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Incorporating Long-Distance Travel into Transportation Planning in the United States

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Incorporating Long-Distance Travel into Transportation Planning in the United States

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A White Paper from the National Center for Sustainable Transportation

Lisa Aultman-Hall, University of Vermont

National Center for Sustainable Transportation

The University of Vermont Transportation Research Center

About the National Center for Sustainable Transportation

The National Center for Sustainable Transportation is a consortium of leading universities committed to advancing an environmentally sustainable transportation system through cutting-edge research, direct policy engagement, and education of our future leaders. Consortium members include: University of California, Davis; University of California, Riverside; University of Southern California; California State University, Long Beach; Georgia Institute of Technology; and University of Vermont. More information can be found at: ncst.ucdavis.edu.

U.S. Department of Transportation (USDOT) Disclaimer

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EXECUTIVE SUMMARY

In the early years of transportation planning and highway infrastructure development in the United States the focus was on intercity or long-distance travel, a contrast to the metropolitan travel and state-based models that dominate today. Daily home and work-based travel, which have been the focus of data collection and models since the 1950s, are well-modeled by regional agencies and a limited number of state travel demand models even include some long-distance travel. Nonetheless, long-distance travel demand and factors affecting behavior are not thoroughly considered in transportation planning or behavior research. Only one recent activity-based model of national travel demand has been created and its scope was limited by a severe lack of data. The conceptualization of models to consider intercity long-distance travel has changed little since its inception in the 1970s and 1980s. In order to comprehensively consider transportation system sustainability, there is a critical need for improved nation-wide annual overnight activity data and models of overnight travel (a re-focus and important distinct re-framing of long-distance trips that this white paper suggests).

Defining long-distance travel is one of the challenges associated with advancing data and methods. The 50, 75, or 100-mile threshold still persists, creating confusion for study participants and lumping together vastly diverse behavior that is often intercity, inter-regional, or global. Trips may or may not involve an overnight stay and thus part of some long trips, but not all, are captured in typical daily household travel surveys. The majority of long-distance and overnight trips are made for personal purposes, compared to work or business, with visiting friends and family becoming an increasing important factor for well-being. Long-distance travel is also an important part of the economy.

The last comprehensive one-year long-distance national travel survey in the United States was conducted in 1995, while the 2001 National Household Transportation Survey (NHTS) and the 2013 California Household Travel Survey included large supplemental surveys covering 3-months and 8-weeks respectively. Although we lack extensive, historic long-distance travel diary data, we can glean some indications of scale within existing federal datasets. Passenger miles by domestic commercial air, Amtrak intercity rail, and motor coach together comprised 19% of passenger miles in 2016. When personal vehicle travel is factored in, long-distance travel comprises an estimated 30% of passenger miles. Globally, air travel is growing between 3 and 10% annually depending on the country. Research reviewed here indicates that a saturation level for long-distance travel must exist, as its limit is constrained by time and speed, though there is no indication that we are approaching that ceiling.

Truly addressing the economic, environmental, and social equity issues required to create a sustainable global transportation system will entail completely updating our existing planning framework to meaningfully include long-distance travel. It is clear that long-distance passenger

miles must be accounted for when addressing greenhouse gas (GHG) emissions and other negative environmental externalities. Less well-known are the questions of social justice that loom large when one considers the details of long-distance travel. Travel in our society is becoming increasingly associated with quality of life. Those without intercity access may miss opportunity and social capital. However, without representative long-distance travel data it is impossible to compare the relative participation by different groups and to consider latent demand. It is difficult to measure who comprises the global mobile elite and who lacks sufficient intercity mobility for reasonable social network obligations and personal services.

Existing research indicates in general that income, gender, age, children in the household, urban versus rural home location, and worker status all impact the amount and extent of long-distance travel undertaken. Network capital describes elements, often technological, that facilitate networking and traveling beyond one place such as mobile phones, internet services, and social contacts at distance. Technology is also likely to assist in filling the long-distance data gap. Use of dedicated semi-passive Apps for long-distance travel tracking avoids many of the complications encountered in App-based daily travel surveys. The long-distance data quality from Apps will be dependent on sound frameworks for data tabulation that, as of yet, have not been agreed upon for the long-distance domain.

This white paper suggests utilizing a common framework for long-distance data collection and tabulation that re-defines long-distance travel into daily or overnight. We advocate using overnight as the defining characteristic for data collection, which complements existing daily travel surveys already capturing long day-trips. Within frameworks moving forward it is important to clearly characterize all trip purposes, including mixed purposes and purposeless travel, which comprise an appreciable portion of long-distance travel. Spatial data that distinguish between simple out-and-back trips and spatially complex trips are necessary and mobile devices have now made this measurement of long-distance tours feasible. In order to truly model all travel in the current system, we must move away from the idea that most travel is routine, within region, and home-based. Many people, especially the most frequent travelers, have long-distance routines including multiple home bases. Additionally, our models should not assume that travelers staying at a second home, hotel, or friend’s home travel like residents. Efforts to measure and model non-home-based travel or travel at destination are essential to accurately modeling behavior. Daily surveys such as the 2017 NHTS are increasingly doing this. A nation-wide annual activity model of overnight travel must fully incorporate both surface and air travel to allow full consideration of alternative future system scenarios.

The popularization of the automobile and then the proliferation of jet airplanes, now combined with relatively low fares and higher deposable incomes, have brought long-distance travel at a wider scale to a broader and growing spectrum of the population. This presents serious questions regarding sustainability that require discourse in the public realm with informed decision makers and an informed public. The most important first step for transportation planners related to sustainability of the global long-distance travel system may be to understand the implications of the system and to work towards public education and conversation using the media or public involvement processes. Next action could include increasing the coverage of long-distance travel within professional research and planning conferences, forums, and academic programs – spaces where technical content remains focused on daily regional travel.

1. Introduction

1.1 Setting the Context

Truly addressing the economic, environmental, and social equity issues required to create a sustainable global transportation system will require completely updating our existing planning framework to include the study and modeling of travel behavior at a national level. This means developing a framework that accurately represents travel of *all* distances, including the long-distance and intercity trips that have traditionally been considered ancillary to local, home-based trips. Daily home and work-based travel, which have been the focus of data collection and models in the United States (U.S.) for many decades, are well-modeled by regional agencies including metropolitan planning organizations (MPOs) and state Departments of Transportation (DOTs). Academic researchers have also tended to focus their advanced modeling on daily home-based travel within one's region. Within the U.S., individual states motivated to improve external travel representation for their state travel demand forecasting models have led the way in long-distance travel data collection and modeling. Even these models of long-distance travel, however, are lacking in detail and coverage, and generally do not address surface and air modes in an integrated fashion. Thus we are left with a two-tier system of travel data collection and modeling that routinely fails to produce the information needed to understand and plan for evolving national and global travel behavior.

State and regional jurisdictional boundaries are no longer useful boundaries for demarcating travel patterns or volumes. It is essential to take a national and global perspective in understanding all passenger movements. These long-distance trips are increasingly routine for some segments of the population, account for a significant proportion of total miles traveled, and have undeniable impacts on quality of life, the environment, and the economy. Only the USDOT has the scope to lead comprehensive data collection efforts based on new travel data sources to model the increasingly complex global passenger travel patterns in order to guide American infrastructure and system planning towards both accessibility and sustainability.

The looming promise of big data, especially passive and semi-passive mobile device data, compel us to reflect on long-distance travel research conducted to date and to revisit why we are interested in this travel as transportation planners. This reflection can guide in the creation of parameters to define future data collection on long-distance travel. Planners concerned with equity and accessibility might reasonably point out that our current travel survey data includes only realized trips, not the desired or necessary trips that are forgone by some. In this context, access or lack thereof, to destinations a "long" distance from our home represents social network interactions, opportunities, and experiences that are important to well-being in contemporary society. There is a need to ensure that new data collection systems include unrealized travel.

While the topic of travel and travel behavior is of interest to a wide range of individuals, the intended audience for this NCST white paper includes the transportation planners, travel behavior researchers, demand modelers, and engineers that focus on passenger travel demand forecasting, most often using data collected during the last 70 years from household travel surveys. These professionals, whom I will collectively refer to as transportation planners, for many decades have included a limited number of passionate advocates for the collection of so-called long-distance travel data describing non-routine trips outside one's home community or region. Despite their reasoned calls, no comprehensive year-long database of long-distance travel has been collected in the United States since the 1995 American Travel Survey (ATS). The U.S. lags other countries, especially several in Europe, in consideration of long-distance travel behavior.

1.2 What Exactly is Long-Distance Travel?

Defining long-distance travel is one of the challenges to advancing data and methods. Long-distance travel in this white paper is defined broadly as "out-of-town" trips. These trips are often intercity or inter-regional and may or may not involve an overnight stay. Generally they are not trips that are made routinely on a daily or weekly basis, although they may be routine in nature for some people. Europeans have typically used the term *journey* for longer trips away from home that involve an overnight stay and this term could be used here interchangeably with long-distance trips. Long-distance travel in this paper's planning context includes travel by choice for work or business and personal motivations, but does not typically include migration, seasonal travel by migrant workers, or movements of refugees.

1.3 White Paper Outline

This white paper contains six sections. Section 2 sets the context by summarizing levels of long-distance travel and how these have grown over the last few decades. Section 3 describes the connections between long-distance travel and sustainability arguing that the exclusion of this travel from most datasets and models is of concern for measuring the environmental, economic, and equity aspects of sustainability. Section 4 describes the research that has been conducted to date on long-distance travel. While this section is focused on the United States, it includes data collected and studies conducted in other countries. Section 5 describes definitions and attributes of long-distance travel data with the goal of recommending common frameworks for long-distance trip purposes and structures focused around an overnight-based structure for data collection that complements well-established one-day travel diaries. The paper concludes in Section 6 with the most pressing and pertinent research questions and needed action related to long-distance travel and sustainability for transportation planners.

2. Long-Distance Travel Over Time

2.1 Air Travel

Although we lack comprehensive, historic long-distance travel diary data, we can glean some indications of the growth of long-distance travel in the U.S. over time using traffic volume and annual enplanements within existing federal datasets. For example, growth in long-distance travel is evident in air travel for which we have solid documentation of commercial enplanements. It is reasonable to assume that almost all international air travel is long-distance and that most domestic commercial air travel is long-distance. In Figure 1 the total international air revenue miles are plotted with domestic air miles. The number of international air miles relative to domestic passenger air miles has been lower in the past but is now increasing significantly. In the last 4 years, international air miles have totaled more than domestic. The Department of Commerce reports[1] approximately 15% of international trips were for business purposes. They estimate growth is significant at 4% average per year for international arrivals and 2% average per year for outbound citizens. Figure 1 supports the premise that long-distance travel is very important to transportation planning at the nation-scale because it is growing.

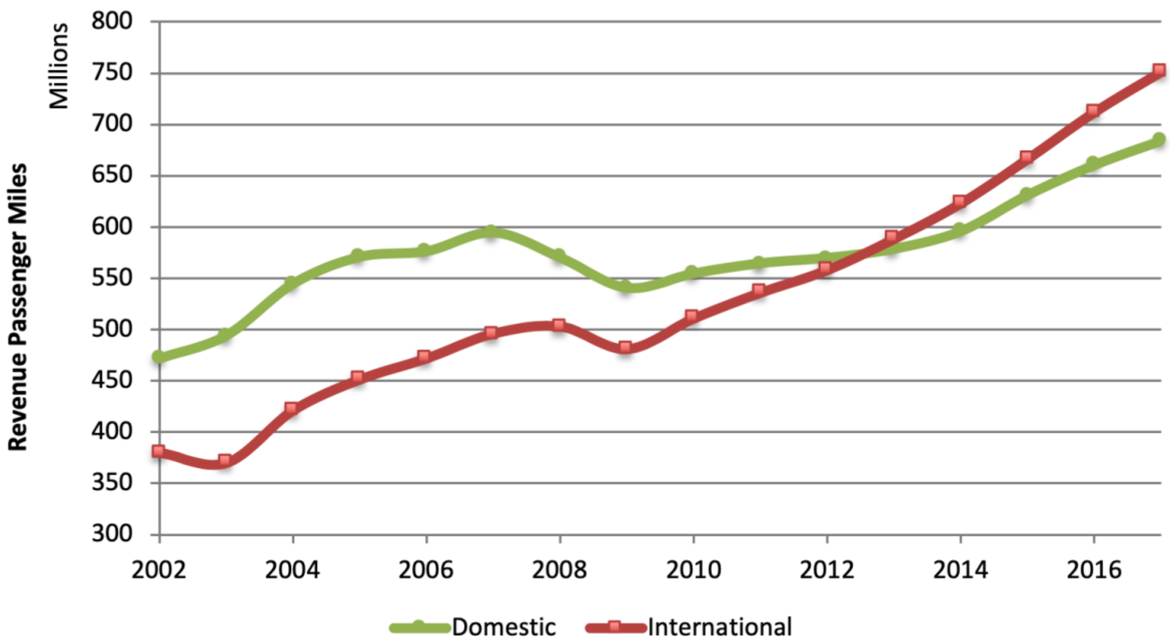

Figure 1. International and Domestic Air Revenue Passenger Miles
(Source: USDOT BTS https://www.transtats.bts.gov/Data_Elements.aspx?Data=3 accessed Sept 2018)

[1] U.S. Dept. of Commerce International Trade Administration Industry & Analysis, National Travel & Tourism Office

2.2 Surface Long-Distance Travel Growth in the United States

Assessing possible growth in long-distance surface travel in the U.S. is more complicated than air. Figure 2 shows the percent of passenger miles of travel (PMT) based on the USDOT Bureau of Transportation Statistics (BTS) by mode. In this case, the passenger miles traveled by air, Amtrak rail and motor bus are summed and taken as a percentage of all PMT. Transit, commuter rail and other modes such as ferry are assumed local. Because the data table only contains domestic air miles, the air miles value was increased by 50% to estimate international air miles assuming domestic and international air miles are approximately equal (Figure 1) and that one half of the international miles accrue to the other country. The percentage of passenger miles traveled in the U.S. by air, rail and motor bus has been increasing for decades. This suggests that long-distance travel may be increasing as a percentage of miles but is not necessarily convincing without understanding what proportion of surface highway miles are undertaken for local versus long-distance travel.

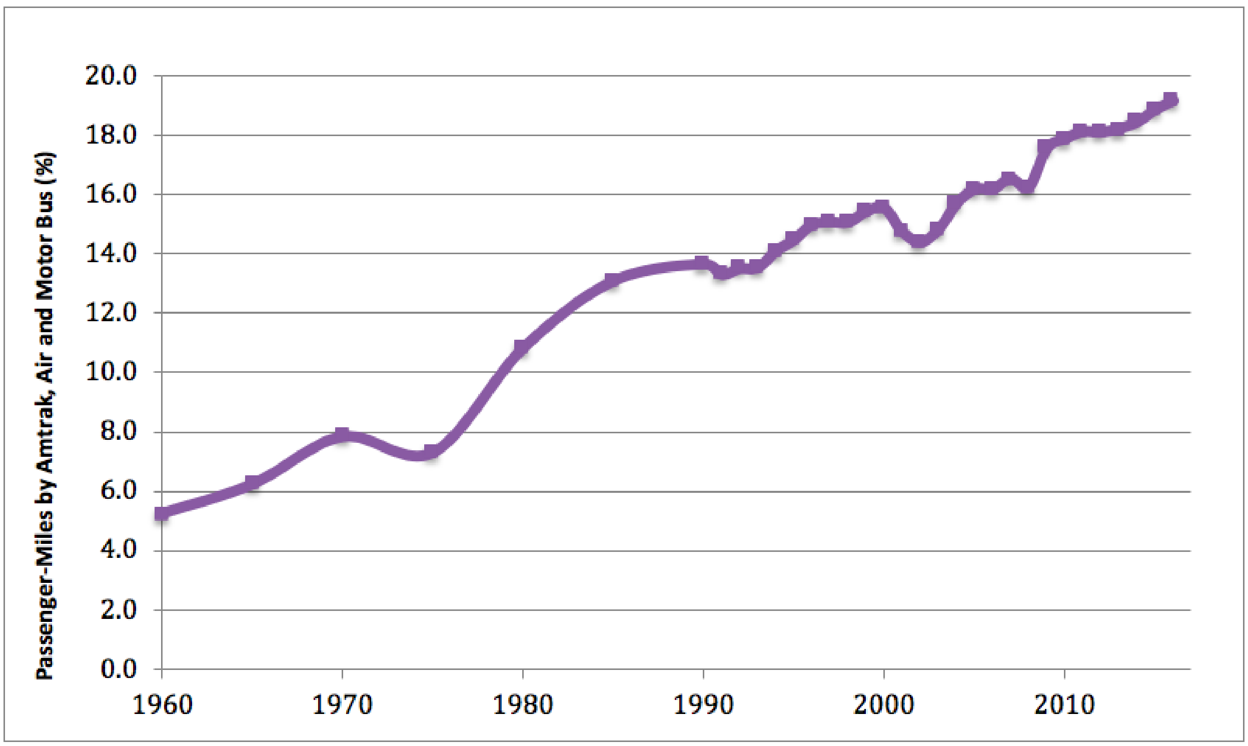

Figure 2. Approximation of Long-Distance Travel over Time based on Rail, Air and Bus Modes
Sources for Surface and Air: USDOT BTS Table I-40 Passenger Miles of Travel - https://www.bts.gov/content/us-passenger-miles - accessed September 2018

The blue line of Figure 3 illustrates average national passenger miles of travel (PMT) calculated by the USDOT based on traffic volume counts and vehicle occupancy averaged by year. This line includes all surface modes. These are the data that generated so much attention in recent years as planners debated whether passenger vehicle travel had leveled out in 2007 or whether this dip was due to the economic slowdown (Circella et al., 2016; Peuntes, 2012). The main dip in this graph is due to a method change in the data procedures. As vehicular travel has begun to increase post-recession (including on a per capita basis), it now seems we have not yet peaked in terms of highway vehicle mile of travel (VMT) or PMT regardless of calculation method. The green line in Figure 3 is passenger miles of domestic air travel measured based on passenger enplanements on domestic commercial flights in the U.S. Because the National Household Transportation Survey (NHTS) conducted every 5-7 years has a deliberate focus on daily local travel one might use the PMT calculated with these data to estimate surface daily (i.e. non-long distance) travel. The NHTS excludes most long-distance travel by virtue of its one-day focus. PMT based on the NHTS that includes predominantly non-long-distance travel is shown in the square red boxes of Figure 3.

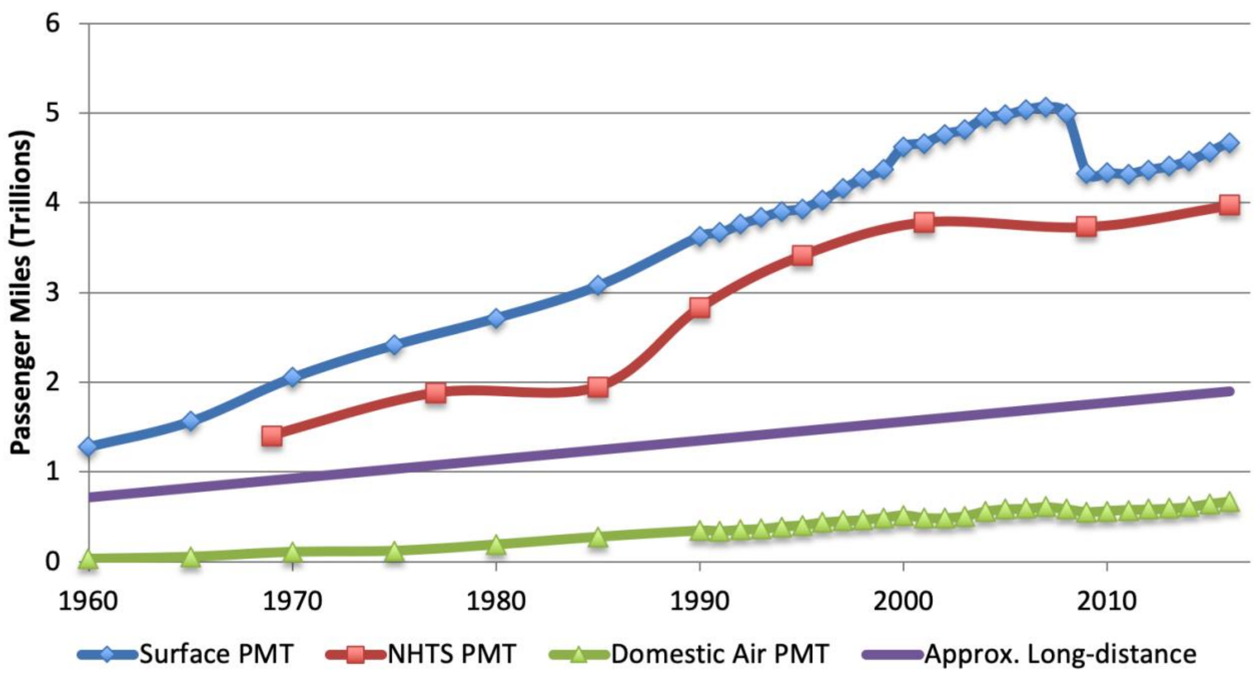

Figure 3. Approximation of Long-Distance Travel over Time in the United States
Sources for Surface and Air: USDOT BTS Table I-40 Passenger Miles of Travel - https://www.bts.gov/content/us-passenger-miles - accessed September 2018
Sources for NHTS: Santos et al. 2011 and https://nhts.ornl.gov/ access September 2018
Approx. LD = three linear regression models for Surface - NHTS + 1.5Domestic Air

The approximation of average long-distance travel over time, shown in purple in Figure 3, was calculated using three linear regression models, estimated for surface PMT, NHTS PMT, and domestic air PMT. Modeled NHTS PMT was subtracted from modeled surface PMT to estimate surface long-distance miles. One and one half[2] of the domestic air PMT was added to account for both domestic and an approximate number of international air miles. Only half of the

[2] See Figure 4. International air passenger miles are about equal to domestic miles and half of those miles are considered here as travel within the United States.

international air PMT was counted as described above. The regression models were used to smooth out measurement error and to account for procedural changes over the years.

Although this is a very rough estimate of so-called long-distance travel over time, it fills a data gap. We can estimate that perhaps 30% of the passenger miles traveled in recent decades in the United States were long-distance travel. This is consistent with 22%[3] of miles traveled being on trips over 100 miles in 1977 and 25% in 1995 (Zhang et al., 2012) neither of which included an estimate of international air. This is lower but consistent with European estimates that range from 30% to 45% (Christensen, 2016; Rohr et al., 2010; Frick & Grimm, 2014). Long-distance travel comprises a relatively large and increasing percentage of total miles traveled in the U.S. making it very important to transportation planning.

[3] From http://www.fhwa.dot.gov/ohim/1977/l.pdf

3. Long-Distance Travel and Sustainability

Transportation planners have come to view sustainability as requiring consideration of not only the impact of transportation system operations on the environment, but also both the economic and equity aspects of the system. The environmental impacts of the transportation system are numerous (Table 1). Long-distance travel embodies many of these costs and benefits, some societal and some individual (some both). Few studies consider the explicit environmental impacts of long-distance travel and fewer still explicitly consider the negative impacts of long-distance travel on the travelers themselves (Cohen & Gossling, 2015). Incorporating measures and analyses of the sustainability of long-distance travel into policy consideration is important given that long-distance travel is a large proportion of all miles traveled and is growing. Both long-distance and more routine daily travel are responsible for, and associated with, the negative environmental impacts in column 1 of Table 1. However, this white paper focuses specifically on greenhouse gas (GHG) emissions (Section 3.1), not only because it is a timely global policy concern, but because traveling longer distances inherently requires more energy resulting in more GHG emissions. The complex comparison of GHG emissions from surface and air travel requires further consideration and research. Section 3.2 discusses the economy, equity, and well-being aspects of long-distance travel suggesting that equity and well-being have been overlooked in the glow of the economic benefits associated with long-distance travel.

Table 1. Costs and Benefits of Long-Distance Travel

Environmental Costs:	Other Costs:	Benefits:
• Noise • Atmospheric pollutant emissions (greenhouse gasses (GHG), other gas emissions, particulate emissions and air toxics) • Storm water quantity (primarily due to impervious surfaces) • Pollutants to surface and ground water (including those related to winter maintenance) • Use of land and loss of natural areas, habitat fragmentation • Solid waste	• Financial costs • Public Infrastructure Costs • Injuries and Fatalities • Physical human health • Time away from home, home social network and family • Productivity losses • Energy for fuel • Time • Emotional health	• Opportunity and experience • Cultural exchange • Economic development • Social network maintenance and development • Break from routine • Leisure • Employment • Emotional health

3.1 Greenhouse Gas Emissions and Long-Distance Travel

In 2016, transportation accounted for 28% of the U.S. GHG emissions (EPA, 2018). Of these emissions 9% were from aircraft and 2% from rail (EPA, 2018). The atmospheric emissions associated with long-distance travel are an important externality that transportation planners have neglected in consideration of travel behavior change. We have for example, undertaken policies, programs, and infrastructure changes to encourage non-motorized and transit commutes to work, without typically considering the impacts of the commuters' long-distance air travel over the year which may represent more impact (Ottelin et al. 2014).

Considerable attention has been paid to the favorable emissions profile of rail, particularly electric rail, when considered per passenger-mile. van Goeverden et al. (2016) estimated the CO_2 emissions associated with different modes of long-distance travel in grams per passenger-km in Holland using 2011 data. Passenger rail had one-third the emissions per passenger-km compared to automobile for personal trips. Alternatively, critics have aptly pointed out that vehicle occupancy matters in the consideration of emissions on a per passenger mile basis. In 2015, the FAA (2015) reported the energy per passenger-mile of rail travel in the U.S. was only slightly lower than air (both rail and air lower than car or bus) presumably in large part due to passenger vehicle occupancy; trains and buses are often less full in the U.S. Chang and Kendall (2011) demonstrate that California high-speed rail (HSR) GHG benefits are a function of ridership levels.

Chester and Horvath (2012) illustrate that environmental impacts assessment for modal comparisons requires life cycle methods, electricity source identification, and consideration of future vehicle technologies. They point out that HSR has the potential to reduce environmental impacts of long-distance travel in some corridors in the U.S. but that policy decisions must consider 1) train size and service levels, including ridership, 2) infrastructure construction, and 3) fossil fuel intensity of the electricity sources. The summary of discussion from the International Transport Forum meeting in 2009 pointed out that standard rail may be undervalued and under considered; it may be the better choice for minimizing environmental impacts (OECD, 2010).

Airline and airplane affiliates are appropriately pleased to point out that energy use per passenger mile traveled by air has been cut by as much as 45% of its 1968 level (Kharina & Rutherford, 2015). This progress can be attributed to many factors including airplane and engine design, operational changes in air and on ground, and higher airplane passenger occupancy. A significant proportion of the energy used for a flight is during takeoff and to some extent landing. van Goeverden (2016) documents regional air (< 1000km) as half the efficiency per passenger-km than longer haul (>1000km). The relative comparison of air to HSR is context dependent (Chester & Ryerson, 2013; Givoni 2007) with only some conditions showing positive comparison for rail. The "greenness" of rail over air cannot necessarily be assumed (D'Alfonso et al., 2015). Assessment of airplane emissions is further complicated by the reality that airplanes emit pollutants at altitude in the atmosphere. The levels of emissions are poorly understood and hard to quantify given changes in location and conditions (Environmental Impacts of Aviation Committee, 2014)

In terms of emissions impact, one must consider the reality that unlike automobile trips, bus, air, and rail require ground access and egress. An air trip is very rarely door-to-door like one can achieve in a personal vehicle. One must take care not to compare the door-to-door energy of an automobile trip to only the line haul impacts of the mass modes (Chester & Ryerson, 2013). Chester and Ryerson (2013 & 2014) outline the structural differences between air and HSR travel (and thus also conventional rail) that make modeling and comparison challenging. Airports serve regions and rail lines serve corridors. Air has nodes across the globe and the distances between are connected by service provided by private service providers. The expensive infrastructure investments are made at airport nodes, and connections and routes between these nodes can change with service schedules. Rail infrastructure investment is more difficult to change because rail is not spatially flexible. Coordinating planning, assessing competition, and evaluating the sustainability between these modes is not unlike comparing apples to oranges. The scale is off not only in terms of trip lengths, but also what can become accessible over a given time horizon.

Ultimately, the challenge of integrating planning models of surface and air modes is the very distinct nature of the airline industry compared to public sector highways and household-based vehicles. Airlines undertaking air service planning are large private companies seeking to make a profit. They sell and market a service between city pairs, thus, their interest in ensuring demand levels are served is different from that of the public highway planner. Yet the future of minimizing GHGs from the long-distance portion of the transportation system will increasingly fall towards understanding the impacts of air travel and for this to happen comprehensive assessments must account for all modes in the full system.

3.2 Sustainability in Terms of Economy, Equity, and Well-being

3.2.1 Economy and Growth

The American Travel Association estimates that in 2017 travelers in the U.S. spent just over $1B that generated $2.4T in economic output and 15 million jobs (1 of 9 jobs in the country) (U.S. Travel Association, 2018). This is true beyond the U.S. as well where tourism in Organization for Economic Cooperation and Development (OECD) countries represents 5% of gross domestic product (GDP), 6% of employment, and 21% of service exports (ITF OECD, 2015). This direct contribution to the global economy is one way to consider the importance of long-distance travel. Any measure to limit growth in long-distance travel as suggested above for environmental reasons would undoubtedly lack support for economic reasons. Alternatively, increases in long-distance highway travel are undoubtedly contributing to increased congestion with effective negative impacts on both freight and passenger transportation which has an economic cost.

Of importance to both infrastructure planning and sustainability is the question of how much more growth we can expect in long-distance travel. There is significant data supporting the association between air service and economic development of a region (Derudder & Witlox, 2016, Baker et al. 2015). On a country level, gross domestic income per capita is strongly related to scheduled airline seat capacity (Bowen, 2014). The direction of the causation between air travel and economic activity varies between studies (Hakim & Merkert, 2016; Van de Vijver et al., 2016). There has been an “iron law” in recent economic history that GDP per capita is proportional to passenger km of travel per capita (Schafer & Victor, 2000). Rising household incomes have traditionally led to more travel distance often representing constant travel time but purchasing faster speeds to go further. This long-standing assumption is coming into question. In some U.S. metropolitan areas, for example, the long-assumed positive growth of GDP as a function of increasing VMT is not seen in recent years (Kooshian & Winkelman, 2011). Crozet (2010) presents data for European nations also showing a decoupling of GDP and mobility. Leunig (2011) illustrates that transportation access is in many ways a necessary but not sufficient requirement for economic growth.

Consideration and forecasting of long-distance travel growth requires consideration of the drivers of travel as well as a potential saturation point. A decoupling of GDP and travel does not necessarily mean that there has been a saturation of long-distance or air travel and Crozet's models of France suggest we are a long way from saturation. While mechanisms proposed to explain reaching a saturation or peak level of travel differ, there is a general sense that a saturation level must exist (Goodwin, 2012). Gillen (2010) outlines the historic drivers of air travel as increases not only in GDP, but also income, trade, changes in international agreements, and air carrier business models. Future projections based around GDP are high as much as 5% per year through 2030. Gillen argues that trade and service levels matter most to passenger air travel demand and suggests that projected growth rates will be lower than what is widely accepted because the increases in demand from system and international policy changes have already accrued. The International Air Transport Association (IATA) (2018) recently announced their 2017 statistics indicating that airlines globally carried 7.3% more passengers in 2017 compared to 2016. The largest increase was in Asia (10.6%) while North America was considerably lower (3.2%). Their press release points out that in 2000 the average global citizen flew once every 43 months, but in 2017 this figure was once every 22 months.

Graham and Metz (2017) suggest that growth rates are an indication of whether any service is approaching saturation. When a new service such as air travel is first introduced the growth is low, then there is rapid growth as awareness of the service increases. Finally, as the system approaches saturation the growth rate slows. Air growth can happen when existing flyers fly more and/or new flyers start flying. Using UK survey data, Graham and Metz (2017) document that the reasons for a person not flying in a year are very diverse and do not suggest that the individuals will remain non-flyers. Graham and Metz (2017) cite IATA and AirBus data on flights per year by country. High-income countries average 1.48 flights per person per year while North America alone is 1.59 and Europe is 0.99. Low income countries average 0.04, and the Asia Pacific averaged 0.24. Growth rates are not slowing and these data suggest saturation levels have not been reached. Long-distance travel is going to continue to see significant growth globally. Realized passenger long-distance travel is undoubtedly related to wealth. Sustainable development presents the possibility that people in poorer nations will have increased resources, including accessibility to destinations, which in turn will increase long-distance travel.

3.2.2 Equity and Well-being

Long-distance trip purposes (which are described in detail in section 5.3) include vacation and leisure, visiting friends and family, exploration and adventure, but also travel for services such as medical trips, shopping, or other personal needs. These out-of-town long-distance trips, regardless of distance, are increasingly what we associate with quality of life. Those without access may miss the opportunity to accrue social capital. Alternatively, many of these trips, say for work, may degrade quality of life. Increasingly, access to air travel (in terms of affordability, airport proximity, or service levels) defines access for out-of-town long-distance travel. Thus, in many ways, air access in current times may be a determinant of quality of life.

Many groups are recognized as typically underserved in terms of their daily mobility needs (work, food, school, medical service) within our existing transportation system: racial groups (Bullard et al. 2000; Bullard et al. 2004) immigrants including refugees (Bose, 2013; Bose, 2014) low-income households (Bullard & Johnson, 1997), senior citizens, disabled individuals, and children. There has been sparse, if any, study of how the need for out-of-town travel manifests for these groups and whether their needs are well-served. Comprehensive considerations of equity in transportation access do not include consideration of long-distance travel or destinations at distance (Karner et al., 2016, De Vos et al. 2013). Delbosc (2012) tabulates prior studies of transport and well-being, none of which are U.S.-based and none of which include long-distance travel.

The economic justice aspects of transportation facilities on minority and disadvantaged communities are increasingly recognized. Historically, lower income neighborhoods have been in closer proximity to airports, highways, and railroads, suffering disproportionately from noise and local air quality impacts. These facilities, especially airports, include those that have been expanded to serve increasing demand for long-distance inter-regional travel. However, there is limited focus on the relative differential burden of system externalities compared to the demand for these long-distance services by population groups. While a limited number of people benefit from improved global mobility, there are limited measures of who lacks out-of-town travel access.

The role of equitable access to destinations at distance and the role in human well-being is an important consideration related to sustainability and the global long-distance transportation system. As social networks expand, due in many cases to migration, relationships require travel for maintenance. Participation in important family and friend functions such as weddings or funerals may require travel (Urry 2002). Leisure travel offers access to education, experience, and opportunity. While some services such as medical or other personal business require travel.

One may think of personal social capital in relationship to mobility, but this relationship is undefined. One can hypothesize the shape shown in Figure 4. At the low end of mobility on the left one can suppose immobile individuals without access beyond their own community lacking access to employment, adventure travel or time with distance family or friends. At a certain level of mobility there is a large jump in well-being potentially due to access to family or services. As mobility increases, more social benefits accrue until maximum slope is reached and then fewer additional benefits are obtained from each additional unit of travel. Ultimately, too much travel compromises quality of life. Perhaps this is the case of the overburdened work traveler. It is difficult to imagine generalizing this curve. But we can begin ask how to calibrate it for different individuals. It is reasonable to think of a targeted lower level of mobility for some people where individual benefits are reasonably high but fewer miles minimizes environmental damage. At the same time others require increases in mobility for reasonable social gain. The personal cost and benefit of a marginal passenger mile of travel varies by individual and by purpose. These policy questions cannot be answered without representative measures of realized long-distance travel as well as assessment of unmet intercity travel need.

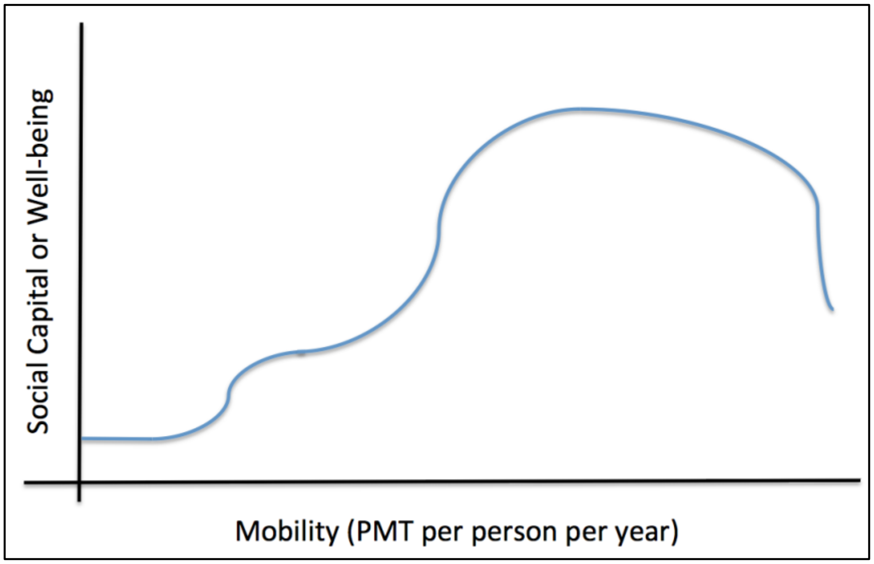

Figure 4. Proposed Relationship Between Long-Distance Travel and Well-being

4. Prior Long-Distance Travel Research

Piecing together what we know about long-distance travel patterns in terms of who is traveling, where they are traveling, and how often they travel is complicated by definitional limitations and a relative dearth of data. Existing research conducted in the U.S. and internationally provides an important general understanding of socioeconomic, spatial, and life cycle patterns in long-distance travel. But data and models are limited. Current efforts at modeling are increasingly nation-wide and new "big data" efforts form a basis for opportunities moving forward.

4.1 Early Years of Long-Distance Travel Modeling in the U.S. (pre-1995)

It is interesting to note that in the early years of transportation planning and highway infrastructure building in the United States that the focus was on intercity or long-distance travel not the metropolitan travel and state-based models that dominate transportation planning today. Originally, the automobile was a "pleasure vehicle" and as a result the first highways led from the city into the countryside, not from city to city (Weiner, 1999). However, by 1921 the Federal Highway Act recognized the need for a continuous national highway system and by the early 1930s most population centers were connected in some way by highway (Weiner, 1999).

The initial focus of the federal government on a system of U.S. highway routes was intended to connect regions and the later Interstate highway system was intended to connect urban areas with a population of 50,000 or more. In 1944, this directive was expanded when the Bureau of Public Roads was directed to build inter-regional highways linking communities of greater than 10,000 people and the first travel surveys were conducted (Weiner, 1999). Early on, it was recognized that rural highway volume growth was greatest on the segments that linked urban areas (Morf & Houska, 1958), a recognition of long-distance intercity travel.

As urban transportation and housing issues gained attention in the late 1940s and early 1950s, the federal aid highway program expanded its aims and investments increasingly toward provision of urban freeways. With the continued needs in urban areas, data collection and modeling focused on the urban areas. This focus was institutionalized in 1962 when Metropolitan Planning Organizations (MPOs) were created for urbanized areas of 50,000 or greater population. In most cases, MPOs create and maintain travel demand forecasting models that rightly or wrongly are the main driving forces for the travel data collection efforts in the U.S. Even by 2007 there was little direct federal involvement in modeling and states and MPOs remain the main developers of travel demand models with half of the states and 85% of the MPOs involved in travel demand forecasting modeling (Committee on the Determination…, 2007).

Since the 1950s, air and rail planning has focused on what we would most certainly term intercity, long-distance travel. These modes were important in the early years of transportation planning in the U.S. The earliest gravity models were applied to air travel (Richmond, 1957). Richmond hypothesized that intercity travel would be proportional to population and inversely proportional to distance but that this would not be strictly true for air. Population was not all that mattered; measures of attraction such as hotel stays were considered by Richmond. Moreover, he suggested based on data between Dallas, Texas and 32 other cities in 1957 that the frequency of air service would also affect ridership.

Congressional calls for a national study of both passenger and freight travel dates back at least as far as 1948 (Hansen et al., 1963). Highway Research Board (HRB) panel discussants in 1961 reiterated the desire for a program to document flow of commodities and passengers by land, air, rail, and water. With the Interstate highway system underway, the HRB panel noted that agencies could not make infrastructure decisions emotionally or by rule of thumb (Hansen et al., 1963, p. 157). Origin destination flows as well as social or economic factors were seen as essential data for model development. These early calls for both passenger and freight data were predominantly intercity. Appropriate methods for origin destination surveys were a specific main focus of discussions due to their complexity and intercity travel analyses were core to this discussion (Hansen et al., 1963). Stakeholders recognized that the comprehensive data collection would be expensive and require careful design. They discussed the need to measure individual attributes and economic driving factors to facilitate forecasting. The concerns and debates of 1961 do not differ significantly from those heard in recent years at TRB meetings regarding long-distance travel, including the debates regarding how to integrate federal and state roles.

The first planning modeling methods in the 1960s and 1970s were intercity applications. Burch (1961) applied a gravity model to 5 cities in North Carolina. Alcaly (1967) used 1960 data for 16 city pairs. Lave et al. (1977) used 1972 census data to consider price elasticities for 33 city pairs. Most long-distance models of the era were aggregate mode choice in specific corridors. Meyburg (1972) modeled the northeast corridor between 1940 and 1960. Koppelman (1989) used the 1977 NHTS to model long-distance mode choice between 130 city pairs. In the 1970s disaggregate intercity mode choice models appear advancing methods beyond the aggregate models (Leake & Underwood, 1978; Watson, 1974). However, disaggregate models did not quickly become commonplace meaning that the advocating for disaggregate models continued into the 1980s (Koppelman & Hirsch, 1986).

In the 1960s, considerable effort was made to formalize state planning structures (Breuer, 1969; Elkins, 1969; Shiatte, 1969) including data systems to support planning programs (Shafer, 1969). The 1962 Federal Highway Act created the transportation planning process. State-based origin and destination studies were conducted by several states. The first years of state-wide transportation planning in New York State are documented in a full volume of the Highway Research Record (Highway Research Board 1969) in which the tremendous growth of air travel is noted as producing severe congestion near airports. By 1969, airports were recognized as having special significance in overall transportation planning in that they “constitute points of transition between intercity and intracity travel” (Lardiere & Jarema, 1969). At the time, significant attention was being paid to airport ground access. Note that the NY, DC, and Boston airline shuttles providing frequent, near on-demand service without reservations were introduced in 1961.

Through the 1960s, high-speed or improved rail service was considered with study between Albany and New York City, as well as from Montreal and Buffalo to New York City (DiRenzo & Rossi, 1971). In 1965, 42% of person-miles traveled in New York State were estimated to be outside of the seven designated major urban areas. It is interesting to note that the competition between, and importance of, surface and air travel in the intermodal system was widely recognized in the 1960s and 1970s, and yet, to this day, integrated models that treat surface and air modes together using person-based disaggregate analyses barely exist. Assessing diversion to rail, including high-speed rail, a common recent motivation for long-distance modeling, was undertaken in the 1970s (DiRenzo & Rossi, 1971; Cohen et al., 1978; Stachurski & Rice, 1981). The importance of terminal access, egress, and parking was recognized in early research (Leake & Underwood, 1981). Focus included both business and non-business purposes. Interestingly, the motivations for considering intercity models as documented in 1981 included short-takeoff and landing aircraft (like those being hyped by Uber for urban rooftop service today), high-speed rail, and energy conservation (Leake & Underwood, 1981).

In 1984, Koppelman et al. documented a comprehensive review of intercity models from the mid-1960s to mid-1980s. They attribute the limited development of long-distance travel models to four factors. First, intercity infrastructure was about linking the nation, which had been accomplished, it was not about reducing congestion, a more pressing problem starting in the 1950s. Second, the data were complex and limited. Third, there was a lack of understanding of the behavioral factors influencing intercity travel. Finally, the transportation problems of concern during that period were not between urban areas but within urban areas. Regrettably little has changed since Koppelman's assessment. Notably, within the factors he lists, he indirectly says that we could not study long-distance travel because we lacked data as a result of focusing on more pressing concerns related to congestion in urban areas. The overwhelming focus on urban congestion, to the exclusion of other topics, was noted earlier by Hansen et al. (1963) as well. The recommendations of needs for intercity travel modeling is also documented by Rice et al. (1981) writing from a Canadian perspective. This team echoes the calls of Koppelman for data as well as the development of disaggregate models.

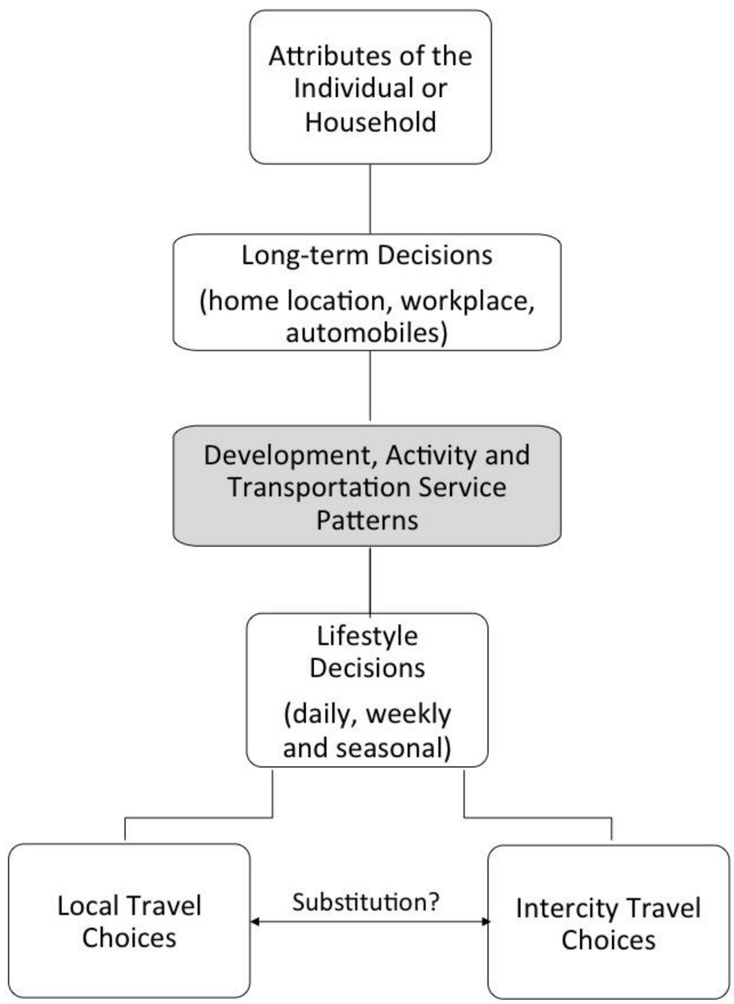

Figure 5. Intercity Travel Choices in Context (adapted from Koppelman and Hirsh, 1986)

Koppelman and Hirsh (1986) recommend a framework for disaggregate long-distance travel models that is still the state of the practice today (Figure 5). Their four-step framework (Figure 6) may be lacking in terms of dealing with multi-purpose and multi-stop long-distance trip tours but it is important to note that the way we conceptualize modeling intercity travel has not changed in 30 years. The details of sophisticated models have not been pursued due to lack of data even though Koppelman and Hirsh recommended specific variables for collection. It is notable that even at this early date this team was recommending collection of locations and including multi-stops in their framework. The predominance of states and MPOs and the failure of long-distance travel to fit within their jurisdictional boundaries is undoubtedly a factor in lack of progress.

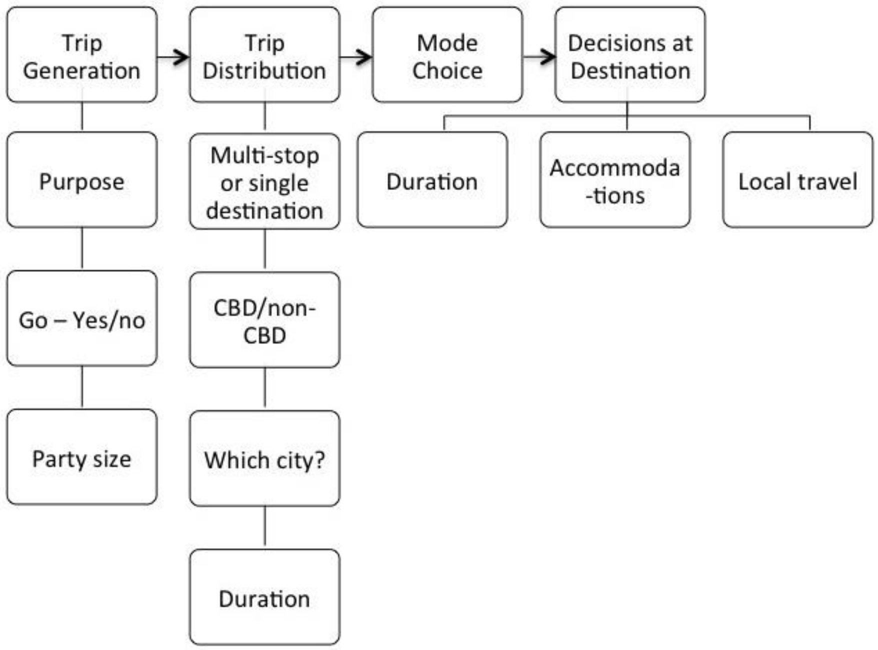

Figure 6. Details of the Modeling Framework (adapted from Koppelman and Hirsh, 1986)

In short, after the initial provision of intercity highway infrastructure, long-distance travel data and modeling yielded to a focus on urban mobility and congestion problems which were by the 1950s considered significant and urgent (Owen, 1956). Despite widespread acknowledgement of the need for intercity transportation planning, aggregate models in select corridors led to few advanced models through the 1980s. Calls for more disaggregate models of intercity travel saw few answers in the 1990s (Abdelwahab et al., 1992; Bhat, 1997; Forinash & Koppelman, 1993; Larson, 1993). Air travel was relegated as an external link that connected to regions beyond the jurisdictions of those agencies directly participating in transportation planning. And, in 1995 the call for a national census of transportation was finally fulfilled for passenger travel with the ATS. However, the frameworks and conceptualization of models to consider intercity long-distance travel have changed little since their inception as established in the 1970s and 1980s.

4.2 Long-Distance Travel Research After the 1995 ATS and into the 2000s

The execution of the American Travel Survey in 1995, as well as the start of several surveys of national travel in the late 1990s in Europe, coincided with more significant changes in the global transportation system. Most important among these changes was the rise of information and communication technology (ICT) that altered the landscape of social networks and work places. Significant travel has become commonplace for an increasing number of global mobile elite. The factors affecting long-distance trip rates and mode choice described here are only generally well-known from a limited number of national as well as a limited number of specialized surveys. While social science research has explored certain aspects of the new long-distance mobility landscape, confounding factors and causal influences in a demand modeling sense are not fully understood.

4.2.1 Long-Distance Travel Data

There is a reason U.S.-based planners still hark back so frequently to the American Travel Survey of 1995 (for example Van Nostrand et al. 2013 uses the ATS and the 2008 FHWA Traffic Analysis Framework dataset which relies on the ATS). The survey was large and nationally representative including 80,000 households in an era when survey response rates had only started to plummet. The coverage included all types of travel to destinations 100 or more miles from home. Participants were interviewed approximately every three months for a full 1-year study frame. This year-long scope is the only way to reasonably include within person variation or patterns. Moreover, it also allows for accurate rates for lower volume travelers and for trip purposes that are undertaken less frequently. Place locations were geocoded in the ATS for distance calculations (Hwang & Rollow, 2000). Interestingly, trips in this survey included long-distance commutes that are often definitionally excluded in more recent long-distance survey questions including the 2017 NHTS.

Traditionally household-based surveys in the U.S. have been conducted through interviews, then phone, and now typically on-line. Most of the surveys from which established knowledge on long-distance travel behavior is drawn may be classed as either 1) add-ons to daily household travel surveys or 2) specialized dedicated long-distance travel surveys. The most common type in the U.S. has been the add-on survey where participants are asked about trips over a certain distance threshold one-way in a time period ranging from two weeks to three months prior to their travel dairy day in the household travel survey. In the best cases, diary materials are provided to assist with tracking so that data describing each individual trip can be collected. But for the most part, these surveys provide general measures of relative trip-making and do not include mode or travel details including destination locations (geocodes are rarely collected). Add-on surveys rarely provide useful data for trip destination or mode analysis. They are typically used for trip rate estimation and comparison of the relative travel between sub-groups of the population. Survey burden is a problem including the resultant underreporting, especially as these questions are often at the end of the other parts of the long daily travel log.

In the 2017 NHTS, six states that participated in the “add-on” elected to ask participants about long-distance travel with their limited number of extra questions. In Arizona, California, Iowa, North Carolina, and Maryland, participants were asked the number of non-commuting trips greater than 50-miles one-way in the last two months (Westat, 2016). In Texas, the same question was asked with a threshold of 75-miles one-way. Few details about these trips were queried due to space limitations, but in Arizona and California some purpose information (business or personal) was collected as well as mode and most frequent city and state traveled to for Arizona residents.

The most comprehensive long-distance add-on survey was conducted as part of the 2001 NHTS. In this case, the add-on survey was a fully-dedicated long-distance survey where information about each trip including mode, purpose, and travel party size were gathered. The daily and long-distance surveys of 1995 were effectively combined and long-distance became an add-on to the NHTS 2001. The scope of long-distance trips (> 50-miles from home) in the last 4 weeks and the last trip if none were undertaken during the 4-week period were collected. Data were included from approximately 45,000 long-distance trips from 26,000 households. Unfortunately, combined methodological changes in 2001 compared to 1995 resulted in limitations to the use of the long-distance data on sub-national scales (Sharp and Murakami 2005).

The 2001 NHTS long-distance data have been well-used, and are still in use, though the survey's limited 4-week collection period is often considered a limitation. The challenges of recall period have been widely debated without clear resolution. Christensen (2017) has recently experimented with measurement of details of the most recent or last long-distance trip using the date of the last and second last trip to extrapolate rate over time. Bricka and Sabina (2012) also incorporate most recent trip to explore recall periods. They ultimately recommend 4-weeks but their analysis regarding the time since trip showed that the distribution of trip purpose, mode, and distance changed when more time prior to the survey was included. Axhausen et al. (2002 and 2007) utilized 6-week diaries including interviewers in Germany and Switzerland. Bias and recall challenges were not as problematic in their European context but it is doubtful such labor intensive or burdensome efforts could be undertaken in the current day U.S. Importantly, the authors recommend a minimum of 2-weeks in order to observe dynamic variation in daily travel. One might therefore hypothesize a much longer time period is needed for full long-distance travel activity space studies. The pilot tests for the 2012-2013 California Household Travel Survey (CHTS) explicitly tested whether in a large enough sample enough long-distance trips could be collected in a one-day survey to avoid the recall periods. They concluded the sample sizes would need to be unfeasibly large. They elected to perform an "add-on" 8-week retrospective survey for long-distance trips with some of the participants.

The 8-week retrospective survey of the 2012-2013 CHTS included a full long-distance add-on with trip details including locations for a subset of participants. All adult respondents were instructed to use a long-distance log to record all trips in the preceding eight weeks with a one-way travel distance of 50 miles or more. As the CHTS included more than 42,000 completed household surveys and captured 77,000 long-distance trips (Kunzmann & Daigler, 2013) it is one of the best most recent U.S.-based resources of long-distance travel. Unfortunately, several challenges were encountered during the survey administration that, while contributing to increased knowledge regarding best practices for long-distance data collection, reduced the analysis options feasible with the CHTS long-distance data. One recent paper (Davis et al. 2018) used the data with latent class methods to propose a typology of tour types: vacation, business travel, medical, and shopping. Bierce and Kurth (2014) also used the CHTS, but research papers using these data have been limited.

In 2003, a long-distance travel dataset was piloted by the Ohio DOT in three different phases and included at total of 551 households in Columbus, OH. The data were collected using either a two- or four-week retrospective survey. The threshold for collecting long-distance trips in this data collection effort was 40 miles and they collected relatively fewer travel variables. Ohio's state travel model has for some time included a nation-wide network with smaller zones as one moves away from the state within which they model trips over 50-miles in length in a two-week period. The model is integrated with the state-wide model (Erhardt et al., 2007). This is one approach to nation-wide or long-distance modeling. Out-of-country is not included and each state has its own data and zone/network system. Ohio has remained committed to the incorporation of long-distance travel in its state-wide program and has pursued some of the first dedicated mobile-device-based long-distance surveys. Other leaders have included Michigan where long-distance trips over 100-miles were measured using add-ons in 2005 and 2009. Colorado collected long-distance trips over 50-miles in an add-on between 2009-2012 (Bricka & Sabina, 2012). Utah included a long-distance supplemental survey in 2012 (RSG, 2013). In 2005, a peer exchange on statewide travel demand modeling was still identifying long-distance as one of seven important topics (Giaimo and Schiffer, 2005). Of the 12 states participating, nine did long-distance modeling in some way. These models included long-distance surface but not air trips. Nonetheless there is still a call for data, rural trip rates, and a national travel model from this peer exchange.

In Europe, researchers have had the advantage in that national travel surveys have often included comprehensive long-distance travel questions relying sometimes on international travel as the definition. The early national surveys with long-distance questions asked of at least a subset of participants include France in 1994, Austria in 1995, Sweden starting in 1996, Denmark starting in 1996-1997, and Portugal in 1996 (Axhausen, 2001). Four of the five surveys used 100km as the definition of a long-distance trip but reporting periods lasted only 2 weeks to 3 months. Long-distance travel is a large enough phenomena that no one survey ever encompasses all aspects of it. In the case of Germany for example, in 2002, 2008, and 2016 the Mobility in Germany survey included 1 day of travel plus a long-distance module for up to 3 journeys that involved an overnight stay in the last 3 months. The German Mobility Panel has been conducted every 3 years since 1994 and includes 7 days of travel, some of which may be long-distance. The Tourist Travel Survey has been conducted annually in Germany since 1970 and includes 5+ day journeys for the past year collected through interviews. Efforts to standardize European Union (EU) methods have been on-going and continue (Axhausen, 2001; Kuhnimhof et al., 2009; Ahern et al., 2013; Aparicio, 2016). Respondents in Europe are still more tolerant of burdensome surveys and willing to provide data for public planning. Many of the summaries of known factors in long-distance travel have come from European studies. It is not unreasonable to assume these general trends between the U.S. and Europe are similar. In Canada, the Travel Survey of Residents of Canada has included monthly measurement of domestic overnight travel in the tourism context since 2005 although it reduced in scope in 2011 to limit survey length. These Canadian data have not been modeled in the travel demand context.

Comprehensive specialized long-distance travel surveys in Europe began in 2001-2002 with the DATELINE survey conducted in 16 countries and carried out monthly with a new sample of one-year for trips greater than or equal to 100 km. Building on the Methods for European Surveys of Travel (MEST) and the DATELINE, the KITE survey in 2008-2009 also focused specifically on long-distance travel for two 8-week periods for 100 km or longer trips for Switzerland, Portugal, and the Czech republic. The first two study areas were conducted by phone and the third by face-to-face interview. These studies have made important methodological contributions but also provide some of the important insights into the factors affecting long-distance travel.

Recognizing the time frame and geographic coverage limitations of long-distance survey data in the U.S., the Federal Highway Administration (FHWA) created the traffic analysis framework (FHWA, 2015) modeled presumably on the nation-wide freight analysis framework data established two decades earlier. The need for the data was stated to be more related to the disproportionately large amount of VMT in long-distance trips as opposed to the proportion of long-distance travel comprising congestion in urban areas, which was assumed to be relatively small (FHWA, 2015). The effort combined existing data sources and modeled county-to-county flows for automobile, air, bus, and rail using numerous data sources for 2008 and forecasted for 2040. Attention was paid to correcting for border impacts and special patterns in Alaska and Hawaii. Released in 2015, the data have not yet seen widespread use or validation. It is interesting to note that the effort still made significant use of the 1995 ATS data as it is large, representative, and one-year in duration.

Some of the most detailed information about long-distance travel has come from qualitative and interview-based studies. Larsen et al. (2006) conducted interview-based research with 24 respondents in the North-West of England (Liverpool and Manchester). They compared domestic and international travel for individuals in three different professions and considered travel related to the home locations of their important social contacts. Travel levels varied by group with the professionals making more trips and although social network location mattered, the direction of causality was unclear. Larsen et al. (2006) and Aultman-Hall et al. (2018) both recommend future surveys seek a better sense of social context and social network geography. Ullman (2017) interviewed 24 women in Vermont and also recorded the home locations of 13 of their personal contacts. Ullman was motivated by the role of long-distance travel in well-being and did find a general relationship between satisfaction with life and the frequency of visiting friends and family. Her interviews suggested access to long-distance destinations was a factor in quality of life.

The long-distance travel data, especially that collected in the U.S. since 1995, is relatively limited. Research on data collection methodologies suggests that a long study time frame (one-year) and perhaps panels are needed. It has been suggested that we gather not only data on specific trips but also more qualitative and social relationship data than has been typically pursued in daily household travel surveys. While convenience samples have successfully allowed a recent one-year U.S.-based panel of long-distance overnight data (Aultman-Hall et al., 2015), and have promise for modeling destination patterns (Harvey & Aultman-Hall, 2018), they are not representative for overall long-distance trip rate measurements. Thus, the challenge of obtaining representative samples of long-distance travel profiles remains. The ATS 1995 remains the gold standard for the U.S. Unfortunately, even with a significant increase in resources, survey response rates preclude collection of this type of data in the U.S. at this time and most likely in the future.

4.2.2 Factors Affecting Long-Distance Trip Rates

Many of the papers published from the surveys above are related to survey methodology and understanding better ways to measure long-distance travel. But in some cases at least some analyses of factors affecting trip rates and mode choice have been conducted. Trip destination however has rarely been considered. In very few studies do we have databases that are large enough to allow for multivariate analysis, variable interactions, or advanced modeling. The descriptive associations typically tabulated may not always be causal and important factors may not be controlled for. Table 2 outlines in general terms the sociodemographic factors that have been found to be associated with the number of long-distance trips undertaken by an individual. Of these factors, income is most certainly the largest and most important factor (Valdes 2015).

Table 3 tabulates the number of trips greater than 50-miles in the last 2-months reported by 2017 NHTS participants who reside in California (data from the California NHTS add-on questions). Rates are weighted for Census-based population using weights provided by the NHTS program. Of particular note here, is the large standard deviations – long-distance travel is highly variable. General patterns found in the literature in Table 2 can be seen in this table. The California data show that older people travel less, men travel more than women for work, and travel increases with income and education. Note the lower rate in the highest category of the income and education variables. This result was error checked. Relationships are not necessarily linear. Urban residents travel more and people with children in some cases travel less (often related to the number of adults in household).

Some researchers have studied business travel specifically (Jeong et al., 2013; Presser & Hermson, 1996) but increasingly more research is turning to the more common personal long-distance trips. For example, in Michigan in 2015 (McGuckin et al. 2016) there were 2,015 survey trips over 100-miles in the last 3 months. Only 12.8% of trips were for business or work. Visiting family and friends comprised 31.5% of trips with other personal purposes measuring significant proportions: vacation was 28.5%, sightseeing, recreation, and entertainment was 16.3%, and shopping and social was 16.5%. Moving forward it will be important to determine which factors are associated with personal travel. It is clearly ideal to define segments of travelers based on multiple factors. For example, Davison and Ryley (2013) show in their studies of air travel behavior that the long-distance traveler market is divided meaningfully not only by having children but also by retirement. Although the segments are different from each other, multiple factors are at play for each group. For example, some retirees may fly more and others less, having the time to drive. Tourism travel patterns have been known to change with time over one's life cycle and have cohort effects (Oppermann, 1995). Recent research work includes analysis of the role of prices that vary based on the traveler and circumstance. (Becken and Schiff, 2011.

Table 2. Socioeconomic Factors Affecting Long-Distance Trip Rates

Socioeconomic Factor	Impact	Select References
Income	Widely demonstrated in all countries with studies that show as income increases, levels of long-distance travel increase. Higher income persons are more likely to fly. Education is confounding.	Mallet 2001 Georggi and Pendyala 2001 O'Neill and Brown 2001 McGuckin et al. 2016 Dargay and Clark 2012 Limtanakool et al. 2006a Limtanakool et al. 2006b Rohr et al. 2010
Gender	Men are typically found to travel more but this is likely associated with men undertaking more work travel. Possible cohort effects over time are not clear. Some studies show women travel more for leisure.	Collins and Tisdell 2002 Limtanakool et al. 2006a and 2006b Gustafson 2006 Jeong et al. 2013 Bose et al. 2004
Age	Older and younger people travel less than middle age adults but the breakpoints in age and the reasons for the relationships are not measured. This factor may be confounded with income and may also reflect mobility limitations of aging.	Collia et al. 2003 Bose et al. 2004 Anderson & Langmeyer 1982
Children in the Household	Children in the household are almost always shown to correlate with fewer long-distance trips but this is not always the case as it varies by trip purpose and number of adults in the household with single parents traveling less.	Aultman-Hall et al. 2016 Dargay and Clark 2012 Davison and Ryley 2013 McGuckin et al. 2016
Urban versus Rural	In some studies urban dwellers travel more potentially owing to airport access, income, or lifestyle. However, in other studies rural residents make more long-distance surface trips possibly for access to services.	Holz-Rau et al. 2014 Berliner et al. 2018 Limtanakool et al. 2006b Naess 2006 Czepkiewicz et al. 2018
Work	Those who travel for work may have more total trips but not necessarily fewer personal trips.	Aultman-Hall et al. 2016

Table 3. Trips Greater than 50 miles One-way in Last 2 Months - NHTS 2017 California add-on

Rates are weighted for population representation N=55,819		Business Trips (/2 months)		Personal Trips (/2 months)		Other Trips (/2 months)	
		Mean	SD	Mean	SD	Mean	SD
Age (Years)	< 18	0.2	2.2	5.5	10.5	0.4	1.5
	18-25	2.2	9.6	4.5	7.4	0.4	1.9
	25-40	2.2	6.1	5.1	10.1	0.5	2.7
	40-55	3.0	8.9	5.0	9.0	1.0	6.4
	55-70	2.5	7.1	4.6	6.4	0.9	4.4
	≥70	0.9	2.9	4.3	7.1	0.7	2.7
Sex	Male	2.7	7.9	4.9	8.2	0.8	5.1
	Female	1.7	6.3	5.0	9.5	0.6	2.8
Race	White	2.2	7.1	5.0	9.0	0.5	3.0
	Black	3.2	10.6	5.0	8.0	1.1	2.8
	Asian	2.3	7.4	4.9	9.0	1.2	7.6
Income ($)	< 25k	2.2	7.8	5.3	10.8	0.9	2.2
	25k to 49.99k	2.3	9.3	6.3	12.1	0.9	4.0
	50k to 99.99k	2.1	6.1	4.4	6.7	0.7	4.6
	100k to 149.99k	2.4	7.4	4.8	8.4	0.3	2.0
	150k to 199.99k	2.8	8.1	5.0	9.6	0.8	7.6
	>200k	2.2	5.1	4.1	5.9	0.5	2.9
Education	< High school grad	1.5	5.6	4.5	8.0	0.5	1.7
	High school or GED	3.5	11.3	5.0	9.2	0.9	5.2
	Some col./Assoc. deg.	2.4	8.2	5.0	8.4	1.0	5.1
	Bachelor's Degree	2.5	6.6	5.1	9.9	0.5	3.9
	Grad/Prof degree	1.9	4.9	4.4	6.7	0.5	3.4
MSA Category	MSA 1mil+ w/ rail	2.2	6.7	5.0	9.0	0.7	4.7
	MSA 1mil+ w/ out rail	1.9	6.3	4.5	8.5	0.6	3.7
	MSA < 1mil	2.8	9.3	5.1	8.7	0.7	2.5
	Not in MSA	1.6	4.7	4.8	7.6	1.2	3.8
Life Cycle	Young, no children	2.7	7.5	4.7	8.0	0.9	6.1
	1 adult, kid(s)	2.4	9.5	4.3	5.4	0.7	2.7
	2 adults, kid(s)	2.3	7.6	5.3	10.4	0.5	1.8
	Retired, no kids	1.2	4.5	4.4	5.9	0.9	4.2

Our limited databases leave determining what proportion of the population is making the long-distance trips an open question. Frandberg (2009) presents a unique study in which 8 different groups of secondary school seniors were studied with respect to their mobility biographies. Transnational mobility, or aeromobility, was found to vary considerably with an elite urban group having access to significant holiday leisure travel. Frandberg and Vilhelmson (2003) indicate 3% of the Swedish population makes 25% of the international trips. The hypermobile were defined as making more than 6 international trips in 1999-2000. This group was predominantly male, higher income urbanites. This status was related to business travel.

LaMondia et al. (2008) have modeled how much time is allocated to vacation travel over the year. Jara-Diaz et al. (2008) have estimated microeconomic models of the value of leisure to consider time allocation. Lanzendorf (2002) has compared the weekend leisure patterns of four neighborhoods in Germany. The role of loyalty and return visits (LaMondia & Bhat 2012; Nicolau, 2010; Oppermann, 2000) is important in both transportation planning and the tourism industry. Destination choice models using predictor variables such as travel time, costs, coastline, and weather have recently been used for sophisticated models of vacation destination choice (Van Nostrand et al., 2013) albeit still with the 1995 ATS data. Recent research has even addressed the role of smartphones in the tourist experience (Wang et al., 2012).

Often, we do not have the time series data to understand changes over time. In Norway, (Denstadli et al., 2006) a comparison of the 2005 to 2001 national survey showed an increasing number of trips. Frick and Grimm (2014) outline a comprehensive list of factors moving into the future expected to influence the relative amount of travel in Germany. They expect an increase of long-distance travel associated with an increase in the relative mobility of the older generations. They also expect increased long-distance travel due to increased urbanization. Many factors studied relate to changes in the economy such as digitization, globalization, consumption demands, and multi-local lifestyles. They predict both positive and negative impacts of these factors on long-distance travel. Increased energy costs, concerns for sustainability, natural hazards, and political instability are expected to decrease travel. Increased supply (i.e. service levels) is expected to increase travel, although not necessarily for everyone.

4.2.3 Factors Affecting Mode Choice

It would seem at first thought that models of mode choice between surface and air travel would be important and common. Early aggregate corridor level models in the 1960s and 1970s were focused on mode. Yet recent long-distance travel mode choice models are extremely limited in number. Although, conducting descriptive tabulation of revealed mode use is straightforward, a choice model requires delineation and attribution of both chosen and unchosen alternatives that an individual faces. Long-distance travel surveys often but not always document the mode chosen. However, unchosen modes are not queried and thus must be assumed with modeled attributes. Even if one can assume that both air and surface modes were considered for a particular origin and destination pair, air-based accessibility is hard to measure and includes many variables. Price, an obvious motivator of travel decisions, is complicated to estimate for any mode, but especially for air.

Generation of attributes describing the air travel options between origins and destinations in a long-distance dataset has been challenging. As shown in Figure 7, the travel time and cost of an air trip is comprised of access, egress, and many elements of wait time in airports and on airplanes between origins and destinations. Some individuals have several viable alternative airport choices at both the origin and destination end of trips. In other cases, travelers have no viable air option for their origin and destination. Modelers have demonstrated that travelers make variable choices of airports (Kim & Ryerson, 2018) including traveling to airports further from home presumably to save airfare costs or to access direct flight service. The closest airport is not always the airport used so consideration of the relative cost of the air mode must incorporate the associated alternatives for surface travel as well. Even if the airports are known, there are usually several routes available to travelers involving non-stop flights and flights with transfers. Table 4 demonstrates the number and variability of flight options in current domestic airport pairs. We derived these data by considering 132 main commercial airports in the U.S. and using the FAA DB1B data[4] for 2017. This table shows the mean number of transfers included in routes actually ticketed and used by passengers for airport-to-airport distance ranges. As trip distance increases on average, the number of transfers increases but in all distance ranges, the variation in number of stops is high. Understanding which of these variable options a traveler considers is difficult to formulate for inclusion in a mode choice model.

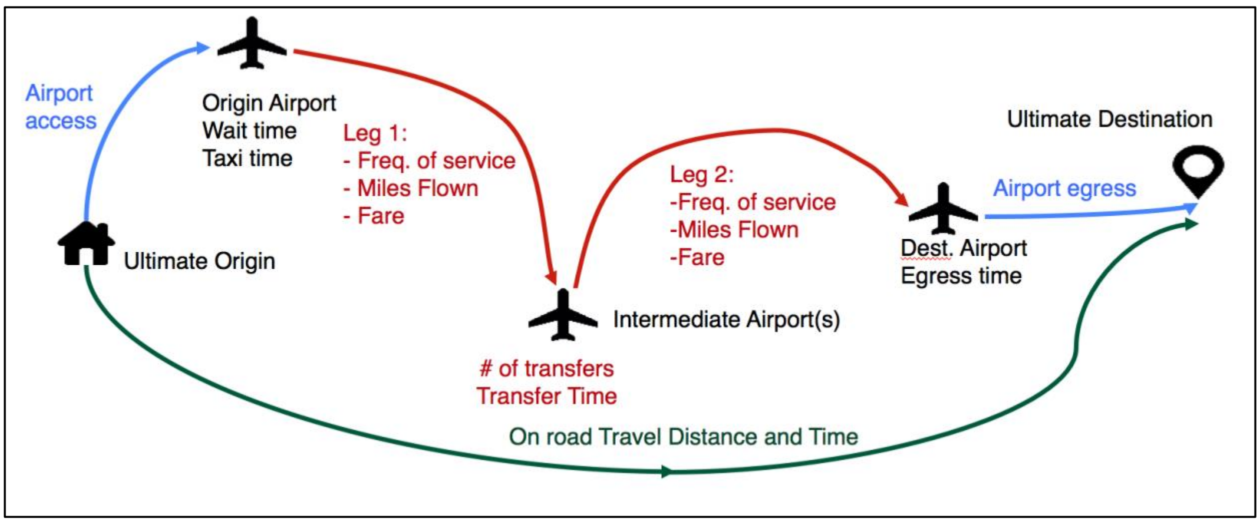

Figure 7. Accessibility Between Origin and Destination for Air Versus Surface Transportation

Table 4. Average & Standard Deviation of the Transfers Between Airport Pairs by Distance

N=16,571	0-250 mi. n=580	250-500 mi. n=1,970	500-1000 mi. n=5,384	1000-1500 mi. n=4,366	1500-2000 mi. n=2,630	>2000 mi. n=1,641
Mean # of Transfers	0.44	0.66	0.82	1.0	1.15	1.16
Standard Deviation	0.49	0.44	0.39	0.41	0.47	0.47

[4] DB1B is a 10% sample of airline tickets from reporting carriers collected by Office of Airline Information of the Bureau of Transportation Statistics. https://www.transtats.bts.gov/DL_SelectFields.asp accessed September 2018.

Similarly, rail and bus access and egress is feasible in a limited number of areas in the U.S. Within the northeast corridor of the U.S., rail dominates for trips under 300 miles and air dominates over 300 miles (Chester & Ryerson, 2013). Behrens and Pels (2012) study the implementation of high-speed rail between London and Paris to consider its impact on air travel. They indicate travel time and frequency matter most to business travelers but that price matters most to leisure travelers. Ultimately their findings suggest competition will decline over time. Keep in mind there is no driving option between London and Paris due to the English Channel thus simplifying the analysis.

Cho (2013) in his University of Florida thesis attempted to develop the travel time and other attributes associated with all mode options for trips for Florida in the 2009 NHTS – it was challenging. Monzon and Rodriguez-Dapena (2006) recommends non-random sampling only for specific OD pairs to overcome choice modeling challenges. Rohr et al. (2010) estimated a nested choice model for the UK. Ashiabor et al. (2007) estimated a U.S.-based county-to-county mode choice model using a measure of airport access based on the 1995 ATS data. Moeckel et al. (2015) developed a nested Logit choice model for North Carolina using the 2001 NHTS. Significant efforts have been invested in modeling mode choice related to high-speed rail in California (Outwater et al., 2010), although the data have not always been ideal (Koppelman et al., 2011). Models addressing HSR and air substitution in Spain have not shown that HSR is necessarily a substitute for air travel (Catillio-Manzano et al., 2015). There are enough reports of long-distance mode choice models to affirm the feasibility of their estimation, but the availability of data for their creation is limiting.

In general, travel behavior experts assume and agree that long-distance mode choice depends on number of people in the travel party, locale, distance, and rural versus urban locations (Larsen et al., 2006). Some people are just not flyers for a range of personal reasons (Graham & Metz, 2017). Frick and Grimm (2014) consider the percent of 5+ day holiday trips by mode in Germany between 1954 and 2012. In 1954, approximately half of these trips were by train. Since 1990, train and bus usage has remained almost constant, but airplane usage has sharply increased and automobile sharply decreased. The automobile enjoyed a significant increase through the 1970s and has since declined. Graham (2006) describes that recent increases in air travel may be more associated with relative ticket price reductions than with income increases.

A common mode choice oversimplification is often made that at some trip length threshold most shorter trips are made by automobile and longer trips by air. The association between mode and distance is not clear-cut. Data from the 1-year Longitudinal Survey of Overnight Travel (LSOT) panel illustrate that this is simply not a strong assumption (Figure 7). In this limited convenience sample of only 628 individuals, numerous trips to destinations less than 500 miles were made by air and some under 250 miles were also made by air. Similarly, a notable number of trips over 2,000 miles were made by automobile and a few surface trips over 3,000 miles were undertaken. None of the alternative threshold combinations tested increased the strength of tour generation models as a function of socioeconomic variables (Aultman-Hall et al. 2016). Working with only a subset of tours so that air and surface travel times and costs could be estimated, LaMondia et al. (2018) have been able to show with LSOT data that travel time by highway and cost of air are significant predictors of mode choice.

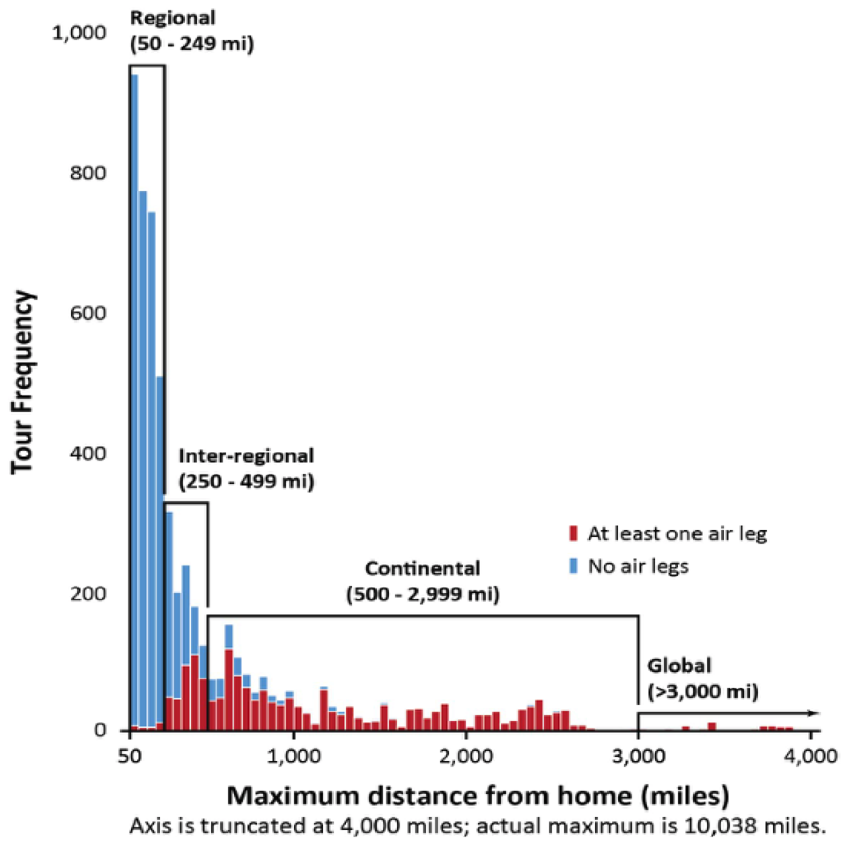

Figure 8. Long-Distance Overnight Tour Frequency by Air (N=5,849 tours)
(Source: Aultman-Hall et al., 2016)

Integrating air and surface network systems and methods to measure air trip attributes including accessibility measured as travel time, cost or both is essential for national mode choice modeling of behavior in today's global transportation system. Indeed, it is even essential for metropolitan and state models in many cases. In the last two decades, there has been a merging of urban and long-distance travel congestion concerns. Long-distance through-travelers undoubtedly comprise a sizable portion of metropolitan congestion, airport destinations represent a significant and congested trip end within the highway system, and rail and air congestion in certain locations rival highway. Technology has brought the globe together and the need to study globe-scale travel is more pressing than ever. Disaggregate mode choice models have been called for for decades and are more essential now than ever.

4.2.4 Technology and Mobile Social Life

While long-distance travel demand models have comprised a limited amount of the literature since 1995, there has been increasing attention during this time period to the spatial societal changes that apply directly to the study of long-distance travel. Larsen et al. (2006) critiques transportation researchers as having ignored the social dimension of travel focusing instead on an individual's travel decisions for given purposes as well as focusing on routine trips to the exclusion of leisure travel. At the same time, viewpoints such as those in Putnam's *Bowling Alone* (2000) see mobility, and in particular driving and commuting, as undermining social capital and community. Travel has been for many years considered placeless and rootless, it is the time between activities. Travel time was seen as an impedance, a measure to be minimized as the base assumption and driver of the demand models. But researchers have now demonstrated quantitatively that there is some positive utility to travel time beyond that obtained at the destination activity (Ory and Mokhtarian 2005, Mokhtarian et al. 2015, Russell and Mokhtarian 2015)). People are not necessarily seeking to minimize their time traveling (Salomon and Mokhtarian 1998).

During this same era, social science research is suggested by Larsen et al. (2006) to have ignored mobility despite recognition of the importance of migration, pilgrimage, war and trade. Social scientists have focused on local community and face-to-face spatial arrangements of social networks. Urry (2002) points out that sociology has traditionally studied people and groups as organized in social structures based on physical proximity. He argues a need to adapt frameworks within a culture of hypermobility or limitless travel. The idea of mobility being a social activity in and of itself is increasingly being addressed. Goetz and Budd (2014) include the context that air travel and mobility embodies social and cultural geography. An airplane flight for example is undertaken in a place, a place with social experiences.

Larsen et al. (2006) point to four types of social networks in particular that rely on long-distance travel: mobile professionals, long-distance relationships; fragmented families; and diaspora families. In these examples, one can understand that the tradition of modeling individual travel attracted to certain destinations ignores important relational commitments and social obligations. Halfacree (2012) defines place-based identities in the era of mobilities focusing in particular on those that are counterurban such as second homes in rural areas distinguishing between people by their frequency of travel to and from the city as well as the distance involved.

Travel has become an entitlement and the idea that one should travel is rarely questioned in our society. Travel is a major component of status and the idea of home has become dispersed. Mobility means power and social capital in our global society. Because travel is now pervasive in social life there is no simple way to say which journeys are necessary versus discretionary. Long-distance travel includes obligation to people and the social purpose of maintaining relationships as well as the obligation to events within one's social network such as weddings or graduations, but there is also an obligation to place (Larsen et al. 2006). People can elect to travel to maintain a relationship with their special "places". This might be due to ancestral family ties as documented by Ullman (2017) or simply a type of place loyalty revolving around attachment to the location as documented by Oppermann (2000) and LaMondia and Bhat (2012). Jansson (2016) uses the term mobile elites. He equates freedom and social success with global travel, longer stays, an internationally oriented career and extensive leisure travel. These mobile elites move because they want to, not because they have to, as is the case for migrant workers and refugees. On the other hand, social need or obligation to social elements is significant within these long-distance trips and an element of non-discretionary travel undoubtedly needs to be incorporated into long-distance model frameworks in some way.

Urry (2002) has explored types of travel with a sociology lens. Urry defines types of travel in these new social spaces in which we can have “global intermittent co-presence” as 1) movement of objects i.e. freight; 2) imaginative travel such as the radio or TV; 3) virtual travel such as the internet and phone; and 4) corporeal or physical travel. He sees humans as seeking proximity in order to have face-to-face, face-to-place and face-to-moment experience. Urry presents face-to-face co-location as important for facilitating human touch and building trust. However, as one reads, Urry’s writings from 2000 forward (Urry 2002), the sense that virtual travel cannot fully replace or substitute for co-presence seems to decrease. Sheller and Urry (2006) present social networks as an essential component of the increasing dynamic space created by transportation and communications together.

One cannot ignore the role of information and communication technology (ICT) in driving the global mobile society that results in increasing long-distance travel. Communication devices by their nature are a connection to another place other than the one where you are. There was a brief moment and time where ICT was seen as a potential driver to reduce the demand for physical travel. Yet it is now widely accepted that the opposite is true (Dal Fiore et al. 2014). Larsen et al. (2006) among others use the term *network capital* to capture these elements of society that facilitate networking beyond one place such as mobile phones, internet services, social contacts at distance, time, money, safe meeting places and movement capability. More simply, network capital is communication, transportation and places. The mobile society is maintained by travel in which communities exist and interpersonal meetings take place. Interestingly, the probability of chance meetings held as so crucial in Bowling Alone (Putnam 2000) is lower in a physically large social network. Encounters must be scheduled (Larsen et al. 2006). Within people’s overlapping multiple networks there are both strong and weak ties. The relative number of these ties varies between people and has the potential to change over time. Traditionally, social network analysis has considered the tie strength and degrees of separation but not location and movement. Recent studies consider the frequency and character of meetings whether face-to-face, electronic or otherwise (Larsen et al. 2006). As Larsen et al. point out technology allows for the constant coordination of space and time. Technology allows for the maintenance of relationship at distance sparking more physical long-distance travel.

Jansson (2016) introduces a special issue of the *European Journal of Cultural Studies* that includes consideration of the emotional and potentially social costs of long-distance travel. The network or cosmopolitan capital that mobile elites possess does not solely represent positive utility to the individual. The authors consider the need to define an everyday territory or home geography. They delve into questions we do not yet have full answers to regarding emotional investment in places, the mobile elites’ value for co-presence and intimacy, and the potential of a longing for home. Technology and mobile lifestyles undoubtedly make disaggregate modeling of long-distance destinations complicated. Research thus far suggests a need to expand and consider the geography or spread of one’s social network as well as a person’s travel history including potentially places lived. These social dimensions are not currently measured in travel surveys and suggest value in longitudinal data for the demand modeler.

4.3 Current Research: National Annual Models and "Big Data"

In 2004, Miller presents a review of the challenges in the intercity travel demand model realm echoing the challenges noted in prior reviews (Koppelman et al. 1984). Oddly enough, Miller compares long-distance trips within the travel demand forecasting profession to the corpse of a man named Harry that keeps turning up in unexpected places at decidedly inopportune times in a 1955 Alfred Hitchcock movie. This white paper attempts to demonstrate that by 2018, long-distance travel is beyond inopportune for demand models, it is simply not possible to consider overall transportation systems while excluding it. Miller's review outlines well the pressing model needs related to mode choice including accounting for new modes, modeling access and egress behavior, and the need for disaggregation. Writing 15 years ago now, Miller advocates for accomplishing meaningful long-distance models on a corridor basis in critical corridors. However, growth in the last 2 decades have complicated the long-distance travel landscape. New models must not just incorporate air but also expand globally and incorporate the explosion of technology affecting travel behavior. Having failed to reasonably survey long-distance travel data for more than a few sub-national models (California and Ohio being the exceptions), researchers are now turning to "big data" as a solution that will not only address the response rate challenges of travel surveys but also measure long-distance trips over long time periods and wide space. Unfortunately, it is not yet clear how the complex motivations for travel as well as the interplay with technology and social networks can be measured in the "big data" approach.

One important step in establishing sophisticated long-distance travel models is movement to an <u>annual</u> activity time frame. In a recent modeling effort for the FHWA Bradley et al. (2016) took an activity-based simulation approach to nation-wide long-distance travel using several existing data sources. Synthetic households were simulated in terms of auto ownership, number of tours, duration, travel parties, destination and mode. The 2001 NHTS long-distance data were augmented with state data from Ohio (2003), Colorado (2010) and California (2012). The effort included 4486 zones consisting of counties in rural areas and smaller Census-based zones in urban areas. Input variables included population, employment and university enrollment. Validation was conducted against FHWA's 2008 Traffic Analysis Framework (TAF) county-to-county origin-destination data by mode as well as by consideration of sensitivity to certain socioeconomic parameters. This national model has since been integrated with a state model for Tennessee (Bernardin et al. 2017). A similar annual activity-based model is under development at ETH Zurich (Janzen et al. 2018). All of the literature reviewed here reinforces the appropriateness of one-year activity models focused on overnight locations.

The existence of both a U.S.-based and a European-based annual activity model for long-distance travel is very encouraging. The challenge remains the disaggregate data to calibrate these models. Household travel surveys have endured as the standard source of detailed origin and destination information together with individual and economic predictor variables but have failed to provide routine and detailed long-distance trip information. It is doubtful given the challenges related to response rates even after a move from interviews to phone to Internet that long-distance can be added in detail to existing surveys. As outlined by Janzen et al. (2018) mobile device-based data collection offers distinct benefits to specific long-distance data challenges. A larger number of people and months can be collected. Mobile devices can be tracked for longer periods of time addressing the problem that one-day travel surveys do not collect a long enough time period to capture a sufficient number of longer trips. Location does not rely on participant recall or accuracy. Under-reporting is presumably minimized and non-travelers are included leading to more accurate trip rates. Mode can be assumed to be easier to infer for long-distance versus local trips given that locations of airports and rail lines are known and that speed can be accurately estimated. The sequence of annual overnight locations advocated here as the best complement to daily household travel surveys is routinely inferred from mobile devices by the private sector for numerous applications.

A survey of practitioners undertaken in 2014 indicated wide-spread interest and even pilot users of passive travel data but also a need for research on certain methodological challenges and the development of accurate processing methods before wider planning agency use is expected (Lee et al. 2016). Assessment of the implications of the use of mobile device-based surveys are still very much under consideration (Antoun et al. 2017). Most of the App-based travel data collection efforts to date have been in conjunction with a daily household travel survey or focused on methodological development (Safi et al. 2015, Greene et al. 2016). The key new contribution of the mobile devices to long-distance travel data is that locations are typically collected automatically reducing the participant burden even if details are checked with the user. For decades researchers have demonstrated that devices providing locations improve recall error problems in travel surveys (Murakami and Wagner 1999, Bricka and Bhat 2006, Wolf et al. 2003).

There are presently two ways that mobile devices provide location data from which we can extract origins, destinations, routes and mode whether for local daily or long-distance trips: 1) locations based on cell tower triangulation when the device interacts with towers in some cases extracted from anonymized billing data; or 2) GPS-based location from a specialized travel App or another App recording location by time. Most of the studies of mobility to date are focused on local travel or general movement (Alexander et al. 2015 for example). Janzen et al. 2018 use the cell-based method for a study of long-distance travel in France documenting better coverage of long-distance trips compared to the national travel survey. Bekhor et al. (2013) used cell phone location in Israel for long-distance travel study. Limitations of the cell-tower method include that locations are not known except when the device is used. Atlanta-based AirSage Inc. is the most long-standing private source of cellular based locations for travel origin destination (OD) data in the U.S. AirSage and other providers generally provide OD matrices to specific regions and states. However, our group has successfully used AirSage data for long-distance analysis to compare relative rates of destination choice by home location (Harvey and Aultman-Hall 2018). As with any proprietary data source, opportunities to validate the OD information are limited.

Using the GPS location from mobile devices in early applications suffered from battery drain and excessive data plan usage. These challenges have diminished. A number of private firms are selling transportation data including locations derived from travel-specific Apps but also other secondary Apps. Several university-based research groups have developed travel Apps, some for travel survey type data collection (Zhao et al. 2015, Jariyasunant et al. 2014). User-tailored surveys to collect trip purpose and travel party can be easily pushed to mobile devices thereby gathering the information beyond origin and destination needed for modeling. Few academic journal articles on these research endeavors exist because the devil is in the many details and high quality full functioning travel survey Apps are very limited in number. RSG Inc.'s mobile App rMove (Flake et al. 2017 and Greene et al. 2016) originally developed for general travel surveys has been tested several times for long-distance travel data collection. The App itself performs well documenting traveler data, gathering trip purpose and party, and tracking location (using GPS). It has been recently used for a two-week period including consideration of social networks (Calastri et al. 2018). Ohio DOT has conducted multiple long-distance data collections with rMoves for 6-months at a time (Ritter et al. 2017). In 2016-17, the data collection moved to 6-month collection for Franklin county Ohio. This is part of a planned 10-year 10-region rotating data collection in Ohio that represents an important commitment to long-distance travel modeling for Ohio DOT, but an important data collection research effort that will benefit all transportation planning.

Our group had the opportunity to analyze the 2015-2016 rMove pilot long-distance data from the Columbus, Ohio area. In working informally with the high quality location data derived from rMove our group assesses that there are not accuracy problems about the technology but rather a failure of the professional community defining what data we want from Apps. Where the App is weak is in trying to parse data into the distance-based thresholds such as 50-miles that persist in the planning agency frameworks. As undertaken long-distance trips have many legs, some of which are meaningful (a meeting along the way, an overnight at a hotel) and some of which are not (an airport transfer, a stop for gas and dinner). Every leg over 50-miles is not a trip. Apps would be better suited for overnight travel data collection where less information may be required of the participants and where the artificial need to divide trips in segments over 50-miles would be eliminated. Considerable effort and logic is also required to address the complex spatial patterns in long-distance trips described in Section 5.4. Our long-distance data tabulation frameworks still persist with out-and-back 2-leg definition of trips but the Apps are of course recording the full range of stops in complex spatial patterns. The data quality from Apps will be dependent on good frameworks for data tabulation that as yet we have not agreed upon for the long-distance realm.

Use of dedicated or secondary Apps for long-distance or overnight travel eliminates many of the concerns about devices in daily surveys. For example, the device not being taken on short local trips presumably does not apply to long-distance travel. However, our work in Vermont suggests older, less educated or poorer travelers may not have smart phones with the GPS-based location (Aultman-Hall and Dowds 2017). Use of call records including all cell phones not just smart phones might include more diverse groups.

In Vermont, recent experimentation with overnight and long-distance App-based data collection was positive (Kaufman and Galford 2017). In this case, locations data were extracted from a secondary App and participants were interviewed to obtain actual overnight locations so that a source of validation data were available. A dwell time at a location combined with distance traveled was used to parse data into segments. The logic was challenged by airport stops to transfer airplanes and was better suited to overnight location collection rather than trip segment or leg identification. Semi-passive Apps conduct this validation in real time asking for post-trip or end of day travel log checks. It is still unclear how this burden impacts data collection. For overnight travel surveys, the number of questions could be reduced to a minimum of once per day while away from home.

Even before the recent release of the 2017 NHTS, the FHWA announced NextGen NHTS (Jenkins and Pu 2018) would be a combination of OD data purchased from private sector big data providers and a smaller more focused travel survey. It is unclear how long-distance travel will be incorporated into the new survey program but the intention is that all trips regardless of length will be included in the national OD. This is one important step forward. Undeniable energy is now focused on the use of big data for travel demand models and other system planning. It is however not clear that that vision extends explicitly to long-distance nation-wide travel with global connections. The existing annual activity models require predictor data and thus the transportation planning community must converge on a framing for long-distance travel and ensure base questions for trips away from home are included in the new NHTS instruments and surveys conducted by other agencies. Limiting user questions to overnight trip purpose and travel party might be all that is necessary to provide sufficient information that cannot be obtained automatically from an App. It would be regrettable if the distance-based definition of long-distance travel persisted into the new era of data collection.

5. A Framework for Moving Forward

The goal of this section is to suggest a common framework for long-distance data collection and tabulation that re-defines what constitutes long-distance travel into daily and overnight travel.

This section describes in detail the myriad of distance-based definitions of long-distance travel in use and their challenges before turning to discussion of long-distance trip purposes. The last sub-section closes by pointing to the elaborate spatial patterns inherent in long-distance travel requiring that future models be more spatially complex than current ones.

5.1 Considerations in Long-Distance Travel Definitions

Regardless of the specific distance threshold used (50, 75 or 100 miles in the U.S. and 40 or 100 km in Europe), distance-based definitions have been problematic. This definitional limitation has been long-recognized (Madre and Maffre, 1999) but action on change slow. There is general agreement that long-distance travel is increasing worldwide and thus the challenges with defining it are becoming increasingly troubling to planners and must be addressed. The research community's current de facto distance threshold for a long-distance trip is in essence *some of those trips that we do not collect enough observations of in our one-day household travel surveys*. Long-distance trips are simply what we miss in an outdated data collection technique. When researchers and planners endeavored to begin collecting household travel survey data in the 1950s, these out-of-town or even overnight trips were less common and therefore safely relegated to outlier status. Given increases in air travel, growing mega-regions, increased standards of living and discretionary income, cultural changes, relatively inexpensive air fares, and spreading social networks, the so-called long-distance trips represent more than outliers in daily lives and routine travel profiles. Travelers are making more trips and more people are traveling. This distance-based definition does not represent a natural or logical breakpoint in travel phenomenon that defines a limited number of trips for research, modeling, or planning. Moreover, it does not correspond to what is routine as originally intended which was implicitly daily.

Travelers in society do not often, if ever, use the term "long-distance trip." One may speculate that we all "know" what a "trip" is – it is when we pack a bag and leave town. For data collection purposes it would be useful to have a clear definition understood by the public. People struggle with many concepts in a travel survey (return home trips and stops along tours for examples) necessitating careful design. In long-distance surveys respondents have been shown to inaccurately estimate one-way distance thus leading to inaccurate reporting. This has been improved some with use of on-line maps. However, a definition based on an overnight stay might be better understood by the public making the overnight definition well-suited for travel surveys. Conducting overnight travel surveys is also the complement that collects what is not contained in daily travel surveys. One-day surveys already capture long-distance day-trips. Overnight location is also straightforward to extract from GPS or mobile device-based location data.

The dichotomous framework of long-distance and non-long-distance travel that is intended to be utilized for data collection and planning is outdated. Moreover, long-distance travel surveys are rarely conducted. Transportation planners have inadvertently created a “bucket” of trips classified under this so-called long-distance definition that are incredibly diverse, increasingly important, and woefully understudied in part because the data are so hard to collect. A distance of 50 miles is smaller than numerous metropolitan areas, the commute distance for many people, and a day-trip for many purposes. Often discussions revolve around updating the threshold for this distance-based definition. Every distance threshold results in overlapping subsets of trips and has inclusion and exclusion errors. This white paper recommends overnight as the appropriate complement to daily travel allowing all trips within an appropriate spatial area to be extracted for particular policy and planning applications from paired data collection efforts, one daily and one overnight.

In summary, distance threshold has been used historically to define a long-distance trip but we know this is problematic. There are not logical universal breakpoints in travel phenomenon, regional variability is large and people cannot estimate distance accurately. We explore these and other definitional problems in more detail below and ultimately recommend using overnight as the defining characteristic for data collection that completes daily travel surveys and complements annual activity model development.

5.2 From 50-miles to Overnight

The prevailing definition for long-distance travel with transportation planners in the United States stems back to the 1995 ATS and remains embedded in the 2017 National Household Travel Survey (NHTS) and the 2013 California Household Travel Survey (CHTS), two of the most recent large comprehensive passenger travel datasets available publicly in the United States. In these two recent cases, the primary survey was focused on collecting one full day of realized travel or trips from all members of the household. Although the sample sizes were large (129,112 households for the 2017 NHTS and 42,431 households for the 2013 CHTS), it was considered impossible that enough so-called long-distance trips would be included in a one-day travel diary and thus supplemental or “add-on” questions about long-distance travel were asked. This assumption was validated in the CHTS pilot survey effort. In both cases, a subset of participants were asked how many non-commute trips they had made of 50 (in the Texas NHTS case 75) miles one-way in the last 8 weeks (or 2 months). These add-on questions represent what is commonly considered long-distance travel by transportation planning professionals in the U.S.: trips longer than 50-75 miles one-way that are not commuting. In some cases, 100 miles is used as the threshold, harkening back to the 1995 ATS. The 1977 National Personal Transportation Survey (NPTS) collected two-weeks of trips ≥75 miles and filtered to trips ≥100 miles one-way for reporting.

There are simply no single thresholds of distance or space-based definitions that serve any meaningful purpose for nation-wide travel data collection in the modern global system thus creating limitations in subsequent modeling or research. Trip distance distributions are continuous, not bimodal. Figure 9 illustrates the distribution of maximum distance from home for respondents that had a stop over 50 miles from home on their single assigned travel day in the recent 2017 NHTS. Using the census block group for national data, city and state/province for Mexico and Canada, and the city and country for international destinations, we were able to calculate the maximum distance from home for persons in the U.S. on their travel day. This measure has the added advantage of including people who are on a long-distance trip during their travel day (for example, a Kentucky resident who makes three walking trips while in Washington, DC on their travel day). It also includes people whose individual trip legs may have been less than the threshold but for whom total travel was longer in distance. Note in Figure 9 that a relatively large proportion of the national sample (6.7%) was at some point more than 50-miles from home on their travel day.

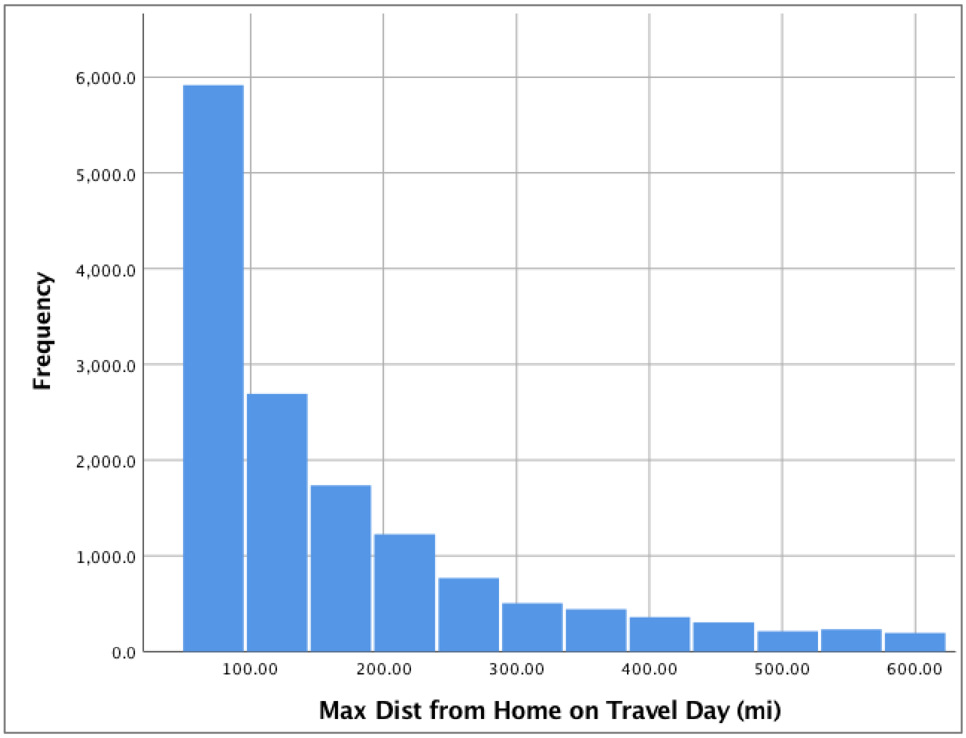

Figure 9. Number of People by Maximum Distance from Home in 2017 NHTS
(N=17,647 people with one stop >50 miles from home, N_{total} = 264,235; axis is truncated at 600 miles)

Figure 10 includes the nation-wide sample as well as five states in different regions. This figure illustrates that trip distance distributions are undoubtedly dictated by the spatial distribution of opportunities or destinations surrounding origins and they vary from region-to-region with infrastructure and service levels. In recent research (Harvey and Aultman-Hall, 2018) that considered the relative distance from home over two months in 2013 for thousands of cell phone users residing in Chittenden County, Vermont, spikes were found in the number of observed travelers in Chicago, and the major metropolitan areas of the east and west coasts. Trip length or distance distributions for trips made from a particular origin are a function of the spatial arrangement of destinations or opportunities around that origin. If there is very little population and few activities in the 50- to 99-mile radius around a community (the case presumably for many people in Texas and Georgia in Figure 10), few people will travel to destinations in that distance range. These regional differences have been previously noted by others. Bricka (2001) found travel differences between residents of New York and Oklahoma. In other research, type of home location has been shown to affect travel (Holz-Rau et al. 2014, Limtanakool 2006b, Naess 2006). Steiner and Cho (2013) find trip distance differences and spatial pattern differences by region for long-distance travel in Florida. These findings demonstrate that a single distance threshold defining a long-distance trip cannot be established nation-wide.

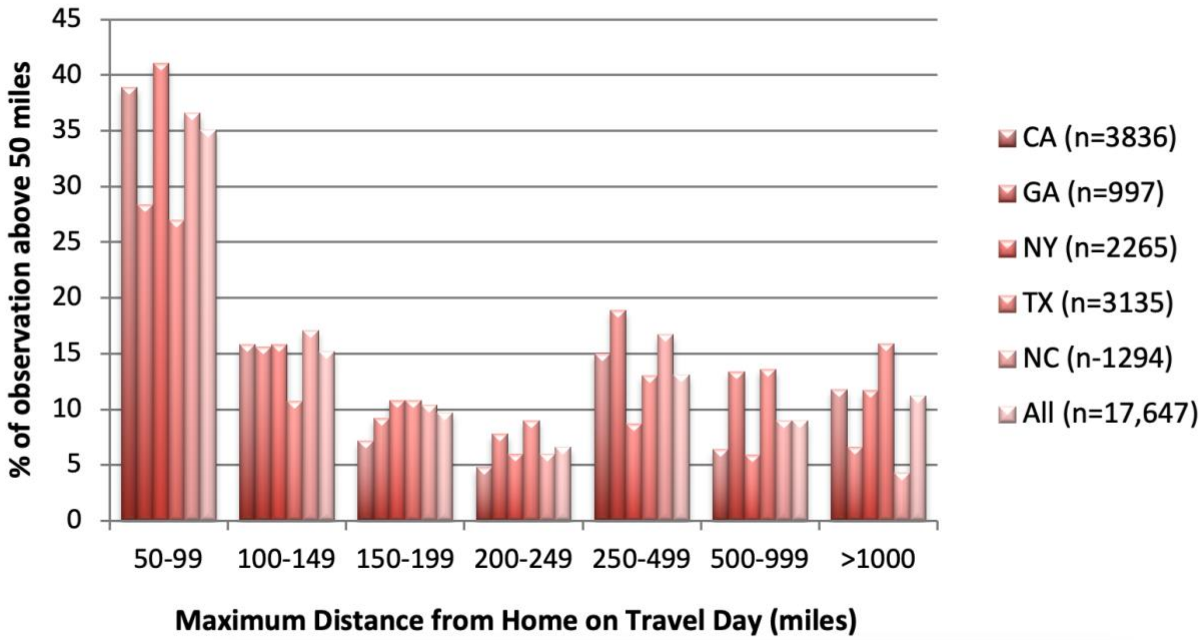

Figure 10. Distance Distribution of Respondents at Least 50 Miles from Home on Travel Day (NHTS 2017) by State

For a long time, researchers have attempted to use multiple ranges to represent different levels of long-distance travel. In early work, Blumer and Swan (1978) labeled 100- to 400-mile trips as short-haul for air modeling. In 1979, Stachurski (Stachurcki and Rice 1981) defined 0 to 800 km as short, 800 to 1,600 km as medium, and 1,600 to 6,400 km as long. Recently, the Transportation Research Board (TRB) Special Report 320 on inter-regional travel focused on the 100 to 500 mile range, indirectly defining medium and long-haul based primarily on data from the 1995 ATS as well as the assumption that trips over 500 miles are made primarily by air (their focus included significant consideration of rail). In our recent work (Aultman-Hall et al., 2016) we sought to evaluate breakpoints in distance distributions using one year of geocoded overnight tour data for 628 survey panel participants from North America collected in 2012 and 2013 (the Longitudinal Survey of Overnight Travel (LSOT)). While results were presented for breakpoints labeled regional (50-249 miles), inter-regional (250-499 miles), continental (500-2,999 miles), and intercontinental (≥3,000miles), statistical evidence of natural breakpoints corresponding to these convenient labels or others was not found.

These out-of-town “trips” that we all supposedly know when we see them, may be long in physical distance, (as in greater than 50 or 75 miles one-way), but they may not be. Although different trips mean different things to different people, it is doubtful people use a distance threshold to classify travel in their own mind. People may consider long trips those that require longer travel times even if the distance is shorter. Some vacations are very close to home yet involve overnight stays. Moreover, long day-trips are common, especially for those with good airport access at both the origin and destination end of the trip. In particular, one must acknowledge that long-distance day-trips, including work or business trips, are viable within both the east and west coast mega-regions of the U.S. as well as from either coast to some destinations in between. Figure 11 illustrates the relative magnitudes of the number of trips and miles undertaken in the four categories defined by existing definitions of travel. Distance-based local versus long-distance is defined by a 50-mile threshold in Figure 11. Day-trips are distinguished from overnight trips. Because all of these types of travel are not routinely collected in any one effort, Figure 11 depends on two sources of data for a non-random subset of travelers. LSOT included 628 adults who were recruited by email and completed a one-year longitudinal panel of overnight travel in 2012-2013 (Aultman-Hall et al. 2015). Data on the right-hand side of Figure 11 were measured in this panel. The average daily travel on the left side of the graphic consists of the corresponding estimates for one year of daily travel based on the 2009 NHTS for the 3 states (VT, AL and CA) where most participants (82%) lived. Figure 11 suggests approximately 47% of the miles traveled annually by this group (of admittedly heavy travelers) is overnight travel and that approximately 75% of the miles traveled are long-distance (over 50 miles in this case). The 75% of miles is higher than general estimates in Section 2.2 and for other countries presumably due to the higher income and educated sample. Long-distance travel in today’s society comprises a large proportion of passenger miles and thus is critically important for policy issues related to environment, congestion, and infrastructure planning. Much of the travel miles are overnight but not all.

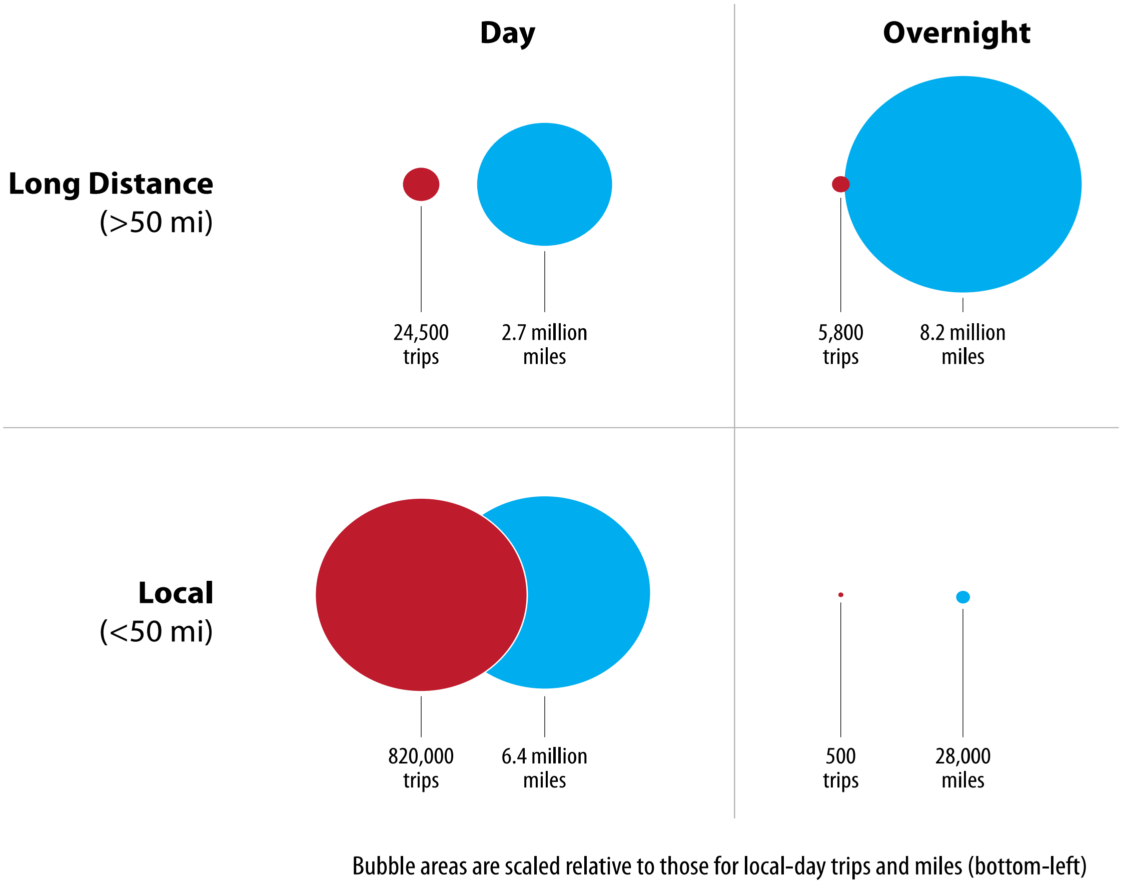

Figure 11. Relative Travel by Type for a Convenience Sample (N=628)
Sources: Chester Harvey from the Longitudinal Survey of Overnight Travel (Aultman-Hall et al. 2015) and NHTS 2009

Figure 11 itself reinforces the arbitrary nature of the quadrants that persist in the transportation planning community relative to defining long-distance and non-long-distance travel. The division between day-trips and overnight is meaningful but the distance threshold is not. Routine trips within region are undoubtedly found in the upper left quadrant of Figure 11 along with longer inter-regional trips. The top portion of this graph includes a diversity of travel that is not logically modeled together. Moreover, designing surveys to collect details on these types of trips is fraught with challenges including the respondents' inability to estimate distances (Bricka and Sabina 2012), and recall bias over the longer recall time periods (Madre et al. 2007).

Both overnight travel and trips made by air are clean definitions of trip types well-understood by the public from whom we seek to gather data. A single distance threshold does not segregate meaningful types of travel. Single metropolitan areas, the most common study area for data and model development, are in numerous cases much larger than the current 50- to 75-mile thresholds. Even trips between metropolitan areas, say from Washington DC to New York City, are different in nature from cross-continental or intercontinental travel, yet they are lumped together in the long-distance bundle of our transportation planning frameworks. One complicating factor in using the overnight definition is that some travel is undertaken during the night. The logical tendency with data collection defined by overnight is to collect the geographic location of where the participant spent the night. Participants have good recall for this type of data collection especially if they can be guided by a calendar or daybook. But data collection is stymied on “red eye” flights, cruise ships, and the longest haul flights where night moves in space. This challenge is not particularly uncommon as it came up in numerous questions and comments during the LSOT one-year panel with only 628 individuals. We can be attuned to these exceptions in our overnight travel data collection efforts but we cannot fully address this limitation.

Travel time dictates what can be accomplished in a day-trip. Engine design and drag as a function of speed will always limit the economically viable fuel efficiency for commercial flying (Wendover, 2017). So although in the past improvements in technology (such as moving from horse to car to jets), and thus speed, affected what was viable as a day-trip, improvements in speed are not expected for future air travel. Commercial aircraft flying speeds have not changed in decades except for the limited use of the turbojet Concorde that was terribly inefficient in terms of fuel efficiency as well as passenger-miles per unit of energy. Increasing availability of air service, such as is on-going in Asia and Africa, will undoubtedly affect overall air travel volume globally including international flights originating in and destined for the U.S. On the ground however, advances in automated vehicle (AV) technology are the factor anticipated to lead to increased surface day-trip distances everywhere in the United States (Mokhtarian 2018 and LaMondia et al. 2016). Global air forecasts and the looming promise of AVs suggest long-distance travel may grow in the U.S. AVs may increase the distance covered in a day-trip but changes in air day-trips are not expected. A robust data collection method that collects both long day-trips and overnight travel can address these expected changes.

Most important to note here related to a proposal to measure long-distance trips using the definition that a trip is overnight is that we fill the data gap. There is no issue in data collection of missing long day-trips as such trips, regardless of length, are already included in our typical data collection schemes. It is the overnight long-distance trips we lack data on and focusing collection methods on overnight location is a way to fill this data gap.

5.3 Long-Distance Trip Purposes

The purpose of a trip or tour is important for travel behavior data collection because it is important for forecasting and for understanding travel motivations and how travel impacts quality of life. The inability of the newer mobile device-based passive survey techniques to collect trip purpose is a concerning limitation. Methods of imputing trip purpose into GPS and cell-phone data are long-standing (Bohte and Maat 2008, Gong et al. 2014, Deng and Ji 2010). Semi-passive Apps which burden the user with few questions about their travel almost always seek to gather trip purpose for each stop on a tour (Ritter et al. 2017 for example). Indeed, we have often defined a trip end in transportation planning by the fact that one member of the travel party undertakes an activity or function at a given stop. This may be a longer duration activity like working or a short duration activity like dropping a passenger. Trip purposes are important to long-distance travel as well but require some careful re-formulation. Researchers and planning agencies are not yet using a consistent framework.

5.3.1 Categories of Trip Purpose

At the most basic, long-distance trips have been categorized as business or personal. The recent FHWA traffic analysis framework (TAF) (2015) used fewer categories (business, pleasure, personal business, and other) for long-distance trips that mapped to the 12 purposes used in the 1995 ATS (Table 5).

Table 5. FHWA Long-Distance Trip Purposes 1995 and 2015

1995 ATS Purpose	2015 FHWA TAF Purpose
Business Combined Business/Pleasure Convention, Conference, Or Seminar	Business
School-Related Activity	Personal Business
Visit Relatives or Friends Rest Or Relaxation Sightseeing Visit A Historic Or Scenic Attraction Outdoor Recreation	Pleasure
	Other

The tour-based activity model of nation-wide long-distance travel recently developed for FHWA (Bradley et al. 2016) used five trip purposes: 1) business, 2) commuting, 3) leisure, 4) visits to friends and relatives, and 5) personal business. In earlier work, by the same group (Outwater et al. 2015) nine purposes were used: a) business travel (conferences, meetings and combined business/leisure) and b) leisure travel (visiting friends and family, personal business and shopping, relaxation, sight-seeing, outdoor recreation, and entertainment). Frick and Grimm (2014) working with German data like Bradley et al. delineate commuting in their shorter purpose list: personal, commuting, business trips, and holidays. Michigan has recently used: 1) family and personal, medical and religious; 2) vacation; 3) sightseeing recreation and entertainment; 4) work and business; and 5) social and shop (McGuckin et al. 2016). Based on the discussion in Section 5.3 the survey in development by our group will use the following purposes for each overnight stay:

- Work/business
- Visiting Friends and Family
- Leisure
- Recreation, sightseeing, vacation
- Shopping
- Religious

- Medical services
- No purpose

The inclusion of commuting in some schemes is noteworthy. Extreme commuters have been defined as 90+ minutes one-way, (Marion and Horner 2007), 50 - 60 miles one-way (Jin and Horowitz 2008), and even only 30 km one-way (Sandow and Westin 2010). Typically, in the U.S., long-distance data collection has excluded commute data no matter its length thereby eliminating these trips from analyses. However, as *workscapes* and *homescapes* become more complicated and telecommuting continues to be common, a robust way to incorporate long-distance commuting will be necessary. A workscape may be considered the set of locations where one often or typically works which may include one main site. A homescape may be considered the set of home-bases used by an individual. This may vary from person to person in the household. For example, some households have smaller apartments or industry-based housing that is used during the work week or work period in large urban areas, for remote mining operations or other locations. Alternatively, some couples have jobs in different metropolitan areas and require two home-bases. Some households have seasonal or weekend homes from which they sometimes commute. If the overnight and daily travel framework above is adopted, some commuting could legitimately be in both models as not all commuting is daily.

The alternative groupings of existing long-distance trip purpose are concerning. The frameworks differ enough that inter-regional comparisons and aggregation would be difficult. Moreover, some trip types are overlapping and could create confusion for respondents resulting in possible drop-outs or inaccurate measures. For example, some trips might legitimately be combined both with family, for shopping and for entertainment. Trip purposes must be mutually exclusive.

5.3.2 Tourism and Other Personal Purposes

Originally, leisure vacations were an activity of the privileged few but personal travel has expanded due to the widespread ownership of automobiles, the increasing affordability of airplane travel and, more recently, dispersed social networks. Careful attention to defining personal trip purposes is essential. There is a long-standing distinct literature on vacation tourism as leisure travel. Crompton (1979) was among the early researchers to consider motivation for pleasure travel. He builds on two earlier ideas. First, that a high flow from origin A to destination B must be driven by a lack of some commodity at A that is available in B. And second, he recognizes that people travel for wanderlust, they seek unfamiliar places. Crompton's interviews suggest people have a need to "break from the routine" that results in either doing something local, a vacation or non-personal travel. Recent interviews in Vermont indicated the same "break from routine" need (Ullman, 2017). In Crompton's work many indicated they traveled to get away and that the destination did not matter. Reasons for personal travel included escape, exploration, relaxing, prestige, and relationships. Like many researchers of the time, the project was intended to help marketing in the tourism travel industry. The paper was not about travel demand or public planning. The conclusions suggest people had not thought about their motives and that the industry could focus on this for advancement. In the 2017 Vermont interviews, topics focused more around the need, desire and obligation for visiting family and friends at distance (Ullman 2017).

Larsen et al. (2006) and Larsen et al. (2007) articulate the need to differentiate between tourism where one sets out to see a new place or have a unique experience versus other personal trips that are about connecting with people. They describe the idea of caring and socializing at distance, a mobile social life. For some people, there is now a difference between being socially isolated and being physically isolated due to increased telecommunications and increased travel. Larsen's papers note that travelers are not free floating seekers of aspirations but they are bound by social obligations and burdens that are located in space.

Recent interviews by our group with female residents of Vermont (Ullman 2017) corroborate that access to long-distance travel was about more than leisure vacations. The women repeatedly suggested that a form of non-discretionary social trips was part of their lives. These included social obligations to attend events and to maintain relationships. Because the group included lower income women, not everyone interviewed was able to attain the mobility they desired. Moreover, they envied those who could both visit family, visit interesting vacation destinations and combine leisure travel with business (discussed below). So while transportation planning may have traditionally considered personal long-distance trips discretionary embodiments of positive utility, they are not always. Personal trip purposes must be distinguished and possibly considered in some cases non-discretionary.

Much of the research on tourism travel, but not all, is contained in journals[5] not typically used by the transportation planning model community. Tourism travel is a significant focus for data and policy within the Organization for Economic Cooperation and Development (OECD). Given the increasingly large share of transportation system miles undertaken for leisure and personal travel, one might reasonably expect increasing interaction between these research communities. The recent literature supports the need to distinguish between leisure such as vacation and visiting friends and family as used in Bradley et al. (2016). Note however, that one's travel party may also be friends and family.

5.3.3 Personal Travel as Routine or Non-routine

The idea that out-of-town long-distance trips are non-routine has been persistent within our traditional transportation model framing. This element of the framework is tied up in a very dated notion of trip types in modeling as home-based. Local trips are also classified as work-based as well as the infamously labeled "other," originally only a limited number of trips. The imposition of the household as the base location and social unit within which constrained travel choices were made was at one point a tidy assumption for modeling and data collection. It allowed other non-routine trips while on vacation or business trips to be outside the model and outside the main sources of data collection on travel. At the time commuting was the majority

[5] Journal of Vacationing Marketing, Annals of Tourism Research, International Journal of Tourism Research, Tourism Recreation Research, Tourism Management, Tourism Economics, Journal of Travel Research

of miles undertaken in the system. The home-based frame also has roots in the access to automobiles being household-based. Mobility is no longer structured this way in our society. Schlich and Axhausen (2003) showed using a six-week travel diary that travel is not particularly routine or in their words it is neither totally repetitious or totally variable. Even the extent of routine that is present is now confounding as daily, weekly, monthly and yearly routines increasingly involve so-called long-distance travel. Interviews and focus groups regarding long-distance travel indicate monthly, annual, and bi-annual patterns for many households. Presumably, only once in a lifetime trips can safely be said to be "non-routine." The question of routine applies equally to business work travel. Like annual vacation routines or a monthly visit to an older parent, people annually travel to the same conferences and may have weekly or monthly long-distance routine visits to alternative workbases.

In a non-trivial number of cases, people do not even have a single household and home-base: workers who work at-distance for weeks at a time, spouses that work in different cities or children who moved between parents' homes. Transportation planners have labeled what does not fit into routine home-based daily travel into either the "other" or long-distance bucket ignoring the reality that routine travel is simply much more complicated than it previously was, previously was thought to be, or was previously modeled. This exogenous non-resident travel has become a non-trivial portion of the volume in our state and metropolitan transportation demand models. It can no longer be excluded. There is arguably no true routine travel in our lives and thus is an inappropriate way to frame travel models. At the same time nothing is routine, everything is routine.

5.3.4 Trips without a Purpose

Several thoughtful papers (Ory and Mokhtarian 2004, Dal Fiore et al. 2014, Xinyu et al. 2008 and Mokhtarian et al. 2015) have called into question the idea that travel is always a derived demand stemming from the need or desire to participate in an activity at a certain location. Mokhtarian and Salomon (2001) directly recommend that "no purpose" should be considered amongst purpose type in data collection. Within long-distance travel, the group's suggestion that the decision to travel is made first and that destination or activity is secondary has even more pertinence than for daily travel. Mokhtarian suggests that people may well be traveling for travel's-sake or increasing physical travel to different destinations or along different routes because they enjoy the travel itself. Travel time is not purely a disutility. In 2017, our group tested these ideas in a random telephone survey[6] of 613 Vermonters with a question about their last overnight out-of-town trip for personal reasons. 4.3% of people indicated they selected their travel mode first and then considered destinations. This is roughly consistent with the proportion of trips that Mokhtarian estimates may be purposeless.

5.3.5 Activities and Trip Purpose while at Destination

Once travelers reach a non-home destination, they undertake daily travel. When away on business trips, workers undertake work at one or more places, but they require personal

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[6] The Vermonter Poll is conducted annually by the University of Vermont Center for Rural Studies

maintenance such as eating and often undertake socializing. Our frameworks ignore the reality that once a person is at distance away from home they have a new base, a cottage or weekend condo, a hotel, or the home of family or friends around which another set of activities exist spurring non-long-distance travel from the non-home-base. Few researchers have studied this travel behavior (LaMondia and Bhat 2011). This has important relevance to overall transportation planning because as the amount of local travel undertaken by visitors increases, whether tourists or not, this travel from the non-home-base is missing in our planning models. Data collection methods moving forward must address local travel behavior by visitors.

5.3.6 Mixed Purposes

Research for this white paper suggests that Bradley et al. (2016) have made the best current choice for long-distance trip purposes (business, commuting, leisure, visits to friends and relatives, and personal business) with two exceptions: purposeless travel (5.3.4) and mixed purpose trips. Our prior work suggests that the aggregation of the number of trip purposes was wise for clarity alone but that dropping the combined business leisure was not.

The LSOT one-year panel already described contained appreciable mixed purpose tours. When we asked the participants to define the overall purpose of their overnight tour into just one of two categories: work or personal. 1887 trips (32.2%) were classified as work, and 3962 (67.7%) were classified as personal. However, we also asked participants to indicate the purpose of each overnight stop on a scale between 100% personal and 100% work with 5 levels with the middle being 50/50. Of the 5,849 total tours in the sample; 3,621 (61.9%) were entirely personal based on stop classification and 1,425 (24.4%) were entirely work based on stop classification. However, 803 (13.7%) of the tours had mixed purposes.

Long-distance tour purpose is complex and the ability to combine purposes may well affect trip generation rates, destination choices and the utility derived from the tours. Mixed purposes are part of an individual’s annual activity patterns. Recall as well, that information and communication technology allow us to work remotely from anywhere. The sole purpose of being at a location might be personal, but one may well be working from that place. Further research is needed.

5.3.7 Summary of Travel Purposes

Trip purpose for long-distance travel is complicated. Undoubtedly, during a long-distance trip tour there are many locations visited and different activities are pursued from the alternative non-home-base (or an alternative home-base). Stop purpose may be part of daily routine or needs and not the primary long-distance trip purpose. A stop for coffee for example in a different city whether while at a work conference or visiting family is part of that local daily travel. The purpose of being in a different overnight location beyond home may be work or visiting friends and family or potentially both. Many collect only the primary purpose of the long-distance or overnight tour, but our work suggests collecting primary and secondary purposes for each overnight location is most comprehensive. Primary overnight location purposes could be business/work, visiting family and friends, leisure/vacation, mixed business/personal and no primary purpose. To complete this, household travel surveys should start collecting daily travel from people even when they are out-of-town on their assigned survey day (as was done in the NHTS 2017). The primary purpose for being out-of-town overnight should be collected in addition to the activity or purpose at each trip stop during the day. Within long-distance travel surveys even when the spatial focus is overnight location, consideration could also be given to collecting the purpose of stops en-route (gas, rest, quick visit with friends). There is work to be undertaken to establish a schema of purpose for long-distance travel. In many ways, the schema may be more straightforward than for daily travel but the structure will be different.

5.4 Spatial Patterns in Long-Distance Travel

It is often implicitly assumed that long-distance trips are “out-and-back” from one’s home city or community to another “out-of-town” location. This is analogous to the trip-based thinking of pre-1990 demand modeling where productions and attractions were simply two-way. It is obvious that long-distance travel must be tour-based with chains of overnight stops. Researchers have considered these spatial patterns even though the constructs have not been operationalized in long-distance demand models.

Lue et al. (1993) based their conceptualization of spatial patterns in leisure travel by distinguishing whether single or multiple destinations were visited and whether a single or multiple benefit was sought from each location. They propose that trips could have a single destination pattern, a main destination with stops en-route, a base camp pattern where side trips are taken from the base location, as well as two types of chaining tours. Lew and McKercher (2006) describe the spatial movement of tourists by defining the size of territory in addition to the path type through that territory. The paths include single point-to-point, repetitive point-to-point, circular loops, radiating hub-based paths, and random explorations. Their models are theoretically based in both transportation planning models and tourist behavior. Prior work based on the 1995 ATS estimated 9% of trips for visiting friends and family had multiple destinations (Hu and Morrison 2002). Although some groups have already observed actual tourists (Tideswell and Faulkner 1999, Hwang and Fesenmaier 2003), it is clear that mobile device data will soon increase the number of publications addressing this question with significant real world data.

Our own model (Figure 12) derived from geo-coded overnight stays in the LSOT panel is simpler than Leu et al. and Lew and McKercher consisting of only three tour types. While this simplicity may have been motivated by our small sample size, it may also be sufficient. Table 6 suggests that traveling a long way motivates the creation of more complex spatial stops and that spatially complex trips are common enough to merit consideration in data collection and modeling.

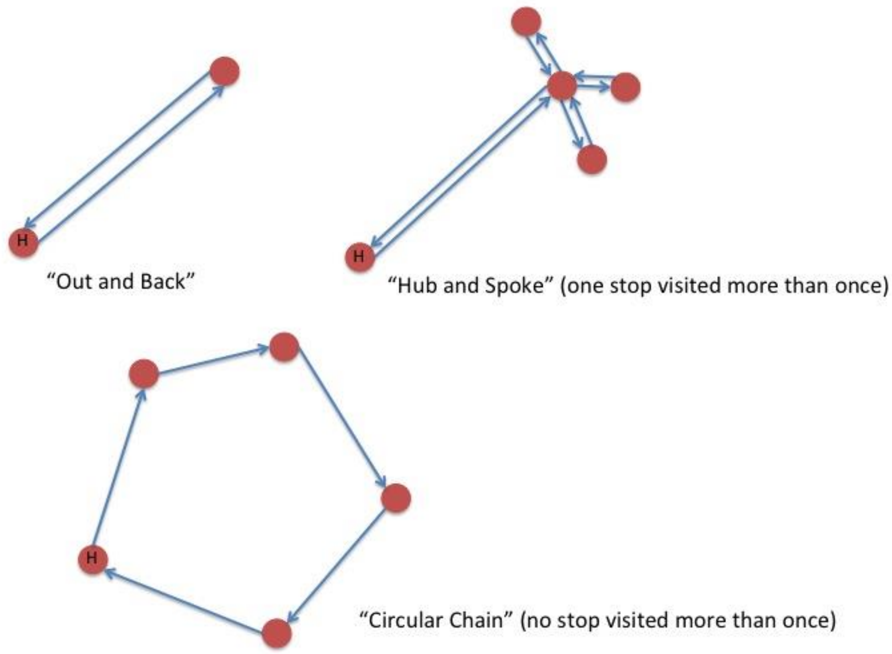

Figure 12. Simplified Long-Distance Overnight Spatial Tour Types (H=home)

Table 6. Average Differences in Tour Attributes Based on Spatial Type

	Out and Back	**Hub and Spoke**	**Circular Chain**
Frequency	81%	15%	4%
Mean One-way Distance	438 miles	1340 miles	1878 miles
Maximum Distance from Home	~2500 miles	~10,000 miles	~10,000 miles
Used Air	27%	48%	63%

Another way to consider spatial patterns in long-distance travel is at the aggregate flow or interchange level. Limtanakool et al. (2007) considered the connectivity and interaction flows between 39 cities in western Europe. They document, not surprisingly, that seas or oceans i.e. water creates a barrier that affects passenger travel interchanges. This seems trivial but is actually an important consideration. Accessibility is not uniform across space as described in Section 5.2. Availability and service level matters. This affects the spatial patterns people undertake. The high-speed rail connection from England to France (Behrens and Pels 2012) and the bridge between Sweden and Denmark (Knudsen and Rich 2013) are extreme examples. However, international borders, geography, desert, lack of flights, and quality of direct flight service all affect accessibility across space which in turn affects long-distance travel demand. For these reasons, spatial models are necessary in long-distance travel modeling.

6. Conclusions

6.1 A Call for Multimodal National Long-Distance Travel Demand Models

Even with the growth in computing power and the increasing availability of big data, it seems unreasonable to recommend global travel demand modeling. However, the creation of a more detailed national model of travel with meaningful external links not only to Canada and Mexico but to intercontinental destinations served by air travel is essential. Only a national framework can adequately answer questions about the growth, and potential peak, of long-distance travel.

Peak long-distance travel is presumably limited by annual time constraints and an individual's desired or ideal levels of time away from home. Annual activity patterns are also influenced by the location of home-bases, social network geography and disposable income. It is unlikely that we are anywhere close to the maximum saturation level of long-distance travel in the United States. While there is currently no creditable sign that intercontinental air travel will increase in speed (thus allowing for more travel per unit time by individuals), the expansion of automated vehicles within the United States itself is expected to change the relationship people have to both distance and time use while traveling. Moreover, structural changes to the airline industry have reduced costs and thus increased volumes. Frandberg and Vilhelmson (2003) note that technology and infrastructure have increased the accessibility of far-away places. But it is not unreasonable to assume that AVs and dynamic ride sharing will enable significantly more travel even beyond that which is currently accounted for in economic forecasts (LaMondia et al. 2016). Robust comprehensive models of national travel are needed to evaluate policies for managing the continued growth.

Since it is unlikely policy efforts that increase the cost of travel through congestion pricing, airport fees, or carbon taxes will be widely implemented in the United States in the near term, infrastructure planning to address both surface and air congestion (including the potential increase in personal flying vehicles or the rise of AV aircraft) are required. Targeted and coordinated management and infrastructure expansion will be essential as it is improbable that unchecked growth will produce the equitable, environmentally friendly and economically advantageous impacts we desire as a society. Given the growing dominance of air travel, congestion in very large mega-regions, and the persistent hope for effective rail in some U.S. corridors, the evaluation of alternative national transportation system infrastructure options can only be achieved with new frameworks that capture annual activity patterns within a nation-level multimodal demand model.

The only agency with the scope and domain to pursue such an endeavor is the USDOT. The leaders in modeling at the regional and state levels, and the mode-specific administrations within the USDOT, do not have the capability to take on this task. At a time when infrastructure is lagging in terms of maintenance and modernity, models of national long-distance travel have become essential to guide investment. After an extended period of limited data, big data and mobile devices are offering the spatial and temporal scale needed for long-distance travel to complement improved targeted household travel surveys. The role of directing such large complex transportation systems with multiple private and public actors towards sustainability can only be pursued by the public sector. The players who have spent the last two decades calling attention to the need for long-distance data should now turn their voices to calling attention to the need for a strategic division within USDOT to address travel demand within the national and international context.

This white paper is not the first to call for federal leadership in long-distance travel demand modeling. Most recently, TRB Special Report 320 (2016) outlined the connection between the lack of long-distance data and planning with the mismatch of funding and institutions to the corridors of long-distance travel. The prominent (and important) role of MPOs in the history of U.S. transportation planning has led to a relative abundance of local home-based travel data but a problematic paucity of long-distance data. The Special Report is clear in emphasizing the necessity for federal leadership to create incentives and mechanisms for multimodal inter-regional organizations. And in many ways, FHWA is heeding that call in its movement towards NextGen NHTS (Jenkins and Pu 2018) with a balance of surveys and "big data." The test for long-distance transportation planning will be whether the transportation planning community can move quickly at this time and re-define focus to overnight travel locations, annual activity models, and a limited number of meaningful survey questions that serve those models.

6.2 Specific Variables and Data Needs

Currently, there is considerable optimism within the transportation community that big data and passive (or semi-passive) mobile device data will meet all of our future travel data needs. A more tempered view suggests that big data will be a valuable complement to on-going household travel surveys but will not replace these traditional data collection methods. The complexity of travel decision-making, and the long-documented importance of attitudes in travel behavior, both point to the need for continued survey data collection. Recent research has suggested several important recommendations for future travel surveys.

Long-distance travel is important to quality of life and there is substantial latent demand for access to long-distance destinations that is poorly understood. This latent demand merits greater attention by planners as it disproportionately impacts underserved and vulnerable populations thereby perpetuating inequality. This data need is more pertinent for personal trips than work or business trips but represents economic opportunity as well as social networking.

Disaggregate mode and destination choice models require more information than passive Apps can collect on trip details and in this arena long-distance travel surveys using convenience samples show promise. Some have recommended collecting detailed survey data on the most recent long-distance trip. Information about mode, travel party, purpose, access, and egress considerations are essential for understanding decision making.

Disaggregate geo-coded information regarding overnight and ultimate origins and destinations that in turn allow for calculation of distance and alternative mode trip characteristics is essential for accurate modeling. Often these locations are collected but not released. The complexity of modeling access and egress in long-distance travel is yet another reason to call for effective ways to release spatial data while protecting confidentiality. Some recent surveys have provided these spatial data to researchers and planners in census block groups and zip codes zones in order to protect privacy. These large zones often frustrate analysts of daily travel as they complicate assessment of distance, routes, and viability of walking and bicycle transportation. But these aggregate zone systems are adequate for long-distance travel and the calculation of distances and airport/rail accessibility. However, an additional spatial complication arises with long-distance data: surveys must be able to collect and record locations globe-wide in a meaningful way where census groups and zip codes do not necessarily exist. While country of travel may be sufficient for most of the globe, travel to and from Mexico and Canada requires more refined locations. While city may work, anonymized latitude and longitude or use of Mexican/Canadian census zones may be necessary.

Researchers and planners have had very limited opportunities to collect comprehensive long-distance travel data. But when they do, long-distance travel measures are person-based, not household-based, pointing to another reason to advance household simulation models. Ideally a minimum of one-year is needed to observe the full variability in long-distance travel. Both passive and semi-passive mobile device Apps can collect locations outside of geo-fenced areas around the home region at limited times per day filtering for non-purposeful stops such as airports with little battery or user burden. Semi-passive Apps can collect trip attributes and query the user about trip purpose and travel party at convenient times even after long-distance trips are completed. Long-distance data collection systems that rely on mobile devices also stand to fill the data gap related to activities around non-home locations such as when one travels on short daily trips away on vacation based at hotels, away from home staying with friends or family, and working from alternative locations.

Ultimately, future modeling and data frameworks will consist of paired data collection and models: daily travel from any base and a one-year time series of annual overnight locations. The new frameworks must incorporate complex, non-single-home-based spatial annual activity patterns. Variables will include number of trips but also days away in total and by trip. Trip purposes must be recognized as being mixed between business and personal for a significant number of tours. More robust spatial models will be essential. This spatial detail will benefit existing state and regional models in terms of external and pass-through trips.

6.3 Key Policy and Sustainability Research Questions

National leadership on data collection and travel demand modeling would support more specialized study of long-distance travel by public agencies and academic researchers. Given the complex social factors that motivate long-distance travel, and the increasing proportion of total miles traveled that are undertaken in long-distance travel, significant effort is needed to understand who is traveling and why. Mokhtarian (2018) refers to the passengerization of travel in suggesting the critical need to assess how both time use and travel time have changed. Global air service and the potential for automated vehicles and intra-urban air service open up the possibility of even greater technologically induced changes to transportation. These profound changes require an assessment of saturation. We should measure better how much travel an individual person wants and can sustain. Then we must ask if the planet can sustain that level, not just environmentally but also economically. Where do we as a global society optimize our travel? Daily travel is constrained to a large extent by distance but annual overnight activity patterns can take on many forms in terms of days away and distance away in different spatial patterns including a variety of home-bases. Presumably, this annual activity pattern is also limited by speed-based constraints but it is more likely that fatigue or emotional limits that vary by individual with age and lifecycle limit the number and types of trips per year.

This interplay of time and distance is largely unstudied. Surely length of time spent at a destination has a relationship to distance from home-base. Limited existing data does indicate that at a certain distance away from home, travelers do make their trip longer in duration and additional stops are added. The mechanism behind mixed purpose trips is largely unstudied. International and intercontinental travel behavior is rarely studied. Understanding these factors would directly inform model formulation allowing long-distance travel to jump away from the model framing that was developed purely for daily trips within region. But this knowledge would also help understand how to change behavior, if necessary, to pursue more sustainable systems.

The questions of social justice loom large when one considers the details of long-distance travel. It is essential to understand who the global mobile elite are and what their travel behavior means. We cannot currently answer basic equity questions such as what percentage of Americans undertake which percentage of the miles of travel. Some recent studies document potentially large latent demand in terms of unrealized trips but the impact on well-being is largely unmeasured. The future may well include new modes such as automated vehicles and dynamic ridesharing that alter activity space and travelsheds in ways that alter performance measures. It is unclear exactly who is potentially left out of these new systems and if inequity is increased rather than decreased with these new modes.

6.4 Including the Public

Long-distance travel is not a new phenomenon. However, in the 1900s widespread availability of the automobile and then the proliferation of jet airplanes now combined with relatively low fares with higher deposable incomes have brought long-distance travel at a wider scale to a broader spectrum of the global population. Creation of our global air system has required decades to negotiate air space politics based on liberalized international conventions and treaties. Business models for airlines have been complex but are now robust (Bowen, 2014). The growth is expected to continue and this creates large questions about sustainability that require discourse in the public realm.

Beyond the data and modeling activities that transportation planners perform to inform infrastructure and system policies, there is the critical role for the public in addressing the relative lack of sustainability of global travel patterns. With the goal of sustainability at the forefront, no one can reasonably suggest that mobility be limited. The right to move although not necessarily explicitly recognized within frameworks of human needs (Maslow 1943 and others adapted since that time) is fundamental. Our global society clearly includes great disparity in terms of access to global mobility. It is unclear if the global mobile elite who access destinations beyond their home continents one or more times per year think critically about their rare status. The skills and know-how to navigate the global system for creating access to opportunity is a part of their network capital but also creates burden in terms of time and stress. There is a lot for the mobile elite to consider and assess. Larsen et al. (2006) set out to consider the "middling," not the transnational elites or under-privileged migrants, but rather those in between (there is lots of diversity in between). But there is also a creditable argument to start behavior change and thought leadership within the global mobile elite category as they represent a very large portion of the miles and the environmental impact.

In terms of sustainability, we are left with a truly challenging situation. Long-distance travel is very costly in terms of the environment but pricing it to limit volume denies mobility to many. The best solutions to such complex global challenges involve informed decision makers and an informed public. The most important first step for transportation planners related to sustainability of the global long-distance travel system may be to expand their focus beyond local travel to understand the facts regarding the global system and to take steps for public education and conversation using the media or public involvement processes. Next action could include increasing the coverage of long-distance travel demand topics within professional research and planning conferences, forums and academic programs - places where technical content remains focused on daily regional travel. Such efforts could culminate in a global summit as ultimately international travel requires international cooperation.

One topic to start discussing within public and professional conversations may be the misleading fact that air travel is so efficient in terms of energy or emissions per passenger mile. This relative advantage cannot eliminate the fact that most air trips are much much longer in distance than most surface trips. Attention to date on air travel as a source of GHG emissions has been limited because it is not yet a large proportion of the total transportation sector emissions. But airplanes are likely to be the legacy users of carbon-based fuels due to the lack of reasonable alternatives. Moreover, air travel demand has large growth rates. Aviation consists of businesses that are understandably focused on highlighting the social and economic benefits of air transportation and minimizing attention to the adverse environmental impacts (Paling et al., 2014). Foremost of the myths or misunderstandings is around the relative atmospheric emissions of air travel. Air travel for individuals that fly is a relatively large portion of their environmental footprint. The most critical need suggested by this white paper may be the act of creating meaningful debate about the costs and benefits of air travel in public and policy maker discussions. Robust long-distance travel data and demand models will then be needed to answer questions these informed stakeholders raise about serving long-distance travel demand with air and other modes in a more sustainable future system.

6.5 The Bottom Line

Long-distance travel is a key driver of the sustainability of present and future transportation systems. The levels of long-distance travel are growing. Yet it has been neglected in the travel data collection and transportation demand models used in the United States to date. The calls for focus on long-distance travel data are not new and the frameworks for understanding this behavior can now be better implemented with technology-based data options. For transportation planners, it is timely and important to consider updated frameworks for long-distance data collection to guide the role that technology-based methods will play in future travel data collection. As we move into a potentially data-rich era, with increasing passive data collection, we have a unique opportunity to reconsider how we characterize out-of-town travel and move beyond outdated long-distance definitions. It has become increasingly apparent that simple distance thresholds do not define meaningful classes of travel and are poorly suited for capturing a complete picture of travel activity across the year and across our global transportation system. For this purpose, travel is better divided between daily and overnight travel that can feed both activity models that are daily and annual in temporal scope. To be effective policy tools, annual activity-based models should incorporate both surface and air modes together. These changes will affect the models, the variables we collect, sustainability policy and research questions, as well as the advance of a more informed public discourse surrounding long-distance travel. In short, sustainability of the transportation system cannot be adequately considered without direct meaningful consideration and focus on out-of-town long-distance travel.

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