphasis added)

This was a perspective that for the most part was not recognized or adopted in the USA, whose goal for the next 50 years was prioritizing automobiles almost exclusively.

Recognition and Description of the Automobile Problem: The report classified the automobile problem as two distinct types of difficulties:

> 1) Frustration in the use of vehicles i.e. congestion. The report acknowledged that the car's main advantages of ease of use and providing door-to-door service now in fact inhibited its use, both in movement and parking. The report described how it was no longer possible to park wherever one wanted; it was now often a matter of finding somewhere legal, let alone convenient. In addition to parking, the report stated that movement had become difficult with so much congestion that even though a car can go 60 miles per hour (mph), in cities the average is 11 mph. Finally, the report states that these problems adversely affected goods deliveries which are essential to city business. It basically described the tragedy of the commons in 1963.
> 2) By-products of the use of cars, e.g. accidents, noise, air pollution. The report elaborated quite a bit on this problem which was divided into two categories: accidents and environment (Buchanan, 1963, p. 14-22).

The report's description of "environmental" problems were quite progressive albeit by-and-large ignored. The report identified five specific environmental problems which are described below. Note even though they were called "environmental", by this was meant "urban surroundings" (p. 19) not the natural environment, (e.g. air, rivers, wildlife habitat) as is usually meant today when one uses the word environment.

Safety: The issue of perceived safety, e.g. feeling free from anxiety, was included as an environmental impact separate from the problem of actual collisions causing death and injury. The report stated that "safety should be put foremost" when talking about the influence of motor vehicles on the environment: "to be safe, to feel safe" and to be free of anxiety that family members "will be involved in a traffic accident are surely prerequisites for civilized life" (p. 19).

Noise: The report cited an official State committee which had concluded that in London, road traffic is the predominant source of annoyance: "no other single noise is of comparable importance" (p. 20). It mentioned five specific kinds of noise from vehicles as problematic: engine and gears, horns, brakes, door slamming, and loose loads /rattling lorries. To reduce noise, the report concluded that, since not much can be expected from improved vehicle design or better building insulation, the "long term remedy must lie with town planning" (p. 20) including diversion of heavy traffic flows away from where people live and the detailed layout of buildings and building groups.

Fumes and smell: The report cited auto exhaust as a nuisance and unpleasantness for those on the street as well as a major contributor to atmospheric pollution. It stated that fumes are "rendering urban streets extremely unpleasant" (p. 21) and not only in canyon-like streets but even on any of the bridges across the Thames. Furthermore, the report added that even drivers and car occupants are not immune as they breathe the same polluted outside air that is drawn inside their cars.

Visual: The report discussed the visual consequences of car intrusion and indeed it was one of only two reports that this research has found that did so. It forcefully argued that the mere presence of cars was an adverse impact. In fact, Buchanan acknowledged that many might disagree that it constitutes such a problem, but he took pains to justify this opinion and listed the many and various ways that cars intrude visually:

> …the destruction of architectural and historic scenes, intrusion into parks and squares, garaging and repair of cars on residential streets creating hazards for children and hindering snow clearance, oil stains which render dark black the only suitable color for pavement surfaces. Other adverse visual effect are clutter of signs, billboards, bollards, railings etc., dreary formless car parks/ parking lots which also sacrifice close knit development, great wide highways that are out of scale with the modest dimension of the towns. (p. 22)

Space / other environmental difficulties: Lastly, the report lists competition for space as an adverse impact and that this manifests itself as the steady encroachment of the motor vehicle onto sidewalks, yards, etc. This particular impact, i.e. competing for space and winning, has continued to manifest itself in other ways beyond those cited by Buchanan in the years and decades since the Buchanan Report was published. Examples include the narrowing of sidewalks to provide more vehicle travel lanes and in the struggle to install bike lanes and bus-only lanes through road diets. Cars also compete among themselves for space in the provision of on-street parking versus another travel lane.

Although the report was very emphatic that these are indeed severe environmental consequences, the extent, range and detailed evaluation of these impacts was not the subject of its research. The report's recommendation was quite simply to reduce the amount of traffic in residential areas and that the recommended way to do this was to apply the concept of "Environmental Capacity" and to create environmental islands. Furthermore, it was implied that society must be prepared to accept these environmental impacts including fumes and noise on the streets outside of environmental areas, in other words, on those streets onto which all the traffic is funneled. The report also acknowledged a lot more study was needed.

Methodology and Findings: In order to develop recommendations for how to handle traffic in towns, the report analyzed four distinct types of areas in detail: a small town, a large town, a historic town, and a central metropolitan block of a large city. After an analysis of these four area types, the report concluded that although the motor vehicle was here to stay: a) there are indeed limits to the amount of traffic that can be accepted in towns, and b) up to those limits, the level of vehicle accessibility a town will have depends on its readiness to accept and pay for the physical changes required. The report concluded that if there was the will for investments, then there was the need for two distinct kinds of areas as shown in Figure 3: a) the "canalization" (p. 191) of traffic i.e. a network of some kind for through traffic, called the distributors; and b) environmental areas where people live and work, within which traffic would be controlled. The report was very strong on the point that through traffic should not use streets which have an "environmental function"

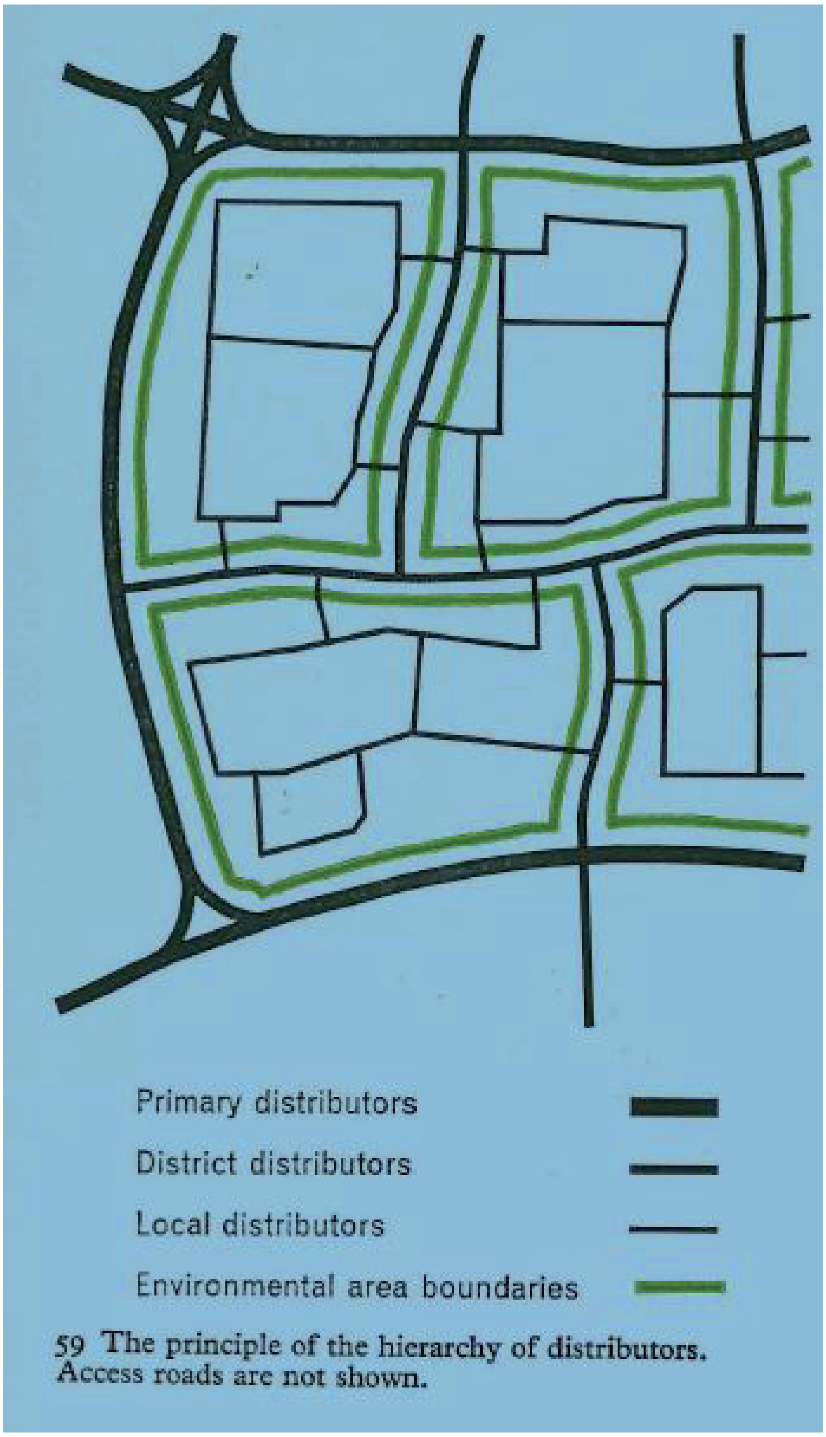

Figure 3: Buchanan's Environmental Areas.
Source: Traffic In Towns. Collin Buchanan

i.e. primarily residential. It essentially called for an end to the by-thenubiquitous practice of what the British called "rat-running", where drivers find short-cuts and avoid congestion and traffic signals by using residential streets, regardless of how narrow, instead of the main roads; and that the first step to accomplish this is to identify the distributor road network and then to establish the environmental areas.

Appendix 1 of the Buchanan Report expanded on the concept of Environmental Capacity, the notion that residential streets should not be subject to their physical capacity level of traffic volumes. With respect to historic towns and city centers, where historic buildings, narrow streets and natural features were present, the Buchanan Report concluded:

- "Any general policy of widening the existing streets to cope with more traffic must be ruled out because this would certainly destroy the historic character of the city." (p. 118, para. 268)
- "The main principle is abundantly clear: if the environment is sacrosanct…., then accessibility must be limited." (emphasis Buchanan's) (p. 118, para. 269)
- "These (historic) areas can be retained in the age of the motor vehicle provided reduced standard of accessibility is accepted including a strict discipline of vehicle movement." (p. 123, para. 289)

By restricting accessibility, it is meant controlling which cars have permission to enter these historic streets; the status quo of unlimited free access was untenable.

Another key recommendation was that city planning must coordinate new development with both private and public transportation in order to enforce the "much needed integration of land use planning and traffic" (p. 193). Therefore the report recommended that each new development plan should also create a Transportation Plan which would contain measures to "influence traffic demand". The Buchanan Report acknowledged that there was little experience at the present time (i.e. 1963) of the best ways to influence demand but "there appear to be four possibilities" (p. 193):

1. Measures to control certain vehicles from entering certain specific zones.
2. Charging for the use of the roadway. While this could take many forms, the report gave as an example the concept of monitoring the amount of time spent in a zone via means of an electronic apparatus, thus enabling the price to be based on the demand for roadway space at that time.
3. Policies affecting parking.
4. Subsidizing public transit so that it would be cheaper than using the car.

Note that the first measure is essentially a ZTL.

Observations and Critiques: This research was very avant garde as it was one of the earliest to elaborate and identify that the problem of automobile traffic is not just congestion and where to park but that cars have many adverse side effects. In fact, 55 years later, it remains one of the very few studies that states outright that in addition to the obvious noise, fumes and safety concerns cars produce, that the mere presence of cars is a problem and that, in certain contexts, cars are visually annoying as well. Although the report devotes an Appendix to furthering this aspect of the analysis, the proposed methodology uses a single proxy for determining how much traffic is too much for a residential street: delay for a pedestrian in crossing the street. The author's main critique is not necessarily with Buchanan but with the transportation engineering profession: in the 55 years since the publication of this report, there has been only sporadic progress in this line of research. There is still no profession-wide consensus for how much traffic is "too much" for a residential street. Appleyard's research helped immensely and the TIRE (traffic intrusion in residential environments) index also helped fill the gap. But Buchanan's three nomographs in the Appendix 1 of Traffic in Towns are largely forgotten. There is still no profession-wide standard or methodology for evaluating traffic volumes and their adverse side effects on residential streets. Despite lack of consensus, it is encouraging that several U.S. communities such as Pleasanton CA and Flagstaff AZ have recognized the issue and have adopted targets or limits for the acceptable amount of traffic on residential streets. Even more European cities take proactive steps to ensure low traffic volumes, e.g. the Dutch woonerf and the Italian ZTL; perhaps the most progressive and effective strategies are the Vauban Germany model, where the entire area, population of 5,000, is not designed around car access, even by residents; cars must park at the periphery and circulation within Vauban is on foot or bike.

A second critique is that the role of public transit was not given its due. Admittedly the purpose of the report was how to handle traffic in towns, but even so the report acknowledged that traffic demand must be managed. Thus, the report could have made a stronger statement that preserving reliable, convenient, fast and frequent mass transit was essential not just for those who do not drive but also to specifically provide an attractive and practical alternative to driving and thereby reduce the adverse effects of cars (the many manifestations of which the report described so well).

Summary and Takeaway: The Buchanan Report identified two distinct types of problems resulting from excessive cars, one affecting cars and their use (congestion and parking problems) and the other being their many adverse side effects. The subsequent discussion of the many environmental and nuisance effects of cars is was very prescient and directly relevant to livability in historic city centers and towns in general. While the report did not explore these adverse effects further, it did at least state that they were contributing to the deterioration of cities and that measures to control automobile use would restore the ambiance both of residential areas and of historic city centers.

The report also concluded that residential areas should be treated differently from streets for through traffic and that access control to certain defined zones was one of the ways to reduce the impact of cars on residential areas. Similarly, the report maintained that historic city centers were different and that indeed measures were needed to keep them "in conditions in which they can be savoured and enjoyed" (p. 123).

> …if major physical changes are out of the question then there must be a reduction of accessibility…..There is a great deal at stake: it is not a question of retaining a few old buildings, but conserving, in the face of the onslaught of motor traffic, a major part of the heritage of the English-speaking world. (p. 197)

Furthermore, to prepare for the future anticipated growth in both population and car use, long-term planning was essential. Future developments should prepare transportation plans which would contain measures to influence traffic demand. This was an early mention of Transportation Demand Management (TDM). However, aside from a mention of subsidized public transit as a TDM measure, Buchanan, just as Jacobs, ignored the importance of having (or improving as necessary) fast, convenient and affordable public transportation.

Observations and Conclusions

In the early 1960s, Jacobs and Buchanan were among the earliest to study and write about the many problems that the influx of personal vehicles were causing in our large cities (Jacobs) and towns (Buchanan). Jacobs described the car problem and its impact on the structure, design and composition of cities in terms of the four required conditions to generate diversity. Buchanan addressed head-on how, in addition to causing congestion and problems for car users, the prevalence of cars in towns also raised five specific problems for the environment, (by which he meant the area /ambiance where humans reside, not the natural environment): safety, noise, fumes/air pollution, visual intrusion and occupation of space. Furthermore, he raised the concept that some areas of the city should have limits to car use.

In the late 1960s, Appleyard went on to analyze and identify the specific problems caused by auto traffic from the perspective of the residents, which he summarized as concerns about traffic safety, annoyance due to traffic noise and soot, impacts on neighbouring and visiting, and loss of sense of home.

While Jacobs recognized that prioritizing automobile access, circulation and parking ruined cities' diversity, she was silent on the mere presence of cars and the role of their by-products in the deterioration of the quality of city life. On the other hand, the premise of both Buchanan's and Appleyard's research was that residential streets are distinct from streets whose main function is to move cars; consequently, different standards of "acceptable" traffic need to be applied. The problems caused by automobiles were not only to life and limb but also annoyances: fumes, noise, visual, and encroachment into space. Buchanan even postulated that one way to restore serenity was to control traffic access to certain streets.

Both Jacobs and Buchanan were silent on the key role that public transit has in a successful vibrant city and under-emphasized how public transportation efficiency and travel speeds were also a major victim of excessive car traffic in cities and towns. In particular, Jacobs did not acknowledge how the New York subway helped make her own Greenwich Village neighborhood as vibrant and diverse as it was. The Buchanan Report admittedly was commissioned to address traffic in towns, but the role of public transport and the need to maintain it was not emphasized. It could be because, like New York, it was part of the background in the UK and was assumed to always be there. Nevertheless, his report did state that future city planning needs to coordinate new development with both private and public transportation in order to enforce the "much needed integration of land use planning and traffic" and that indeed one of the strategies to contain vehicle use would be to subsidize public transit sufficiently such that it would be cheaper than using the car.

In the 55 years since these early treatises which recognized the car problem, both Europe and the USA have gone on to the next two stages identified by Hardin:

- establishing a new criterion of judgment; to wit, acknowledging that pedestrian, bicycle, and transit convenience and safety, and the ambiance of the city center are indeed as important if not more important as the accommodation of the motor car; and
- accepting and adopting mutual coercion on the use of the commons, i.e. laws, regulations, policies and procedures to put these new criteria of judgment into effect. The relative adoption and success of such regulations and strategies varies widely, but nevertheless progress has been made on both sides of the Atlantic, particularly in European city centers, such as pedestrian-only streets, congestion pricing, low-emission zones and ZTLs. How the USA will continue to respond to the challenge of the overuse of the automobile, particularly with the advent of Transportation Network Companies (TNC) and autonomous vehicles, remains to be seen.

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Piazza Maggiore, Bologna c.1960

Piazza Loggia, Brescia c.1910

Figure 4: Italian piazzas throughout the decades: Cars inundating Italian piazzas has been a perennial problem since the beginning of the auto age, which has resulted in most cities banning cars from most of the grand piazzas.

Piazza Sarzone, Genova 2009

Piazza Plebiscito, Napoli c.1980

San Francisco TDM Ordinance: A tool for promoting sustainable transport

Charles R. Rivasplata

Preface

Transportation Demand Management (TDM) is often seen as the glue holding together a diverse set of measures and practices aimed at improving the quality of life by lowering our dependence on the automobile. Dr. Joseph Kott fully understood this need to promote transport systems that can effectively reduce traffic congestion, and embraced numerous TDM measures in his capacity as Chief Transport Official of the city of Palo Alto (California) and throughout his professional career. In addition, he duly practiced what he preached, regularly opting to bicycle or walk to his destination, rather than jump in a car.

In the spring of 2016, Joe invited me to his Presidio Graduate School transport class in San Francisco to present my thoughts on the city's draft travel demand management ordinance. What better way to share some of the document's proposals, in exchange for an invaluable session with Joe and his students! It was Joe's invitation to showcase the TDM Ordinance that prompted me to take an even greater interest in the draft ordinance and its later adoption. In turn, this allowed me to reflect on the future of TDM in San Francisco, both in our joint classes at San Jose State and Stanford, as well as in my own research. I respectfully dedicate this paper to Joe's memory.

1. Introduction

Currently, one of the biggest urban challenges faced by cities is to reduce the negative impacts of private vehicles. With an increase in the number of cars worldwide, not only has there been an increase in the level of urban congestion and harmful air emissions, but also a serious imbalance between transport and land use in cities. In recent decades, transport planners have become increasingly aware of the need to promote mobility strategies, especially in light of the decentralisation of activities away from urban centres. The negative impacts of increasing private vehicle use (e.g., rising levels of traffic congestion and fatalities, deteriorating air quality conditions, lack of physical activity) on cities and suburban areas are well documented, causing a great deal of concern amongst local residents (WHO 2011). As a result, many local governments have sought to curb private vehicle use, employing practical, low-cost solutions, such as Transportation Demand Management (TDM) measures.

Increasingly, local and regional governments have found that whilst it is necessary to build urban infrastructure for the movement of goods and services, it is also important to make efficient use of existing facilities when designing mobility programmes and promoting alternative modes to the private vehicle. This is especially true in low density communities where public transport is limited. In order to be effective, a suite of TDM measures must form part of a comprehensive TDM programme.

This paper begins with a description of TDM and its evolution, and provides a brief overview of the city of San Francisco and its surrounding region. It explores transport policy in San Francisco and recent efforts to coordinate transport investment with local land use planning. These efforts to provide new travel alternatives to the auto have been implemented in a number of European and Asian cities, as well as in a small number of cities in Latin America and Africa.

Next, the paper reviews San Francisco's Transportation Sustainability Programme (TSP) and the role that TDM plays in promoting mode shift through the further improvement of TDM programmes, i.e., which increasingly have been developed to closely respond to the access needs of specific population groups. It presents not only the complex myriad of issues facing the city in the next twenty years, but also the tools employed in ensuring that buildings commit to a specific set of TDM strategies aimed at increasing the number of travel options available.

1.1. Transportation Demand Management

Transportation Demand Management (TDM) encompasses a set of low-cost tools and short-term strategies that encourage the use of sustainable transport options whilst improving the efficiency of the transport system and reducing transport agglomeration. TDM is a layer of information, programmes and policies that make sustainable transport options (e.g., public transport, active transport modes) more attractive and easier to use (Tumlin 2012). TDM raises the knowledge and experience of residents, workers and visitors with various transport options and reinforces wider transport goals in the city and region.

Rather than accept the traditional "predict and provide" practices of increasing the supply of road space to meet private vehicle demand, TDM strategies advocate increased use of alternative options, such as public transport, bicycling or walking (Goodwin 1999). This demand-side focus responds to evidence showing that increases in road capacity often do not provide long-term solutions to traffic congestion, but rather, promote vehicle use, leading to increases in traffic levels and congestion (Noland and Lem 2000). Demand-side options normally require less space and are more energy-efficient than vehicle-oriented, supply-side options. In addition, they are cheaper to use, i.e., when gas, maintenance, insurance and other costs are considered.

In general, a TDM programme is "an institutional framework for implementing a set of TDM strategies" for a target population (Litman 2018). TDM programmes and strategies have focused on producing changes in travel behaviour, improving access to public transport and non-motorised modes, making it more difficult to travel alone in a private vehicle. For example, since the early 1970s, many employers have helped organize formal and informal carpools for their employees. These strategies are charged with increasing vehicle occupancy, often placing restrictions and/or fees on private vehicle use. The principal types of TDM measures are education, promotion and outreach, and travel incentives and disincentives, which are complemented by sustainable travel options and supportive land use practices (Transport Canada 2012). Under this framework, vehicle restriction is an effective TDM measure, complemented by an enhanced public transport network. Congestion pricing, successful in a handful of foreign cities, is another effective measure.

In concept, a TDM programme normally:

- Provides accessible information on sustainable travel options through effective user interfaces;
- Encourages mode shift from the single-occupant vehicle trips to other modes;
- Improves the efficiency of the transport system by managing the demand for transport facilities and services (e.g., through transit and carpooling incentives);
- Affects and complements land use planning; and
- Uses market prices to eliminate the hidden costs of solo driving and the barriers to active and collective modes of transport (e.g., through parking management).

In practice, these TDM strategies have been implemented by some developers to address all kinds of trips, such as those based on geographic location, trip purpose, route, mode and time-of-day. The implementation of these strategies normally entails a good deal of planning and negotiation with authorities. Often, they are linked to wider government policies and actions advocating low cost solutions to the urban mobility issues encountered by both large and medium-size cities. Nevertheless, in order to encourage alternative transport, it is important that regulators require that developers contribute to public transport enhancements, and not merely road improvements.

A number of cities have implemented city ordinances requiring that certain employers develop and manage an ongoing TDM programme of commute benefits. The city of Cambridge in the United States established an Ordinance in 1998 and has done evaluation studies. In Cambridge, the Parking and TDM Ordinance (PTDM) requires that projects reduce the motorisation rate by 10 percent below the current rate. Each year, commercial projects present a TDM plan: those with more than 20 parking spaces must reserve 10 percent of these for high occupancy vehicles (HOV) and build the same number of bicycle spaces (City of Cambridge 2018). With the implementation of the PTDM Ordinance, there has been a change in the size of parking lots, there has been less traffic generated by the regulated projects, the air quality has improved markedly and the city has experienced increases in bicycle and public transport use.

In the same way, the Zoning Ordinance of the City of South San Francisco addresses TDM measures for new non-residential buildings that estimate generate 100 trips per day. All developers subject to this zoning must implement TDM measures that demonstrate a reduction in the number of trips and a partition of alternative modes of 28 percent or more.
However, each city is different and impacts in San Francisco are not the same as in Cambridge or South San Francisco. In addition, emerging modes, such as "ride sourcing" (e.g., Uber, Lyft, etc.) and "shuttles" (small buses or vans provided by large employers), now dominate the market and need to be considered as well.

1.2. San Francisco
San Francisco is a city of approximately 880,000 inhabitants, located within the Bay Area, a metropolitan region of more than seven million (U.S. Bureau of the Census, 2018). Historically, the city has been the hub of the region, with important financial and governmental institutions. Despite the importance of San Jose and Silicon Valley–a global centre of high technology, San Francisco has maintained its position as an important commercial hub, as well as a key location for government agencies and emerging private companies, such as Uber and Twitter.

Due to its location on a peninsula, transport has historically played an important role in the development of the city. Like many other cities in the U.S., San Francisco had a dense network of streetcars and trains up until the end of World War II, when the country experienced an exodus of residents to outlying suburban areas. However, unlike many other cities in the U.S., San Francisco retained a good part of its public transport system (see Figure 1), converting some tram lines to bus (Rivasplata and Albert 1998), but preserving many of its rail lines. Consequently, the city did not witness the full effect of the automobile boom experienced in other cities. By the 1960s, there was a revolt against the state's planned expansion of freeways in the city, resulting in the eventual rejection of a number of freeway projects.
Meanwhile, in order to conserve its transport network, the municipality encouraged the use of public transport through new municipal legislations such as "Transit First", approved in 1972. According to this legislation, the project sponsor has the obligation to design development projects that facilitate the use of public transport. In 1999, this policy was expanded to include non-motorised modes of transport, such as cycling and walking, and became an important component of the Municipal Charter (City and County of San Francisco 2007).

On several occasions, the voters of the city have supported transport policies that favor sustainable modes. In 1989 and 2003, voters approved an increase in the local sales tax (value-added tax) to finance new sustainable transport programmes. In 2014, San Francisco voters subsequently

Figure 1: Market Street, Principal Corridor of San Francisco
Source: SFMTA

approved two funding measures to encourage the use of public transit and build safer streets in the city's neighborhoods (SFCTA 2014). Whilst critics rightly point out the fact that sales tax measures do not effectively provide a nexus between payers of the sales tax and transport users directly benefitted by sales tax programme improvements (Wachs 2003; Taylor 2017), these sales tax measures have become popular amongst voters, providing the revenue necessary to improve public transport service and active transport facilities.

2. San Francisco Transport Policy

San Francisco is an attractive place to work, live and visit because it offers a great deal of variety and a good number of travel mode options. In turn, this high level of activity places some pressure on the existing transport network. It is projected that the city will grow substantially in the next 25 years: by 2040, up to 100,000 new homes are expected (as the city reaches one million inhabitants) and 190,000 new jobs in San Francisco. This growth may generate as many as 600,000 additional trips per day. Without improvements in related transport infrastructure, this growth could result in hundreds of thousands of new solo trips each day (SFCTA 2013). TDM clearly has an important role to play.

San Francisco faces challenges related to expected growth in a geographically isolated peninsula. As the city increases in density, transport and land use planners seek solutions to make the city work better for residents of the region, as well as for the future. Due to the costs of building a new automotive infrastructure, San Francisco seeks to do more with the existing system, whilst concentrating on important public projects, such as the Central Subway and the Van Ness Bus Rapid Transit (BRT) project. To be successful, it is necessary to have an ambitious TDM programme that can face the challenges of maintaining mobility and access.

The implementation of Transit First has supported the conservation of sustainable modes, however, its scope has been limited by an ongoing increase in transport demand, the proliferation of the auto in some areas and the commercial construction in outlying areas. Since 1979, the San Francisco Planning Department (SF Planning) has attempted to control development impacts, requiring that owners of buildings with more than 2,500 square metres of office space develop and manage a TDM plan for workers. This effort has included the ongoing regulation of buildings through periodic evaluations. Unfortunately, this regulatory effort has often lacked the necessary resources, and consequently, some buildings have avoided their TDM programme responsibilities.

In response to growing public concern, city government has more recently prioritised the need to follow-through in consistently enforcing all kinds of developer requirements, and has called for greater cooperation between the private sector and the public sector, as well as an environment of greater transparency and trust. San Francisco has also identified the urgent need for a new comprehensive approach to address transport challenges, particularly one that seeks to achieve greater mode shift.

The Sustainable Transportation Programme (TSP) attempts to improve and expand San Francisco's transport system, in order to accommodate new growth. In developing the TSP, smart planning and investment are designed to ensure safety and comfort now and in the future (San Francisco Planning Commission 2017). The TSP is composed of the following components:

- Invest - improve transport to accommodate growth, where developers are required to pay a Transportation Sustainability Fee ("TSF") for new projects, i.e., to improve transport capacity and reliability, as well as infrastructure;
- Align - modernise the environmental review process, changing how the city analyses project impacts on transport, and its relationship with the California Environmental Quality Act (CEQA); and
- Shift - encourage sustainable travel, regulating the overall demand for transport network through mobility management, and ensuring that new projects facilitate the use of sustainable transport modes by residents, workers and visitors.

One of the principal tools of the Shift component is the San Francisco TDM Plan, which is based on the 2014 Transport Demand Management Strategy (San Francisco Municipal Transportation Agency 2017). This document describes the policies, projects and programmes that San Francisco uses to guarantee access and mobility for all sectors of the population. This work involves the efforts of four key partner agencies: Municipal Transportation Agency (SFMTA), Transportation Authority (SFCTA), SF Planning, and Department of the Environment (SF Environment).

In order to implement and regulate the new TDM building plans, the city created a legislative mechanism requiring developers to develop and implement a transport demand management plan. In 2017, after months of research and consultation on the part of the SF Planning, the Board of Supervisors approved the Ordinance. The following section describes the Ordinance and its principal components.

3. TDM Ordinance

The primary goal of the TDM Ordinance is to establish a new transportation demand management programme for employers, residents and other transport users. It requires that each developer create a building-based TDM plan that features measures for reducing vehicle-kilometers travelled, or VKT (San Francisco Planning Department (2017). Planners of the city agencies involved in TDM (SF Planning, SFMTA and SFCTA) developed a menu of TDM measures for implementation. Each measure represents a certain number of points toward compliance, depending on its level of effectiveness in effecting mode shift (SF Planning 2017).

3.1. TDM Programme

The TDM programme is part of an initiative to improve and expand the transport system in order to accommodate local growth and ensure that the development sector contributes to minimising project impacts on the transport system. This includes helping pay for managing and improving the transport system (San Francisco Planning Commission 2017). Each new project is assigned a goal (a specific score), based on the project's land use and its provision of on-site vehicular parking. Developers must choose a combination of measures (from a TDM Menu of eight themes) that collectively achieve the point total. That is to say, the sum of the points from each measure must counterbalance the total goal points established by the city. With more than 25 measures in total, this menu offers options for the developer to comfortably reach its corresponding goal total. The TDM Menu measures are designed to reduce the number of single occupant vehicle trips and the VKT (San Francisco Planning Commission 2017). It includes some of the same measures previously identified by the city. At the bottom of the diagram (Figure 2) the point values of these measures are listed, such as the installation of wayfinding signage (one point), or reduction in parking supply (10 points).

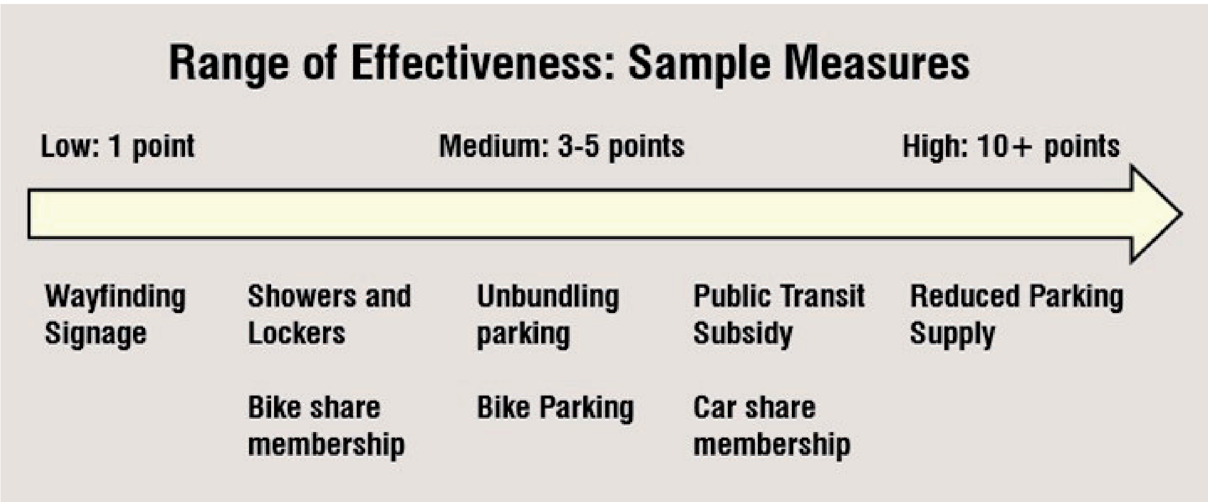

Figure 2: Scale of TDM Measurement Values
Source: SFMTA

The implementation of the TDM Plan of the project is the responsibility of the developer and the eventual owner of the new building. However, he/she has the option of becoming a member of the Transportation Management Association (TMA), a building association that collectively (and with the annual fees paid by its members) offers professional help to its members to comply with their TDM Plans. Each measure of the TDM Menu is assigned a point value based on the relative effectiveness of each measure with respect to other measures in terms of VKT reduction. The scoring system approved by the four agencies of the city is based on a review of the available literature, the collection of local data, the research of best practices and the professional opinions of transport experts. A maximum number of points is also provided for certain categories in the TDM menu (San Francisco Planning Commission 2017).

Some TDM measures, such as bicycle lockers, showers and parking fees, were already included in the San Francisco Planning Code, however, many of these were voluntary measures, or tied to a specific mitigation action. Now, new projects must incorporate TDM measures prior to approval by SF Planning. This requires that the developer study and consider a range of different options. For example, if a project is assigned a goal of 20 points, is it sensible to provide 50 parking spaces, or is it better to sharply decrease the number of parking spaces provided so that goal is overall project lowered? Each developer must carefully measure the costs and benefits of these options at the beginning of the application process and consider formulating a TDM programme strategy.

The cities of Boulder, Cambridge and Los Angeles also have TDM ordinances, but their policies have been applied mainly to commercial and office projects (City of Los Angeles 1993). Instead, with the support of the San Francisco Planning Code, the Ordinance applies to all new buildings of a certain size (more than nine units in residential buildings or more than 930 square meters in commercial or institutional buildings). In addition, the San Francisco TDM Ordinance requires that developers commit to supporting and encouraging the use of public transport amongst the occupants of their building.

3.2. Objectives and benefits of the Ordinance

Like all of the municipal ordinances currently in operation in San Francisco, this TDM Ordinance represents a legal norm. That is to say, all parties subject to these standards are obliged to follow the legal requirements, without distinction. Non-compliance with the norms of the TDM Ordinance can result in monetary penalties, as well as the inability to secure subsequent building permits to undertake building alterations or additions. With these guarantees, the Ordinance is more effectively capable of ultimately achieving some of the objectives listed below.

3.2.1. Objective: maintain mobility

The objective of the TSP is to maintain a standard level of mobility whilst the City of San Francisco continues to grow. The Shift component of the Programme was developed around the desire to minimise the impact of new construction on the city's urban transport system. The primary tool of Shift is the TDM Ordinance, since it is designed to achieve its principal objective: improve personal mobility within the city, focusing on a reduction in the number of single-occupant vehicle trips and a corresponding reduction in the total number of vehicle-kilometres travelled.

Due to its geographic and spatial constraints as a densely populated city at the head of a peninsula, San Francisco cannot accommodate a substantial increase in the number of vehicles on its streets and highways. To this end, the TDM Ordinance is designed to reduce growth impacts on the transport system by reducing the number of vehicle kilometres travelled for new residents, employees and visitors. A reduction in the VKT can be achieved through a substantial change in transport mode share; or an increase in the average occupancy rates of vehicles (more shared trips).

3.2.2. Secondary benefit: better environmental results.

Both a reduction in the percentage of single-occupant vehicle trips and a reduction in the VKT generated by the construction of a new project can improve or at least stabilise environmental conditions. The single-occupant vehicle is the least efficient mode of transport, given the number of seats that are left empty and the sheer amount of space that it occupies on the road. In addition, most vehicles still emit pollutants into the air.

Despite technological advances, the transport sector still contributes to environmental deterioration. For example, it accounts for 36 percent of greenhouse gas emissions in California, 37 percent of emissions in the San Francisco region and 40 percent of emissions in the city of San Francisco (San Francisco Planning Department 2017). The transport sector also emits other pollutants: it accounts for 83 percent of nitrogen oxide emissions in California, a precursor to ozone, a major environmental criterion at the state level (California Air Resources Board 2012).

3.2.3. Secondary benefit: better public health and safety

By reducing the percentage of trips in single-occupant vehicles and the VKT—two figures commonly generated by the construction of a new project—it is possible to improve the state of public health and safety. The former is improved when trips are made on active transport modes, that is, trips made by people who walk and ride bicycles, i.e., they do not emit pollutants. The TDM Ordinance includes measures that developers can research and choose from when developing a TDM programme. Reducing the VKT improves security as well.

3.2.4. Secondary benefit - better process of review of development and projects

The TDM Ordinance also provides more certainty and flexibility to new developments, providing project sponsors with a clear path toward compliance (see Figure 3). Each developer determines the amount of parking that is to be provided and thus, determines the goal of his/her TDM plan before submitting an application. The legislation also provides sponsors flexibility in the development of a TDM plan that best suits the project and area needs of a new project.

The transport options offered by the new projects required to develop a TDM plan clearly work in favour of the occupants (owners and tenants) of the building, representing important benefits. For example, real estate ads have increasingly promoted the public transport access that a project can offer, along with the bicycle facilities provided on site. TDM measures that are incorporated into the design of a project provide operational services that are considered benefits because they improve comfort and create travel options.

In addition, in the environmental review analysis undertaken for a project, development impacts on air quality, greenhouse gases and CEQA analyses are taken into account. The City's wider effort to implement TDM as a way to reduce the VKT is consistent with recent changes to CEQA,

Figure 3: Steps for Complying with TDM Programme Requirements
Source: SF Planning

according to California Senate Bill (SB) 743 (State of California. OPR 2016).

3.2.5 Regulation and Evaluation

As the principal municipal agency regulating land use in the City and County of San Francisco, SF Planning is the lead agency overseeing the regulation of buildings with TDM requirements. However, unlike most requirements, this program will include proactive monitoring.

For physical measures, such as bicycle facilities, appropriate signage, and the supply of car share spaces, monitoring will be determined by inspection prior to occupancy, and on an ongoing basis. For programmatic measures such as transit passes and marketing, monitoring will be determined through ongoing reporting. The City will work with non-compliant projects to support them, however those that do not come into compliance will face monetary penalties.

SF Planning has committed resources to monitor and evaluate the efficacy of the TDM Plans that projects put in place. This will allow the city to study individual measures at the project and city levels over time. If certain measures are found to be less effective than desired, or not appropriate for certain land uses or locations, the TDM Programme may be amended. SF Planning will also track new research that looks at effectiveness of other TDM measures.

4. Impacts

Whilst a significant proportion of TDM strategies have modest impacts, only affecting a small percentage of total trips, programme impacts are cumulative and synergistic. A comprehensive TDM programme often impacts a significant portion of travel, resulting in substantial benefits. For this reason, it is important to carefully evaluate entire TDM programmes. The Ordinance effectively converts new buildings into transport demand laboratories. After approving the TDM Programme Plan for a building, officials regulate these documents, surveying residents and building workers to see travel patterns in different ways. In addition to revealing how travel patterns in regulated buildings compare with patterns in unregulated buildings, the data also help establish sustainability objectives and serve as important benchmarks for later studies.

However, since this ordinance was only adopted in 2017 and its implementation began at the end of that year, a full evaluation of its impacts has yet to be undertaken and the overall effectiveness of the Ordinance is still uncertain. The corresponding 2017 legislation requires a series of evaluations starting in the second year of operation. In two or three years, there will be sufficient data to perform this analysis.

Cities including Boulder, Cambridge, and Santa Monica have established TDM ordinances as a means of forcing developers to comply with TDM programme standards. However, the policies of these cities have almost exclusively applied to either commercial developments or office space (Citilab 2017). In contrast, the San Francisco TDM Ordinance applies to all new buildings of a specific size. As a result, it applies to a much larger area of the city and more effectively ensures that transit and active transport modes are not an afterthought, but rather, are immediately given priority and are appropriately incorporated into the design of the project.

5. Conclusion

This paper has explored the recent development of TDM measures, proposing to distribute mobility benefits to a wider target population. Whilst the San Francisco TDM Ordinance promises to change residents' patterns and disseminate important information about the network of travel options for residents and workers, the new TDM programme requirements have only been in operation for 18 months and it is too soon to determine their full impact. Only time will determine to what degree benefits will outweigh costs. Over time, we may be able to determine, for example, that there is a high influx of passengers in high density neighbourhoods, or that a specific bicycle programme has generated a reduction of X percent in the VKT, compared to the percentage in other neighbourhoods. Only the expected increase in construction will give us an idea of the level of pressure it exerts on networks and infrastructure. In addition, it will provide us with a profile of the type of passenger, cyclist and pedestrian using the system.

For a number of years, the detailed estimation of development impacts has become increasingly commonplace. San Francisco is interested in acquiring reliable data on programmes and their impacts from the TDM Ordinance, providing an example and case study for the rest of the world. In San Francisco, we can move from assumptions about the mobility of residents and workers— exemplified by the old parking requirements—to the objectives supported by the research, in accordance with the trends of "smart cities" (and also with the urban culture infused by Bay Area technology). Nevertheless, these "smart" cities need to consider how the money saved by developers (not having to provide as much parking) can be channeled into alternative transport enhancements. Are there lessons that other cities in the region, state and country can learn from San Francisco?

Finally, other world cities can learn from and make use of some of San Francisco's TDM programme to do their own planning and future programme development. However, it should be noted that each city has a unique set of urban characteristics related to such factors as local land use patterns, political orientation, existing transport patterns and mode split. For this reason, TDM programmes and ordinances must be developed on a case-by-case basis. Whilst vital, the mere adoption of a programme does not, in itself, guarantee widespread success. First, it is essential that programme planners seek input from city, state and federal agencies, transport experts and the general public. This process will help planners as they explore the various alternatives for implementing TDM programmes within an established set of constraints and responding to a unique set of local needs and resources.

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Freedom to Drive and the Tragedy of the Commons of U.S. Cities: Reflections on Policy, Culture and Technology

Michelle DeRobertis, Richard W. Lee

Preface

As his own personal and professional networks testify, Joseph Kott was no technophobe: he embraced and used new forms of web-based communication. But he recognized the folly of thinking that new technology alone could solve our transportation and sustainability problems. With this in mind, we dedicate this article to Joe.

Since the appearance of a germinal draft of this article in 2017, (a much-abbreviated version of which was published in the ITE Journal, June 2017, as "The Tragedy of the Commons of the Urban (and Suburban) Arterial"), significant research and arguments emerged on both the potential and the drawbacks of emerging technology such as autonomous vehicles (AV). Two key works were published in 2018 regarding the role of technology in the future of transportation: Daniel Sperling's Three Revolutions and Graham Currie's "Lies, Damned Lies, AVs, Shared Mobility, and Urban Transit Futures". Currie in particular shares our view that 21st century technology is overhyped, and we heartily recommend it be read. We are grateful not to be the only voice in the wilderness.

In this article, we offer our perspective of more than 35 years' experience, using the tragedy of the commons metaphor to frame both the problem and solutions. We find this metaphor is particularly valid with respect to the need to address the innate "freedom to drive" and the need for both the carrot and coercion. This article contains our observations about standard professional practice interspersed with personal experiences and popular culture as well as standard academic references to critique past approaches and axioms that addressed urban transportation issues.

Introduction

The convergence of many issues makes it timely to reassess U.S. transportation policy: climate change and other environmental concerns, global movements toward complete streets and sustainability, ongoing urban population growth, reductions in per capita driving, and, last but not least, the allure of 21st century automotive technology.

In a much-cited article published a half-century ago, "The Tragedy of the Commons: the population problem has no technical solution; it requires a fundamental extension in morality", biologist Garrett Hardin postulated that technological advances in agriculture would not solve the overpopulation problem; rather, humans must relinquish their unconditional freedom to breed. Hardin likened his argument to that of Wiesner and York's on nuclear war, in which those authors concluded that: "Both sides in the arms race are ... confronted by the dilemma of steadily increasing military power and steadily decreasing national security. It is our considered professional judgment that this dilemma has no technical solution. If the great powers continue to look for solutions in the area of science and technology only, the result will be to worsen the situation." (quoted in Hardin, 1968, p. 1243).

The focus of this article is neither nuclear proliferation nor overpopulation, but rather the general conclusion that Hardin and Wiesner and York reached: some problems have no technical solution. For decades, even centuries, an implicit axiom of scientific endeavor has been that a technical solution always exists. However, it is our contention that the problem of automobile congestion cannot be solved by technology that facilitates and reinforces the paradigm of single-occupant automobiles. Beginning with the premise that urban roadways are public commons, this article reframes many of Hardin's "tragedy of the commons" arguments to explore this theme, changing the thesis from the human overpopulation problem to the interrelated issues of automobile proliferation, automobile dependence and traffic congestion. Some of the false paradigms that have contributed to these problems will be described and explored.

Technological or Human Behavioural Problem

A basic underlying goal of U.S. transportation policy for over 100 years has been to accommodate any and all who want to drive. Flink (1970) states that "By 1910, the motor vehicle had definitely been accepted as an integral part of American life" (p. 51) with virtually no restrictions on its use on streets and highways. Although Flink described that the need for drivers' licenses, car registration and insurance was recognized early, for example 26 states required car registration by 1905, free and unrestricted access was and is provided to virtually all roads and highways by all licensed drivers and vehicles. Admittedly there are some toll highways and parkways, predominantly in the eastern and southern half of the USA, but these are a very small percentage of total highway miles; moreover, they are not city streets. The only restrictions on driving on city streets are local ordinances limiting heavy trucks. To address the resulting crescendo of automobiles, the second half of the 20th century witnessed implementation of technical auto-focused congestion "solutions" costing trillions of dollars, from national highway expansion to local traffic signal coordination. The best that can be said of these solutions is that they worked sporadically and temporarily.

Now, in the 21st century, with congestion worsening in cities across the globe, automobile-based technologies are still proffered as solutions: sustainable fuels, electric cars, Transportation Network Companies (TNCs) such as Uber and Lyft, and autonomous vehicles (AV, also known as driverless cars). However, relying on automobiles for urban transportation, regardless of how "green" or "smart", will not solve the problem of too many cars disrupting the functionality and livability of our cities and exceeding their roadways' capacity, degrading mobility for all modes, including cars (DeRobertis and Lee, 2017). A city designed for cars is not a city designed for human interaction. This premise is not new: Jane Holtz Kay articulated it well in Asphalt Nation 20 years ago as did Colin Buchanan for Great Britain in Traffic in Towns over 50 years ago. Yet we Americans have unfortunately made little progress since Buchanan and Holtz Kay in acknowledging this dichotomy. In effect, transportation policy in the U.S. is still based on the premise of the "freedom to drive".

Hardin stated: "a technical solution may be defined as one that requires a change only in the techniques of the natural sciences, demanding little or nothing in the way of change in human values or ideas of morality." (p. 1243). This definition precisely describes 21st-century automobile-technological solutions: electrification, Uber, and driverless cars renew and reinforce our dependence on cars, requiring little or no change in travel behavior and mode choice. Such solutions reinforce de facto values that disproportionately favor cars over people. They also ignore fundamental facts about alternatives, e.g. that mass transit can move ten times as many people in half the space as automobiles (Vuchic, 2005).

The current "war on science" notwithstanding, Americans' general faith in technology and "progress" makes it almost blasphemous to assert that a technical solution is not possible. Yet both Wiesner and York (regarding the nuclear arms race) and Hardin (regarding overpopulation), maintained that solutions to these problems were not to be found in science or in technology. This article is intended to further the discussion of this class of human challenges, which Hardin called "no technical solutions problems". Specifically, traffic congestion and automobile dependence will be addressed, which the authors maintain are fundamentally human behavior problems. It is a problem that does have a solution, but it must be recognized that basing any solutions on unlimited automobile use is an exercise in futility; the goal of an unlimited freedom to drive must be addressed.

Hardin presented tic-tac-toe as an example of a problem with no technical solution; the futility of trying to win at tic-tac-toe was also the crucial plot-point of the 1983 movie War Games which dealt with the possibility of nuclear holocaust (also the subject of Wiesner and York's article). A more practical example of a problem where society looks to technology for a solution is America's sedentary lifestyle. Rising rates of obesity, cholesterol, strokes, and Type 2 diabetes are due in part to less use of our legs to transport ourselves. The lack of physical activity is also a risk factor for less obvious health conditions such as breast and colon cancers and depression (Mendis, 2014). The connection between automobile dependency and human health has been receiving increased attention from many researchers and organizations such as Raynault et al, 2013; American Public Health Association, 2017; and even the U.S. Federal Highway Administration (U.S. FHWA, 2019a). Even though this relationship is now recognized and acknowledged, we as a society turn all too often first to medical technology to lower our cholesterol, correct our blood glucose, repair our hearts. The underlying human behavior problem is ignored: too little physical activity is compounded by the fact that we Americans frequently drive instead of walk for even short trips. The choice often hinges on whether there will be a parking place, not whether we are capable of walking the distance. In Manhattan, for example, driving one-half mile would be unthinkable, whereas in much if not most of the USA, driving is the default routine. We drive our children a half-mile to school, four blocks to the grocery store, even to the gym. Nationally, about two-thirds of trips under two miles are taken by car (NHTS, 2010). In short, if parking is available, many Americans' first instinct is to drive. In A Walk in the Woods, Bill Bryson's memoir of walking the Appalachian Trail, Bryson describes the incredulity of local townspeople near the trail at his desire to walk one mile to the drugstore and his difficulty in doing so in the car-oriented rural town. This illustrates how pervasive our tendency to drive is; quite simply, most Americans have forgotten what legs are for. Our sedentary lifestyle harms our health but medical technology, not a more active lifestyle, is viewed as the cure.

Hardin wrote "It is fair to say that most people who anguish over the population problem are trying to find a way to avoid the evils of overpopulation without relinquishing any of the privileges they now enjoy" (p. 1243). The challenge of traffic congestion is that most who address this problem also aim to leave untouched any privileges now enjoyed. Those who promote purely auto-based technological solutions to solve congestion aim to maintain all of the benefits that cars provide, e.g., door-to-door service, privacy, little or no interaction with strangers, a comfortable personal space with cup-holders and stereos (Diekstra et al, 2003). Buying a Tesla makes it possible for us to feel better about driving without changing our behavior (DeRobertis and Lee, 2017). Our thesis is that the solution to traffic congestion will not be found in new automotive technology, whether it is electric or driverless; rather human behavior itself is precisely what must change in order to solve the seemingly intractable congestion of our urban environments, climate change and improved public health.

Our premise that car-oriented technology is not the solution was recently well articulated by Currie (2018). Currie details the flaws (and "lies") in the theory that new technology in general and TNC and AV in particular will be the solution to urban congestion. Our proposal that individual behavior and policy changes are essential was also behind the recommendations in Sperling's Three Revolutions. Sperling argues that the confluence of three revolutions (electrification, shared mobility, in which he included TNC, and autonomous vehicles) has the possibility to either worsen or dramatically improve urban and suburban transportation. He forecasts two completely different scenarios, a dream and a nightmare, depending on whether there are changes to both individual behavior and government policy. The authors would modify and augment Sperling's proposed policies and behavior changes, but concur that without such policies, the nightmare scenario is likely. And Currie, Sperling and the authors all reject the notion that public transit is no longer relevant; indeed it is the solution.

Maximise Cars or People?

For decades, standard practice among transportation modelers has been to assume that background traffic volumes continuously increase (ITE, 2010, p. 26-30) and they were generally proven right, especially when roads were widened accordingly. But whether a 1% or 5% annual rate, it is ludicrous to assume that this can continue indefinitely. The number of motor vehicles grew from nil in 1885 to 1 billion in 2010; 2 billion vehicles are projected by 2030 (Laurance, 2016). Considering that the average car is 20 times larger and its energy consumption is more than ten times greater than that of the average human underscores the inherent unsustainability of ever greater automobility. The footprint of 2 billion cars is far greater than 7, 8 or even 12 billion humans. One city has recognized the adverse impact of the sheer volume of cars within its cityscape, Brescia, Italy, (population 200,000), which in 2018 included a metric in its Sustainable Urban Mobility Plan to monitor automobiles' physical presence. The indicator is the volume in cubic meters of cars circulating and parked on city streets during the peak hour in the most historically sensitive parts of the city (City of Brescia, 2018). Indeed, this is the only instance the authors know of where it is official policy to measure what Buchanan described as the adverse "visual impacts" of cars (Buchanan, 1963, p. 22).

Just as a finite world can support only a finite population, a finite city can only support a finite share of its space dedicated to cars: roadways to move them and areas to park them. As the space allocated for moving and parking cars increases, it eradicates elements that make a city a city: buildings for living, working, shopping; places to visit and socialize; green space for aesthetics, recreation, and health. Norton (2008) reports that by 1930 American streets had already become primarily thoroughfares for motorists, where children did not belong and where pedestrians were condemned as "jaywalkers". But he explains that this did not occur without a significant fight and cultural change. In 1961, Jane Jacobs devoted Chapter 18 to the destructive-to-cities practices of accommodating the automobile in dense urban areas. In 1963 in the seminal report Traffic in Towns (which has been unfairly blamed for exacerbating automobile dependency), Colin Buchanan wrote how automobile traffic was degrading cities:

> The overriding context in which the problems of urban traffic have to be considered is the need to create or re-create towns which in the broadest sense of the term **are worth living in, and this means much more than the freedom to use motor vehicles**. It is a mixture of all manner of things, convenience, variety of choice, contrast, architecture, history visible in the buildings—all more or less subtle qualities. Life in towns could no doubt be lived without any of them, but it would be a poorer and emptier life as a result. (emphasis added, p. 32)

Buchanan correctly forecasted that:

> The potential increase in number of vehicles is so great that unless something is done the conditions are bound to become extremely serious within a comparatively short period of years. Either the utility of vehicles in towns will decline rapidly, or the pleasantness and safety of surroundings will deteriorate catastrophically–in all probability both will happen together. (p. 7)

These authors all share the notion of: what are cities for if not for people—to live, work, shop, congregate? The means to move within them is—or at least should be—subordinate to the multiple needs and well-being of the people being moved. Therefore, this article argues that perpetual automobile traffic growth rates in cities cannot be sustained. In fact, many western European cities have passed this point and have seen declines in auto use: Paris' decline began in 2001 and Vienna's in 1992, as documented by Jones (2014).

Ongoing urban growth worldwide indicates that traffic congestion is not stemming the desire for urban living. But since one cannot simultaneously maximize space for cars and space for people, we must ask ourselves: as a society, what do we most want ? Cars or livability? To answer this question, society must first reflect on the goals of our investments in transportation. It is not merely to accommodate driving for the joy of driving (although it is acknowledged that the first motor cars were indeed recreational, which coined the term "Sunday driver"). In our time, the purpose of cars and the roads they use is to get people where they need to go; people's needs, not cars, are the crux of the matter.

Bentham's goal of the greatest good for the greatest number is a difficult concept because it seemingly attempts to maximize two variables simultaneously. However, this article maintains that in transportation there is a proven solution: rapid mass transit. For the authors, with respect to the transportation of people in and between cities, the greatest good for the greatest number of people is clearly rapid rail transit. It can transport ten-fold or more people per equivalent width than roadways (Figure 1, which also illustrates that walking and biking is much more space efficient compared with road-carrying cars). As Currie (2018) wrote: "The truth is that transit systems are the only option available for shared occupancy at the volume needed and the quality provided that can meet the needs of large and growing cities" (p.27). Cities such as London and Paris (metropolitan populations of 9 and 11 million, respectively) not just Tokyo (37 million) (World Population Review, 2018) are inconceivable without a robust extensive subway network. Even small cities benefit from rapid mass transit (not simply slow city busses) such as Brescia, Italy, (population 200,000) with an underground **driverless** 3-car metro which can move 8,500 passengers per hour per direction. Indeed, driverless transit vehicles are not just part of the future solution, they exist today in many Asian, European and even American cities; Currie agrees with Sperling that "autonomous" technology is indeed important, however it is driverless trains and improved mass transit technology, not driverless cars, that should be the focus of solutions to urban transportation. "AV trains are not trials; they are not theoretical; they are full systems in passenger operation today." (Currie, 2018, p.22). Such application of 21st century technology is superior to autonomous cars in terms of both feasibility and results.

Furthermore, as William Whyte wrote: "Mass transit makes a pedestrian downtown possible" by making unnecessary vast acreages of parking (p. 320). Cities need public transit, both above and below ground, that is convenient, reliable, fast, frequent and affordable to remain functional and livable. Some would even go further and argue that better public transit is not enough: Dellheim and Prince (2017) argue it should be free to users to maximize usage and equity. Indeed Tallinn, the capital of Estonia, has made public transit free to city residents since 2013 (Jones, 2018), Dunkirk, France free for residents and visitors since 2018 (https://www.eltis.org/in-brief/news/free-public-transport-dunkirk-one-year-later). Even in the USA, the college town of Missoula, Montana has free public busses and in December 2019, Kansas City, Missouri announced it would provide free public transit in 2020.

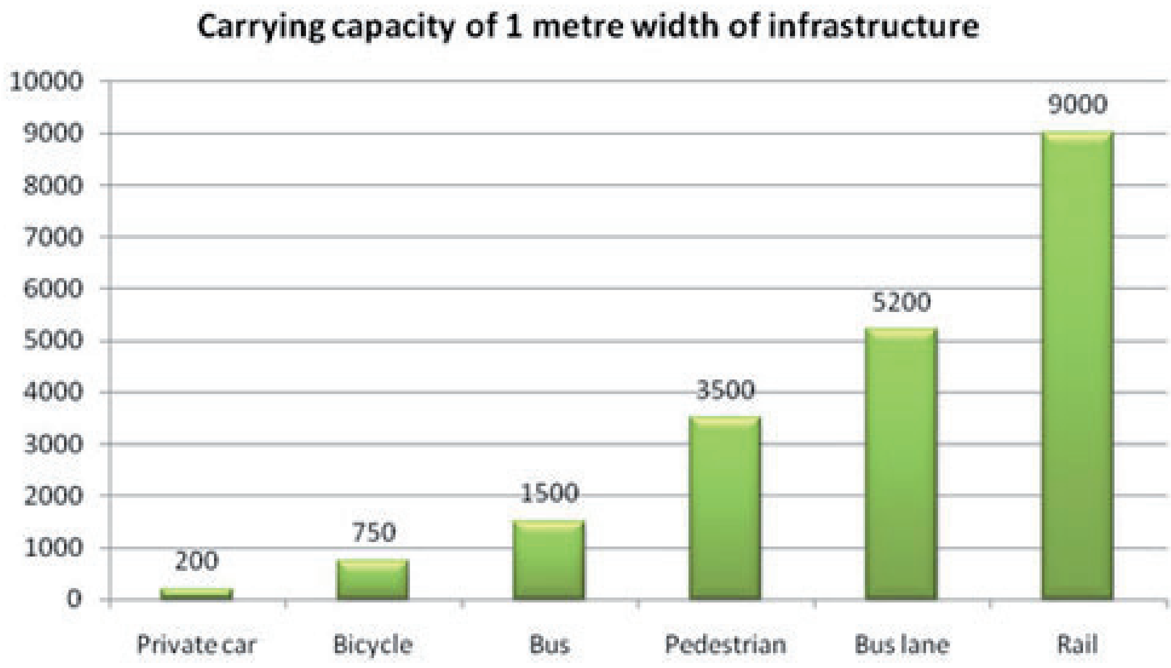

Figure 1: Carrying capacity of 1-meter width of infrastructure.
(Source: www.stagecoachgroup.com)

Attempting to build our way out of congestion with more roads and wider freeways is not just a problem of the past—recently, the idea of a second bridge crossing from Oakland to San Francisco has been resurrected. Admittedly the existing Bay Bridge is at capacity during peak periods, but second bridge proponents overlook that approaching and departing roadways on both sides are also at capacity. Where would these cars go when they reach the other side? A better approach would be to provide mass transit on the other bridges across the bay and expand **t** transit in the Bay Bridge corridor.

It is recognized that people have personal preferences and should generally be free to manifest them. One way they do is in their choice of where to live and work. But when personal preferences collide with the constraints of built-out urban areas, then the clear answer is to provide transport choices that serve the greatest number of people within the context of the cityscape.

If it is impossible to create cities that allow everyone to drive without limits, how do we as a society weigh the tradeoffs and evaluate reasonable personal choices within a finite amount of space? Appropriate criteria are essential to assess the tradeoffs between space for people vs. space for cars. But for the past 70 years, American transportation planners have used a skewed system of judging and weighing tradeoffs. Their methodologies typically evaluated auto travel exclusively, which in turn led (unsurprisingly) to auto-based solutions. Transit has often been disregarded even in situations where transit seems an obvious solution. The status quo for transportation studies is to ask: "Of all who would drive, how can we provide road and parking capacity?" Transit, walking and biking are afterthoughts at best, and are often ignored entirely, as was recently found in a study of U.S. and Canadian practice (ITE, 2019). A different system is needed to evaluate mobility, especially in built-out communities. What if it was asked instead: "How do we make it possible and safe to walk and bike to this site? How can transit travel times become as fast or faster than driving?" (DeRobertis and Lee, 2017).

The evaluation of our transportation priorities must address inevitable conflicts, and solutions will be compromises. But to optimize outcomes, hidden assumptions and decisions behind transportation studies must be exposed. The fallacy of attempting to accommodate unlimited automobile traffic growth entails many hidden decisions and buried costs. Two in particular need to be made explicit (DeRobertis and Lee, 2017). First, some object to expanding public transit because it must be subsidized, but auto driving also has many subsidies, including both the cost of building and maintaining roads and underpriced parking on city streets. Many have addressed this including Roelof and Komanoff regarding New York State in 1994, O'Toole in 2006 and Donald Shoup regarding on-street parking in 2005. More recent pieces have even made it into mass media as editorials (Washington Post, 2013). Furthermore, these direct subsidies do not take into account what economists call negative externalities—costs incurred by those (a third party or society as a whole) who did not participate in the activity that causes the harm. Analysts, economists, and policy makers have acknowledged the many negative externalities produced by automobile use, including but not limited to air, noise and water pollution and greenhouse gasses. Pollution not only damages the environment; it causes direct and indirect adverse impacts to human health as does another negative externality, the lack of physical activity, and above all, the heartbreaking loss of life and limb from the 2 million injury collisions every year in the U.S. alone (NHTSA, 2018). Another of the many reports on how automobiles fail to pay their way was prepared for the U.K. nonprofit RAC foundation which stated "Road use generates costs which are borne by wider society instead of the motorist. These 'externalities' mean that in the absence of taxation or pricing, there is an inefficiently high level of road use" (Johnson et al 2012). This is essentially describing a tragedy of the commons.

Second, the primary focus of Traffic Impact Analyses (TIAs) for new development has been how to accommodate cars, with transit relegated to a separate document if it is addressed at all (DeRobertis et al, 2015). Indeed, the report that purports to guide transportation planners on how to assess the development of a site in terms of its transportation needs and impacts, published in 2010, addresses transit very minimally compared to assessing automobile traffic (ITE, 2019). It is hardly surprising, then, that these studies to plan future transportation needs recommend more and wider facilities for only automobiles. The Institute of Transportation Engineers has recognized this failing and a committee is currently developing recommendations that TIAs routinely examine transit for land development sites at the same level of detail as automobile traffic.

The Tragedy of Freedom in a Commons

The term "Tragedy of the Commons" was popularized by Hardin but predated him by more than a century. Hardin borrowed the metaphor from Reverend William Forster Lloyd, Oxford Professor of Political Economy who, in 1833, described the "commons" to illustrate the problems of Malthusian population growth. Lloyd describes two hypothetical economic situations, the first where each farmer owns his own pasture and the second where all farmers share a common grazing area: "If a person puts more cattle into his own field…. he reaps no benefit for the additional cattle" because what the new cattle eat is deducted from what the other cattle could eat. Thus "what is gained in one way being lost in another. But if he puts more cattle on a common, the food which they [his cattle] consume forms a deduction which is shared between all the cattle" (his own as well at the cattle of others), "in proportion to their number, and only a small part of it is taken from his own cattle. In an inclosed pasture, there is a point of saturation … beyond which no prudent man will add to his stock." (Lloyd, 1833, pp. 30-31)

In short, in exploiting a commons, the individual farmer receives all the benefits of the additional cattle, but the disadvantages are shared by all cattle owners: consequently, the commons becomes depleted, bare-worn and cropped, and all the cattle become puny and stunted.

After Hardin, the concept of the Tragedy of the Commons spread widely and it is now applied to a wide variety of problems arising from unmanaged consumption of freely available resources, referred to as "common pool resources" by economists. The universal lesson is that freedom in a commons brings ruin to all. In particular, freedom to drive brings gridlock to the commons of our roadways, as more and more of us experience daily.

Role of Government

Colin Buchanan (1963) realized that the problem of traffic in towns was more than just an infrastructure or technology problem, but was a social problem:

> …there could be no question of a simple 'solution' to the traffic problem. … For the traffic problem is not so much a problem waiting for a solution **as a social situation requiring to be dealt with by policies** patiently applied over a period, and revised from time to time in the light of events. There is no straightforward or best solution. (p. 8, emphasis added)

Consideration of problems that affect all of society reveals the principle of Situation Ethics (Fletcher, 1966): what is considered acceptable in one circumstance may not be acceptable in another. This is particularly true regarding the things that are constructed to enable civilization, i.e. thousands or millions of people living together in the small spaces called cities. Consider wastewater: two families using a lake for drinking, bathing and waste disposal may be acceptable; for an entire city it is a recipe for epidemics. Urban civilization required new standards as well as technology. Not only do individual ethics change depending on the situation, community values change over time: A half-century ago, razing a neighborhood to build a freeway was standard procedure, as was ignoring public opionion. Today such actions are viewed as politically and socially if not morally unacceptable.

Who is to gather, assess and enforce social values and morals of our day, or as Buchanan suggested, implement the new policies? Put simply, this is the role of government. Some might point to Elinor Ostrom's Nobel prize-winning research on shared resources to argue otherwise, i.e. that the ordinary people using the common resources (and not a central government) are capable of creating rules and institutions to effectively manage the scarce resources of a commons (Indiana University, 2019). This applied to the situations Ostrom studied, such as fishing waters, forests, and groundwater basins, particularly in small local communities. But the evidence of growing congestion on streets and highways of the past 50 years seems to demonstrate that indeed the users of city streets are not sufficiently organized or motivated to manage themselves. It would seem that in the case of city streets, the owner—i.e. the city government—does indeed need to be involved.

Government and government solutions are in disfavor worldwide, but governance is essential, particularly in cities. The role of good government is succinctly illustrated in the scene "What have the Romans ever done for us?" from Monty Python's Life of Brian in which the activists rebelling against Roman occupation grudgingly acknowledge that public works projects (e.g. roads, water, sanitation) and competent city administration have improved their quality of life. In today's urban areas, it is city governments who must respond to the changed situation of our nation's roadways and to moderate the use of cars. Sperling (2018) also argues that significant policy changes (i.e. government action) are needed to ensure that the three revolutions he described does not bring about the nightmare scenario. As Hardin noted "Prohibition is easy to legislate (though not necessarily to enforce); but how do we legislate temperance?"(p.1246). The 21st century challenge is to get people to be more mindful of the use of the car when the commons are at the brink. In short, the use of the commons of our city streets needs to managed, but currently in the USA it is not.

Freedom to Drive vs. Freedom to Choose

The tragedy of the commons of our nation's roadways is irrevocably tied to our freely-made choices to drive even when there are other options like walking. Given the saturation of more and more urban roadways, it is time to recognize that the freedom to drive is unsustainable in finite cities in a finite world. Even if by some technological miracle cars could run on air, both the danger they impart, and their space demands would still exist; the fact remains that cities should prioritize people not cars.

Three important aspects of the concept of the Freedom to Drive include:

1. Transportation planning based on the freedom-to-drive paradigm assumes that demand for auto travel exists independent of outside influences.
2. Often there are few reasonable transportation "choices".
3. The freedom to drive adversely impacts other freedoms.

Let us examine these three points:

The average U.S. household makes ten one-way car trips per day (ITE, 2017). Transportation planners often regard this as a fixed number not influenced by external conditions, but this is wrong. Individuals, consciously or not, weigh their transport options, avoiding the peak hour when they can; choosing other options such as carpooling when parking is expensive. It is a question of human behavior, not physics.

Second, the problem with American cities is that in many cases, transportation choices are extremely limited: people often drive not because they want to but because they have to; there is a lack of other reasonable choices. Is bicycling a fair choice when one must share a car lane on a six-lane arterial with a 50-mph hour (80-km/hr) speed limit? Is transit a fair choice when the bus trip takes one hour versus 15 minutes to drive?

Third, policy makers have so over-focused on Americans' presumed desire to drive and only drive that they have forgotten that there are other worthwhile freedoms: the freedom to walk in comfort, to bike in safety, to hop on the streetcar and not worry about parking, and even the freedom to not own a car and incur its substantial costs in the first place. Eleanor Roosevelt noted: "With freedom comes responsibility" (p. 152). Americans singularly focused on the freedom to drive lose sight of the responsibilities and costs of that freedom (DeRobertis and Lee, 2017). This article maintains that restricting the freedom to drive would relieve us Americans of many these costs, e.g. not only the purchase price but the costs of car insurance, registration, repairs, parking tickets, moving violations, collision deductibles and the responsibility to be a safe, focused, and sober driver. There is also the rarer but still far too common emotional and social cost of premature death or maiming. It is heartening that many millennials are recognizing there are freedoms to be gained in not owning a car, as documented by McDonald (2015) and others. Indeed, the percent of those age 20–24 with drivers' licenses declined from 88% in 1998 to 77% in 2014 (U.S. FHWA, 2019b).

The freedoms surrendered and choices lost due to automobile dependency are many. Few today remember urban life before 1938 when General Motors (GM), Standard Oil and Firestone Tires formed National City Lines, which then acquired and shut down streetcar systems across the USA in favor of GM buses:

> General Motors' (et al) destruction of electric transit systems across the country left millions of urban residents without an attractive alternative to automotive travel. Pollution-free rail networks, with their private rights-of-way, were vastly superior in terms of speed and comfort to smoke-belching, rattle-bang GM buses which bogged down with cars and trucks in traffic. Likewise, electric buses were faster, quieter, cheaper and more durable than gas or diesel units. No one knew this better than General Motors. To prevent the cities it motorized from rebuilding rail systems or buying electric buses, GM and its highway allies prohibited them by contract from purchasing "any new equipment using any fuel or means of propulsion other than gas." Ultimately, the diesel buses drove away patrons and bankrupt bus operating companies. By the mid-1970's, hundreds of communities throughout the Nation lacked any form of public transportation. (Snell, 1974) .

Some, including Jones (1984), argue that Snell here overstates the claim that General Motors et al were the primary cause of rail transit's decline, which began earlier and had multiple causes. The essential point is that electric transit was allowed to wither in U.S. cities. Increasingly, the transportation policy focus—even in urban areas—was to facilitate automobiles. The automobile became the sole option for many trips, even in larger cities.

To ensure all our freedoms, walking, biking and public transit must be made viable choices. These forms of transport will not work everywhere nor for every trip but are viable in many cases. For example, if more children could walk to school—say, with adult crossing guards at busy intersections and by using pedestrian-only shortcuts and bridges that could make their walk to school faster than driving—many more parents would allow their children to walk. The more who walk, the more safety in numbers, resulting in still more school pedestrians. And children might grow up with greater mobility and continue to walk for more trips even after learning to drive. Meanwhile, parents would be rewarded with more hours in their day having been relieved of their duty as school chauffeurs.

For many adults, the criteria for driving or not driving is often parking. The more difficult or expensive it is to park, the more they choose to walk or carpool. Whether transit is chosen depends first on whether it even exists, and then its speed and cost relative to driving.

Mutual Coercion: Carrot and Stick

Hardin cited taxes and parking meters as examples of society's acceptance of "mutual coercion"; he added that "An alternative to the commons need not be perfectly just to be preferable… But we can never do nothing" (p. 1247). While Hardin called it "mutual coercion", a marketing expert might label it pricing and persuasion. Whatever it is labeled, it is well established American practice. People may not enjoy and indeed may tend to resist restrictions on their freedom to drive. Yet citizens accept many restrictions in order to maintain society. Indeed, many car restrictions are already accepted as routine:

in addition to parking regulations, there are driver's licensing, car registration, liability insurance requirements, emissions systems checks, stop signs, traffic signals, speed limits, and seat belts. They may not be popular, but they are still fair, acceptable and socially beneficial. This article maintains that still other measures of mutual coercion are needed to both increase choices and decrease driving.

Recognising the Problem and the Solution

The freedom to drive has had many unwelcome and unanticipated side effects including gridlock, congestion, unsafe streets and unpleasant and less livable conditions in many cities (Appleyard, 1981). To preserve and reclaim our cities as spaces for human beings rather than cars, and to regain other freedoms, including the freedom to walk safely on our streets and freedom to spend our discretionary dollars on items other than car expenses, we must address the freedom to drive, at least in our city cores and elsewhere where streets are congested and dysfunctional. If insanity is doing the same thing over and over again and expecting a different result, the latest echelon of car-centric congestion "solutions" is insane, their high-tech trappings notwithstanding.

The first step in battling addiction is to recognize there is a problem. The first step in overcoming our over-habituation to driving is to recognize that there are two problems: 1) a behavior problem for those of us who drive when we very easily could walk or bike; and 2) a problem of the political failure to rectify the dismantling of mass transit and provide other transport choices in U.S. cities.

Western Europe also experienced a phenomenal growth in car ownership and use after World War II, building autobahns and motorways, resulting in traffic-jammed cities. However, they also chose to limit traffic in cities in various ways: Dutch cities have designed their residential streets as "pedestrian-first" woonerfs for over 40 years (ANWB, 1980). In 1970s, Italian cities began restricting car access in city centers to only city-center residents (Formaglini, 1975 and DeRobertis and Tira, 2016) and today the practice is so widespread that there is an app to help drivers know the affected streets as well as the hours and restrictions, which vary from city to city (https://www.accessibilitacentristorici.it/). In 2003, London instituted congestion charges (DePalma and Lindsey, 2011) and Eliasson and Lundberg (2003) describe other pricing strategies including how Bergen and Trondheim, Norway charge a toll at all highway entrances. German cities have extensive 30 kilometer per hour zones and major streets across Europe have bus-only lanes. Pedestrian streets and zones in city centers are so commonplace (Hass-Klau 2015) that several European cities vie for the distinction of having the longest pedestrian-only street in Europe. Such urban access traffic restrictions are so widespread in Europe that a website was created in 2008 to track them for the benefit of both city planners and ordinary citizens driving in unfamiliar cities (www.urbanaccessregulations.eu). All these measures can be considered sticks—restricting the freedom of driving in cities and city centers.

To be fair some U.S. cities have implemented or are considering such sticks. Many cities have reintroduced or revamped downtown pedestrian streets including Santa Monica (Pojani, 2005). As of June 2019, Manhattan may be on the verge of implementing congestion charging; recently Southern California completed a congestion pricing feasibility study and San Francisco has embarked on a such a study. But even of those strategies that are present in the USA, the extent to which they are used pales in comparison to western Europe, and U.S. cities are seriously behind the curve.

There need to be carrots as well. Although the ultimate result—attractive and vibrant cities—is certainly a carrot, restrictions on driving need to be accompanied by the provision of reasonable options for other transport modes. In short, urban arterials should be more than just conduits for cars. They must accommodate all modes and all travelers at high quality standards. The Complete Streets movement has been a great step forward in this direction, but many cities are only going part way, addressing bicycling and pedestrians but not better transit; even complete street advocates typically insist on the inclusion of biking and walking infrastructure but not transit-only lanes, even on major arterials.

What the U.S. lacks most is vision, specifically a vision not based on auto dependency. A 2011 report published by Building America's Future Educational Fund (BAF Ed Fund, a bipartisan coalition founded by former Governor Edward Rendell of Pennsylvania, former Governor Arnold Schwarzenegger of California, and Mayor Michael Bloomberg of New York) agrees and states that the USA's "lack of vision, lack of funding, and lack of accountability has left every mode of transportation in the United States—highways and railroads, airports and sea ports—stuck in the last century and ill-equipped for the demands of a fast-paced global economy" (Milikowsky, 2011, p.19). Furthermore it states: "Stunningly, the United States has not made a significant strategic investment in the national transportation network since we finished building the Interstate Highway System decades ago. We have let more than half a century go by without devising a strategic plan on a national scale to update our freight or passenger transportation systems." (Milikowsky, 2011, p.14).

We need 50-year comprehensive *transportation* plans with key roles for rail and mass transportation, not 25-year *highway* plans. In contrast, European countries never abandoned urban public transit (Logemann, 2012); moreover, since 2013 the European Commission has encouraged cities to prepare "Sustainable Urban Mobility Plans (SUMP), has issued guidelines for the development of SUMP, and has sponsored an annual SUMP conference since 2014 where cities can share ideas and strategies (https://www.eltis.org/mobility-plans). While many U.S. cities have rebuilt some rail transit lines, partially undoing the damage of the freeway era, there is no federal-level, or in most cases, no state-level vision for robust urban mass transit. For comparison, federal legislation authorizing the interstate system was passed in 1956, and it was completed in 1991, a span of 35 years, for a cost of $500 billion.

Some version of a Green New Deal could be the answer. The BAF Ed Fund calls for more U.S. spending on infrastructure; countries on every continent have outspent the USA in upgrading freight as well as passenger rail which is affecting USA's global competiveness (Milikowsky, 2011). Furthermore investing in public transportation not only creates good local jobs but spurs economic activity and investment. It is notable and encouraging that of ten experts consulted by Time magazine in their 2017 special Infrastructure issue (Von Drehle, 2017) to share their "big infrastructure ideas", five mentioned transportation and two specifically mentioned the pressing need for better urban mass transit, including real estate tycoon Stephen Ross and Columbia University professor and author Kate Ascher:

> Too many regions have antiquated—even nonexistent—transit. America needs high-speed rail connecting regional centers, as well as reliable metro systems that reduce traffic on clogged roadways and improve urban living. And by reducing barriers to employment, efficient and convenient transit can stimulate economic opportunity. (Stephen Ross, quoted in Von Drehle, 2017, p. 37)

> Instead of a quasi-privatized super-efficient national rail network, we have an unreliable patchwork system that defeats the federal government's anemic attempts to revive it and forces Americans onto congested heavily subsidized highways. If we can send humans to the moon, how come we can't make trains run as fast or as punctually as Japan? (Kate Ascher, quoted in Von Drehle, 2017, p. 40)

There are multiple reasons why Japan and Germany have mass public transit systems that are envied in the USA, with multiple layers of rail transit (light rail, subways, suburban commuter rail, intercity rail and high speed rail, as in Frankfurt Germany, 2010 population 680,000 (Figure 2), and it is not solely higher urban density. Surrender terms of World War II prohibited virtually any military spending in Germany and Japan and when it resumed in the 1950s, it was (and remains) a fraction of the USA's

(SIPRI, 2017). Instead, Germany and Japan invested heavily in rail and rapid transit; many argue these investments helped their economies bloom. In contrast, in 2016, over 45% of the U.S. federal discretionary budget went to the Department of Defense and to defense contractors, a total of $606.2 billion, more than was spent by the next nine countries combined (Trading Economics 2018, and Reuters, 2019). If to this is added the $90 billion for the "war on terror" including Iraq and Afghanistan, and veterans spending, the proportion rises to over 60%. This has only been exacerbated in the last four years, the USA just approving a 2020 military budget of $740 billion, but if all is included, is really $989 billion (Amadeo 2019), which is an astonishing 69% of the U.S federal discretionary national budget.

To be clear, the authors found no research that made a direct connection between defense spending and public transit spending but the massive amounts of money speak for themselves. Logemann (2012) attributes differences between German and USA postwar mass consumption, (and underlying infrastructure support, including public transportation) to "public policy, societal and cultural norms, and the metropolitan landscape" (pp. 170-171). With respect to policy and cultural differences, one difference is manifested by the fact that in Germany the railroads were nationalized in 1879, which was considered "early recognition of the state's responsibility to meet the infrastructural needs of business." (Yago, 1984, p. 31)

Yet German policies also actively promoted motorization and highways. Afterall, Germany was home of the late 1800's automobile inventions of Daimler, Benz, Otto and Diesel. Pro-automobile policies continued, including during the 1930s under Hitler (Yago, 1994). Promoting car use recommenced very shortly after World War II with the restoration of the automobile industry which influenced transportation policy that favored the private automobile (Yago, 1994), for example strategies to make car ownership more affordable. The key difference between USA and Germany is that after the war, in addition to repairing roads and building autobahns, the Germans also invested in public transportation—rail and trains were never abandoned: "post war road construction was balanced by a continuing commitment to rail and mass transit" (Logemann p. 171). Even though car ownership increased from 7 to 207 per 1000 inhabitants between 1949 and 1969, (p.171) and "[d]espite West Germans' clear fascination with cars, their postwar standard of living had more to do with trams and trolleys than with chrome and tailfins. In this respect, their contrast to American consumers was glaring" (Logemann, 2012, 2).

In contrast, after the war in the USA, Friedrich Lehnert, a German urban planner, wrote in 1960 "Everything was done for the automobile, and space-saving public transportation was neglected in a way that is incomprehensible" (quoted in Logemann, 2012, p. 173). To this, it should be reiterated that by practically any measure the USA spends far more on "defense" than any other developed (first-world) country: more in absolute dollars, more per capita, more per GDP. And every year politicians call for more, including, as we have just seen, in December 2019, despite the cold war ending 30 years ago. This is simply unsustainable. Furthermore, these funds are not available for other needs or priorities. To illustrate the magnitude of the disconnect, if only 10 percent of the national defense budget went instead to public transportation and Los Angeles (LA) County California received its share according to its population (3.1%), the USA would **still** be spending more for defense than the next top seven countries combined and LA County would receive $21 billion every year. This is 6.5 times the amount LA County will receive through regressive sales taxes that in 2018 was increased by yet another half cent to total 2 cents per dollar. This sales tax increase was hailed as a massive investment in transportation (Los Angeles Times, 2015) and total transportation sales tax revenue was projected at $3.3 billion for 2018 (LA Metro, 2019). Imagine if the equivalent amount of $21 billion annually had been spent on LA public transit since 1950.

Diversion of defense spending is not the only way the USA could have afforded (or could still afford) more investment in public transportation. The federal gas tax has not been raised since 1993, stagnating at 18.4 cents per gallon. In 1979 when independent John Anderson was running for U.S. president, the federal gas tax was $0.04 per gallon and the average price of gasoline in the USA was $1.19/gallon ($0.86 in 1979). If his proposal for a federal gasoline tax of $0.50 per gallon had been adopted, an additional $45 billion per year would have been raised. Even in 2016 with the 18.4 cents/gallon tax, an additional $40 billion annually could have been raised from the additional 31.6 cents by raising the gas tax to 50 cents/gallon. This is the same order of magnitude as diverting 10% of the defense budget.

Others have identified other potential funding mechanisms including Milikowsky (2011. In sum, it is lack of vision not resources that is keeping the USA from significantly ramping up its public transit investments. With no more room to physically accommodate wider roads in most of our cities as well as many suburbs (and many reasons not to do so in those suburban locations where it may still be possible), America must turn again to mass rapid rail transit—the only solution that moves large quantities of people efficiently in terms of space, energy, and dollars, and in many cases can even more time-efficient.

Conclusion

The freedom to drive has resulted in a tragedy of the commons in our large and even medium-sized cities. Unrestricted motor vehicle population growth on finite urban transportation networks is as unsustainable as human population growth in a finite world. For cities to remain, or return to being, places where people not only live but enjoy living, we must limit our freedom to drive, at least in our city cores and on congested corridors. There are a variety of strategies being used in cities and city centers across the globe such as pedestrian areas, bus-only streets, woonerfs, traffic-restricted zones and congestion charges. The USA must simultaneously provide and improve the mass transit within and serving cities to be fast, frequent, and affordable. Neither the autonomous vehicle revolution on its own nor the TNC revolution on its own nor the combined effect of the “three revolutions” will change this conclusion. Indeed, both Currie (2018) and Sperling (2018) agree that mass (rapid) transit will remain essential with or without the increased adoption of AV and TNC and any future combinations and permutations of auto-oriented technology.

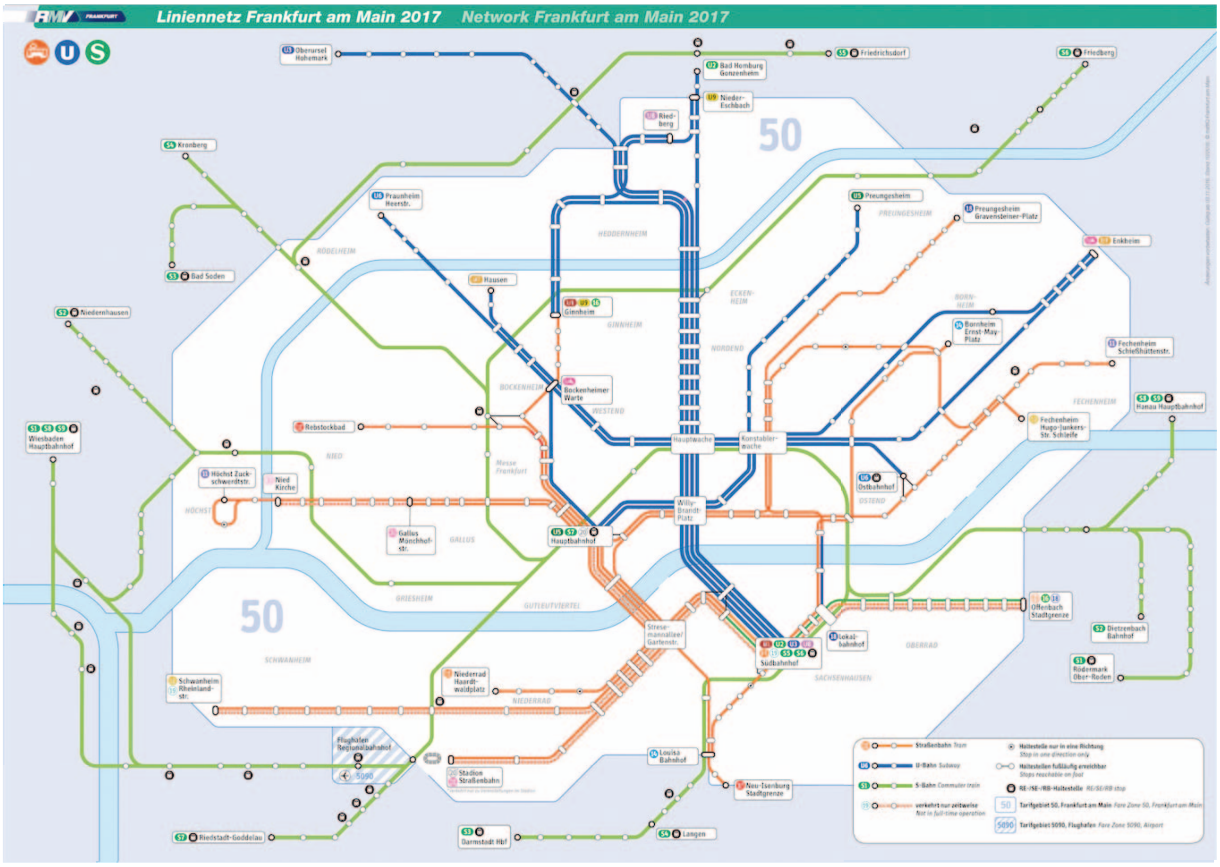

Figure 2: Multiple layers of rail transit in Frankfurt Germany.

This article raises issues and questions, some of which have been raised before, but are in many ways becoming more important. Rather than providing specific answers, some of the implicit assumptions of U.S. transportation planning are critiqued and it is suggested to reframe the U.S. approach from auto-dependent "technology" to instead question individual travel choice behavior, transportation planning practices and public policies. Some may argue that, for example, asking Americans not to drive when they could easily walk or for city officials to implement pedestrian zones is too much of a culture change for Americans. But cultures do change, even in the USA, including the fact that more people are living in cities and the fact that cities as well as suburbs are becoming denser.

As Norton (2008) explained, U.S. culture changed in the 1920s and 1930s to accept the car takeover of residential as well as commercial streets. Two other major culture changes happened just in the last 30 years—recycling and public smoking. Not too long ago, only committed environmentalists recycled by voluntarily taking their aluminum cans, glass bottles and paper to a recycling center. It wasn't until 1980 that the first U.S. city, Woodbury New Jersey, mandated recycling and instituted curbside recycle pick-up (Eschner, 2017; Citylab, 2019). Now many communities in the USA have mandatory recycling (if not zero-waste goals) such that the nationwide recycling rate for municipal solid waste increased from 6% to 36% between 1960 and 2015 (U.S. EPA). The increased recycling rate in some cases can be attributed to state laws such as AB 939, California's Integrated Waste Management Act of 1989, which required cities and counties to reduce the amount of waste going to landfills by 25% by 1995 and 50% by the year 2000. With respect to smoking, thirty years ago smoking in public, including workspaces and in restaurants, was normal. Those who didn't smoke, even if in the majority, had to put up with smoke-filled restaurants, offices, and other public indoor spaces. Today, subjecting nonsmokers to the hazards of second-hand tobacco smoke is not only considered rude, it is illegal. In 1995 California became the first state to ban smoking in the workplace. Federal laws followed in August 9, 1997. As of July 2018, 26 states have enacted statewide bans on smoking in enclosed workplaces (Wikipedia, 2019) .

As can be seen, these major cultural behavioral shifts were assisted if not kick-started by laws and regulations, as Hardin had suggested was necessary when he used the word "coercion". Similarly, laws that restrict driving in our cities can and will become acceptable. And yes, the USA can afford to quintuple our investment in mass transit. Coupled with "Buy American" policies, the new demand for transit vehicles and rail cars could also help the economies of those areas impacted by the reduced use of fossil fuels (e.g. coal) and reduced military spending. We must address human transport behavior with policies that both push and pull us towards more human-scale—and human-centered rather than car-centered—transportation options.

We still have not recognized the folly posited by Wiesner and York in 1964, i.e. that relying only on technology will just worsen the situation. Meanwhile, the failure of our national budget priorities to instead invest in sustainable robust mass transportation continues into its seventh decade. Our cities, mobility, environment, economy and—ironically—national security are all suffering from our persistence in treating human behavior problems, both personal and political, as technical problems.

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Other Research Ideas Developed by Joseph Kott

Michelle DeRobertis, Chris Ferrell and John Eells

Dr. Joseph Kott was always focused on the many and varied aspects of sustainable transportation and the need for applied research to help practitioners and policy makers. He had many ideas for needed research. Below presents two ideas that he was extremely interested in pursuing but did not get a chance to explore.

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Public Transport Service to Sustain Successful Transit-Oriented Developments

Michelle DeRobertis

Preface

Three years ago, Joseph Kott asked me to co-write an article with him on the theme of emphasizing the "T "in TOD—transit-oriented development. He wrote an abstract but we did not have the time to bring it to fruition. It is a topic that we are both passionate about and I regret that we were not able to conduct this research. In Joe's memory we are including it here in the hope that this or a variation of it can still be realized.

Draft Research Proposal Abstract

Transit-oriented development (TOD) is predicated on convenient proximity to adequate public transportation. But what is "adequate" public transport? Transit service frequency, capacity, average speed, reliability, and access to destinations are all dimensions of transit service quality. TOD only works as such if transit service quality support development density. The timing of transit-oriented development and the provision of corresponding levels of transit are crucial. This research would explore the relationship between development oriented to public transit stations and stops and the transit service requirements for TOD success. A range of transit- oriented developments in the San Francisco Bay Area and the Washington, DC metropolitan area would be analyzed with respect to the transit service and quality levels provided to these TODs. The findings would illuminate the importance of transit service capacity, frequency, speed, reliability, and coverage to realizing the potential of transit-oriented development. The research would provide insight into the importance of coordinating development with corresponding transit services. The methodology could include information gathered from a literature review, evaluation of development and transit service data, and interviews with TOD and public transit professionals. Lessons learned from this study would be helpful in decision-making by developers, municipalities, and public transit agencies.

Commentary

An illustration of the U.S. mentality of what constitutes high quality transit is the definition in California law for a high-quality transit corridor: "a corridor with fixed route bus service with service intervals no longer than 15 minutes during peak commute hours" (California Code, Public Resources Code 21155). We would argue that one bus line with a peak hour frequency of 15 minutes should not be considered "high quality". Rather, a corridor should have multiple lines with frequencies of ten minutes or less and which have travel speeds superior to the congested traffic lanes in order qualify for "high quality" and thus the TOD designation.

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Success Factors for Pedestrian-Oriented Streets

John Eells and Christopher Ferrell

In addition to pedestrian-only streets, Dr. Joseph Kott was very interested in what factors make pedestrian-oriented streets vibrant and successful for all modes including vehicles, bicyclists and pedestrians. Dr. Kott was keenly aware that highly motorized European nations like Germany and the Netherlands have many vibrant pedestrian-oriented streets. So why not in America? This question was always on his mind.

Dr. Kott was eager to investigate the attributes that would make pedestrian-oriented streets successful in America the way they were in Europe. He wanted to answer many key questions, including what are the land use, transportation, economic, social, urban design, and street design factors that contribute to or detract from successful pedestrian street environments? Where do the cars go? How is parking handled? How important is public transit in supporting pedestrian activity and vice versa? When and how did these streets become transit and pedestrian-friendly? What difference, if any, does the type of transit, bus or rail on or near these streets make? How important is the location of these streets in relation to major downtown activity nodes such as employment centers, convention and shopping centers, and sports arenas? What difference does proximity to other landmarks and scenic features make? What are the future prospects for these and other transit- and pedestrian-oriented streets?

Dr. Kott was firmly committed to conducting a comprehensive research effort to answer these key questions. He was hoping to identify a set of success factors for pedestrian-oriented streets in the United States. It is our hope that these questions can still be investigated.

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Dr. Joseph Kott's Legacy

To illustrate Joseph Kott's vast experience, interests and influence, the following is a list of the presentations, publications and community service that he was involved in over the course of his distinguished career.

Courses and Webinars

In addition to University courses:
● Co-presented a four-session on-line Webinar on Bus Rapid Transit: Planning, Design, and Operation, for University of California, Berkeley Institute of Transportation Studies Technology Transfer Program (April 2017).

● Co-presented a four-session on-line Webinar on Transit-Oriented Development: Putting It All Together for the University of California, Berkeley Institute of Transportation Studies Technology Transfer Program (March 20, 20, 22, 29, 2017).

● Complete Streets Planning and Design Workshop, co-presented with Ray Davis,, at Caltrans District 3 offices, Marysville CA (April 12-13, 2016) and at Caltrans District 1 offices, Eureka CA (June 1-2, 2016).

Presentations

● A Future for Pedestrian Streets in America?, presented at the Association of Collegiate Schools of Planning Annual Conference, Portland, OR (November 5, 2016).

● Failure and Success of Pedestrian Streets in America, presented at the International Conference on Transport and Health, San Jose State University, San Jose, CA (June 13, 2016).

● Transportation Planning for People: Right-Sizing the Car in Our Cities and Suburbs, presented at Let's Get Moving, Silicon Valley! 2016 Summit, Microsoft Corp. Conference Center, Mountain View, CA (May 7, 2016).

● The Emergence of Sustainable Transportation in America's Communities, presented to Transport Presidio, Presidio Graduate School, San Francisco, CA (January 23, 2016).

● San Francisco Bay Area Urban Planning, Transportation, and the Environment: Challenges and Opportunities, presented to visiting officials from Xiamen, China, under the auspices of the US China Exchange Council, Union City, CA (January 5, 2016).

● Urban Transportation and Development in the San Francisco Bay Area and the Emergence of Sustainable Transportation in America's Communities, presented to visiting officials from the China Railway Corporation under the Auspices of China's Ministry of Transport, Faculty Club, University of California, Berkeley (November 25, 2015).

● The History, Practice, and Teaching of Urban Development Planning in the U.S. with an Introduction to the San Francisco Bay Area, presented to visiting faculty from Hunan University of Finance and Economics, Alameda County Conference Center, Oakland, CA (August 24, 2015).

● The Emergence of Sustainable Transportation in America's Communities, presented to the Sustainable Enterprise Conference, Rohnert Park, CA (April 30, 2015).

● The Emergence of Sustainable Transportation in America's Communities, presented to the Department of Environmental Studies at San Jose State University, San Jose CA (September 23, 2014).

● Best Practices in Managing Travel Demand, presented to Mayor M. Regis Labeaume and a delegation of Quebec City officials under the auspices of the Stanford Office of International Affairs, Stanford University (March 25, 2014).

● Transforming Streets, Transforming Freeways: The Emerging Transportation System in America's Communities and Metro Areas, presented at the 11th Annual North Carolina State University Urban Design Conference, Raleigh NC (March 7, 2014).

● Focusing Freeways on Moving People Not Just Cars: The Case of San Mateo County's Highway 101, presented at Let's Get Moving: Transportation Choices & Healthy Communities Summit, Palo Alto CA (February 22, 2014).

- Best Practices in Managing Transportation Demand In Downtown and Other Commercial Districts, presentation given to the Palo Alto Chapter of the League of Women Voters, Palo Alto CA (November 13, 2013).

- Participant on the Active Transportation Panel at the Fall 2013 San Jose State University Urban Planning Symposium, Planning for Healthy Communities, San Jose CA (September 21, 2013).

- Urban Development and Establishing Sustainable Environmental Systems, presentation given at Stanford University to visiting Chinese local officials sponsored by the North American Chinese Educational Foundation. (August 20 and September 3, 2013).

- Sustainable Streets, Sustainable Transportation, presented to the faculty and students of the School of Architecture, University of Virginia, Charlottesville, VA (January 28, 2013).

- Limitations of Travel Demand Simulation and Forecast Models for Use in Climate Action Plans, presented at the 2012 Annual State Conference of the California Association of Environmental Professionals, Sacramento, CA (May 7, 2012) and 2012 Annual California Conference of the American Planning Association in Rancho Mirage, California. (October 24, 2012).

- Research on What Makes Arterial Streets Active and Sustainable, presented to faculty and students of the Department of Urban Planning and Urban Studies, New Orleans, LA (April 19, 2011

- Streets of Clay: Assessment of Six Arterial Streets in the Bay Area for Sustainability and Livability, presented at the 11th International Walk21 Conference and 23rd International Workshop of the International Co-operation on Theories and Concepts in Traffic safety, The Hague, Netherlands (November 17, 2010).

- Discussant, Sustainable Transportation in the Urban System Panel. Smart Green Cities Conference, Stanford University (May 10, 2010).

- Multiple Measures for Evaluating Re-Designed Main Streets, presented at the Institute of Transportation Engineers (ITE) Annual Meeting, Anaheim, CA (2008)

- Mythbusting Common Traffic Calming Misconceptions: Transportation Planning in Palo Alto, CA, co-presented at the California Chapter, American Planning Association (APA) Annual Conference, San Jose, CA (2007).

- Mobility, Environment, and Quality of Life: A Perspective on Transportation Planning in Palo Alto, a public lecture presented at the City of Palo Alto Council Chambers, Palo Alto, CA (2005).

- Smart Growth Transportation Panel Presentation: Planning for Transportation Alternatives in Palo Alto, California, presented at the American Planning Association National Conference, San Francisco, CA (2005).

- Careers in Urban and Regional Planning. Presented at the Stanford University Urban Professions Seminar, Palo Alto, CA (2005).

- Intelligent Transportation Systems Early Deployment Planning for a Small Region, co-presented at the Sixth National TRB Conference on Transportation Planning for Small and Medium-Sized Communities, Spokane Washington, (1999).

- Intelligent Transportation Systems Early Deployment Planning for the Portland (ME) Area. Panel presentation at the Maine Intelligent Transportation Systems Conference, the University of Southern Maine in Portland, August 1997.

- Participant on a Panel on Local and Regional Planning, USDOT Region 1 Conference, Cambridge MA (1993).

- Participant on a Panel on Transportation Issues in Portland, Downtown Portland (ME) Lunch and Learn Series (1992).

- The Regional Economic Impact of Institutions of Higher Education, presented at the Regional Conference of the Society of College and University Planning, St. Louis MO (1987).

Selected Publications, Papers, Reposrts and Studies

• Tribal Transportation Safety Assessment Technical Reports (co-author) for the Bishop Paiute Tribe, the Karuk Tribe, the Blue Lake Rancheria, and the Cher-Ae Heights Indian Community of the Trinidad Rancheria for the University of California, Berkeley Institute of Transportation Studies Tech Transfer Program (November, 2016; December 2016; March 2017).

• Streets of Yesterday, Today, and Tomorrow. World Transport Policy and Practice (February 2016).

• Changing the Paradigm of Traffic Impact Studies: How Typical Traffic Studies Inhibit Sustainable Transportation (co-author), ITE Journal (May 2014).

• Streets of Clay: Design and Assessment of Sustainable Urban and Suburban Arterial Streets (Doctoral dissertation), Curtin University (November 2011).

• Electronic Transportation Survey of Palo Alto Residents, co-authored paper presented at the Transportation Research Board (TRB) Annual Conference on Transportation Planning for Small and Medium-Sized Communities, Portland, OR (September 2008).

• Measuring Our (Dis)contents: Conceptualizing and Assessing the Impact of Traffic on Residential Street Livability, co-authored paper presented at the Institute of Transportation Engineers (ITE) Technical Conference and Exhibit, San Antonio, TX (March 2006).

• Neighborhood Traffic Management Reloaded: A 30 Year-Old Update, co-authored paper presented at the Institute of Transportation Engineers (ITE) Technical Conference, Las Vegas, NV (February 2005).

• Traffic Calming a Residential Arterial Street: Palo Alto's Charleston-Arastradero Corridor Plan, co-authored paper presented at the Institute of Transportation Engineers (ITE) Western District Conference, Kalispell, MT (July 2005).

• Palo Alto's Innovative Project Relieves Traffic Congestion (co-author). Western City, 78:7, 18-20 (July 2002).

• Greater Portland (ME) Intelligent Transportation Systems (ITS) Early Deployment Plan, co-authored for the Greater Portland (ME) Council of Governments, (March 1998).

• Greater Portland (ME) Goods Movement Study: Report of Findings. Greater Portland (ME) Council of Governments (August 1996).

• Alternative Modes Feasibility Study: Final Report - Findings and Recommendations. Maine Department of Transportation and Maine Turnpike Authority (January 1996).

• Greater Portland (ME) Travel Demand Case Study Management Study: Evaluation of TDM Measures Currently in Use in the Portland Region and Nationally, co-authored for the Greater Portland (ME) Council of Governments (March 1993).

• Regional Impact of Institutions of Higher Education. Planning for Higher Education (December 1987).

• Illinois Bus Service Since the Bus Act: A Diminishing Intercity Network. Illinois Commerce Commission (October 1984)

• North Carolina Transportation Indicators. North Carolina Department of Transportation (1984).

• Increased Motor Fuels Vehicle Fuel-Efficiency and North Carolina Motor Fuels Revenue Outlook to the Year 2000. North Carolina Department of Transportation (April 1983).

•Highway Fund Prospects. Co-authored for the Transportation Planning Division, North Carolina Department of Transportation (March 1981).

• Coal Train Movements Through the City of New Bern. Co-authored for the Transportation Planning Division, North Carolina Department of Transportation (March 1981).

● East-West Rail Passenger Service in North Carolina: A Preliminary Analysis (co-author). Transportation Planning Division, North Carolina Department of Transportation (May 1980).

Professional and Community Service

● Moderated the Transportation and the Environment Panel at the San Jose State University Mineta Transportation Institute Transport and the Triple Bottom Line Conference in San Jose, CA. April 28, 2017.

● Judge, San Jose State University's Mineta Transportation Institute 2017 Garret Morgan Sustainable Transportation Competition; a national competition for middle school student teams, April 25, 2017.

● Peer Reviewer, white paper on application of commuter incentives and smart mobility technology to reduce Bay Area traffic congestion; peer review submitted to the Mineta Transportation Institute at San Jose State University, September 6, 2016.

● Peer Reviewer, article on complete streets; peer review submitted to Case Studies on Transport Policy on February 25, 2016.

● Panel Moderator on the Life Beyond Private Cars: Exploring Transportation Options to Create Multi-Generational Communities Panel at the Fall 2014 San Jose State University Urban Planning Coalition Symposium, Millennials and Boomers: Planning for Changing Demographics in the Bay Area, San Jose CA (October 18, 2014).

● Peer Reviewer, grant proposal to conduct research on the evolution of street design and use in Vienna; peer review submitted to the Austria Science Fund, February 15, 2016.

● Facilitator, Workshop to the TRB Automated Vehicles Symposium 2014, Transportation Research Board, San Francisco, CA, July 18, 2014.

● Participating Expert, Stanford Research Park Transportation Demand Management Charrette, Palo Alto, CA, March 18, 2014.

● Transportation Expert Working Group Member, Sustainability Accounting Standards Board, San Francisco, CA, November 2013 – February 2014.

● Placemaking Leadership Council, an initiative of the Project for Public Spaces, February 2013.

● Expert Panel, Transportation, Showcase for Solutions for Planetary Sustainability, Sustainable Silicon Valley, Santa Clara, CA, November, 2012 – January 2013.

● Grand Boulevard Initiative Working Group, SamTrans, San Carlos, CA, 2008-2012.

● Regional Advisory Working Group on a Sustainable Communities Strategy for the Bay Area, Metropolitan Transportation Commission & Association of Bay Area Governments, Oakland, CA, 2009-2012.

● Bay Area Regional Agency/Congestion Management Agency Travel Demand Modeling Working Group, 2008-2011.

● Bay Area Regional Agency/Congestion Management Agency Planning Directors Working Group, 2008-2011.

● Gateway Corridor Study Technical Advisory Committee, City/County Association of Governments of San Mateo County, Redwood City, CA, 2004-2005.

● Santa Clara Valley Transportation Authority (VTA) Technical Advisory Committee, San Jose, CA, 1999- 2005, Vice-Chair, 2003-2004, Chair, 2004-2005.

● Caltrans Statewide Bicycle Advisory Committee, Sacramento, CA, 1999-2005.

● Planning Board, City of Auburn ME, 1993-1998, Vice-Chair, 1996-1997, Chair 1997-1998.

● Organizer and Convener, Maine Intelligent Transportation Systems Conference at the University of Southern Maine in Portland, August 1997.

● Intelligent Transportation Systems America Member for the Portland (ME) Metropolitan Area, 1996 –1998.

- Region 7 Regional Transportation Advisory Committee, Maine DOT, 1993 - 1998.

- Advisor to the Natural Resources Council of Maine in Sensible Transportation Policy Act Rulemaking Process, Augusta, ME, 1992-1993.

- Lewiston-Auburn (ME) Comprehensive Transportation Study Technical Advisory Committee Member, 1989 -1991.

- Transportation Committee Member (Illinois Commerce Commission Transportation Division representative), Springfield (IL) Area Chamber of Commerce, Springfield IL, 1984-1986.