Transportation Engineering: Professional Practices & Priorities

Chapter 1 Introducing Today's Sustainability-Minded Transportation Professional

CHAPTER OUTCOMES

By the end of this chapter students will be able to:

- Identify transportation modes and stakeholders
- Recognize United Nations goals for sustainable development
- Define sustainable mobility
- Identify career opportunities

Students who have fully achieved chapter outcomes will also be able to:

- Associate personal travel experiences with the professional work of planners and engineers
- Explain how goals for sustainable development are either advanced or hindered by the strengths and weaknesses of regional transport
- Explain how a project that is both socially responsible and economically responsible can deliver an equitable solution, but not necessarily a sustainable solution
- Outline professional licensing requirements

PRE-READING QUESTION(S)

Prepare to begin this chapter by responding to the prompt(s) below.

> Activity 1-1: Think about what you'll be doing this weekend and where you'll be going. First, describe one particular activity and identify the corresponding destination. Next, respond as prompted here. 1) How much time are you willing to spend to get where you're going? 2) How much money are you willing to spend? 3) What mode(s) of transport will you use? See for example the modes featured in Exhibit 1-1. 4) When traveling this way, how safe will you feel? 5) When traveling this way, how safe will you truly be? 6) What will be your impact on the environment? 7) What will be your impact on your own well-being? 8) What will be your impact on the well-being of others?

Activity 1-2: Consider the physical items within your immediate control: clothing, backpack, phone, water bottle, etc. First, identify a particular item. Next, review the modes featured in Exhibit 1-1 and respond as prompted. 1) What raw materials were used to manufacture the item? 2) What mode(s) of transport were likely used to deliver raw materials to the production process? 3) What mode(s) were likely used to distribute the finished product to the wholesaler? 4) What mode(s) were likely used to distribute the finished product to the retailer? 5) What mode(s) were likely used to distribute the finished product to you?

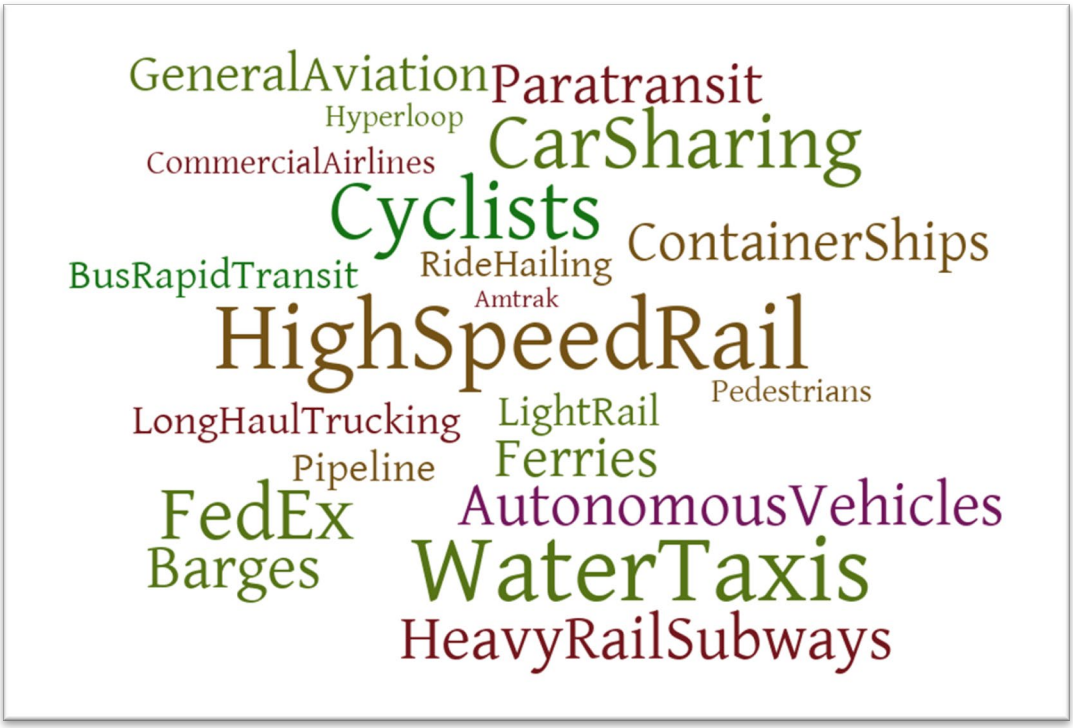

Exhibit 1-1 Modes of transportation

Exhibit by Kim Allyn Wormley née K. Mastako using WordItOut via worditout.com September 2019. Used with permission from WordItOut.

Alt Text for Exhibit 1-1: Word cloud with 20 modes: water taxis, barges, Amtrak, pedestrians, light rail, general aviation, Hyperloop, cyclists, long haul trucking, autonomous vehicles, high-speed rail, ride-hailing, car-sharing, pipeline, paratransit, ferries, FedEx, bus rapid transit, container ships, commercial airlines, and heavy rail subways.

PERSONAL AND PROFESSIONAL PERSPECTIVES

Transportation is a part of everyday life. It's also a rewarding engineering profession. It's a profession that features a mind-bending variety of regional and modal contexts; one that's characterized by an ever-shifting terrain of challenges and opportunities. Fortunately, newcomers to this part of civil engineering are also daily users of transport services. These everyday travel experiences make the study of transportation systems personally meaningful.

Newcomers to this field of study are often surprised by what they learn. Many of the underlying concepts and analytic methods are not as intuitive as the student first anticipated. Some of the 'surprise' can be explained by the expansive breadth of sciences required for a transport system to function well. What may also be unexpected is the energetic participation of specialists and stakeholders who collectively perceive a given transport project as both an opportunity for economic vitality as well as a threat to livability.

> Activity 1-3: Consider a heavily utilized congested urban freeway and a proposal to expand a 2.5-mile [4-km] section by adding new lanes. Inspect Exhibit 1-2 and select any three stakeholders. Respond as prompted.1) What is their primary interest in this freeway likely to be? 2) How are they likely to respond to this proposal? Respond separately for each stakeholder you selected.

Exhibit 1-2 Specialists and stakeholders

Exhibit by Kim Allyn Wormley née K. Mastako using WordItOut via worditout.com May 2018. Used with permission from WordItOut.

Alt Text for Exhibit 1-2: Word cloud with 19 stakeholders: policymakers, planners, engineers, land developers, activists, labor unions, community organizers, economists, business interests, taxpayers, commuters, property owners, neighbors, freight interests, elected officials, environmentalists, railway companies, airport authorities, and law enforcement.

CAREER OPPORTUNITIES

Some transportation professionals work in the public sector on behalf of municipal, regional, state and federal entities who own infrastructure. These government entities are accountable to the public to provide safe, reliable, affordable, equitable and responsible mobility. Various *private* entities also own and operate conveyance systems, rolling stock, aircraft, watercraft, pipelines, and terminals. Private entities are directly accountable to regulators and investors.

RECOMMENDED – View the following:

"Design Your Future: Careers in Transportation" (minute 5:05 – 9:00) published by Institute of Transportation Engineers on YouTube, June 2011 tinyurl.com/y8molowg

"Transportation Engineer – Cool Jobs" (minute 0:30 – 3:00) published by Work4NC on YouTube, June 2015 tinyurl.com/y9hug8bo

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Activity 1-4: Identify public and private-sector entities that partner with local area colleges and universities to recruit transportation interns and graduates. Do this by asking anyone who serves as an industry liaison (e.g., student club leader, career fair organizer, faculty). Next, select one private firm or public agency from your list and respond as prompted. What are the likely roles and responsibilities that this organization has in delivering a transportation project?

Activity 1-5: Think of Google or any well-known tech company with thousands of employees. What might their in-house transportation professional(s) be expected to do to reduce the number of vehicle trips to the principle worksite? What programs and services might they implement?

WHAT *IS* TRANSPORTATION ENGINEERING?

Transportation engineering is a fairly extensive discipline; one that has broad interaction with other professional fields within civil engineering and beyond. Examples include geotechnical, structural, water, public policy, regional planning, land development, heavy civil, construction management, finance, and more.

The primary purpose of transportation is to satisfy a fundamental societal need: *safe, effective, and responsible* movement of people and goods. The Wikipedia definition of transportation engineering is given below. It describes a fairly bold endeavor associated with a complex array of performance metrics.

"Transportation engineering is the application of technology and scientific principles to the planning, functional design, operation and management of facilities for any mode of transportation to provide for the safe, efficient, rapid, comfortable, convenient, economical, and environmentally compatible movement of people and goods."

- Wikipedia tinyurl.com/jtxprje accessed August 2019

Activity 1-6: Inspect the *Wikipedia* definition given above for the seven featured attributes (safe, efficient, ...and environmentally compatible). In your opinion, which three are the most important? Give your reasons for prioritizing these three over the other four.

The American Society of Civil Engineers (ASCE) operates numerous technical committees to help inform the practices of the transportation engineering profession. Select technical committees within ASCE's Transportation & Development Institute are listed in Exhibit 1-3. Experts in these areas serve the profession via ASCE and other professional societies, including the Transportation Research Board (TRB), WTS International, the Institute of Transportation Engineers (ITE), the Eno Center for Transportation, and numerous others based in the U.S., Europe, Asia and beyond.

Activity 1-7: Review the list of ASCE committees given in Exhibit 1-3. First, which three are most interesting to you? Next, choose any one of the three and respond as prompted. What is it about this committee's focus area that you find interesting?

Activity 1-8: Organizations such as NACTO, AICP, AASHTO, APTA, and ITS America focus primarily on streets and highways. Become familiar with these organizations by reversing their acronyms from letters to words. Do this by performing some light internet research. Next, choose one of these organizations and respond as prompted. What is the host city of this organization's next annual meeting or conference?

ASCE Transportation & Development Institute Committees	
Airfield Pavement	Public Transport
Aviation Planning and Operations	Rail Transport
Connected and Autonomous Vehicles	Highway Construction
Economics and Finance	Highway Pavement
Freight and Logistics	Street and Highway Operations
Sustainable Transportation	Transportation Safety
Automated People Movers	Infrastructure Systems

Exhibit 1-3 ASCE Transportation & Development Institute Committees

Exhibit by Kim Allyn Wormley née K. Mastako, 2019 informed by asce.org tinyurl.com/yb4cjacf accessed August 2019.

Alt Text for Exhibit 1-3: Fourteen committees presented in two columns.

Engineering practitioners are licensed professionals. U.S. licensing requirements include examinations administered by the National Council of Examiners for Engineering and Surveying (NCEES). The 2019 Fundamentals of Engineering (FE) Civil exam contains 110 questions, 8 – 12 of which require knowledge of transportation engineering. The 40-question breadth portion of the 2019 PE Civil exam includes several questions that assess knowledge of highway geometrics and traffic flow. The transportation depth exam (one of five options for completing the PE Civil exam) covers the topics listed in the final column of Exhibit 1-4.

> Activity 1-9: Inspect Exhibit 1-4 for topics with which you may already be familiar. Have you had any prior classroom, lab or work experience with some of these? If so, respond as prompted. Choose up to three topics with which you have some prior experience. For each of these, describe the context and the nature of that experience.

FE Civil Exam	PE Civil Exam	
	Breadth	Transportation Depth
Geometric Design of Streets & Highways	Circular Curve Elements	Capacity Analysis & Planning
Geometric Design of Intersections	Vertical Curve Elements	Horizontal Design
Pavement System Design	Traffic Volume	Vertical Design
Traffic Safety		Intersection Geometry
Traffic Capacity		Roadside and Cross-Section Design
Traffic Flow Theory		Signal Design
Traffic Control Devices		Traffic Control Design
Travel Forecast Modeling		Geotechnical and Pavement
		Drainage
		Alternatives Analysis

Exhibit 1-4 NCEES exam specifications pertaining to transportation engineering

Exhibit by Kim Allyn Wormley née K. Mastako, 2018 informed by ncees.org tinyurl.com/y848l3mh and tinyurl.com/ybutjzkk accessed June 2018 and August 2019.

Alt Text for Exhibit 1-4: Eight specifications for the FE exam in the first column. PE exam specifications in the center and final columns. Three PE breadth in the center column; 10 transportation depth in the final column.

HISTORICAL PERSPECTIVE

The basic needs of any civilization – ancient or modern, large or small, urban or rural – include water, food, sanitation, shelter and transportation. The vital significance of transportation is evident wherever history is shaped by migration, battles and trade; initially by land and then along inland waterways and across seas; ultimately by rail, air and beyond.

Moreover, it's no great surprise that world-class cities are intentionally situated where the natural topography accommodates either a deep-sea port or a reliable inland waterway. From here, early decisions on rail and highway alignments provided access to natural resources, fueled industries, and promoted the expansion of population centers.

> Activity 1-10: Inspect Exhibit 1-5 for emerging megaregions in the U.S. Which of these is home to either a deep-sea port or a reliable inland waterway?

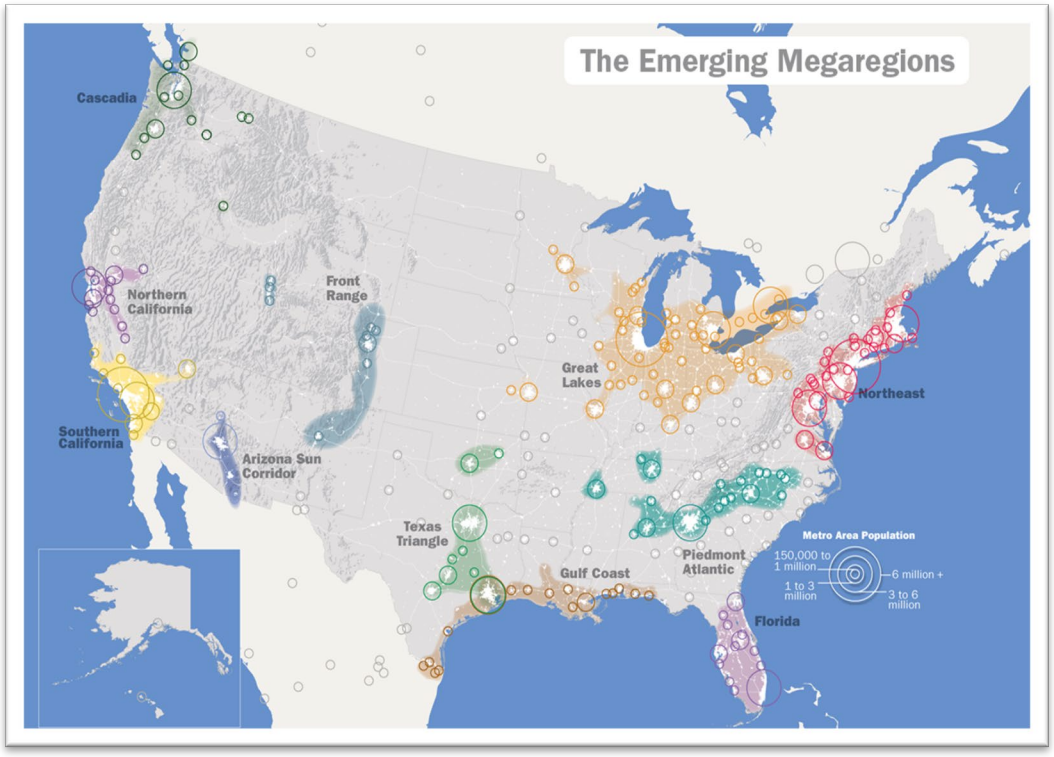

Exhibit 1-5 Megaregions of the U.S.

Source: Map of Emerging US Megaregions by the Regional Plan Association licensed under CC BY-SA 3.0. Accessed August 2019 via Wikipedia tinyurl.com/hsh48av.

Alt Text for Exhibit 1-5: US map with 11 emerging megaregions: Cascadia, Northern California, Southern California, Arizona Sun Corridor, Front Range, Texas Triangle, Gulf Coast, Great Lakes, Piedmont Atlantic, Florida, and Northeast.

RECOMMENDED – Scan the following:

"Transportation and Society" in Transportation Planning Handbook published by the Institute of Transportation Engineers 1992 or 2009

RECOMMENDED – View the following:

"An Animated History of Transportation" (minute 0:00 – 2:33) published by The Atlantic on YouTube, July 2015
tinyurl.com/jjga2ky

In terms of historical study, there's no shortage of relevant topics beginning with the Silk Road trade routes established during the Han Dynasty of China and the military highways of the Roman Empire. In the Western Hemisphere, there's the golden age of steam-boating, the Wright Brothers flight at Kitty Hawk, the first transcontinental railroad, Boston's system of streetcars, the Panama Canal, the Federal-Aid Highway Act of 1956, Apollo 11 and more.

Activity 1-11: Identify two historical events in transportation not mentioned in the preceding paragraph. Sketch a timeline featuring your two along with those previously mentioned in the preceding paragraph.

Activity 1-12: Choose one historical event and conduct some light internet research. How did this event impact the people of the time? Were there any unintended consequences that informed future decision making?

Proper analysis of historical events generally leads to a fuller understanding of present circumstances, and potentially wiser decision-making in the future. Certainly, the lessons of the past have informed the priorities of the present in terms of sustainability and resiliency. Still, there can be little doubt that future generations will critically evaluate the investment and policy decisions made today.

SUSTAINABILITY

In various ways, the current generation has unfavorably judged some of the investment and policy decisions of the latter half of the 20th century. One consensus is that decisions of the past caused growth patterns, social systems, and auto-centric travel habits that are not sustainable. Another consensus is that too many vital assets lack resiliency against natural disaster, terrorist attack, etc. As the practices of the profession continue to modernize in alignment with greater social and environmental responsibility, one can anticipate a future that is more sustainable by design.

RECOMMENDED – View the following:

"Cities Rise to the Challenge – Sustainable Mobility" (minute 0:00 – 6:52) published by WWF on YouTube, Feb 2018
tinyurl.com/y3d9ttn6

Sustainable Development

Forward-thinking individuals aim to prioritize vulnerable people and resources. In 2015, the United Nations General Assembly adopted the 2030 Agenda for Sustainable Development. The agenda features seventeen goals based on the principle of leaving no one behind (no poverty, zero hunger, good health and well-

being… justice). The goals inform the programs and projects of the United Nations Education, Scientific and Cultural Organization (UNESCO). Ultimately, they are the responsibility of policymakers and practitioners in every developed and developing region.

Exhibit 1-6 UNESCO sustainable development goals

Source: United Nations Education, Scientific and Cultural Organization licensed under CC BY-SA 3.0. Accessed August 2019 via en.unesco.org/sdgs.

Alt Text for Exhibit 1-6: Seventeen sustainable development goals: 1) no poverty, 2) zero hunger, 3) good health and well-being, 4) quality education, 5) gender equality, 6) clean water and sanitation, 7) affordable and clean energy, 8) decent work and economic growth, 9) industry, innovation, and infrastructure, 10) reduced inequalities, 11) sustainable cities and communities, 12) responsible consumption and production, 13) climate action, 14) life below water, 15) life on land, 16) peace, justice, and strong institutions, and 17) partnership for the goals.

Upon initial inspection of Exhibit 1-6, it may or may not be apparent that most sustainable development goals are either advanced or hindered by the strengths and weaknesses of regional transport systems. In the case of good health and well-being (UNESCO Goal #3), transportation affects access to services for preventing and managing disease, access to nutrient-rich foods, and options for heart-healthy activity during the daily commute. Moreover, wise decisions concerning the planning, financing, design, and operation of transport systems can advance just about any sustainable development goal.

Activity 1-13: Consider the sustainable development goals featured in Exhibit 1-6 and respond as prompted. How is Goal #1 No Poverty either advanced or hindered depending on the quality and resilience of local transport infrastructure? How is Goal #2 Zero Hunger either advanced or hindered depending on the local transport infrastructure? Finally, is there any goal among the first 15 that has no relationship to transportation?

In the pages that follow, specific attention is given to the topic of sustainable mobility. When evaluating an existing system or project proposal for indicators of sustainability, it's wise to keep the UNESCO goals in mind. They point to the reasons why users consume transport services in the first place, and challenge policymakers to act responsibly in their provision.

Activity 1-14: Reflect on the trips you made in the past 30 days. Begin by identifying 4 – 6 unique purposes for the trips you made (e.g., medical care, recreation, education). Next, rank these based on the frequency of your trip making within the past 30 days. Place the purpose associated with the greatest frequency of trip making at the top, followed by the purpose associated with the second greatest frequency, and so on.

Sustainable Mobility

A sustainable system is one that serves the needs of today without compromising the resources available to serve the needs of tomorrow. This can be done by striking a balance between three realms of responsibility: social, environmental, and economic. Together, the three realms are referred to as the triple bottom line. They are commonly depicted in the form of a Venn diagram as shown in Exhibit 1-7, or a tetrahedron as shown in Exhibit 1-8.

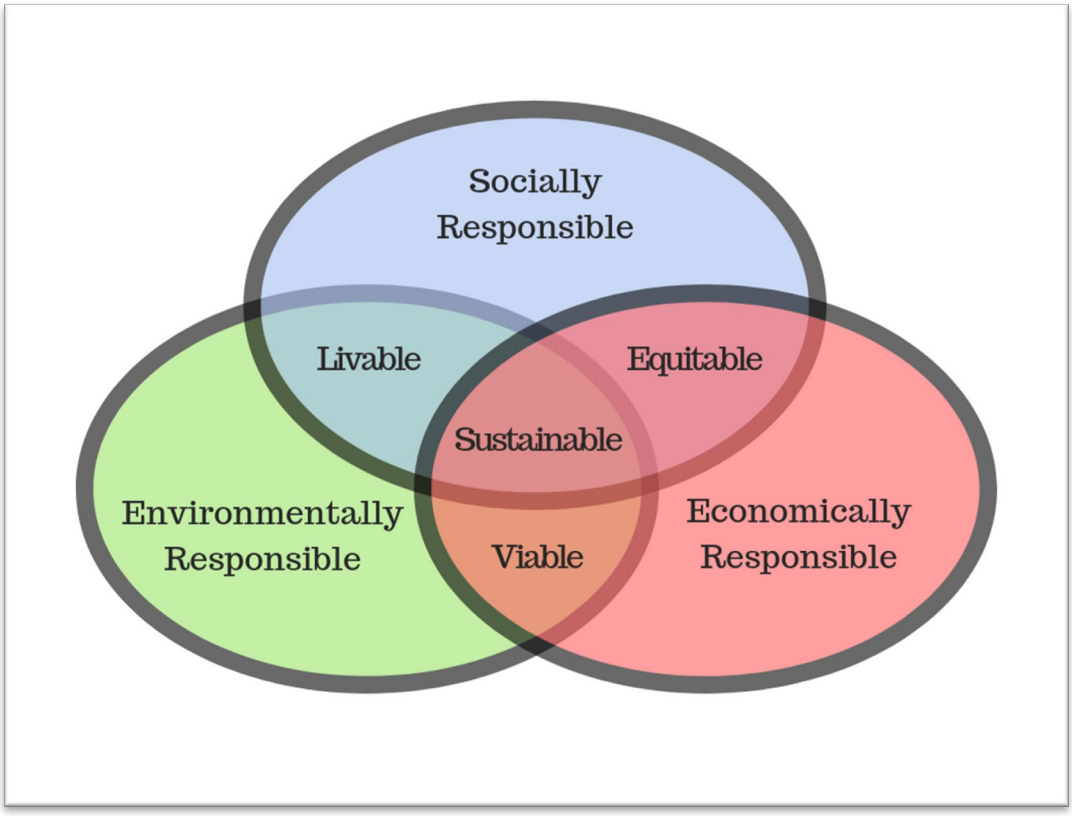

Exhibit 1-7 Sustainability Venn diagram

Exhibit by Kim Allyn Wormley née K. Mastako using Canva via canva.com June 2018. Inspired by similar graphic "La mobilité durable – schéma" appearing in 2009 – 2010 @mobiped publication "What is the sustainable mobility?" accessed June 2018 and August 2019.

Alt Text for Exhibit 1-7: Three overlapping ellipses for social, economic, and environmental responsibility. Sustainable where all three overlap; livable where social and environmental responsibility overlap; equitable where social and economic overlap; viable where economic and environmental overlap.

The same three realms of responsibility are also referred to as the three Ps (people, planet, price.. or people, planet profit) and occasionally as the three Es (equity, environment, economics).

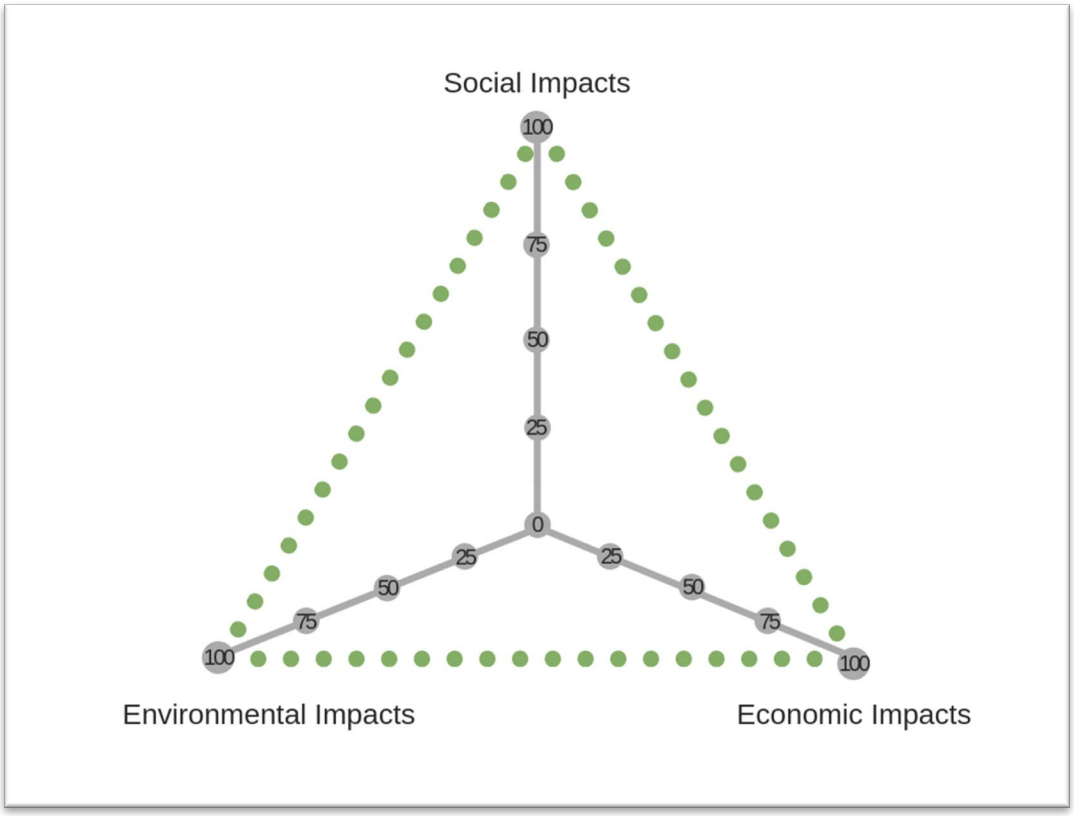

Exhibit 1-8 Sustainability tetrahedron

Exhibit by Kim Allyn Wormley née K. Mastako using Canva via canva.com June 2018. Inspired by similar graphic "The sustainability triangle" appearing in 2017 American Society for Engineering Education (ASEE) publication "A New Framework for Teaching the Triple Bottom Line: The Sustainability Triangle and the Sustainability Index" by Penn, Michael R., and Kristina M. Fields accessed June 2018 and August 2019.

Alt Text for Exhibit 1-8: Tetrahedron with a zero-vertex from which three evenly segmented edges radiate {25,50,75,100} and vertices at 100 for social, environmental and economic impacts.

To qualify for an Envision or LEED[1] certification, a project is evaluated by an expert with specialized knowledge, and judged according to industry standards. At the sketch-planning level, project alternatives tend to be more loosely evaluated. For this purpose, Penn and Fields (2017) recommend a semi-quantitative sustainability index representing magnitude and balance among

[1] Reference Institute for Sustainable Infrastructure, founded by ASCE (Envision) and Leadership in Energy and Environmental Design, U.S. Green Building Council (LEED)

impacts. The analyst identifies and categorizes the likely impacts, estimates a 0 – 100 score for each realm of responsibility, and then computes an overall rating. Because the scores are intended for relative comparison, they do not need to be definitive.

> Activity 1-15: Consider two project alternatives. Alternative A rates 30 on social, 90 on environmental, and 90 on economics. Alternative B rates 70 on social, 80 on environmental, and 60 on economic. Next, notice that the combined sums happen to be equal (i.e., 210 for Alternative A and 210 for Alternative B). Respond as prompted. 1) Would it perhaps be appropriate to assign *unequal* weights to the three dimensions? 2) Why do you say so? 3) How would you proceed?

Sustainability mobility principles are central to modern transportation planning. One commonly adopted principle is the prioritization of people over vehicles. This principle can be articulated in any number of ways. An example sourced from *Shared Mobility Principles for Livable Cities* is given below.

"The mobility of people and not vehicles shall be in the center of transportation planning and decision-making. Cities shall prioritize walking, cycling, public transport and other efficient shared mobility, as well as their interconnectivity. Cities shall discourage the use of cars, single-passenger taxis, and other oversized vehicles transporting one person."

- "Shared Mobility Principles for Livable Cities" sharedmobilityprinciples.org accessed June 2018

Social Responsibility

Social responsibility is an ethical obligation to be inclusive; to not marginalize. A project that increases connectedness among individuals and neighborhoods is more socially responsible than one that separates or isolates. Portions of the U.S. interstate highway system as enacted in the 1950s and 1960s are known to have divided neighbors and segregated communities.

> Activity 1-16: Perform some light internet research on the term 'highway revolt.' Seek to identify U.S. cities where highway projects met with community opposition, and where projects were either halted or removed. Next, choose one controversial highway project and describe in terms of the following: a) the city, b) the project, c) the objection(s), and d) the resolution.

Today, more communities are prioritizing equitable access to healthy foods and medical care. In 2016 Columbus, Ohio made a commitment to reducing infant

mortality by connecting low-income residents with better mobility to medical care and won the U.S. Department of Transportation's Smart City Challenge.

Economic Responsibility

A system with a more favorable benefit-cost analysis (BCA) is more *economically responsible* than one with a less favorable BCA. Making this determination requires defensible estimates and an impartial comparison among viable alternatives.

Initial cost-benefit estimates are necessary, but not always reliable. For big projects, it's wise to acknowledge uncertainty and estimate a range instead of a single dollar figure. California High-Speed Rail, approved by voters in 2008, was initially estimated to cost $40 billion. In the ten years that followed, indirect benefits associated with planning, design, and construction accrued. Project costs also escalated. In 2018, the California High-Speed Rail Authority estimated the economic impact of project development to include 30,000 job-years of employment, $2B in labor income, and $5.5B in economic output.[2] The Authority also re-estimated the project's costs at twice the initial estimate.

> Activity 1-17: First, perform some light internet research on California High-Speed Rail. Next, locate the California High-Speed Rail Authority's 2018 Business Plan and scan Chapter 4: Lessons Learned and Managing Risks. According to this publication, what are the principal cost increase drivers (e.g., the primary reasons for increasing the cost estimate)?

Environmental Responsibility

One project is more environmentally responsible than another if the impacts on the surroundings are less adverse. Most project proposals are accompanied by an environmental impact study (EIS) or report (EIR), which gives a detailed analysis of likely impacts to air quality, water quality, native species, noise levels, etc. Here, each impact is named, described and classified: avoidable or not; favorable or not; significant or not; mitigatable or not. A more environmentally responsible

[2] 2018 Business Plan accessed via hrs.ca.gov August 2019.

project would have fewer unfavorable environmental impacts; fewer that are significant; more that are mitigatable.

> Activity 1-18: Consider an airport expansion that is expected to increase noise levels. Next, consider the following proposals for mitigating the noise impact: a) upgrade the roofs and windows of buildings near the airport, b) operate quieter aircraft, c) enforce night flying restrictions, d) erect 12-ft sound wall barriers around the perimeter of the airport, e) increase the takeoff angle by ten degrees. Respond as prompted. 1) Which one is unlikely to be effective? 2) Which one does not impact airport operations? 3) Which mitigation would you advocate for if you lived close to the airport? ..and why do you say so?

PROFESSIONAL CAPACITIES TO CULTIVATE

A practitioner's ability to be successful in this collaboration hinges on knowledge and experience, plus a commitment to the practices listed below.

- Adhere to standards, yet critically evaluate accepted practice
- Seek to understand the local context
- Don't try to force a one-size-fits-all solution
- Nurture professional relationships and engage with the public
- Remain flexible and be willing to seek a design exception
- Exhibit the highest standard of honesty and integrity
- Seek wise counsel and listen well
- See clearly where one desired outcome is at odds with another
- Be willing to prioritize and know when to compromise

> Activity 1-19: Of the professional capacities listed above, which have you already demonstrated? Which would you like to cultivate? Respond by sorting the list so that the ones you would like to do more to cultivate are at the top, the ones you have already demonstrated are at the bottom, and the rest are in the middle.

CHAPTER SUMMARY

The pages of this chapter intend to achieve learning outcomes initially revealed at the start and repeated below. A useful strategy for verifying these is to spend time reflecting on the full set of activity prompts.

By the end of this chapter students will be able to:

- Identify transportation modes and stakeholders
- Recognize United Nations goals for sustainable development
- Define sustainable mobility
- Identify career opportunities

Students who have fully achieved chapter outcomes will also be able to:

- Associate personal travel experiences with the professional work of planners and engineers
- Explain how goals for sustainable development are either advanced or hindered by the strengths and weaknesses of regional transport
- Explain how a project that is both socially responsible and economically responsible can deliver an equitable solution, but not necessarily a sustainable solution
- Outline professional licensing requirements

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Chapter 2 Prioritizing Sustainable, Active, Resilient Mobility

CHAPTER OUTCOMES

By the end of this chapter students will be able to:

- Explain how land use and transportation are related
- Define latent demand
- Classify programs and policies in terms of transportation demand management (TDM) vs. transportation systems management and operations (TSMO)
- Identify the benefits of a 3- to 4-lane road diet conversion
- State the purpose of Federal Highway Administration Order 5520
- Define resilient mobility

Students who have fully achieved chapter outcomes will also be able to:

- Characterize land uses associated with a transit-supportive neighborhood
- Identify aspects of the built environment that promote walking and cycling
- Explain how micromobility options can help a region achieve its sustainable mobility goals
- Relate tactical urbanism to a road diet intervention, and as a catalyst for a long term change to a more complete street
- Contrast resilience versus preparedness relative to infrastructure that's vulnerable to storm surge, wildfire or landslide

PRE-READING QUESTION(S)

Prepare to begin this chapter by responding to the prompt(s) below.

> Activity 2-1: Consider your local area college or university campus. Identify aspects of the built environment that promote active modes of transportation: transit, walking, cycling, etc. How might the transportation to, from and within the campus be adapted to further promote active modes of transportation? Are there aspects of the land use within the campus that could be adapted to further promote active modes of transportation?

SURFACE TRANSPORTATION TODAY

Today's surface transportation system is considerably more complex than it was 75 years ago. Performance deficiencies are rarely corrected simply by adding new capacity. Often the new capacity merely shifts the congestion downstream to the next bottleneck, or is shortly overwhelmed by induced latent demand.

Latent demand is travel that does not happen because the constraints are too great. Induced demand is a phenomenon whereby an increase in capacity triggers more travel to occur.

> Activity 2-2: Consider the following statement: Travel that happens only because new capacity has been provided, and would not otherwise occur. Does this more accurately describe latent demand or induced demand?

Fortunately, a wide variety of strategies are being tested and deployed. Some strategies primarily intend to reduce the number of private vehicle trips. Strategies that intend to reduce the number of private vehicle trips are commonly referred to as Transportation Demand Management (TDM). TDM examples include flexible work hours, rideshare incentives, and costlier parking fees for private vehicles. Other strategies aim to enhance capacity without expanding the infrastructure's physical size. Strategies that enhance capacity without expanding the infrastructure's physical size are commonly referred to as Transportation Systems Management and Operations (TSMO or TSM&O, often pronounced "tizmo"). TSMO examples include technologies for detecting shockwaves, operating procedures for managing incidents and special events, and smarter signal timing. Various TSMO and TDM strategies are given in Exhibit 2-1.

Transportation System Management and Operations (TSMO)	Transportation Demand Management (TDM)
Incident and event management	Flexible work hours and telecommuting
Work zone and road weather management	Cashing out employer-paid parking
Smarter signal timing	Transit and rideshare incentives
Ramp metering	Incentives for walking and cycling
Lane and shoulder management	Dynamic parking fees and restrictions
Variable speed limits	Car-sharing
Transit management	Ride-hailing
Freight management	Congestion pricing
Access management	Education and enforcement
Connected and automated vehicle deployment	Decupling housing and parking

Exhibit 2-1 TSMO and TDM strategies for enhancing mobility

Exhibit by Kim Allyn Wormley née K. Mastako, 2018.

Alt Text for Exhibit 2-1: Ten TSMO strategies and ten TDM strategies in the first and second columns, respectively.

Activity 2-3: Consider a strategy that aims to enhance capacity without expanding the infrastructure's physical size. Would this be classified as TSMO or TDM?

Activity 2-4: Consider each the following: a) improved traffic signal coordination, b) more costly parking fees, and c) expansion projects that convert four-lane freeway segments to six-lane freeway segments. Which of these would be classified as TSMO? Which would be classified as TDM? Which would be classified as neither TSMO nor TDM?

Activity 2-5: Consider each the following: a) improvements that convert partial freeway interchanges into full freeway interchanges, b) temporary restrictions on left turns before and after sporting events, and c) priority parking to carpool and vanpool vehicles. Which of these would be classified as TSMO? Which would be classified as TDM? Which would be classified as neither TSMO nor TDM?

Activity 2-6: Consider each the following: a) toll roads along which users are charged a premium during peak travel periods, b) roving freeway service patrols dedicated to expeditious removal of disabled/stranded vehicles, and c) funding for new parking garages. Which of these would be classified as TSMO? Which would be classified as TDM? Which would be classified as neither TSMO nor TDM?

A favored strategy for moving forward is to provide attractive alternatives to solo driving, and educate the public about their transportation options.

Activity 2-7: Think about a weekday commute for which most commuters appear to choose solo driving by private auto. Choose a commute with which you are reasonably familiar. Identify the commute by origin, destination, departure time, route and expected arrival time. Next, identify the transit and rideshare options for this same commute. Finally, describe the most attractive of these options for achieving the same arrival time. Describe in terms of route, fare, payment method and departure time.

Another favored strategy is to redevelop the built environment in a manner that encourages residents and visitors to choose walking, biking, and transit. This means reshaping the built environment to achieve a more diverse mix of land uses, and greater land use densities (e.g., more housing units per acre, more employees per acre). Density is an important feature because public transit tends to thrive where people and jobs are concentrated within a compact space. When a compact space also contains a rich mix of land uses, the distances between origins and destinations are short and people tend to choose more active modes of travel. Land use strategies for sustainable mobility include:

- High-density development
- Mixed-use development
- Infill development
- Transit-oriented development
- Tiny houses
- Decoupling housing and parking

LAND USE AND TRANSPORTATION

The symbiotic relationship between land use and transportation cannot be overemphasized. It's a relationship that wasn't as fully appreciated 75 years ago as it is today. That many years ago in the U.S., it was standard practice to 1) separate residential uses from other uses, 2) ease peak-period traffic congestion by expanding capacity, and 3) expand outward by developing natural and agricultural lands. More often than not, a repeating cyclical pattern between highway capacity and land development manifested. This was ultimately seen as unsustainable.

As depicted in Exhibit 2-2, the cycle begins with a capacity expansion project that improves accessibility (making travel to adjacent properties more convenient), thereby increasing the value of these properties and motivating landowners to choose more intense development (e.g., more housing units per acre, more square feet of commercial activity per acre). When redevelopment generates more trips than can be accommodated, and traffic congestion becomes unbearable, taxpayers become anxious for additional highway capacity to be added ...and the cycle continues.

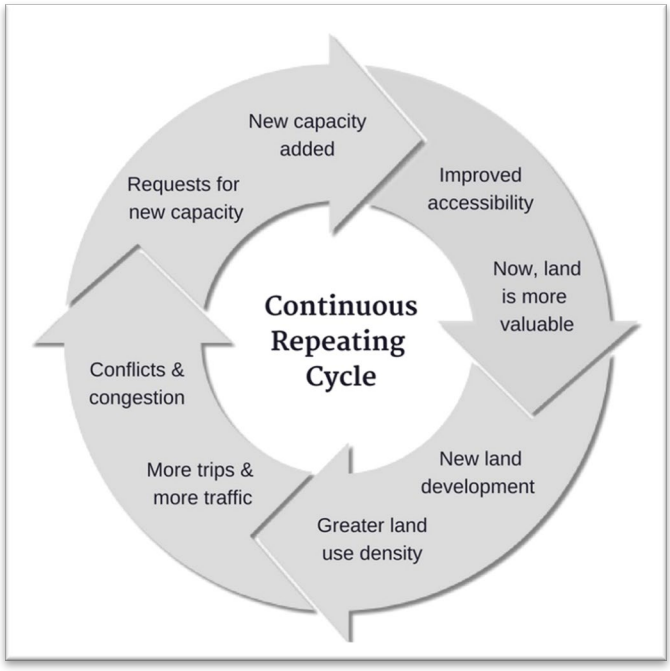

Exhibit 2-2: Land use transportation cycle

Exhibit by Kim Allyn Wormley née K. Mastako using Canva via canva.com June 2018. Inspired by similar graphic "Transportation Land Use Cycle" published by Connecticut Metropolitan Council of Governments via ctmetro.org at tinyurl.com/vcjgojl.

Alt Text for Exhibit 2-2: Continuous, circular eight-stage cycle: new land development, then greater land-use density, then more trips & more traffic, then conflicts & congestion, then requests for new capacity, then new capacity added, then improved accessibility, now land is more valuable, then back to new land development… and repeat.

Activity 2-8: Describe the land use-transportation cycle by sorting the following in sequential order beginning with widen road (f): a) land prices rise and landowners request rezoning to allow more development, b) repeat, c) people drive faster and further, d) congestion develops, e) under political pressure land is rezoned, f) widen road, and g) subdivisions and businesses develop and people move further out to larger and more affordable homes.

RECOMMENDED – View the following:

"Sustainable Thurston – The land use-transportation connection" (minute 0:00 – 7:50) published by TRPCorg on YouTube, Jan 2012 tinyurl.com/yamvbxnz

Activity 2-9: View the video Sustainable Thurston – The land use-transportation connection. According to this video, what's the distance (miles) that most Americans are willing to walk when making a utility trip (e.g., hardware store, post office, pharmacy)?

Activity 2-10: View the video Sustainable Thurston – The land use-transportation connection. According to this video, what's the duration (minutes) that most Americans are willing to accept when choosing to ride transit?

Activity 2-11: View the video Sustainable Thurston – The land use-transportation connection. According to this video, what land use mix and densities are needed for a transit-supportive neighborhood where transit routes are likely to make good economic sense?

Activity 2-12: View the video Sustainable Thurston - The land use-transportation connection. According to this video, what would cause Family A who lives in a green building and operates a green vehicle to likely to consume more energy than Family B who lives in a building that is not green and operates a vehicle that is not green?

RECOMMENDED – Scan the following:

"Does Density Matter? The role of density in creating walkable neighborhoods" (pp. 8 – 31) published by National Heart Foundation of Australia, 2014 tinyurl.com/y85a5fnd

In many cases, the wisest approach is a triad system of management strategies that combine TSMO, TDM and land use management. Exhibit 2-3 recommends a balance among these strategies; one that's appropriately tuned to the context and the values of the community. In many places this means:

- prioritizing walking and cycling,
- providing attractive bus and rail options,
- simplifying multimodal journeys, and
- using vehicles that consume and pollute less.

Activity 2-13: Consider the category of light-vehicle transport commonly referred to as micromobility, which includes electric scooters, shared bicycles, and electric pedal-assisted bicycles. How might the deployment of micromobility options help a region achieve its sustainable mobility goals?

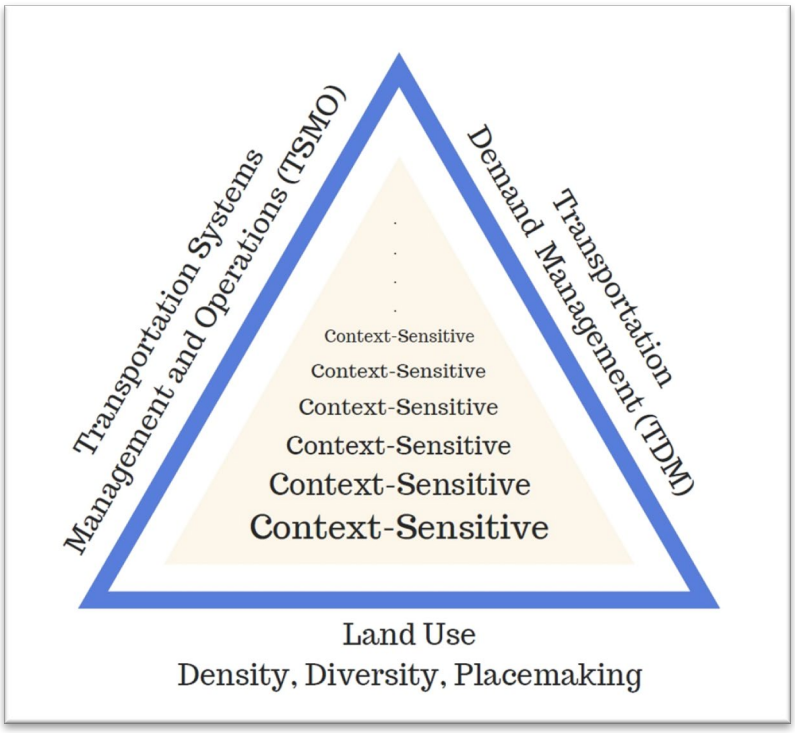

Exhibit 2-3 Triad system of mobility strategies

Exhibit by Kim Allyn Wormley née K. Mastako using Canva via canva.com June 2018. Inspired by similar graphic "Elements of a Mobility/Congestion Reduction Program" appearing in 1997 FHWA/ITE publication A Toolbox for Alleviating Traffic Congestion and Enhancing Mobility FHWA-SA-98436 by Michael D. Meyer.

Alt Text for Exhibit 2-3: Triangle sides for transportation systems management and operations (TSMO), transportation demand management (TDM), and land use: density, diversity, placemaking. Center textbox reads: context-sensitive.

PRIORITIZING ACTIVE MOBILITY

Desirable transit, pedestrian and cycling outcomes are even more likely to manifest when the built environment is further enhanced with pedestrian-scale streetscapes and placemaking features that invite people to linger. Today, it's not uncommon for a street design that had originally prioritized motor vehicles to be adapted in order to reprioritize more active modes of mobility.

In many cases, the first step is a road diet. One type of road diet is a 4- to 3-lane conversion where a four-lane road (with two moving lanes in each direction) is re-striped to provide one moving lane in each direction and a two-way left-turn lane

(TWLTL) as the median. The TWLTL provides a predictable and more comfortable space for left turns. With fewer moving lanes, there are fewer points of conflict. A 4- to 3-lane road diet also frees up space that can then be dedicated to transit, cyclists, and/or pedestrians, thereby making a more complete street that more fully serves a wider variety of users.

It is not uncommon for a road diet to begin as an intervention scheme initiated by neighborhood activists assisted by community leaders. A road diet intervention by volunteers (aka a complete street intervention) is commonly referred to as tactical urbanism. Tactical urbanism is a short-term, low-cost streetscape conversion that's intended to catalyze long term change. One example of tactical urbanism is the High Street Temporary Improvement Project in San Luis Obispo. For three days in May 2017, the High Street Better Block community transformed the 300-block of High Street using fiber rolls, potted plants, pylons, wood pallets, hay bales, and adhesive tape for marking the pavement.

Exhibit 2-4 High Street Better Block event, May 2017

Exhibit by Photo by Jonathan Roberts Bluephoto Wedding Photography via www.bluephoto.biz. Used with permission.

Alt Text for Exhibit 2-4: A four-image photo grid. Clockwise from upper left: 1) volunteers putting pylons into place, 2) fiber rolls, potted plants, pylons and adhesive tape placed to narrow the road, 3) parklet constructed out of low-cost materials, 4) curb extension constructed out of low-cost materials.

Activity 2-14: Search YouTube for a video advocating for complete streets projects. Identify a video segment (5 - 10 minutes) that you would recommend to your peers. Identify the URL web address, title, publisher, upload date, segment start time, and segment end time.

Activity 2-15: Perform some light internet research on 'complete streets' and respond as prompted. What are the benefits of a complete street?

RECOMMENDED – View the following:

"Superblocks: How Barcelona is taking city streets back from cars" (0:00 – 5:30) published by Vox on YouTube, Sep 2016 tinyurl.com/yd9ozowr

"Road diets: designing a safer street" (0:00 – 5:14) published by Vox on YouTube, July 2018 tinyurl.com/yas6t3w7

"Urban Design: Effects on Walking Behavior" (minute 0:00 - 3:22) published by McGill University on YouTube, Oct 2018, tinyurl.com/y2b4fc8s

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Activity 2-16: View the videos listed above and respond as prompted. 1) What's the speed limit within a Barcelona Superblock? 2) Identify three benefits of a road diet. 3) Name five attributes of the built environment associated with walking behavior and choose any three to define.

PRIORITIZING RESILIENT MOBILITY

Communities of all sizes rely on transport systems to thrive, and to survive. Understandably, there are serious concerns whenever vital infrastructure is threatened by wildfire, flood, tectonic shift, etc. Wherever transport systems are vulnerable, people's lives and livelihoods are at risk. The degree of vulnerability is commonly referred to as resilience, or resiliency.

The below definition of resilience is attributed to 100 Resilient Cities (100RC), a network of cities established during a recent six-year period (2013 - 2019). 100RC was commissioned for the purpose of strengthening resilience to social, economic, health, and environmental challenges. As a result of this effort, dozens of forward-thinking cities have since appointed a Chief Resilience Officer and given that person responsibility for incorporating resiliency into the sustainable development process.

***Resilience** is the capacity of individuals, communities, institutions, systems, and businesses to survive, adapt and grow no matter what kinds of chronic stresses and acute shocks they experience. – 100 Resilient Cities (100RC)*

In addition, various transportation agencies have adopted formal policies on environmental security, examining threats to infrastructure posed by

environmental events and trends. The general consensus is that extreme weather in the future reduces the lifecycle of a physical asset compared to what was anticipated when it was initially engineered to withstand historic climate conditions. In 2014, the Federal Highway Administration issued Order 5520, committing itself to "system preparedness and resilience to climate change and extreme weather events." [1]

While a flood evacuation plan indicates preparedness, a flood protection system indicates *resilience by design*. For an asset that's vulnerable to storm surge, a flood protection system may be a wise investment. Prior to Hurricane Sandy (2012), the New York City Transit Authority had a recovery plan for draining and pumping water from a flooded subway. After Hurricane Sandy, the Transit Authority made a strong commitment to flood resiliency by investing in a system of flexible barriers. Each flexible barrier consists of a soft cover that's engineered like a spacesuit and capable of holding back 14 feet of water. The cover sits rolled up in a canister perpendicular to subway entrance railings, ready to unfurl when needed.

> Activity 2-17: Perform some light internet research on the flood infrastructure designed to protect Rodderdam, a port city in the Dutch province of South Holland. Describe this infrastructure in terms of its purpose, placement, design, cost, and potential efficacy.
>
> Activity 2-18: First, express in your own words the difference between preparedness and resiliency. Next, explain how each of the following could boost resiliency: rock shed, beach nourishment, bridge deck elevation.

Threats to resiliency are numerous. They include flood, wildfire, tsunami, hurricane, earthquake, landslide, terrorism and other violent acts. Transportation services may also be vulnerable to pandemic, economic upheaval and/or political unrest. Thus, it may be appropriate to distinguish between external shocks and chronic (or slow-burning) stressors, and for the Chief Resilience Officer to tailor ‘resilience by design’ recommendations accordingly. Examples of external shocks and chronic stressors (also referred to as slow-burning stresses) are given below in Exhibit 2-5. In addition, three potential accelerators are acknowledged.

Acute shocks	Chronic stressors	Accelerators
Natural disaster	Poverty	Climate
Infrastructure collapse	Income inequality	Urbanization
Terrorism	Water scarcity	Globalization
Pandemic	Crime	
Cyberattack	Corruption	

Exhibit 2-5 Resiliency threats: acute shocks, chronic stressors, and accelerators

Exhibit by Kim Allyn Wormley née K. Mastako, 2019. Inspired by "Resilient City Infographic" published by Lake Union Laboratory.

Alt Text for Exhibit 2-5: Five acute shocks, five chronic stressors, and three accelerators in the first, second, and third columns, respectively.

With adequate investment, just about any vulnerability *can* be resolved. Even so, funding for resiliency projects can be difficult to prioritize, particularly when the probability of catastrophic failure is uncertain.

CHAPTER SUMMARY

The pages of this chapter intend to achieve learning outcomes initially revealed at the start and repeated below. A useful strategy for verifying these is to spend time reflecting on the full set of activity prompts.

By the end of this chapter students will be able to:

- Explain how land use and transportation are related
- Define latent demand
- Classify programs and policies in terms of transportation demand management (TDM) vs. transportation systems management and operations (TSMO)
- Identify the benefits of a 3- to 4-lane road diet conversion
- State the purpose of Federal Highway Administration Order 5520
- Define resilient mobility

Students who have fully achieved chapter outcomes will also be able to:

- Characterize land uses associated with a transit-supportive neighborhood
- Identify aspects of the built environment that promote walking and cycling
- Explain how micromobility options can help a region achieve its sustainable mobility goals
- Relate tactical urbanism to a road diet intervention, and as a catalyst for a long term change to a more complete street
- Contrast resilience versus preparedness relative to infrastructure that's vulnerable to storm surge, wildfire or landslide