SAVING TIME AND MAKING CENTS:

A Blueprint for Building Transit Better

Eno Center for Transportation

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About the Eno Center for Transportation

The Eno Center for Transportation is an independent, nonpartisan think tank whose vision is for an American transportation system that fosters economic vitality, advances social equity, and improves the quality of life for all. The mission of Eno is to shape public debate on critical multimodal transportation issues and build a network of innovative transportation professionals. As an organization, Eno values independence, collaboration, relevance, excellence, and entrepreneurialism. These core values are reflected in everything we do.

Executive Summary

Cities, states, and metropolitan areas across the United States are looking to invest in a range of public transit projects in order to connect people to jobs and economic opportunity, reduce greenhouse gas emissions from vehicles, and shape development patterns. According to one estimate, the United States invested about $50 billion in new transit projects in just the last decade.[1] These include underground subways in Los Angeles, commuter rail lines along the Front Range near Denver, a streetcar in downtown Atlanta, light rail lines in suburban Phoenix, and bus rapid transit in Richmond, Virginia, among many others.

While these projects are as diverse as the country itself, they all have one thing in common: increased scrutiny over their costs and timelines to build. A few very visible projects have reinforced the narrative that rail transit investments have systemic issues that are endemic to the United States.

This all begs the questions: Is this true? If so, why? And what should we do about it?

These are precisely the questions Eno set out to answer through this research, policy, and communications project to analyze current and historical trends in public transit project delivery. We convened a set of advisors and conducted in-depth interviews with key stakeholders to understand the drivers behind mass transit construction, cost, and delivery in the United States. A comprehensive database of rail transit projects was created and curated to compare costs and timelines among U.S. cities and peer metropolitan areas in Western Europe and Canada. Through this quantitative and qualitative approach, we developed actionable recommendations for policy changes at all levels of government as well as best practices for the public and private sectors.

UNDERSTANDING COSTS AND TIMELINES

Eno's Construction Cost Database of 180 domestic and international public transit projects completed since 2000 shows that the United States pays a premium of nearly 50 percent on a per-mile basis to build transit for both primarily at-grade and primarily tunneled projects. The tunneling premium in the United States rises to roughly 250 percent when New York City's disproportionately expensive projects are included.

Tunneled projects are not only less expensive abroad, but also more common. Just under 12 percent of U.S. rail transit projects represented in our database were constructed primarily below ground, compared to 37 percent of non-U.S. projects. In fact, many international projects constructed below grade have similar costs to those that are at-grade in the United States. For example, Toulouse, France's 9.3 mile Metro Line B was built entirely underground at a cost of about $176 million per mile while Houston Metro's 3.2 mile Green Line is all at-grade and cost $223 million per mile.

Despite their lower construction costs, international projects are often more complex than similar lines in the United States. They tend to have more stations that are built closer together than U.S. projects, often run through crowded historic city centers, and usually share street space with cars and other vehicles. Rail projects in the United States tend to be routed along "paths of least resistance" such as freight rail or highway corridors, rather than dense areas where transit would make the most sense for riders or communities. Of course, this is not always the case. Seattle's 1 Line corridor traverses well-developed urban areas and operates in a tunnel between the University of Washington and downtown. But many U.S. transit projects resemble Minneapolis' Blue Line, whose mostly at-grade alignment along existing right-of-way was specifically intended to limit impacts on the local community and minimize the need to acquire private property.

Even with more straightforward alignments, U.S. projects with minimal tunneling still take about six months longer to construct than similar non-U.S. projects. U.S. projects that are almost all underground take nearly a year and a half longer to build than abroad. The time it takes to construct a transit project is also highly correlated with its cost, reinforcing the aphorism "time is money."

RESEARCH METHODS

With an understanding that transit projects in the United States do suffer from high costs and take longer to complete than they do abroad, it is important to investigate the "why." To do so, we conducted a thorough examination of existing literature and research and interviewed 117 professionals with both intimate knowledge of specific projects or regions and transit project delivery expertise generally. We also conducted detailed case studies of project delivery in four domestic regions (Los Angeles, Seattle, Denver, and Minneapolis) and four international regions (Copenhagen, Madrid, Paris, and Toronto) to help identify real-world examples of cost and timeline drivers for transit projects as well as best practices. We also compared a transit project to a highway project in Virginia to compare how regulatory processes, project delivery practices, institutional support, and governance differ across modes.

Through our literature review and case studies, one clear finding emerged: there is not one, easily identifiable reason for high costs or delivery delays. Rather, we identified a dozen drivers of transit construction costs and timelines that fall into three overlapping and interrelated categories: *governance, processes, and standards*. These findings form the basis of our resulting recommendations and best practices to deliver transit projects quicker and more cost-effectively.

POLICY AND PRACTICE RECOMMENDATIONS

The responsibility for cutting costs and timelines for transit projects does not rest solely on federal reforms, fixes at the agency level, or with private sector practice. Rather, the challenges are acute, complex, and multi-faceted. The solutions are, too. The recommendations below are based on that fundamental premise.

First, we need to get the institutions, oversight, and decision-making right.

The public institutions charged with leading the delivery of transit projects need authority, staff, and good governance to move them forward.

Today in the United States, transit projects are delivered almost exclusively through existing entities. Public transit agencies are institutions that were designed as operating entities often to pick up the operation of struggling bus lines from private companies decades ago. Setting a clear structure for organizational decision-making responsibility, as well as coordination with other agencies and transportation modes, is critically important to the success of a transit project. The successful, low-cost expansion of Madrid's metro system between 1995 and 2003 provides a clear example of how small, multi-disciplinary internal management teams can deliver projects effectively when they are empowered to address issues as they arise. In Denver, a delegated authority approach for the region's FasTracks system expansion led to faster turnarounds on key decisions and fewer project delays.

Our research shows that independent, special purpose delivery vehicles (SPDV) are an attractive option to manage construction before handing the ownership and operation back to the public agency. States or regions need to create a temporary, independent SPDV, or modify an existing institution, with the necessary authorizations and abilities to manage and focus on the most complex of projects. Institutions responsible for project delivery need to be self-permitting, should be able to issue debt (if necessary), use eminent domain to acquire land, relocate utilities, as well as enter into contracts and agreements with public and private entities. Governing boards should be made up of funders and the relevant other stakeholders that are necessary to push the project forward. The organization should also have the ability to set salaries to attract and hire top project management talent and borrow staff from existing institutions. For its part, the FTA should encourage project sponsors to reform governance, authorizations, and other factors as part of receiving federal funds.

Project sponsors need to understand, manage, and commit to whatever project delivery method is most appropriate for the project.

Anecdotally, many experts have a preferred method for delivering projects. Some swear by traditional approaches, like design-bid-build while others prefer design-build or

partnerships with private partners. Our work makes clear that no single delivery method on its own is a panacea for cost and timeline issues. Rather, agencies' commitment to a delivery method and understanding of how to manage it is essential.

Project sponsors need to adopt a formal evaluation process to determine the appropriate procurement method on a project-by-project basis. Once a specific procurement method is selected, the project sponsor should commit to it and manage it accordingly.

Projects need to be developed smartly so contracts are not too large to be effectively managed, procurement goals are realistic, and the best value is returned for public dollars.

After selecting the procurement method for a particular aspect or section of a transit line, project sponsors in the United States tend to simplify contracts by bundling its discrete elements into one mega agreement. However, smaller contracts invite more competition and reduce the ability for a single contract or contractor to jeopardize progress on other segments of a project. U.S. agencies should similarly break up construction projects into manageable sections and cap contracts at $300 to $500 million.

Sponsors should also stop dictating that public procurements must go to the lowest bidder. A better approach is a blended scoring process that places greater weight on the quality and past performance of the contractor, rather than cost as the primary driver. State and local procurement regulations should be reformed to allow transit agencies to apply best value selection rather than lowest bid, and the Federal Transit Administration (FTA) should develop guidance and technical assistance to share best practices on implementing best value selection, including formulas that agencies can use to evaluate proposals.

Agency staff need appropriate training in order to manage projects, construction staff, and consultants.

Overburdened and undertrained public agency staff have trouble coordinating environmental review and planning documents, creating discrete and clear procurement plans, writing smart and effective contracts, and ensuring adherence to contract terms during construction. These all lead to problems with litigation, change orders, and delays throughout a project. Project sponsors need to invest in better training and support for front office staff who are responsible for overseeing, monitoring, and managing projects from inclusion to operation. They should also establish small, multidisciplinary teams of high-quality, experienced executives with control over on-the-spot decisions, and enough junior staff to support them. FTA needs to work with project sponsors to more precisely determine their workforce needs for project delivery management and oversight.

In addition, this research found that the unionized, frontline construction workforce is not a primary target for cost or timeline efficiencies on major projects domestically or abroad. Project sponsors should, however, establish equitable project labor agreements (PLAs) as a valuable way to avoid worker strife by providing clear arrangements for dispute resolution, pre-approved compensation, and work rules. Labor leaders should be at the table at the beginning of project development in order to address potential concerns early on, create flexibility in work rules and overtime, as well as establish a shared understanding about conflict resolution and scheduling to keep projects moving efficiently and safely.

Second, some of the processes, procedures, and practices that public and private actors must undertake in order to build transit projects—from conception to final completion—are often too slow, cumbersome, or outdated. We need to make it easier to build more and better transit projects.

The federal National Environmental Policy Act (NEPA) statute does not need to be reformed, but the processes by which federal agencies reach a record of decision does.

NEPA is an important part of making sure that projects are transparent about their potential impacts to the built and natural environment, the air, and the communities affected. It is one of the few mandated opportunities for historically underrepresented communities to provide input into projects. It is also, however, subject to an uncoordinated, duplicative, and convoluted process. Although environmental rules, regulations, and requirements in other countries are as just as elaborate, the environmental review processes are generally better streamlined, and approval is obtained faster than in the United States. Many of the challenges with NEPA are attributed to misunderstandings and conflicts between agencies. Early and consistent coordination between agencies during planning and environmental assessment would undoubtedly help foster agreement on issues and avoid delays. Sharing of best practices in environmental assessment between agencies and project sponsors would further help improve common challenges in reaching a record of decision.

The Council on Environmental Quality (CEQ), an entity within the Executive Office of the President, should require more regular face-to-face meetings of federal agency field staff involved with preparing environmental documents and require sharing of environmental documents between permitting agencies to cut down on duplicative tasks. The Biden Administration should issue an executive order focusing on better coordination and consolidation of the disparate timelines and processes among the various regulations that fall under the umbrella of NEPA. Once issued, the FTA should execute an agreement with relevant federal agencies such as the Army Corps of Engineers and commit to working together in a more frequent, collaborative manner. CEQ should also set up an annual environmental permitting conference to build expertise and allow for exchange of best practices among stakeholders.

To go a step further, the United States can look to Madrid and Ontario, whose respective governments have set up specialized environmental reviews for transit projects. Given the net-positive environmental benefits of transit, Congress should create a pilot program to allow the federal transportation secretary to exempt select public transportation projects from NEPA if sponsors are able to demonstrate that they conducted robust community engagement and evaluation of project alternatives through the planning process. FTA should monitor this pilot program to measure its effectiveness at saving time as well as ensuring environmental protection.

States and project sponsors also need to invest in the staff and processes for their own permitting and environmental review.

Highway projects interact with the environmental review process more regularly given how routinely the United States builds roadway projects. To lean on their deep expertise, transit project sponsors should borrow staff from state departments of transportation (DOTs) and the federal highway administration (FHWA) to assist with preparing environmental documents. Transit project sponsors should take advantage of revised federal regulations to no longer require the evaluation of "*all* reasonable alternatives" and instead examine only those alternatives deemed feasible. Congress should also dedicate more resources to the FTA to increase staffing in their regional offices and help assist transit agencies with preparing and coordinating environmental documents.

But since state laws and regulations are often as complicated and suffer from the same siloed nature as federal permits, states should set up their own entities similar to the Federal Permitting Improvement Steering Council. If structured correctly, they would help local agencies navigate state environmental regulations and coordinate between various state and federal staff.

The planning and community stakeholder engagement process needs greater investment and more attention.

Despite their efforts, project sponsors generally invest too little in early planning and public outreach, and still employ outdated tools. Project sponsors need to dedicate more staff and resources to working directly with communities and secure scope agreements as early as possible during the project planning stage to prevent disagreements and issues from causing delays and issues further into a project. In doing so, sponsors should employ non-traditional forms of public engagement including opportunities to provide virtual feedback, having smaller meetings in individual communities (rather than the traditionally large, informal public meetings held in an auditorium), and hosting meetings at non-traditional hours.

Project sponsors should work with the community to recognize trade-offs and push for greater short-term disruption to advance construction faster. Agency staff also need to be more empowered to make tough decisions on project scope and requests through a transparent process, with public sector planners documenting all comments to demonstrate how they inform an agency's final decisions. Staff should take care to respond to every comment, document why certain options regarding project scope were advanced or taken off the table, and show how decisions were made with public input and social equity top of mind.

Policy and practice reforms are needed to address significant shortcomings related to utility relocation and land acquisition.

Utility relocation is among the most complex elements of a transit project and is frequently cited as a major cost and timeline driver. Old and inaccurate maps complicate efforts to identify utilities and lead to additional costs and delays to address unexpected site conditions. As a result, project sponsors need to dedicate enough staff with expertise in utility relocation. These staff should be brought on early in the planning phase and remain through the duration of construction. Project sponsors and utilities should sign agreements early in the project development process and relocate or identify as many utilities as practical prior to construction. Early utility identification and relocation yields significant cost and timeline savings throughout the course of a project's construction. On the other hand, misidentification of utilities can lead to significant costs due to change orders and unexpected findings during construction.

Similar challenges exist with the land acquisition process, which can be lengthy and involve confrontations or disputes with communities along a project's alignment. Early and prompt land acquisition can result in significant time and cost savings for projects. Since highway departments conduct land acquisition and utility relocation on a much more regular basis, transit project sponsors should work with staff at state DOTs to borrow staff experienced in utility relocation and land acquisition.

Third, building more and better transit demands a new framework for how we think about projects, the standards that are applied, and the policy environment in which they operate.

Customization should be deemphasized in favor of updated standardization to save on construction costs and speed up delivery.

Undeniably, transit investments—especially stations—help shape communities, neighborhoods, and define a community's character. But this research found an overemphasis among U.S. decisionmakers to customize stations and vehicles when designs could be simplified and streamlined by standardizing components. The Copenhagen Metro, for example, used standardized station designs, equipment,

materials, components, and off-the-shelf rail cars to minimize costs and allow for easy repairs. U.S. project sponsors, particularly those constructing new systems, should adopt vehicle and station designs from peer agencies to simplify design and trim costs.

Further, the longstanding U.S. approach to safety and other project standards should be revisited. Project sponsors, FTA, and transit constituency organizations should review existing construction standards to see if they can be more performance-based and useful in ways that can maintain safety but open avenues for more creative ways to meet them. To help inform such a review, the FTA and project sponsors should establish dedicated programs to exchange best practices on project delivery and station design, including but not limited to regular study tours. This involves looking at other countries beyond Western Europe, too, where great examples abound.

Transit projects in the United States need to maximize their public benefits.

When faced with escalating costs and community resistance, project sponsors in the United States often select routes that are significantly less expensive, do not interface with communities, nor require the intensive utility relocation often necessary for at-grade options along boulevards or other urban roadways. Project sponsors should weigh the tradeoffs between cost, complexity, and ridership when considering alignments. In doing so, project sponsors should enact a policy that clearly outlines when and how stakeholders can request project enhancements ("betterments"), include a process to evaluate whether to grant the request, and require the requesting entity to cover the cost in most circumstances. Community benefit agreements should be used to address community concerns and are useful when conducted early in the process.

Federal incentives are another powerful tool to enable project sponsors to increase the overall standards of their transit projects. For example, the federal Capital Investment Grants program needs to require minimum zoning densities or level of development around stations as a condition for federal funding. Similarly, federal evaluation needs to de-emphasize ridership as a key component of a project's success and rely on accessibility metrics more often.

CONCLUSION

During this time of economic uncertainty, environmental concerns, and social anxiety, it is critically important we get the most out of our existing public investments. The dramatic changes foisted upon the nation as the result of the COVID-19 pandemic highlighted the importance of public transit for essential workers, low-income riders, and neighborhood connectivity. While the federal government literally came to the rescue with emergency funding to keep most of these systems afloat, there is appropriate scrutiny now to make sure the projects we do undertake are successful both during the planning, construction, and implementation phases.

Our national goals around economic growth and opportunity, climate change, and social equity all mean we are going to need more and better transit than we have today. But we are not going to get more or better transit if we cannot figure out how to deliver projects in a timely and cost-effective way. As we consider transit investments in a new post-pandemic light, it is critically important our investments are as efficient as possible.

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1.0 Introduction

The desire to build infrastructure projects faster and cheaper has persisted since the earliest infrastructure projects were completed. Famous projects like the Hoover Dam, the Golden Gate Bridge, and the Empire State Building are celebrated for the speed in which they were completed, and the transcontinental railroad was literally a race to see which company could lay track the fastest.

Of course, those historic projects were all designed, built, financed, and governed under different circumstances and very different regulatory environments. The rules, procedures, and preferences that exist today at all levels of government are intended specifically to avoid the horrific way workers, the environment, and neighboring residents were impacted by infrastructure projects in the past, and to ensure that safety remains paramount for users. While those rules and regulations have certainly helped to achieve those goals, infrastructure projects have become so costly and take so long to build that few large projects are being built, especially for public transit. This is particularly disheartening when we examine other countries in Europe, Asia, and elsewhere that have similar standards but much lower costs.

But why? What can we learn from previous research and practice to understand how transit projects are delivered, the primary cost drivers, and impediments for their timely delivery?

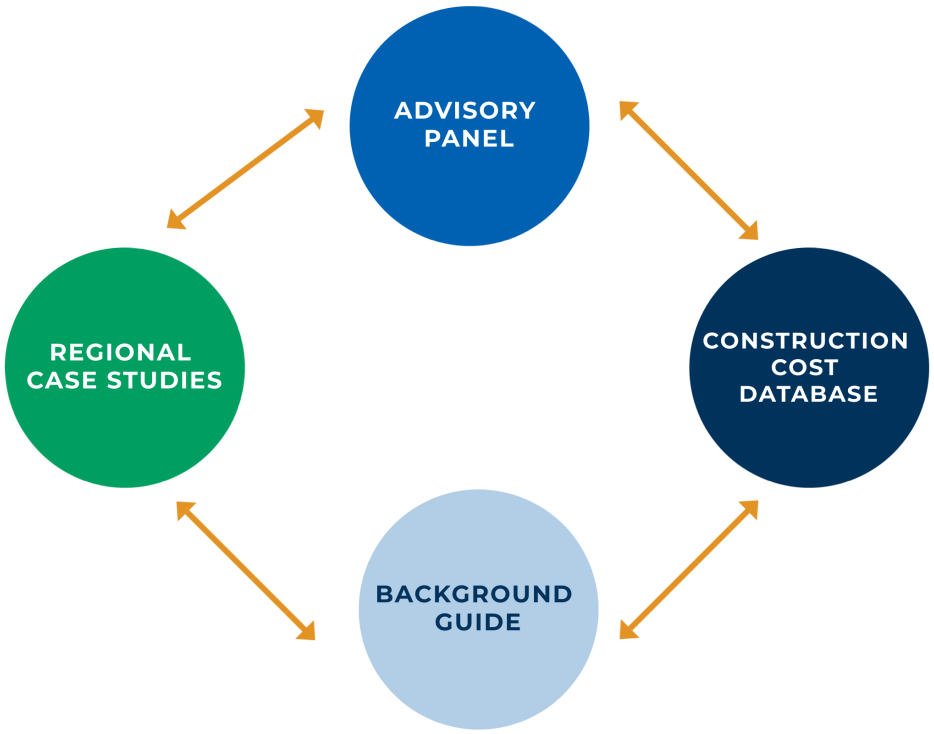
This report answers these questions albeit with important caveats. For one, there is significant attention given to individual projects that take much longer than expected or experience cost overruns. We address those problems to a limited extent but are primarily interested in whether and why transit projects cost more and take long to deliver than international peers *in the first place*. As a result, this report focuses on overall project timelines and costs. Much of the existing work on cost and timeline drivers tends to be narrowly focused either on cost *overruns*, or on specific elements of project delivery. Recently completed subway projects in New York City, which are among the most expensive ever built, also receive a substantial amount of coverage given the outsized role public transit plays in that region. Other case studies often focus on a single transit line, region, or country, resulting in conclusions that are relevant to a particular area or specific project, but might not be broadly transferable. In addition, research conclusions on certain subjects—like delivery models—occasionally conflict.

This research and resulting policy recommendations aim to shift the current national conversation around transit project delivery from simply diagnosing problems to identifying and implementing opportunities to deliver better and more cost-effective projects. This report raises the level of discourse around project delivery by relying on comprehensive qualitative and quantitative findings, as opposed to idiosyncratic and isolated anecdotes. Lastly, the work directly informs federal decisionmakers as they pursue reform-minded policies, as well as helps state and local actors more effectively invest in transit networks to grow local their economies, reduce greenhouse gas emissions, and connect people to opportunity.

2.0 Methodology

To fully explore how projects are delivered, understand where the challenges occur, and develop solutions to overcome those challenges, this research employed an approach that had four distinct components, illustrated in Figure 1.

FIGURE 1: TRANSIT COST AND DELIVERY METHODOLOGY



The first step was to better understand the problem and where it was most acute. To do this, the Eno team created a **construction cost database** of 180 domestic and international rail transit projects completed over the past 20 years. The database is limited to examples in the United States, Canada, and Europe. The research team kept the geographical range to these countries and regions because of their comparable political culture, government structures, and infrastructure development and age.[2] For each project, factors such as number of stations, grade alignment, station spacing, and mode, adjusted for purchasing power parity and inflation, allow for comparisons.

The database helps draw conclusions about the extent to which transit construction costs differ in the United States and peer countries, as well as sheds light on the differences between project characteristics and complexity across countries. The database informs the analysis in Section 3 and is also available for download to other researchers investigating similar topics.

A range of academic, media, industry, and government resources were used to obtain reported construction costs for all new lines entered into the database. It draws from official cost reports wherever possible, either from agencies or other entities directly responsible for construction. When using media reports, we aimed to confirm whether the same—or very similar—cost figure was used across other outlets. Additional project detail collected includes the year and month of groundbreaking and opening for service to the public, project length (kilometers and miles), number of stations, grade alignment (i.e. the share of total alignment that is below ground, at-grade, and above-ground), and station spacing (calculated as average miles between stations). The database also uses inputs from construction cost data collection from the Federal Transit Administration's Capital Cost Database and by researchers Alon Levy and Eric Goldwyn at the NYU Marron Institute and Yonah Freemark via The Transport Politic.[3]

With the data showing a clear cost and timeline premium in the U.S., the next step was to better understand why. The research includes a **thorough background assessment** of existing documentation and previous research related to project delivery to understand key cost drivers and how they influence project outcomes. We evaluated reports, data, project-specific documents, and presentations from academic, research, and government sources. The documentation on project delivery we assessed spanned all phases from the preliminary idea and design phases through construction.

This report classifies cost and timeline drivers into three broad, interrelated categories with 11 specific topic areas, detailed in Section 4:[4]

- ***Governance***: the public authorities that oversee transit project funding and construction in our federalist system. Includes how they function, the way they make decisions, and how they work with other public authorities and with the private sector.
- ***Standards***: the federal, state, and local rules and regulations that must be adhered to in order to achieve an overall policy goal directly or indirectly related to the project.
- ***Processes***: the procedures and practices that public and private staff undertake to build transit projects from conception to final completion. Includes the steps that must be followed, timelines, and tasks to be completed.

To fully understand how public transit projects are delivered, this report includes **detailed case studies of nine regions** in the United States, Canada, and Europe. These studies not only yield facts and details of the specific projects within those regions, but also uncover elements that may not otherwise be captured in the data, literature, or popular reporting. While each region is uniquely different, there are clear commonalities in project delivery across regions that determine cost and timeline drivers, and impact project outcomes. This report includes the following case study regions, detailed in Section 5:

- Domestic: Denver, Los Angeles, Minneapolis, Seattle
- International: Copenhagen, Paris, Madrid, Toronto
- Highway case: I-495 HOT Lanes in Virginia

The case studies also help determine whether projects in the United States are being built to higher technical and safety standards than elsewhere, and to what extent factors like governance, institutional experience and staff capacity, project management, and contracting practices influence project outcomes. By identifying specific drivers as well as best practices in project delivery, the case studies inform the policy and practice recommendations in Section 6.

For this research, a case study is defined as a project or several projects delivered by an agency or agencies in a region, opened to the public between 2000 and 2020.[5] This timeframe ensures that a project has a clear final cost and is also recent enough in interviewees' memories that they can recall important details. For each of these cases, the lead agency in each region has completed at least two projects in the past 20 years. This allowed the research team to learn from an agency's experience delivering multiple projects in a single region. Since this work is intended to inform transit project delivery in the United States, the international cases are limited to regions with comparable development patterns, economies, and governmental and legal structures.

The final cases also highlight comparable transit modes to what is typically constructed in the United States, specifically light rail. In particular, Paris and Madrid invested heavily in their regional tram systems, which provides direct comparisons to U.S. light rail projects. Domestic cases avoid outliers such as extremely expensive projects (like in New York City) that are unlikely to provide comparable lessons for other regions in the United States.[6]

A key part of the case study research was conducting interviews with stakeholders and experts in regions. The not-for-attribution interviews were not limited to organizations building rail transit, but also included other groups that have direct and indirect input to the governance, planning, and execution of capital projects. Specifically, interviewees included senior level representatives from the following types of organizations:

- Transit operators
- Transit oversight agencies, where applicable
- Metropolitan planning organizations (MPOs)
- City governments, including planning departments and officials in select cities
- State government, including officials from state departments of transportation
- The Federal Transit Administration and regional offices
- Academics with specialized knowledge in transportation and an understanding of the region
- Advocacy organizations and think-tanks, including riders' unions, business groups, chambers of commerce, and other nonprofits
- Labor unions
- Former transit and government officials with specialized knowledge in transportation and an understanding of the region

The findings included in this report are almost entirely based on consistent information from multiple sources and interviewees. As part of this project, the Eno team interviewed 117 individuals at 72 organizations. While this methodology generated a set of findings that is inherently subjective, it also provided a level of insight not often found in the existing literature. Much of the agency-specific detail in the background and case studies is publicly available on the agencies' websites, unless otherwise indicated.

Woven throughout the data analysis, background research, and case studies is consistent engagement with a high level, 21-person **project advisory panel**, consisting of experts from academia, industry, transit agencies, as well as state, local, and federal government. Eno consulted with the advisory panel before and during each major stage of this project, including case study selection, creation and release of Eno's construction cost database, and development of our policy recommendations. Eno also convened separate sub-panels of representatives from labor unions and major design and engineering consultancies to gain further insight into various phases of project delivery and receive input on preliminary findings.

Insights and consistent themes that emerged from the research formed the basis of the takeaways and recommendations in Section 6. The recommendations also incorporate best practices that emerged from the literature review, case studies, Advisory Panel meetings, and discussions and feedback from additional interviews with experts and practitioners in various elements of project delivery such as environmental review, permitting, engineering, and labor, among others.

3.0 Analysis of Transit Construction Cost Data

The following analysis is designed to help set the baseline for the systemic problem in the United States with high costs and long timelines associated with delivering transit capital projects. The data shows three important findings:

- When evaluating transit projects, grade alignment has a stronger impact on costs than mode.
- The United States pays a premium for rail transit that gets worse as projects get more complex, particularly for tunneled lines.
- The United States takes longer to complete construction of rail transit projects than international counterparts, which also drives-up costs.

The full construction cost database is available for download at https://projectdelivery.enotrans.org/

Section 2 of this report details the methodology for Eno's capital cost database, but several points are important to reiterate because they are relevant to this analysis.

First, this analysis includes projects that have been *completed* between 2000 and 2020. There are some exceptions made on a case-by-case basis to include projects outside this range to help provide additional context and comparisons. Similarly, the database generally does not include projects that have not yet opened for service, but the database does include a few projects in Boston, San Francisco, and others that are set to open in 2021 because of their complexity and importance in the national discussion around transit project delivery.[7]

To compare projects across geographies and over time, the database adjusts costs so all project costs are compared in 2019 U.S. dollars. This is done with a two-step process. First, international reported costs were adjusted using purchasing power parity (PPP) rates for projects reported in non-U.S. currency. Currency conversions were based on the OECD's PPP table, which documents conversion rates for international currencies to U.S. dollars in a given year, taking differing price levels between countries into account (measured as foreign currency needed to purchase $1 worth of goods).[8]

Then, projects were adjusted to 2019 dollars for inflation using the project's midpoint. Instead of using a standard inflation calculator based on the consumer price index (CPI), the research team decided to use the Engineering News-Record (ENR) Construction Cost Index (CCI). The CCI is a more accurate reflection of buying power for construction as opposed to the CPI, which is based primarily on consumer spending in categories like healthcare, housing, and utilities. Eno also evaluated other indices, including several producer-price indices published by the Bureau of Economic Analysis, and decided that the ENR CCI was most applicable and appropriate for transit projects.[9]

Comparing as-built construction costs can offer some clues as to whether other countries are building public transit systems more cost-effectively. However, there are several caveats and challenges when attempting to make a true "apples to apples" comparison between domestic and international construction costs. The final output of the database is a comparable "unit cost," in inflation- and currency-adjusted dollars per mile of rail line.

But not all projects and agencies are transparent in their cost reporting, and when they are, the data tend to be reported inconsistently. For example, some projects include costs not associated with the actual unit cost of mile of rail line. Elements like maintenance facilities or rolling stock are included in some projects, but not others. Worse, detailed cost breakdowns are typically not reported for most projects, and if they are, there may be vast differences in the categories used. For federally funded projects in the United States, regulations require agencies report cost breakdowns using nine Standard Cost Categories (SCCs), shown in Table 1.[10]

TABLE 1: FTA STANDARD COST CATEGORIES

SCC	Description
10	Guideway & Track Elements
20	Stations, Stops, Terminals, Intermodal
30	Support Facilities: Yards, Shops, Admin Buildings
40	Sitework & Special Conditions
50	Systems
60	ROW, Land, Existing Improvements
70	Vehicles
80	Professional Services
90	Unallocated Contingency
100	Finance Charges
Total Project Cost (10-100)	

However, as the Eno team discovered when reviewing select cost breakdowns received through Freedom of Information Act (FOIA) requests, some agencies in the United States also use their own internal methodology to track costs, especially for projects that are locally funded. Rather than reporting project costs for items like stations, sitework, and stations, costs in some cases are broken down by project phase (i.e. preliminary engineering or final design). Cost breakdown methodologies between countries can also vary.

Of the 26 projects in the database that have full cost breakdowns (all U.S. projects), 22 reported vehicles as part of the total cost, and 14 reported a maintenance or support facility. Land acquisition costs were reported in all 26 of the projects, indicating that these are likely included in most U.S. projects. The database does exclude the cost of maintenance facilities and rolling stock when available.

When comparing construction costs, it is important to avoid drawing sweeping conclusions or over-interpreting trends, though such comparisons will become richer with more data. Keeping these caveats in mind, the following takeaways will inform our research and spark additional questions that in-depth case studies can answer with more accuracy.

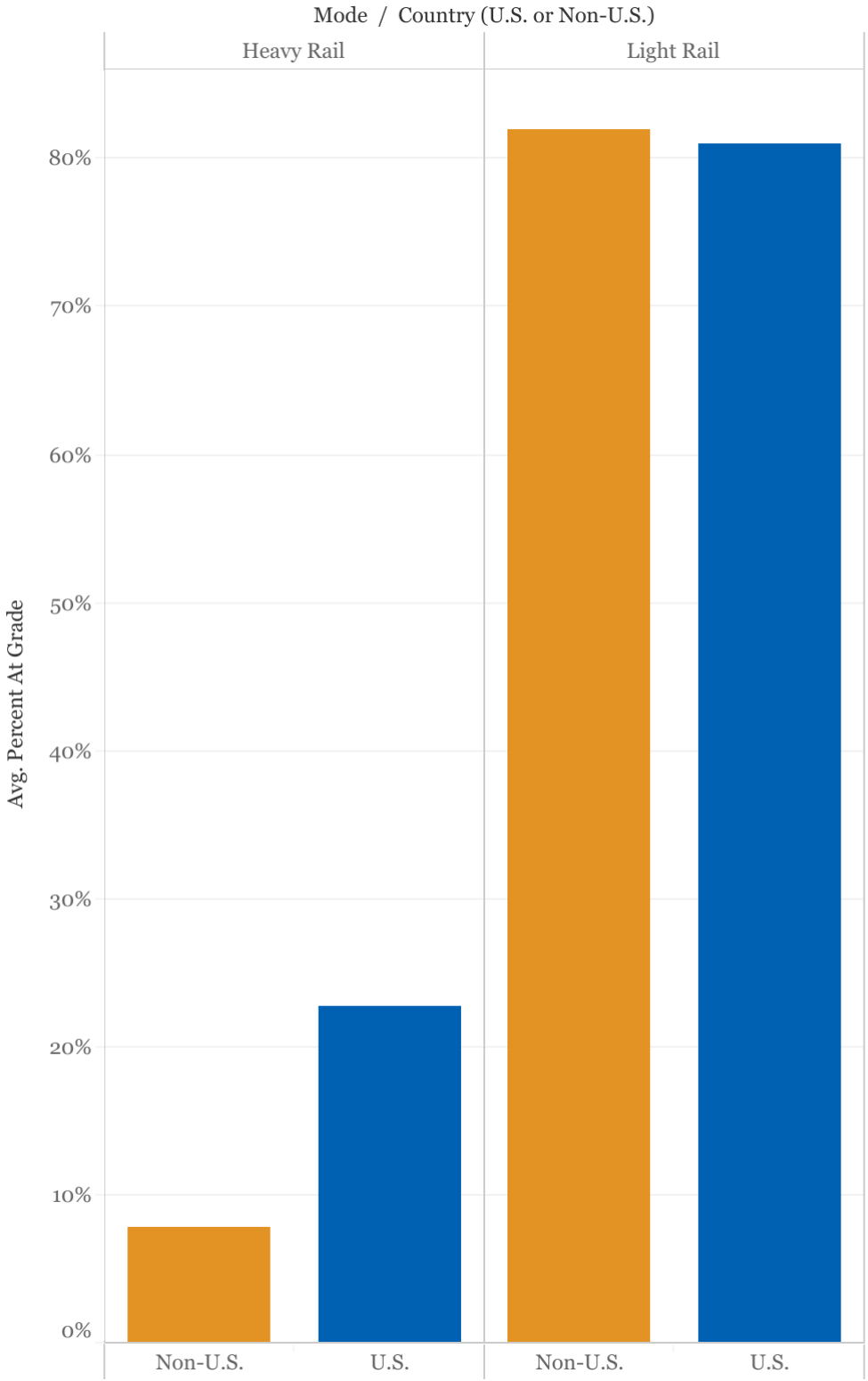
3.1 Grade alignment is much more correlated with cost than the mode of transit.

Defining "modes" of transit is a perennial debate, with inconsistencies across and within countries around the world. For the most part, the Eno capital cost database focuses on heavy rail and light rail transit projects. Most new transit infrastructure in the United States is light rail, so the database includes many international examples of light rail projects. In most cases, European trams are similar to U.S. light rail in their grade alignment (surface, tunneled, or elevated), stations, and vehicles.

The database does not include intercity rail projects (like California High Speed Rail or comparable international examples). The database also avoids U.S. streetcar projects, which rarely travel in their own right-of-way (ROW) and are often loops instead of bidirectional track, making cost comparisons difficult. Some commuter and regional rail projects were included, particularly if they involved building new infrastructure (and are thus like heavy rail). But many U.S. commuter rail projects, which primarily run from outlying suburbs to city cores, were also excluded from the database, as most of these projects were conversions of existing freight rail infrastructure for commuter rail service and include little new construction.

Defining the mode of a transit project—whether it's light rail or heavy rail—does not correlate well with its construction cost. Most of the construction and planning inputs for both modes are the same, despite shorter trains and stations for light rail projects. A transit line, whether heavy or light, includes laying track, installing electrical systems, and building accessible stations. Therefore, when making cost comparisons, light rail is not inherently cheaper than heavy rail—it is only that light rail tends to be at-grade, while heavy rail is usually not, making the latter more expensive.

FIGURE 2: GRADE ALIGNMENT COMPARISON—U.S. AND NON-U.S.

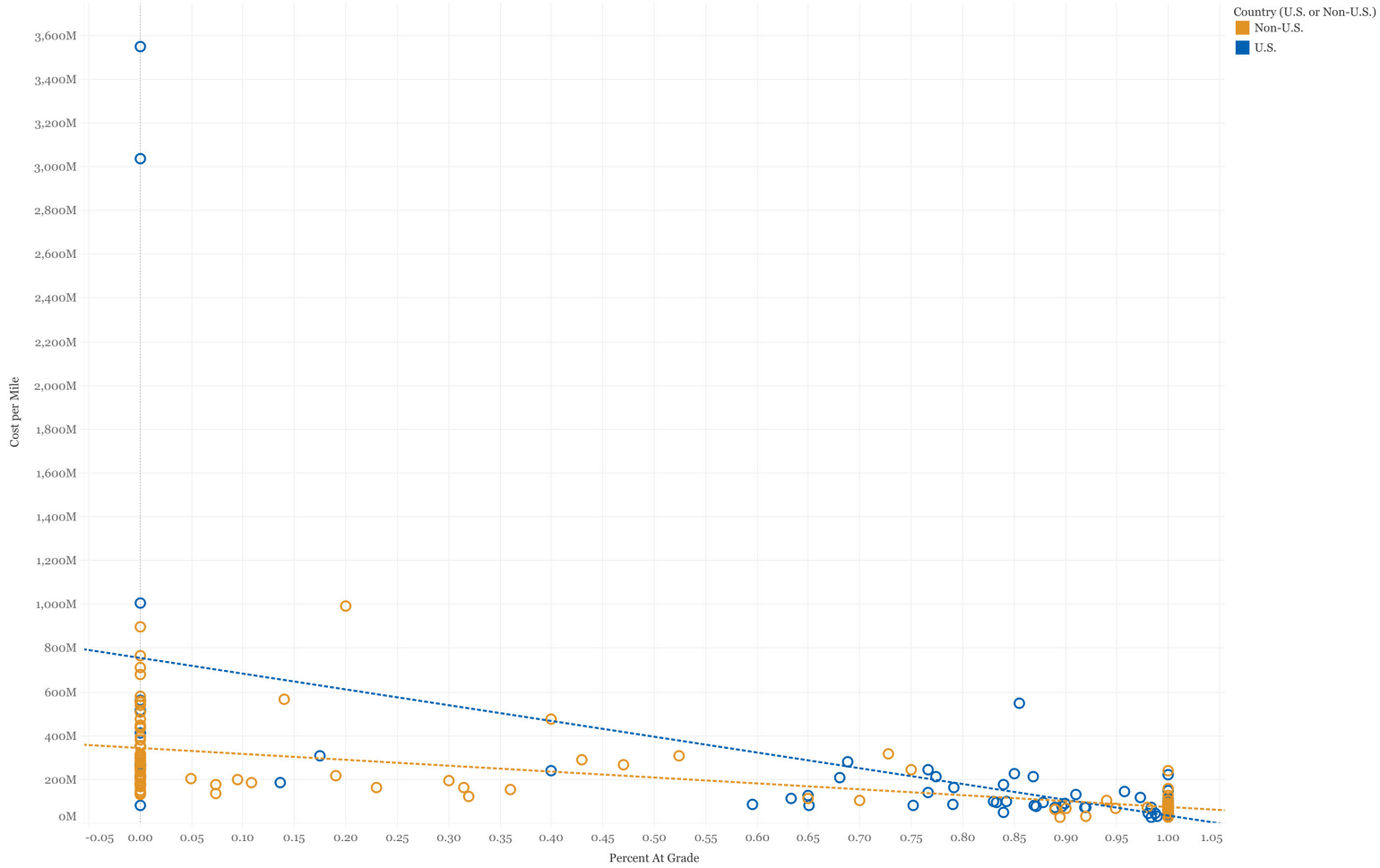


Source: Eno Capital Cost Database

3.2 The U.S. pays a greater premium as projects get more complex, particularly with tunnels and stations.

Figure 3 below plots project grade alignments (percent of total alignment that is at-grade) against costs-per-mile and illustrates how most U.S. rail transit projects in the database are built primarily at-grade in contrast to non-U.S. projects.

FIGURE 3: GRADE ALIGNMENT (PERCENT AT-GRADE) VS. COST-PER-MILE



Source: Eno Capital Cost Database
Note: The trendlines are not intended to represent or be interpreted as a linear regression, but rather to illustrate the general direction of construct costs as they relate to a project's grade alignment.

Despite some successes domestically and some costly projects abroad, the United States in general pays a significant premium to tunnel, a dynamic that has also caught the attention of some trade publications.[11] The database shows New York City's Second Avenue Subway and 7 line extension cost $3.5 billion per mile and $3 billion per mile, respectively. Transit projects elsewhere in the United States are much less expensive than these two outliers. Many international projects are built primarily below-grade but have similar costs as at-grade projects in the United States.

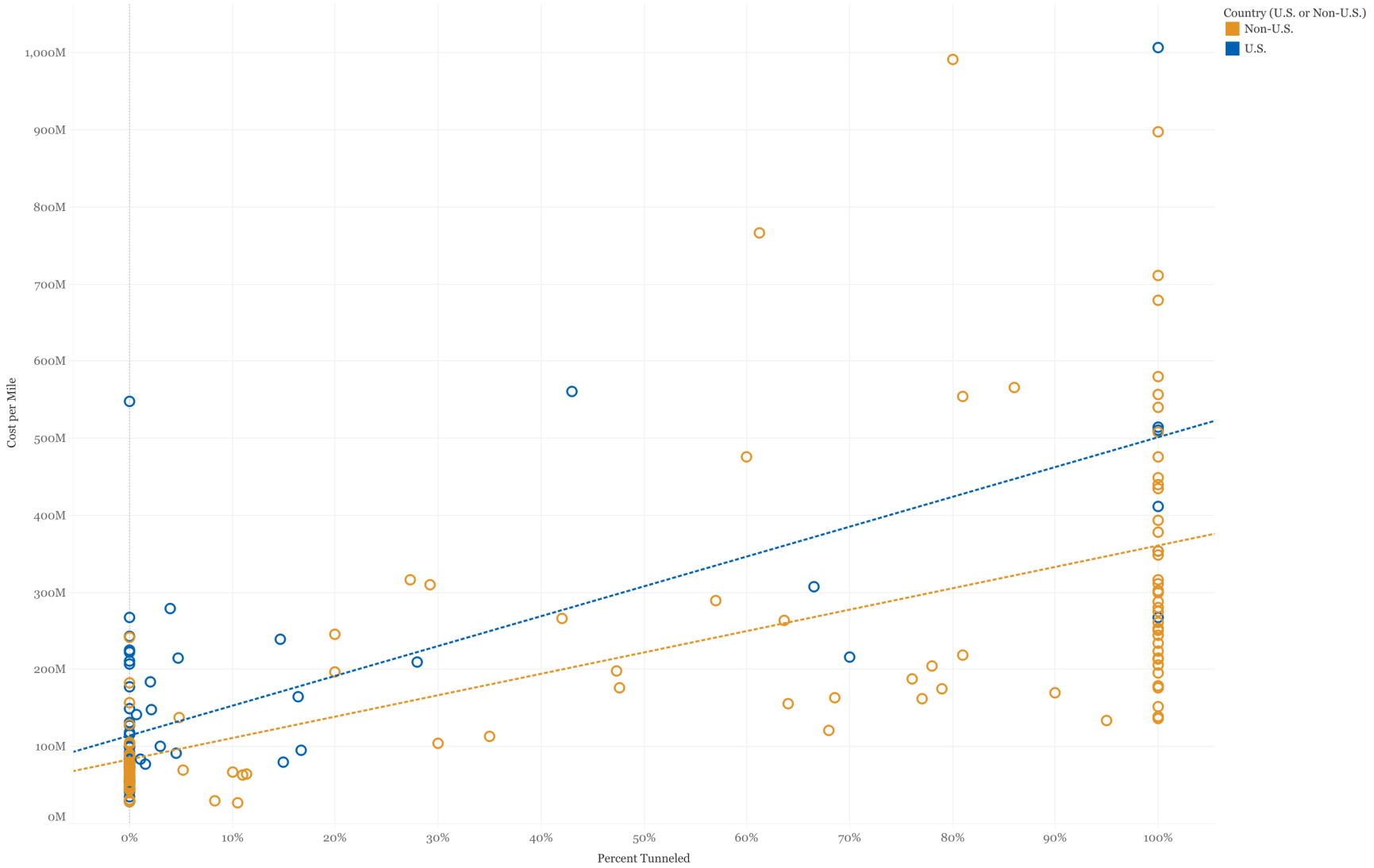
TABLE 2: AVERAGE CONSTRUCTION COSTS PER MILE (USD)

Percent Tunneled	Sample Size	Non-U.S.	U.S.	Difference (U.S. Premium)
0-20%	56 U.S. / 51 Non-U.S. Projects	$81M	$118M	46%
20-80%	4 U.S. / 19 Non-U.S. Projects	$286M	$323M	13%
80-100%	8 U.S. / 42 Non-U.S. Projects	$346M	$1.2B ($511M excl. NYC)	247% (48% excl. NYC)

Source: Eno Capital Cost Database
Note: Only four U.S. projects are within the 20-80 percent bucket and conclusions for that part of the dataset are limited

As Table 2 above illustrates, there is a U.S. premium for both mostly at-grade and mostly below-ground projects, though the premium is higher for tunneled projects (particularly when including New York City). The tunneling premium can be seen more clearly in Figure 4 below by plotting projects' share of below-ground alignment with their cost-per-mile, and excluding the two outlier projects in New York City.[12] Not only is the cost trendline for U.S. projects steeper than for non-U.S. projects, but there is a sizeable number of fully tunneled international projects that were built at a comparable cost to at-grade U.S. projects in the $100-$300 million per mile range.[13]

FIGURE 4: PERCENT TUNNELED VS. COST-PER-MILE

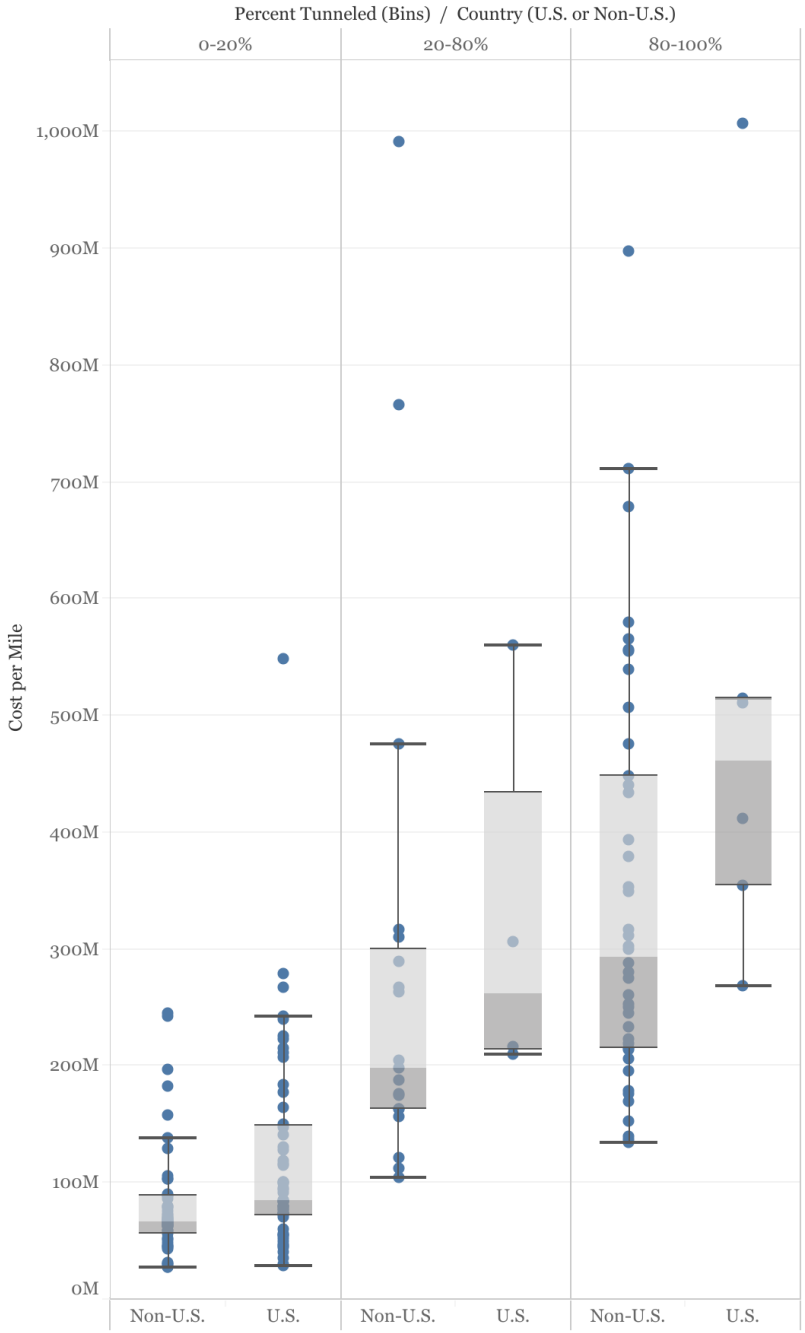


Source: Eno Capital Cost Database

Note: The trendlines are not intended to represent or be interpreted as a linear regression, but rather to illustrate the general direction of construct costs as they relate to a project's grade alignment.

Tunneling increases the complexity of a transit project, resulting in much more variability in costs. Figure 5 illustrates the distribution of construction costs-per-mile by the share of project alignment below ground. There is noticeable, but not dramatic, variation in construction costs for mostly above-ground projects (<20 percent tunneled) in both the United States and abroad. However, costs can vary considerably for projects that are largely below ground (>80 percent tunneled).

FIGURE 5: COST VARIABILITY BY SHARE OF ALIGNMENT IN TUNNELS



Source: Eno Capital Cost Database
Note: NYC Projects are excluded from this plot

Outside of the United States, where tunneled projects are more common, below-grade lines range from as low as $135-215 million per mile for fully underground tram and metro lines in Madrid and Toulouse, to as high as $500-900 million for subway projects in Barcelona and London (and some Parisian Metro lines). Tunneled projects in the United States range from $270 million to 1 billion per mile (and up to $3.5 billion for projects in New York City, which are excluded from the plot). There are significantly fewer U.S. tunneled lines in the database compared to international projects, and the presence of two large outlier projects in New York City further contributes to the dramatic variation in U.S. costs for tunneled projects. However, Current budgets and cost estimates for tunneled lines that are not in the database but are under construction or proposed are still significantly higher than most peer projects abroad, with a notable exception in Seattle.

- Seattle Light Rail Northgate Extension (4.3 miles, 3.5 miles in tunnels): $419 million per mile[14]
- Los Angeles Purple Line Extension Phase 1 (3.9 miles): $1.2 billion per mile (excl. vehicles)[15]
- Los Angeles Purple Line Extension Phase 2 (2.6 miles): $967 million per mile (excl. vehicles)[16]
- Los Angeles Purple Line Extension Phase 3 (2.6 miles): $1.4 billion per mile (excl. vehicles) [17]
- Los Angeles Regional Connector (2 miles): $900 million per mile (excl. vehicles)[18]
- Downtown Austin Light Rail Tunnel (1.5 miles): $1.3 billion per mile[19]

If included in the database, these projects would still fall within the higher cost-range for U.S. projects. The U.S. tunneling premium, excluding New York City, would increase from 48 percent to 123 percent, reflecting an average construction cost of $771 million per mile, compared to $511 million per mile. These projects further reinforce the relatively high cost of building below-ground transit in the United States.

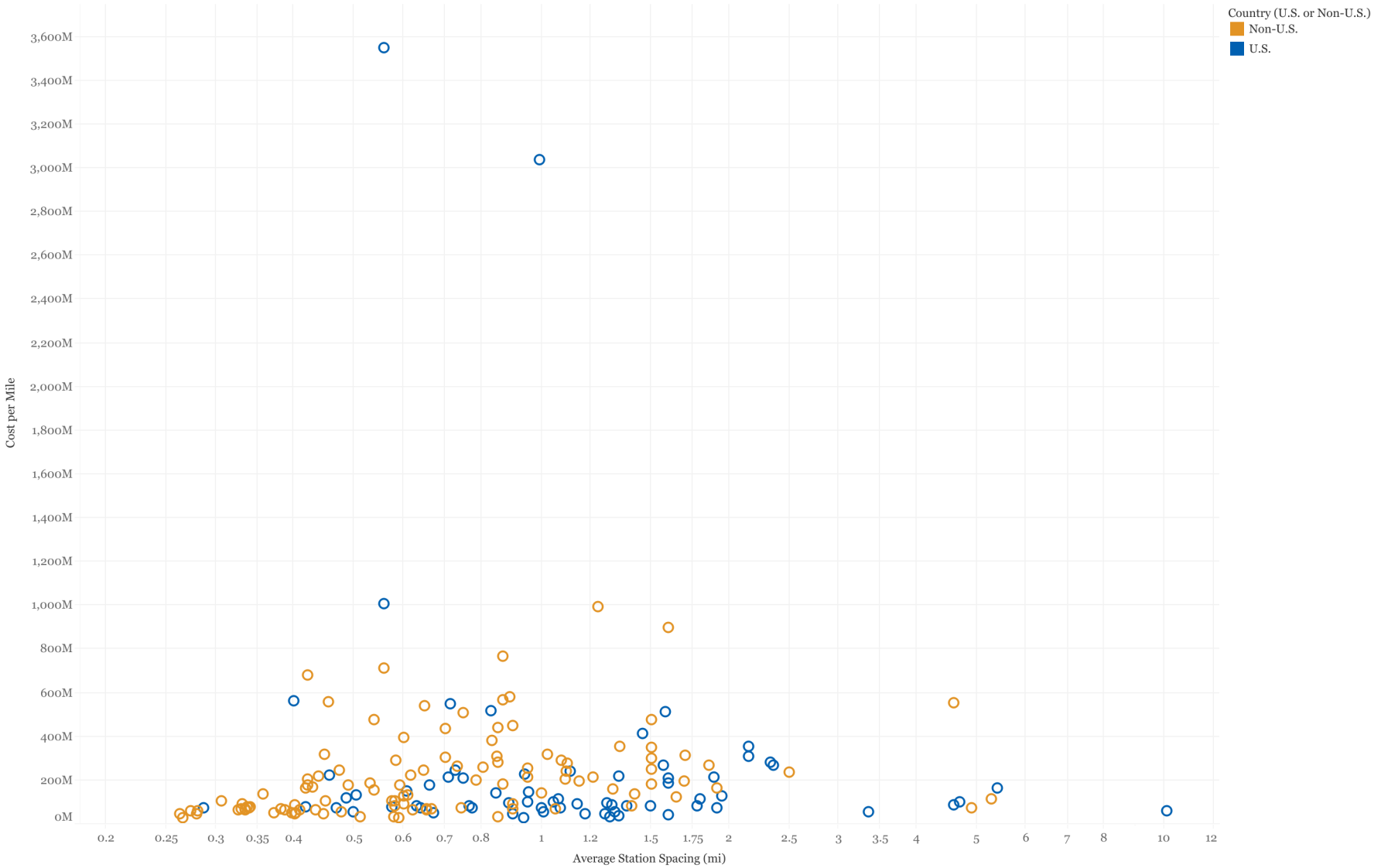
Some of the cost variation for tunneled projects can be attributed to factors like geological conditions (which vary considerably in each region and can significantly influence the cost and complexity of tunnel boring), technical specifications, tunnel depth, or station design (see Section 4.10). The detailed, regional case studies in Section 5 shed light on other governance or process-related elements that can affect construction costs, including project and contractor management, institutional expertise, permitting, and regulation.

Stations can also constitute a large portion of overall transit project costs and add more complexity to the projects. For tunneled projects in the United States, the database shows stations accounting for around 25 percent of total project costs. Research shows that station depth, size, and architecture is a significant project cost driver (see Section 4.10). But despite their generally lower cost per mile, international projects have more

and closer stations on average, which is usually more common and useful in denser areas. However, the database analysis shows station spacing does not seem to have a clear correlation with cost.

The database calculates the average distance, in miles, between stations.[20] A high-level comparison of station spacing across U.S. and non-U.S. project suggests in Figure 6 that transit stations are spaced closer together abroad, especially for lines mostly at-grade, which have nearly a third of the distance between stations as at-grade U.S. lines. These at-grade lines—most of which are tram or light rail projects—often run through dense, historic city centers and are usually not grade-separated.

FIGURE 6: STATION SPACING VS. COST-PER-MILE



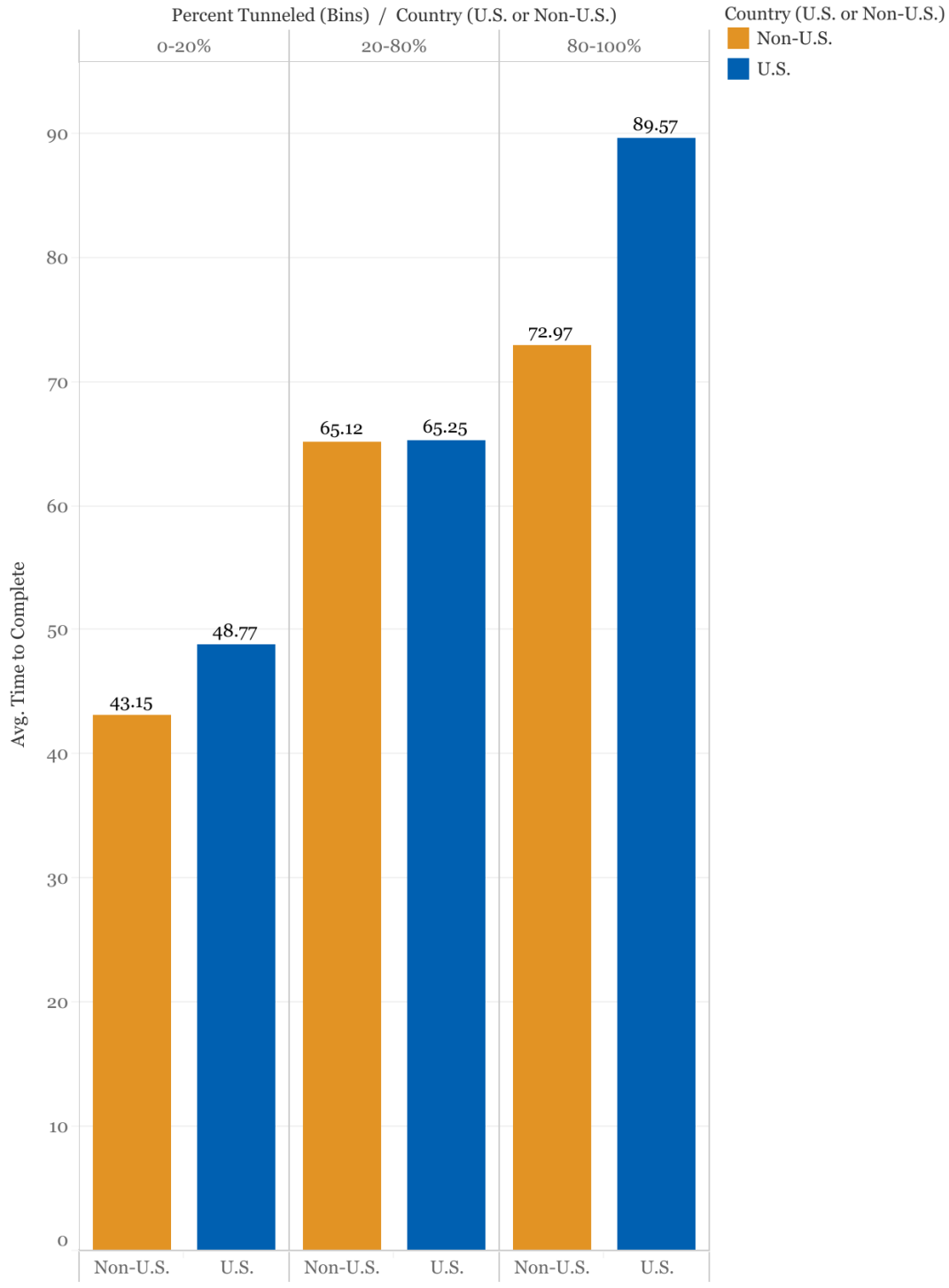
Source: Eno Capital Cost Database

Comparing average station spacing of projects with their cost-per-mile does not indicate a relationship between station spacing and costs but suggests that European transit projects have higher station densities without a significant cost premium. This comparison, however, may not fully capture differences in technical complexity between U.S. and non-U.S. projects, particularly considering that some international tram lines might have more in common with mixed-traffic streetcars compared to fully grade-separated light rail in the United States.

3.3 Projects outside of the U.S. take longer to build, mostly because they are far more complex.

In addition to project costs, this database also includes information on project timelines—measured as groundbreaking and opening months and years. On average, non-U.S. projects in this database take slightly longer to build than U.S. projects (5 years abroad compared to 4.7 years in the United States).[21] However, there are considerable differences in the time it takes to complete projects based on their grade alignment.

FIGURE 7: PERCENT TUNNELED VS. TIME TO COMPLETE (IN MONTHS), U.S VS NON-U.S. PROJECTS



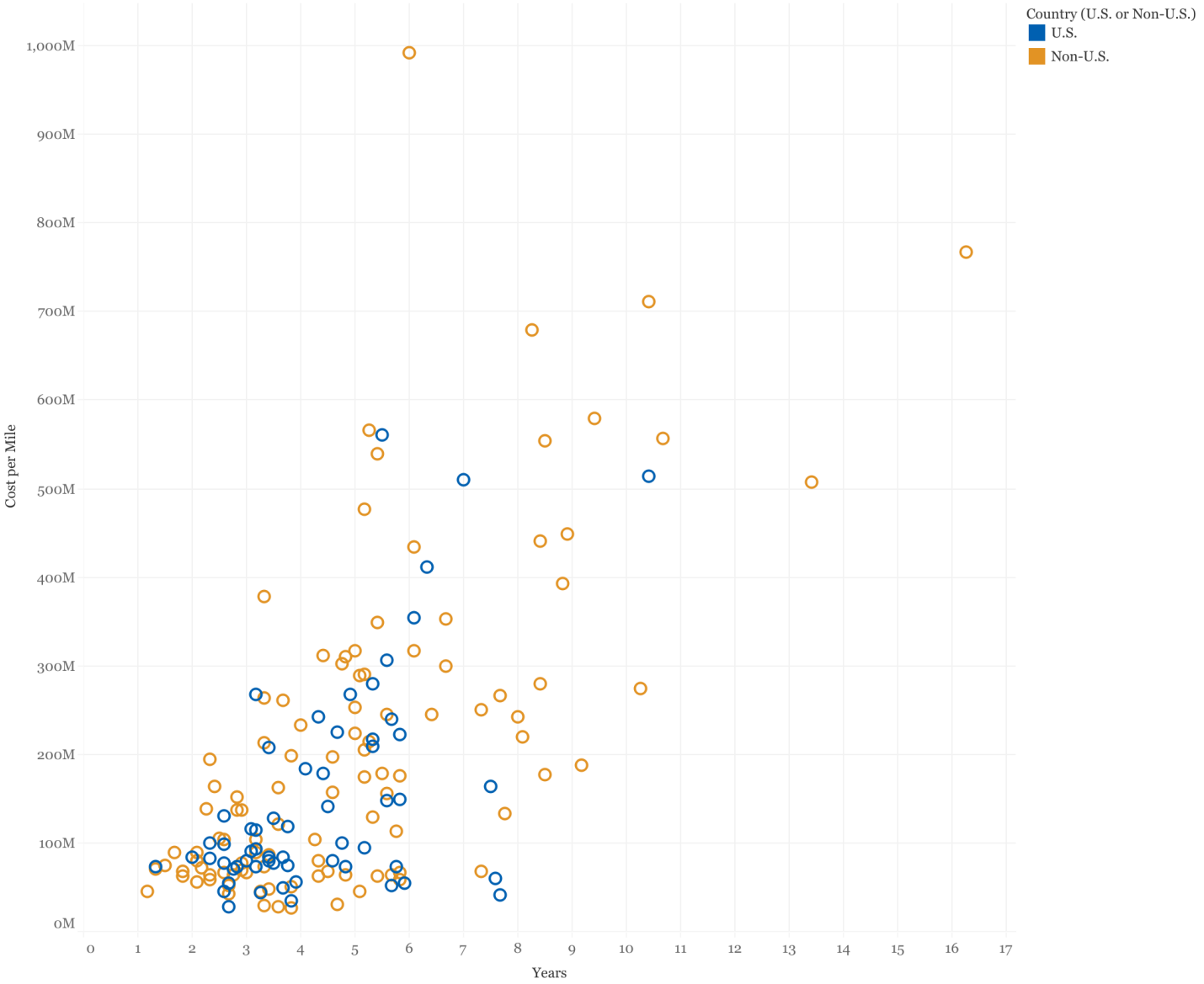
Source: Eno Capital Cost Database

Note: This graphic excludes projects that took more than 150 months to construct. Additionally, the 20-80 percent tunneled bin in the U.S. has only four projects, which limits the takeaways of that portion of the data.

According to Figure 7, projects in the United States that are mostly at-grade take almost six months longer to complete, while projects that are mostly tunneled take more than 16 months longer to complete than comparable projects abroad. But the other countries represented in the database account for many more tunneled projects. In Figure 7, 41 of the 106 international projects are 80 percent or more tunneled, compared to only 8 of the 68 U.S. projects. (Section 5 explores why this is the case).

However, these project timelines only cover the construction period. While unexpected site conditions, scope changes, and other issues arising during construction can affect project timelines, many of the timeline drivers identified in this report, including preparatory sitework, utility relocation, the environmental review process, land acquisition, stakeholder engagement, and lengthy planning periods, are not captured in these timelines. Projects may be proposed in one form or another, but not formally become reality until years or decades later. It is thus difficult to pinpoint a precise and consistent "start" date for transit lines.

FIGURE 8: TIME TO COMPLETE VS. COST PER MILE [22]



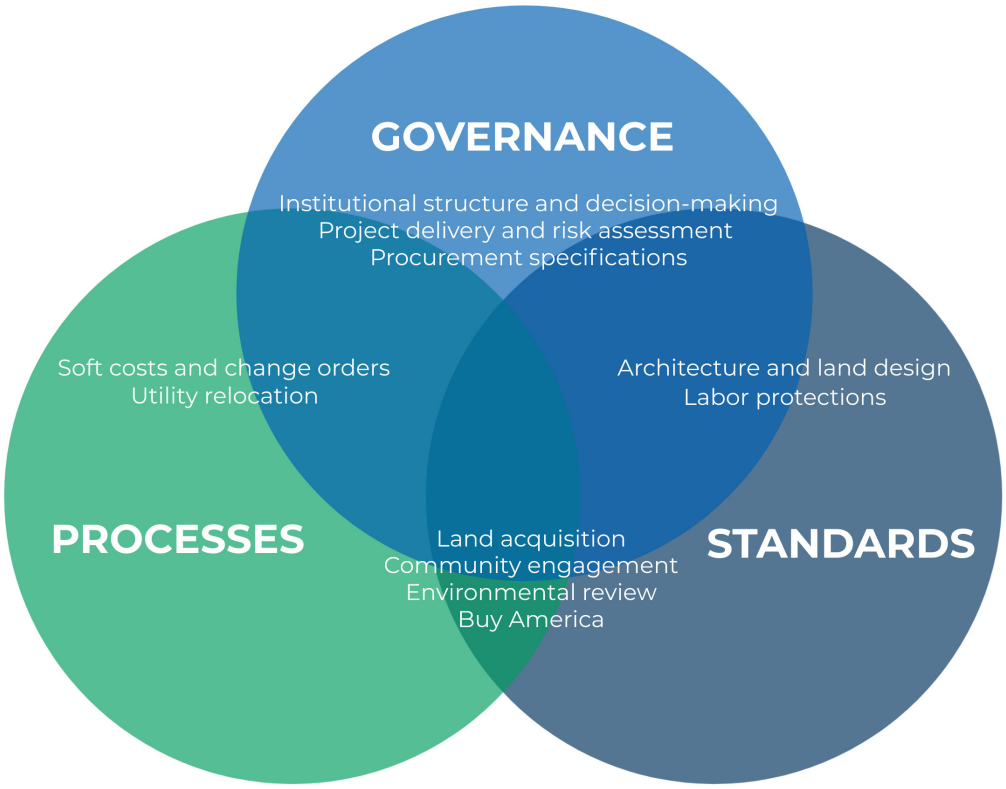
Source: Eno Capital Cost Database

Though the metrics used do not capture the full timeline of a project, there is still a clear relationship between the time it takes to construct a transit line and its final construction cost across both U.S. and international projects. Some of the relationship between time and cost might be attributed to the complexity of a project and its alignments. However, within this database, there is little relationship between a project's length or grade alignment and its timeline. There is also minimal variation in timelines for new lines compared to extensions of existing lines, though the most notable outlier, the North-South Line in Amsterdam, was a new build. Other complicating factors like the share of project in existing ROW, the density or level of development around the alignment, and geological conditions not captured by this database may further influence timelines. Nonetheless, these findings suggest project timelines themselves can be a significant driver of costs.

4.0 Background: Potential Cost and Timeline Drivers

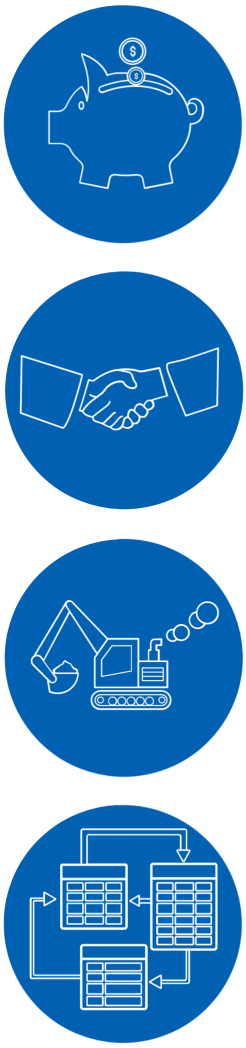
This section reviews 11 potential areas that have been identified as potential cost and timeline drivers for public transit projects. These cost drivers fall into roughly three categories: governance, processes, and standards. As illustrated in Figure 9 and throughout this section, there is clear overlap among these topic areas and the groupings are admittedly subjective. Nevertheless, they are helpful to understanding the complexities in delivering large transit projects and highlighting the differences between the United States and other countries.

FIGURE 9: CATEGORIES AND TOPICS OF MAJOR POTENTIAL TRANSIT COST AND TIMELINE DRIVERS



Also, there are terms that describe important actors in transit project delivery. While many terms, like transit agencies, state DOTs, and labor unions are self-explanatory, some terms are used in different ways by varying stakeholders. Figure 10 defines some of the entities frequently referred to in this section.

FIGURE 10: KEY ACTORS/TERMS IN TRANSIT PROJECT DELIVERY



PROJECT SPONSOR

The public entity managing and overseeing the project.

CONSULTANT

A private sector firm that provides services such as engineering, planning, project management, and design.

CONSTRUCTION CONTRACTOR

A private sector firm responsible for building physical infrastructure.

PROJECT MANAGER

A single person or small team in charge of the project, either an employee of the sponsoring agency or a hired consultant.

4.1 Institutional Structure and Decision-making

Perhaps one of the most overlooked but most important issues in transit project delivery is institutional governance. Research shows that transit projects can suffer or fail due to lack of focus on establishing the institutional structures that will ultimately deliver and operate the project. The literature shows that setting a clear structure for organizational decision-making responsibility and coordination with other agencies and transportation modes is important to the success of a project.

FEDERAL CAPITAL INVESTMENT GRANTS (CIG)

The Federal Transit Administration (FTA), through its Capital Investment Grant (CIG) program (formerly New Starts), provides billions of dollars in support to new rail capacity projects throughout the country that typically cover up to 50 percent of project costs. State and local transit authorities must apply for this funding and are subject to CIG program requirements and other federal regulations. CIG grants are awarded before construction and are fixed in their amount, which means that cost overruns are borne solely by the sponsoring agency.

Current law authorizes about $2.3 billion annually in discretionary grants to fund three types of fixed guideway (rail and bus rapid transit) projects:

1. *New Starts. Large capital investment projects ($300 million or more) that are seeking more than $100 million in federal aid for a new fixed guideway system or extension.*
2. *Small Starts. Similar to New Starts, but the total project cost is less than $300 million and federal funding sought is less than $100 million.*
3. *Core Capacity. CIG funding to rehabilitate a major existing corridor that can increase capacity by at least 10 percent.*

All CIG grants involve an intensive and detailed process with the FTA. For New Starts grants prospective grantees must work through the following process:

1. *Project Development. Grantees must develop and review project alternatives as part of an environmental review process, select a "locally preferred alternative," and adopt it into the region's long range transportation plan. FTA must approve this process.*
2. *Project Engineering. Grantees must complete preliminary engineering and design for the project and gain commitments from non-New Starts funding sources. FTA evaluates, rates, and approves this step.*
3. *Full Funding Grant Agreement (FFGA). After approval, the grantee and FTA sign a full funding grant agreement. Once the FFGA is signed, the grantee can begin construction.*

Through the New Starts process, FTA evaluates and rates each project based on "project justifications," which are benefits to mobility, environment, congestion relief, economic development, land use, and cost effectiveness (measured on a cost-per-trip basis). The FTA also evaluates and rates each project based on evidence of stable and dependable financial resources at the local and state level. All projects must meet a "medium" or higher overall rating.

The FTA, with the discretion of the Secretary of Transportation, makes its funding recommendations based on four stated criteria:

- *The "readiness" of the project for capital funding*
- *The project's overall rating*
- *Geographic equity*
- *The amount of available funds versus the number and size of the projects in the pipeline*

For New Starts and Core Capacity projects, CIG grantees are required to collect and analyze the before and after data to discern the effects of the Project on the Grantee's costs, overall transit services, and ridership. The FTA requirements for CIG grantees do not specify a certain type of governance or method for project management, but they do require the sponsoring agency to consider how project management is structured. For example, CIG grantees must (among many other requirements):

- *Evaluate the risk, scope, cost, schedule, financial plan, and project management before and during the project*
- *Describe staff organization, reporting relationships, functional responsibilities, and staff qualifications*
- *Budget for project management, consultants, utility relocation, and audits*
- *Create a change-order procedure that outlines how the sponsoring agency will deal with scope changes*
- *Define quality control and quality assurance programs*

In the federalist system of the United States, governance for transit is largely devolved to state and local governments which, in turn, develop their own unique way of organizing transit networks and the institutions that govern them. Transit capital projects are often carried out within the existing construction divisions of the same public authorities responsible for bus and rail operations. In some instances, independent special purpose delivery vehicles are used to deliver major projects. Most operating funds come from state and local sources, and federal grants cover a significant portion of capital projects, including rail transit expansions (see CIG summary above).

4.1.1 Special Purpose Delivery Vehicles

A special purpose delivery vehicle (SPDV), sometimes called a special-purpose public authority, or SPPA, is sometimes created to oversee the planning and delivery of the asset. The specific way in which these are organized can vary, but in general they are temporary, self-governed entities empowered to make coordinated decisions about project delivery. They are typically dissolved once the project is completed.[23]

SPDVs are common in Europe, where they can help deliver projects yet insulate them from traditional bureaucracy.[24] For example, an SPDV is delivering the Crossrail project, a nearly $5 billion regional rail project in London, helping to streamline internal decision-making, bolster expertise in-house, and allow for a flexible approach to project management.[25] SPDVs in the UK were also used to deliver the High Speed 2 lines and the 2012 Olympics. The Madrid Infraestructura del Transporte (MINTRA) SPDV was created to lead the successful construction of their subway expansion in the late 1990s and early 2000s.[26] The use of a state-owned SPDV was also "essential" to the successful construction of a metro line in Athens.[27] Independent SPDVs have been recommended for each future mega project in New York, citing the desire for equal representation between the MTA, city, and state to enhance coordination and budget control.[28]

SPDVs typically have independent boards that are composed of relevant regional stakeholders such as members of transit agencies and municipal governments, which can help to streamline jurisdictional coordination and ensure that all parties have a direct stake in achieving successful project delivery.[29] City representation on an SPDV governing board allows the agency to use the city's powers and relationships with utility providers to order and negotiate relocation, often at minimal or zero cost (see Section 4.5.)

Whether through an existing transit agency or through SPDVs, transit capital projects need a well-functioning board of directors to set high-level policy, choose the executive team, and empower that team to make decisions without getting involved with the day-to-day management of the project. Some boards explicitly state these principles in their bylaws.

4.1.2 Management Structure

Projects can get bogged down when processes become overly reliant on board action. Los Angeles Metro previously had issues concerning excessive involvement of board members in routine capital project activities, calling it "distracting" and out of alignment with the fundamental best practices of good project management, and linked procedures that require excess board involvement to project delays and cost increases.[30] In response, Metro staff proposed, and the board approved, that change orders would only require formal board approval if they exceeded the project budget. This greatly expedited project management decision making. Regular reporting on change order status was still required, providing a high level of transparency while also enabling an efficient process.

Research shows that project management teams with rigid or overinvolved boards do not have the capacity to adapt when confronted with a problem.[31] Since large transit projects in urban areas are very complex and routinely face unanticipated challenges, transit boards should establish a "small" and "multidisciplinary" team of executives with control over on-the-spot decisions. Management and the board should anticipate many changes during design and construction and should have a clear plan that proactively integrates change into the decision-making processes.

Manuel Melis Maynar, who oversaw the recent expansion of Madrid's Metro, recommends "a very small group of experienced engineers driving the works, more like close friends and colleagues, than people under a rigid hierarchical organization."[32] The tunneling projects in Madrid from 1995 to 2003, which constructed a remarkable 80 miles of subway for an average of US$85 million per mile, utilized three chief engineers and six additional engineers, all directly employed by the public sector. No consultants were hired for general project management positions.

However, in many cases, consultants can be helpful to project management by bringing in targeted expertise or advice and by assuming specialized tasks, that might need help from internationally experienced professionals, especially in large, complex projects. But external consultants have limitations: they are often more expensive than in-house staff and require quality oversight by the agency so as to avoid conflicts of interest.[33] Some research suggests "upskilling," in which consultants will train agency staff as part of their contract, thereby requiring consultants to pass on key knowledge to the personnel that will continue to work on the project after the contract expires.[34]

Balancing power asymmetries is an important consideration when designing the governance of project delivery. Transit construction projects are often politically charged processes and successful efforts require the full commitment not only from the sponsoring agency, but also from other local, state, and regional entities.[35] A clear hierarchy of decision-making authority has the potential to compress project timelines, while more balanced power within and between agencies can enable the development of more creative solutions for overcoming deadlocks.[36]

The institutional structure and decision-making processes of the implementing entity have significant impact on project outcomes. SPDVs commonly used in Europe have been successful at delivering major subway expansions and megaprojects, largely because of their flexibility in contracting, independence, and board structure. Representation of all relevant stakeholders and jurisdictions on the governing board of the entity responsible for project delivery can help ensure all jurisdictions have a stake in successful project delivery and utilize their ability to order relocation. However, overreliance on board actions for routine decision-making can slow down projects and lead to cost increases. Additionally, strong public sector management staff that are adaptable and empowered to make major decisions have been cited as critical to moving projects along. Conversely, research suggests an overreliance on external consultants can be more expensive and result in suboptimal outcomes compared to in-house management.

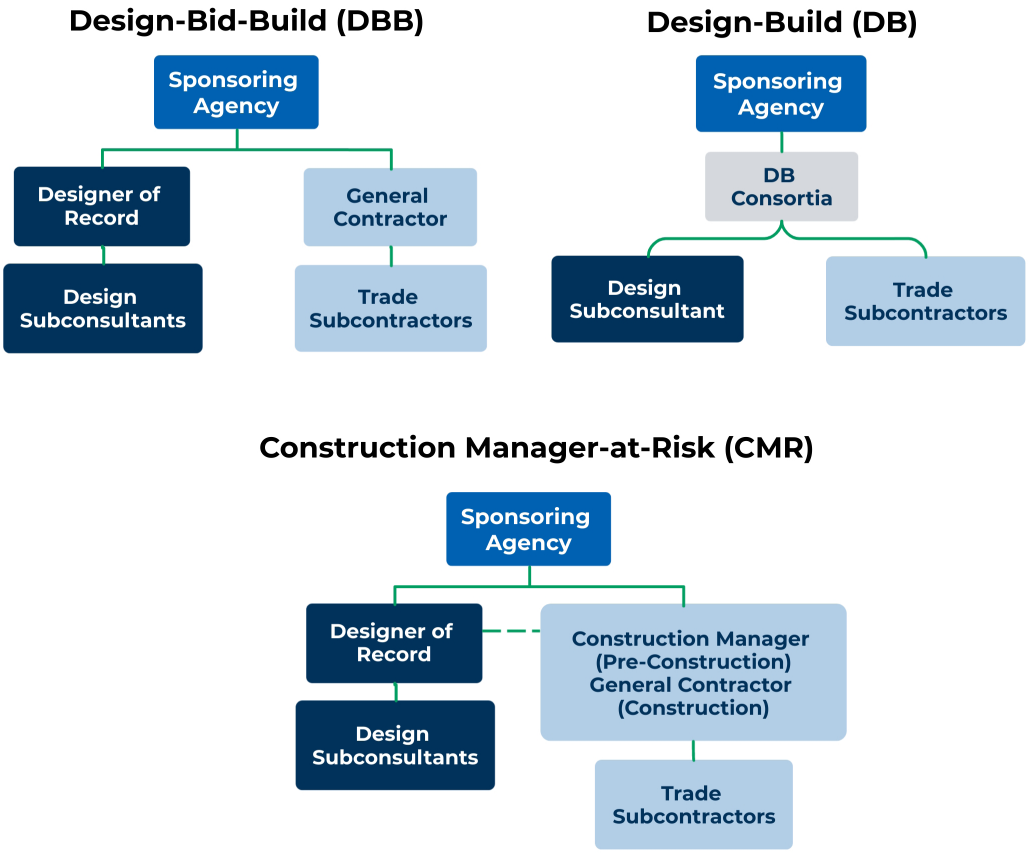
4.2 Project Delivery and Risk Assignment

Transit projects require the coordinated involvement of public and private actors with varying tasks, risks, and costs. For example, public transit agencies rarely own concrete plants or tunnel boring machines (TBM) and therefore rely on the private sector for design and construction. The scale and scope of the contractual relationship and delivery method between the public agency and private contractors can vary widely and directly affects project success. While there is extensive research on different models, there is no single method that is preferable in all cases, each with advantages and disadvantages.[37]

4.2.1 Primary project delivery models

The literature describes myriad forms of project delivery but in the United States there are three fundamental methods: design-bid-build, design-build, and construction manager-at-risk.[38] These are summarized below and in Figure 11.

FIGURE 11: PRIMARY TYPES OF PROJECT DELIVERY IN THE UNITED STATES



Source: Various
Note: While DBB and CMR have very similar structures, in CMR the Construction Manager is hired early in the process during design, unlike the General Contractor in DBB which is hired after the design is complete.

Design-bid-build (DBB) is the traditional and still most common project delivery method for transit infrastructure. The sponsoring agency first hires an engineering and planning firm to create complete designs for the project. The agency is then responsible for awarding and managing separate contracts to trade-based construction companies based on the designer's completed plans. The sponsoring agency owns the design details and is usually financially responsible for design errors or omissions encountered by the contractor.[39] The majority of the project design control and risk are retained by the public sector.

Design-build (DB) is a model in which the sponsoring agency procures the design and construction elements together in a single contract with a design-builder. The DB entity is often a consortium of several firms and is typically liable for delivering designs and construction costs according to a fixed price identified in the project proposal. Sponsoring agencies often use requests for qualifications (RFQs) then requests for proposals (RFPs) rather than going straight to bid in DB. The risk of cost and timeline

overruns are shifted to the design-builder. A proper DB procurement involves the agency giving up control over much of the design specifics. DB projects are generally quicker to construct because construction can begin during design, but they are often much longer to procure than DBB. DB is often referred to as "alternative" project delivery because it is different from traditional DBB.[40] DB-based delivery models such as design-build-finance (DBF, sometimes called a public-private partnership, or P3), design-build-operate-maintain (DBOM), and others expand the responsibility of the design-builder and assign more risk to the private sector partners.

Construction Manager-At-Risk, also commonly referred to as "Construction Manager/General Contractor," or CM/GC, shifts control and risk to the private sector (though to a lesser extent than in DB). In CMR, as in DBB, the sponsoring agency controls and owns the project design. However, a key difference between DBB and CMR is that in CMR, the Construction Manager is selected prior to the completion of design via a pre-construction agreement, enabling them to participate in the design process. The Construction Manager and General Contractor work closely together and, unlike in DBB, contract directly with construction firms to complete the project. This direct contracting arrangement often makes it possible for the project contract to include a maximum guaranteed price.[41]

While federal law is not a barrier to DB or CMR, there is a patchwork of state laws governing alternative procurement methods. Twelve states do not allow for the use of public-private partnerships for public transportation projects, including both New York and New Jersey, though all but two states (Iowa and North Dakota) allow for the use of design-build.[42] Some states restrict the use of alternative delivery methods in part as an attempt to avoid corruption and also because traditional DBB procurements retain most of the risk and control with the public sector, which some states are reluctant to give up. Other states legislate specific exceptions for projects, but the lack of local enabling legislation remains a substantial barrier to broader use of these methods.[43] Similarly, some local laws and agency policies limit the use of reimbursable price contracts, restricting pricing contracts to some form of fixed price agreement.[44]

Due to both inertia and limiting regulations, DBB remains the most prevalent delivery mechanism worldwide. But there is an increasing trend toward alternative methods for shortening timelines and cutting costs persists, with mixed results.[45]

Pricing Models

Contract structure is a crucial factor in determining the benefits and drawbacks of the DBB, DB, and CMR delivery methods. Agencies often desire to know the total cost of the project up front and set the contract so that the contractor is tied to the projected price. In theory, this arrangement provides significant incentives to private contractors to keep costs down and meet deadlines. In practice, circumstances outside of the contractor's control often lead to "change orders," which drive up project cost

beyond what was anticipated in the original contract (see Section 4.4). This pattern of discrepancy has led to the development of several different methods for pricing construction projects, each with its own advantages and disadvantages. Ultimately, the pricing mechanism decision revolves around balancing the allocation of financial risk and costs among all parties involved.[46]

Fixed Price contracts can be structured either as unit price or lump sum. In unit price contracts, the contractor fee is based on a measurable deliverable. For example, a contractor would receive a specified amount for each length of subway track completed (typical agreements contain many unit costs). The unit price includes labor, materials, overhead, and profit. Unit price contracts can be helpful when specific delivery quantities are unknown or expected to change during the design and construction process and can also help with contractor cash flow during long-term projects. Fixed unit pricing is common for urban rail projects and DBB delivery methods, and some research suggests it is preferred by contractors.[47]

Lump sum contracts are inclusive of all materials, labor, overhead, and profit. This contract structure transfers significant risk to the private sector and provides a strong incentive to complete the work efficiently.[48] Lump sum contracts are common for smaller, discrete tasks. For large, complex projects, lump sum contracts can force contractors to include significant cost buffers, driving up overall costs.

Many agency policies require that a contract include an upfront, fixed price, in part because sponsoring agencies have a strong desire for budget control and certainty. But using a CMR-type procurement often requires some kind of reimbursable or guaranteed maximum pricing scheme given the uncertainties in the design and subcontracting process.[49]

Reimbursable Price contracts provide compensation to the contractor for the project costs, including labor, materials, overhead, and profit. It is structured either as a "cost-plus" contract in which the contractor is reimbursed for labor, materials, and overhead and then given a percentage-based profit, or as a "fixed fee" contract in which the contractor is similarly reimbursed but the profit and overhead are fixed rather than percentage-based. Reimbursable price contracts are most commonly used for complex projects involving high-risk estimating.[50] Agencies must exercise additional oversight of reimbursable price contracts in order to limit the potential for wasteful spending given the lack of incentive for cost containment.

A **Guaranteed Maximum Price** contract is a combination of fixed- and reimbursable-price models in which the contractor is reimbursed and paid a fee, up to a previously-agreed-upon limit. If the cost of the project exceeds the limit, the contractor is responsible for covering the overrun. If the costs are less than the maximum, the sponsoring agency and the contractor split the remaining budget, creating an incentive

to keep costs low. But guaranteed maximum price contracts can provide a false sense of security if set too low, and they have the potential to precipitate adversarial relationships similar to those created when lump sum contracts are underbid.[51]

Industry trends indicate that guaranteed maximum and reimbursable cost pricing might become more common in the future. Some project managers say that lump sum fixed price contracts are simply not compatible with the complexities of tunneling.[52] With cost overruns on fixed cost projects becoming more prevalent, major firms are declaring a desire to not bid on fixed cost projects.[53]

4.2.2 Key factors driving project delivery method selection

There is no single consistently preferred delivery method for large transit projects.[54] In fact, a review of several projects at Los Angeles Metro found different results for DB and DBB projects, with no single method consistently performing better than another.[55] Research suggests sponsoring agencies tailor the project delivery model to align with staff capacity at the agency, project characteristics, and the state of the market and they should do so early in the project—during project scoping, if feasible.[56] However, most agencies, even those with robust capital programs, do not have formal processes for selecting a project delivery method. Such a process can be formalized and conducted on a project-by-project basis, weighing several interrelated factors:

Cost

When it comes to project delivery methods, the literature mostly agrees that delivery method has a small effect on the overall cost of the project. A study of nine U.S. transit projects found that the use of DB and CMR did result in some cost savings over DBB projects.[57] Some of these savings may be attributed to the avoidance of cost overruns related to design and scope changes that the sponsoring agency typically bears under DBB.[58] Another study showed that no single delivery system performed best in terms of unit costs.[59] Other research indicates that DB and CMR project delivery methods appear to have a positive effect on cost certainty even if they do not deliver lower cost projects.[60]

Experience in Los Angeles shows that DB projects can run into problems when designers do not account for utility relocation (a major cost driver, see Section 4.5) and when the DB entity does not have the relationships and experience needed to coordinate utility relocation with other entities. This shortcoming significantly increased costs for DB projects in Los Angeles.[61]

Timeline

By combining the design and construction firms into a single entity using DB or CMR methods, construction can begin very early in the process while the design is still unfinished.[62] In this way, DB is specifically noted as a way to meet aggressive delivery schedules or to approach projects that need to be fast tracked.[63] Of course, DB is not a panacea for paring back timelines. Citing the DB examples in Los Angeles, accelerated

construction timelines led to problems being discovered much later in a project, making them more expensive to resolve and subsequently increasing costs.[64] Regardless, if length of construction time is more important than cost, it appears that using DB or CMR might be helpful for accelerating timelines.

Size and complexity

Some experts say that large, complex projects are good candidates for DB given the need for greater experience from the private sector while DBB may be appropriate for smaller, more manageable projects. Based on his experience in Madrid, Maynar recommends that the large tunneling projects use DBB in order to separate design from construction, allowing for more flexibility and control by the agency.[65] It is important to note that neither project size nor complexity alone typically affects the choice of delivery method.[66]

Innovation

Alternative delivery methods allow for more innovation (loosely defined in the literature) in design and construction because the construction team can communicate more closely with the design team to make design adjustments that enhance constructability.[67] Rather than providing 100 percent completed design documents as the basis for construction contracts, agencies can instead specify a set of performance criteria for DB projects. This approach was cited as a major cost-saving measure in the Denver Eagle P3 project, which utilized a design-build-finance-operate-maintain (DBFOM) delivery model.[68] Instead of providing detailed design specifications as traditionally done under DB projects, the agency provided 30 percent design documents and high-level performance standards as reference materials to maximize bidders' design flexibility and creative freedom. The P3 team credited the use of performance-based procurement in lowering project costs, with the winning bid coming in $300 million below the agency's original cost estimate.[69] Maryland's Purple Line project, also a DBOM, proposed a higher-voltage system that required fewer substations, reducing overall costs.[70] Although not all demonstrate significant cost savings during construction, small changes that improve constructability can effectively improve overall project design.

Staff capacity and experience

It is the responsibility of the sponsoring agency to retain sufficient, high-quality staff to manage a project. The delivery method selected determines the kinds of skills staff needs to have to successfully execute the project. For DBB, the public sector is in control of the project at all times, and thus staff need to be skilled in project management. Many failings of DBB projects often result from inadequate management of the various contractors, which affects the overall progress of the project.[71] This problem seems to be particularly acute within smaller agencies.

DB projects need personnel with project oversight skills. With hundreds of millions of dollars at stake, agency staff must be vigilant in providing strong and active oversight.[72]

For example, a DB firm might produce a design that is cheaper to construct but that does not have a long life cycle before significant maintenance is needed. Because they have no direct long term stake in the project (aside from reputation), a DB firm might choose a poor outcome for the agency without such oversight.[73] Quality assessment and quality control procedures are vital to ensure a lasting product, but many agencies do not invest enough planning and resources into creating such a system.[74] Providing a contract to operate and maintain the asset for several decades builds in an incentive for life cycle cost planning, but few examples of DBOM transit projects exist.

Competition

Under traditional DBB procurements, a project sponsor may choose to bring on a single prime contractor to oversee project development and construction, or instead award individual project components under separate contracts to multiple prime contractors.[75] Combining contracts into a larger package may be more attractive to bidders and allow the project to benefit from economies of scale and the consistency of a single entity to deliver the entire, integrated project. However, it may also limit competition to a handful of larger firms due to project size and complexity, either pricing out smaller contractors or relegating their involvement to the role of subcontractor.[76] Dividing a project into several smaller contracts may increase competition, potentially lower costs, and provide more opportunities for small contractors to serve as primes, but it can also introduce more complexity by requiring project sponsors to coordinate several prime procurements and manage a larger group of contractors.[77]

4.3 Procurement Specifications

How agencies legally obtain goods and services—from vehicles and parts to engineering and construction services—is a major element of any transit project. The FTA requires agencies to ensure full and open competition when procuring goods and services, as well as adopt written codes of conduct to prevent any employee or board member with a conflict of interest from participating in the "selection, award, or administration of contracts."[78]

For procurements over $100,000, which encompass rolling stock, design, engineering, and construction contracts, agencies are required to adopt formal procurement methods. The two broad types are sealed bids and RFPs. Under a sealed bid procurement, agencies provide firm, rigid, and detailed specifications for potential bidders and award contracts to the "lowest responsive and responsible bidder."[79] Sealed, low-cost bids are not recommended for complex procurements in which significant variation among bidders is expected beyond price (i.e. qualifications, management approach, schedule).[80] Through an RFP process, agencies provide a scope of work or general requirements rather than detailed specifications and then solicit feedback from potential bidders on the proposed scope of work.[81]

When procuring architectural and engineering services, agencies must award contracts based on contractor qualifications, rather than price. This requirement is borne out of the Brooks Act of 1972, which established a Qualifications Based Selection (QBS) process for all federal design contracts.[82] Under a QBS procurement, price is not a consideration, and pricing data is often not collected.

Agencies are not federally obligated to award contracts solely based on price. They can also use "best value" procurement that considers other factors, including contractor qualifications, approach, local hire provisions, and project schedule (though state and local laws may require otherwise).[83] While RFP processes can allow for consideration of factors beyond price, existing literature suggests agencies often end up choosing the lowest-priced proposal because of existing agency policy, out of reluctance to seek board approval for more expensive purchases, or fear of negative public reaction to choosing a pricier bid.[84]

Examples from Madrid and elsewhere demonstrate that best value procurement keeps construction costs low and projects on schedule by prioritizing technical expertise and preventing under-qualified contractors from receiving contracts.[85] When scoring construction bids for the 1999-2003 metro extensions in Madrid, 30 percent of the final score was based on bid price, 20 percent on schedule considerations, and 50 percent on the technical qualifications of the bidder and their proposal.[86] Most other European countries have similar bid evaluation criteria. Several states, including Minnesota and Delaware, allow best value procurement for major public works projects.[87] Best value statute in Delaware requires selection criteria to be provided to bidders in the bid invitation, and agencies must first determine that the bidder is "responsive and responsible" before awarding them a contract.[88] The weight attached to bid price must fall within a range of 70 percent to 90 percent of the total score and schedule considerations within 10 percent to 30 percent.[89] While this statute allows for the consideration of factors beyond price, the outsize role of price in the final score can still lead to the lowest-price bid prevailing.

4.3.1 Disadvantaged Business Enterprise Considerations

Another major consideration for project sponsors during the procurement stage is the participation of disadvantaged business enterprises (DBE). DBEs are small businesses that are owned and controlled by socially or economically disadvantaged individuals, including women and people of color.

The federal government has employed minority preference policies since the 1960s in order to provide opportunities specifically through federal spending and counter the effects of past discrimination. In 1983, Congress passed a statutory provision requiring 10 percent of all federal financial assistance for highways and transit to be expended by DBEs.[90] The program has been re-authorized regularly since 1987. State and local transportation agencies are required to develop overall, statewide DBE goals every

three years, which are supplemented by specific subcontracting goals for any federally-assisted contracts. These goals must be "narrowly tailored" to each contract based on the availability of DBE firms in a project's market area(s). Bidders must demonstrate how they will meet the stated DBE goals (often with a list of funding commitments to specific DBE firms) or demonstrate a good faith effort to meet the targets. If they are unable to accomplish either, their bid must be rejected.

While the literature does not show that DBE goals are a major cost driver, transit agencies have found it increasingly difficult to incorporate DBE participation into contracts through alternative delivery methods such as DB or CMR.[91] Considerations for DBE participation can inform an agency's choice of delivery method or how it packages design and construction contracts. Challenges in meeting DBE goals at the outset of a project can also lead to project delays and complications, which may indirectly affect final costs.[92] Agencies need to consider the tradeoffs between larger, consolidated contracts that may streamline project delivery but limit the pool of bidders, and a handful of larger firms and smaller contracts that introduce more competition and opportunity for DBE firms but require strong contractor and project management capacity.

Given the large size and complexity of many DB contracts, most DBE firms often participate as subcontractors.[93] However, the lack of a completed design when awarding DB contracts can also make it difficult to set specific DBE subcontracting goals for bidders when exact quantities of work and needs are not known.[94] Additionally, there is often a lengthy gap between the signing of a DB contract and the actual utilization of subcontractors (sometimes up to two years), which can cause some subcontractors to withdraw from the project if they are unable to carry out the work or maintain their original prices.[95]

In response to these challenges, several state DOTs have modified their DBE processes to allow for more flexibility in meeting DBE goals for DB projects. DOTs including South Carolina, Delaware, California, Colorado, and New York allow DBE commitments to be made as a project progresses, rather than at its inception.[96] This approach relieves DBE firms of the risk inherent in bidding on incomplete plans. These approaches provide agencies with more flexibility and ease in meeting DBE requirements and reduce the risk of delays or complications if a project fails to meet its DBE goals.

Varying federal, state, and local regulations govern the method by which project sponsors procure the different elements of a transit project. In many states, project sponsors are legally required to award contracts to the lowest bidder while in other cases, sponsors may opt for a low-bid procurement even if not necessary out of concern for board or public backlash. Evidence from Madrid and other regions suggests best value procurements, which weigh bids according to a combination of price, technical expertise, and schedule, can result in better outcomes and avoid potential cost increases resulting from underqualified contractors. Additionally, DBE and local hire regulations

can provide traditionally under-represented firms an opportunity to build up experience in the local market, but may be difficult to meet if set too high. Other factors, including the choice of delivery method and contract bundling, can further impact the ease or difficulty of achieving DBE goals.

4.4 Soft Costs and Change Orders

Transit project construction cost estimates inform a range of project aspects, including design, alignment, financing strategies, and community reaction. While there has been significant attention to the measurement of hard costs—physical elements of a project like vehicles, tracks, stations, and steel—soft costs are overlooked and understudied.

Soft costs typically encompass activities and services needed to plan, build, and start up a transit project aside from physical construction. Examples include design and engineering services, legal work, security and safety analyses, environmental review, risk assessment, cost estimation, administration, and project management.[97] While few studies have directly analyzed the magnitude and scope of soft costs, research shows they have increased over time. There is no consensus on a specific source of increases but some research points to poor project management practices that lead to excessive change-orders, high contractor profit margins, long planning phases, unusual political influence, and project complexity.[98]

Among a 2010 sample of federally-funded projects, soft costs comprise an average of 30 percent of the total cost, ranging from 11 to 54 percent.[99] Soft costs have also increased over time, from an average of 21 percent of the overall project cost in the 1970s to nearly 35 percent in the 2000s.[100] The limited quantitative analyses on soft costs show percentages for heavy rail projects were six percent higher than those for light rail projects, while soft cost percentages for new, stand-alone lines that did not interface with an existing line were 3.8 percent lower.[101] Additionally, soft cost percentages for projects with lengthy planning periods (beyond 5-7 years) were 7.1 percent higher than others while projects that experienced unusual political influence - like contentious design, need for approval by multiple boards and commissions, or intensive public involvement - had 6.6 percent higher soft cost percentages.[102]

A 2012 study explored the effect of a range of variables on project soft cost variation, including: delivery method, project mid-point (year), project type (new or extension), length, number of stations, grade alignment (percent at-grade, below grade, and not at-grade), and length of project development phase.[103] It found that one of the most consistently significant variables was time, as project soft costs increased by 4-5 percent as a share of total project costs each decade for both light and heavy rail projects.[104] This could potentially be attributed to increasing design and management service costs over time or changing regulations (i.e. new environmental review standards that require more professional services to meet). Additional research is needed to investigate whether this trend holds true for projects built since 2010.

4.4.1 Contractor Management

Activities associated with soft costs can be performed either by agency staff or by outside consultants. The decision to bring on outside consultants is informed by a range of factors including the project complexity as well as an agency's technical knowledge and staffing capacity. Agencies may utilize in-house staff to deliver a project if feasible; hire another transit or state/local government agency as a third-party contractor; use a general consultant or series of consultants overseen by an in-house project management team to plan, design, and build a system; or outsource oversight of consultants to an external project manager.[105] While many of the decisions involving contracting are dependent on an agency's procurement practices (see Section 4.3), agency capacity to manage contractors and resulting consequences of procurement decisions can affect soft costs.

As explained in Section 4.2, project sponsors are able to control the size and structure of major contracts. While dividing major design and construction work into smaller packages can increase competition and agency control over the project, the increased number of contractors on a project can also increase complexity. The New York MTA employs separate consultants for environmental assessment, design and engineering, and constructability assessments, resulting in a complex project organization structure. This approach has been cited as a potential cost driver by causing the agency to incur project management costs, contract defaults, and delays that might have been avoided with use of a single contractor.[106]

While agency expenditures on external consultants for design, engineering, and other professional services are likely to be counted towards a project's formal soft costs, other indirect costs associated with construction contractors may not be. Agency payments to construction contractors may be classified as a hard cost, though these costs may include indirect expenditures like overhead, administration, and other activities on behalf of the contractor that are not captured in the formal soft cost total.[107] Frequent change orders and poor management practices can lead to contractors incorporating higher overhead and profit margins into their bid prices, further driving up both soft and hard costs.

4.4.2 Change Orders

Change orders typically occur when the project sponsor makes an addition or modification to a project's original scope of work during construction.[108] Much like soft cost estimates, a project's scope can evolve as it moves from the conceptual and design phases to construction. Some of these modifications occur due to errors or omissions in the initial design, while others are prompted by unexpected events, budget constraints, changing needs and standards, or poor project management.[109]

While change orders can affect hard costs by modifying physical components of a project, they can also drive up soft costs due to increased administrative capacity necessary to process the change orders, manage changes in construction, and oversee contractors.[110] Additionally, change orders can cause delays in a project's timeline,

further introducing new costs and complications. Analyses of past projects indicate that, on average, change orders contribute to a nearly 24 percent increase in project costs.[111] These cost overruns often exceed the fixed percentage of project costs reserved for contingencies.

In New York City, change orders have been a major cost driver, particularly on the Second Avenue Subway and East Side Access projects, by introducing significant project delays and driving up budgets. Though an outlier due to its unusually high cost, the Second Avenue Subway project underwent over 270 change orders for a single station (96th Street), modifying nearly 70 percent of its original scope.[112] Several factors contribute to the magnitude of change-orders for New York projects, including a lack of agency capacity to quickly process change orders (often requiring months to be approved), inaccurate designs and budget estimates, and increasingly customized specifications to maintain compatibility with older systems as required by the MTA's operating agencies.[113]

These challenges not only introduce delays but also inflate soft costs by increasing overhead and profit margins on the part of contractors. When bidding for projects, contractors often account for profit, change orders, and other overhead expenses by adding 10 percent to their final cost estimate.[114] In New York City, contractors' overhead margins often exceed 20-25 percent to account for risk associated with MTA's notoriously numerous change orders, custom specifications, and bureaucratic challenges.[115] Though New York may be an outlier, persistent change orders could also impact the ways in which contractors price risk and overhead into their bids for other agencies, leading to further inflated soft costs.

The delays associated with change orders are compounded by a lack of agency capacity to manage contractors, limited ability to respond to construction issues as they arise, inaccurate cost estimates, and flawed or poorly managed project design.[116] Proposed solutions have included the integration of contractors into the design process to better anticipate and prevent changes that materialize during construction; improvements in project management and oversight capacity; and more transparent contracting.[117]

As discussed in section 4.2, agency staff in Madrid employ several measures to minimize costs, change-orders, and delays, including the use of unit cost contracts in lieu of lump-sum contracts and reliance on a small team of in-house engineers for project management.[118] These contracting measures allow Madrid Metro to increase transparency by enabling change orders to be more easily priced and quickly agreed upon with contractors. Relying on in-house project management also enabled Madrid Metro to expedite decision-making (major decisions among leadership can be made within 24 hours), reduce bureaucratic complexity, minimize disputes between the agency and contractor, and resolve disputes before they become unmanageable, which helped keep project costs low.[119]

Notably, overhead rates for public works in Spain are limited by law to 13 percent, and profit margins to 6 percent.[120] These unique legal factors, combined with differences in engineering methods (cut-and-c-cover vs. tunnel boring), governance structures, and public ownership of utilities, partially explain the unusually low cost of transit projects in Madrid. However, Madrid's approach to transit projects also highlight the impact that project management and contractor oversight capacity can have on the prevalence of change orders and the resulting magnitude of a project's soft costs.

Soft costs on a transit project encompass most non-construction activities, including environmental reviews, planning, legal fees, administrative costs, and expenditures on design or engineering consultants. Research has found soft costs as a share of project costs have increased over time. A project sponsor's approach to contracting and management can play a significant role in shaping the extent of soft costs within a project. In cases where agencies rely heavily on outside consultants, lack of proper oversight and management can lead to change orders and delays that result in additional fees and cost increases, which factor into a project's soft costs. Poor oversight over the design, engineering, and management process can also lead contractors to incorporate more risk into their bids, further inflating soft costs. By using in-house management, unit-cost contracts, and caps on contractor profit margins, these best practices can keep soft costs in check by minimizing scope modifications, change orders, and delays.

4.5 Utility Relocation

A major element of transit construction, particularly for rail projects, is the relocation of utilities along the proposed alignment. These may include power, water, gas, phone, internet, and sewer lines often owned by private sector enterprises with completely different goals and motives. Transit projects can cross utilities both above and below ground, requiring them to be moved vertically, horizontally, or both. It is among the most complex elements of transit projects, and one of the most common reasons cited for issues and project delays.[121]

Utility relocation needs are typically identified during the initial project design phase. When a preferred alignment is chosen, agencies begin to assess affected utilities, notify utility owners, and coordinate relocation plans as design progresses. One frequently cited issue in relocation, particularly in the case of older utilities, is unavailable or inaccurate information on the location of existing utilities often due to missing historical records or abandoned utilities that were left undocumented.[122] An inability to accurately locate existing utilities can greatly complicate the relocation process and require additional work and delays that increase costs down the line.

Early identification and mapping of existing utilities is a major cost-saving measure. One commonly cited statistic claims that every $1.00 invested in early utility identification saves $4.62 in future delays, scope changes, and re-excavation.[123] Poor constructability

assessments and limited site access during the initial stages of project development can jeopardize the ability of project sponsors to fully identify utility relocation needs.[124] Limited site access may be a result of poorly managed design processes, or a reluctance to disrupt existing service (particularly for extensions of existing lines). A report by LA Metro cites poor relocation drawings submitted by consultants and compressed timelines as a driver of utility-related delays.[125] While compression of project timelines is often a desirable goal, agencies often do not dedicate sufficient time to carrying out field work and the actual relocation and utility companies are not incentivized to prioritize the timeline of a transit project.[126]

In addition to timing, utility relocation often requires significant coordination among various public and private entities, and demands a high level of staff capacity. According to law in the United States, private utilities (like the private streetcars in the past) must bear the full cost of relocation.[127] But given the immense cost associated with relocation and the propensity for utility companies to sue, legal proceedings are frequent, and companies have found ways through the legal process to argue around or against this rule, and courts have sometimes sided with the utilities.[128] Most utility relocation is governed by state or local station, and utilities operating within public rights of way often have franchise agreements with cities, providing the city—but not necessarily the transit agency—with significant leverage to order the relocation of utilities at the owner's expense or at a negotiated cost.[129]

Ownership, governance, and staff capacity play major roles in the outcome of utility relocation. Cities, rather than transit agencies, often have the legal authority to order relocation, and strong working relationships between agencies, municipalities, and the utility owners can lessen the time and expense of utility relocation. Both the city and county of Los Angeles have franchise agreements and working relationships with utility providers, as well as representatives on the Board of LA Metro. This relationship allows the city and county to negotiate better rates for relocation work, while in New York, the politically isolated nature of the MTA (and minimal involvement of the city on the agency's megaprojects) often requires the agency to accept the relocation rates provided by the utility owners.[130] Site work and utility relocation costs for the Second Avenue Subway were two and a half times higher than the Purple Line extension in Los Angeles, a similar underground project ($214 million vs. $94 million).[131] The Charlotte Area Transit System (CATS), on the other hand, is owned by the city, which allows for a straightforward relocation of city-owned utilities for capital projects.[132] The city also has a good working relationship and cost sharing agreements for relocations with the local electricity provider, which has facilitated smooth relocations.

Another coordination issue involves staff capacity to manage utility relocations both at the agency as well as the utility. Staffing requires specialized knowledge of utility technical requirements, processes and people. This is cited as a major issue for LA Metro, where understaffing makes it difficult to keep up with the increasing relocation

needs.[133] Best practice shows utility relocation managed by a dedicated team of staff with expertise in relocation for the duration of the project and with the same effort that is dedicated to design and construction oversight.[134] Experienced staffing and proper oversight is associated with fewer delays and issues than outsourcing the work.[135]

Projects utilizing alternative delivery methods may also experience complications in implementing utility relocation. This is primarily a result of compressed project schedules and staff capacity. The tightened timelines for DB projects often do not leave enough time for utility relocation, and the lack of completed design documents can make it difficult to identify and relocate utilities early in the project. Delegating utility relocation to the design-builder without sufficient assistance or oversight can pose its own set of challenges, particularly when there is not a strong relationship between the contractor and utility companies.[136]

Utility relocation is among the most complex elements of a transit project and is frequently cited as a major cost and timeline driver. Project sponsors typically begin identifying utilities during the project design phase and begin notifying and coordinating with utility owners once an alignment has been chosen. Old and inaccurate utility maps, however, can complicate efforts to identify utilities, and lead to additional costs and delays to address unexpected site conditions when conducting relocation. Additionally, insufficient time dedicated to relocation, limited site access, lack of staff capacity, existing agreements between public entities and utility companies, and the need to coordinate with various third party entities can lead to further delays and cost increases during the utility relocation process. Research indicates that investment in early utility identification and relocation planning can result in significant cost savings further down the line by reducing delays, scope changes, and re-excavation.

4.6 Land Acquisition

The acquisition of land and ROW is necessary for any transit project and its route, grade alignment, stations, and maintenance facilities impact specific land needs and costs. Federal and state regulations, including eminent domain laws, environmental statutes, and other statutes governing the purchase of property for infrastructure projects, also influence the land acquisition process and costs.[137]

Land and ROW acquisition can constitute anywhere from 5.8 percent to 15 percent of project costs.[138] When deviating from public right of way or public land, below-grade projects involve the purchase of underground easements from property owners, often with minimal impact to the surface.[139] The valuation of these easements depends on depth and anticipated disruption to the surface property like noise or vibrations, which may be considered as part of the environmental review process (see Section 4.7). Easements are sometimes necessary for the placement of aerial guideways for above-ground rail systems.[140]

Anecdotal evidence from a 2019 GAO report suggests that the costs of ROW acquisition are closely correlated with local land values, and that many project sponsors use existing ROW—such as a highway median—to avoid costly and time-consuming acquisitions.[141] However, construction costs are not necessarily higher in more expensive cities. Construction costs-per-mile are much lower in cities like Madrid, Paris, and Copenhagen than in similarly expensive cities like New York and San Francisco, though further detail on actual land acquisition costs would allow for a more accurate comparison.[142]

4.6.1 Federal Regulations for Acquiring Land

Acquisition of real estate for federally-funded projects must abide by the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (URA), as well as 49 CFR part 24, which establishes protections for owners and lessees of property acquired as part of an FTA-funded project. These laws outline procedures and requirements for land appraisal, price negotiation, and just compensation for displaced property owners. As part of the environmental review process, project sponsors are required to document land acquisition needs for alternative alignment scenarios. If relocation is deemed necessary, a social impact analysis is conducted that analyzes the people and businesses displaced, the availability and type of replacement dwellings, potential relocation issues, and efforts to mitigate adverse impacts.[143]

In addition to these documentation requirements, the National Environmental Policy Act (NEPA) prevents project sponsors from acquiring real estate or ROW prior to the completion of the NEPA process and final determination by FTA. This prohibition on early acquisition is intended to avoid bias towards or against any particular alignment scenario, including a No Build scenario. Limited exceptions are granted for circumstances involving: 1) hardship acquisitions, 2) protective acquisitions, or 3) acquisition of railroad ROW.

For cases in which a transportation project is unable to avoid negative impacts to natural resources or wildlife habitats, agencies are required to employ compensatory mitigation to offset environmental impacts.[144] Mitigation efforts are typically conducted on a per-project basis during the later stages of project development. On average, natural resource mitigation constitutes 7.5 percent of project costs (excluding the costs of ROW acquisition) and can range from two to 12 percent of project costs.[145]

4.6.2 Land Acquisition Process

Pursuant to federal and state requirements for just compensation of property owners, project sponsors must obtain a property appraisal and make an offer to the owner accordingly. In some states, like Colorado, property owners retain the right to choose the appraiser, and the agency covers the cost of the appraisal process.[146] The agency and property owner then come to a negotiated agreement for purchase and sale. However, if an agreement cannot be reached, an agency may exercise its powers of eminent domain and acquire the property through condemnation as a last resort.

Various elements of the acquisition process act as a cost driver mostly by making the process time consuming. These elements include the timing of property acquisition, whether land is obtained through negotiation or condemnation, and the extent to which relocation assistance or litigation is necessary. Several studies have found that early acquisition can lead to significant cost savings.[147] This is largely attributed to reduced delays and likelihood of litigation, as well as the impact of inflation and rising property values on land acquisition costs.

Currently, FTA allows project sponsors to purchase corridor property (ROW) prior to conclusion of the NEPA process at their own risk, so long as it does not preclude the consideration of any alternatives, including alternatives that do not utilize the corridor.[148] ROW acquired under this provision must be for a new transit line or core capacity improvement to an existing line. Property not associated with a new or improved transit line or for facilities for a new or improved transit project that are not directly adjacent to the ROW (i.e. maintenance or storage facilities) cannot be acquired under this provision.[149] FHWA allows project sponsors slightly broader authority to purchase real property, not just ROW, at their own risk for highway projects prior to the completion of the environmental review.[150]

An expedited and prompt acquisition process can reduce costs by preventing prolonged negotiations, costly and time-consuming legal battles, and compressed project schedules. Review of best practices in the U.S. and Europe have identified early involvement of the public as a way to compress acquisition timelines and prevent litigation.[151] By incorporating public input early in the acquisition process, agencies can determine whether particular alignments are likely to be contentious when acquiring ROW and avoid litigation by planning accordingly.[152] During the acquisition process, poor communication between negotiators and property owners, slow pay-outs, and unresponsive acquisition staff can lengthen the negotiation processes, reduce trust between property owners and staff, and lessen the likelihood of a successful negotiation.[153]

Condemnation is reserved as a final resort, and federal regulation requires agencies to exhaust all possible attempts at negotiation before using their powers of eminent domain.[154] Data from 1996 to 2002 reveal that the rate of condemnation varies significantly by state (as low as 0.5 percent in Colorado to nearly 50 percent in Rhode Island) and that more urbanized states are associated with higher rates, likely due to the increased complexity of urban projects.[155]

Condemnation is not only contentious but can also be far more costly given the likelihood of litigation and associated delays. In Texas, acquisition costs were 78 percent higher for condemned properties, and added up to eight months to the process.[156] The Utah Transit Authority's ability to acquire more than 1,000 parcels without resorting to condemnation was similarly found to be a major cost saver.[157] While condemnation can enable the rapid acquisition of property for transit

projects, it is inadvisable given the associated cost increases, project delays, and general loss of trust between the public and government.

While the full extent of land acquisition costs as a share of transit projects can vary significantly, the process can serve as a cost and timeline driver, particularly in the event of lengthy negotiations or if condemnation is required. Beginning the land acquisition process as early as possible with ample community input can allow project sponsors to anticipate and plan for potentially contentious acquisitions and foster trust with property owners. Advanced land acquisition has also been cited as a potential cost saver, and the FTA currently allows project sponsors to acquire ROW before completion of the environmental review process at their own risk.

4.7 Environmental Review

A variety of federal laws, rules, and regulations govern environmental review of federally funded transit projects in the United States. Compliance with these standards falls under the process established in 1970's National Environmental Policy Act (NEPA), but also involve more than two dozen other federal statutes that span several federal agencies. NEPA acts both as a holistic method of determining the environmental impact of a federal undertaking and as a collection point for the many permits and consultations required under federal environmental law.[158]

While a few transportation projects are exempted from complete environmental review, a full environmental impact statement (EIS) is typically required of projects built in new ROW. Completing an EIS is often a long process (a median of 3.6 years for EIS completion time) that can contribute to project delivery time and costs. There is general bipartisan support for streamlining the environmental review process, but the approach to do so is either unspecific or divisive.

The emphasis on sources of delay due to environmental protections tends to be on the process of implementing those protections rather than on the standards or stringency of the protections themselves. Some suggest that conforming to environmental mandates may even prevent project delivery delays due to litigation or redesigns later in the process.[159]

While NEPA is often cited as a source of delay, the law has also enabled projects to be more responsive to local needs and reduced adverse environmental impacts.[160] NEPA has become the primary method for engaging with and informing the public of project details, and thus serves an important role in community engagement. Disagreements about how to proceed given different project alternatives are associated with delays in the overall NEPA process. Finally, many of the preliminary engineering decisions made about a project occur during the NEPA process and would have to occur irrespective of NEPA.

4.7.1 The National Environmental Policy Act

NEPA requires federal agencies to assess potential environmental effects and evaluate any significant impacts in advance of proposed major federal actions prior to making final decisions about how to implement those actions. These may include decision-making about permit applications, adopting federal land management actions, and constructing publicly-owned facilities like federal highways. "Effects" can be the result of direct or indirect actions and include ecological (i.e. effects on natural resources), aesthetic, historic, cultural, economic, social, and health outcomes.[161] In this sense, the definition of environmental effects constitutes not only natural resources (e.g. air, water, and ecological resources), but also historic, social, and cultural resources (e.g. historic properties, districts, and archaeological sites).

NEPA applies to highway or transit projects with any federal nexus, including direct federal projects, federally permitted or approved projects, or any project receiving federal funding assistance. Projects that do not use federal funds or require federal permits or authorizations, like preparation of a regional transportation plan, typically do not require NEPA review but may be subject to similar state-level environmental review processes.[162] While NEPA is largely procedural (i.e. primarily encompassing assessment and disclosure of environmental impacts), parallels at the state level are in some cases more stringent in that they are both procedural and substantive, in some cases requiring mandatory mitigation efforts.[163]

The Council on Environmental Quality (CEQ), an entity within the Executive Office of the President, is tasked with oversight of NEPA implementation and the development of national environmental quality recommendations and policies. The regulations established by CEQ are binding on all federal agencies. Federal agencies also supplement CEQ regulations by establishing their own NEPA procedures that reflect their agency's mission. A federal agency's NEPA procedures reflect their internal statutory requirements, regulations, and guidance. Typically, a single federal agency is designated the "lead agency" responsible for NEPA review for the proposed action based on expertise and relationship. If more than one agency has expertise on resources impacted by the proposed project, those agencies will also conduct assessments, though the lead agency typically has the biggest review responsibility.

To comply with NEPA and receive federal funding, transit project sponsors must consult with FTA. The project sponsor prepares statements that assess a project or action's environmental impacts as well as the potential effects of alternative projects or actions.[164] Alternatives can be determined through local planning processes or based on prior transportation project planning studies. Through an approach called planning and environment linkages (PEL), transportation planners and NEPA practitioners can coordinate their analysis efforts to potentially accelerate project delivery. However, the application of this approach to transit projects has been limited. Through the NEPA process, FTA and the project sponsor work together to devise a list of economically and

technically feasible "reasonable alternatives".[165] FTA is responsible for ensuring that NEPA documentation is complete.

The assessment statements prepared by FTA or the responsible federal agency falls into one of the following categories:

- **Categorical Exclusions (CATEX or CE)**: Certain types of federal actions are categorically excluded from a full environmental analysis because they are considered to not individually or cumulatively have a significant effect on the environment. The federal code lists these types of actions, which require only administrative approval because past experience has demonstrated that these project types or categories do not involve significant environmental impacts. Examples include utility poles, power substations, energy retrofits, training, landscaping, and technology upgrades.[166]
- **Environmental Assessments (EA)**: If an agency determines that a CE does not apply to a proposed action, it prepares an EA. An EA includes: discussion of the need for the proposal; alternatives; environmental impacts; and a listing of agencies and individuals consulted. The EA process determines whether a project will have significant environmental impact. Once the EA is completed, the agency either issues a Finding of No Significant Impact (FONSI), which describes why the agency believes there are no significant environmental impacts, or it prepares an Environmental Impact Statement.
- **Environmental Impact Statements (EIS)**: If a proposed action may significantly affect the human environment as defined by NEPA, a federal agency will issue a Notice of Intent and begin preparation of an EIS in conjunction with the sponsoring agency. An EIS includes information about the agency and the action it intends to take; the purpose and need of the action; alternatives; a description of the affected environment; and direct and indirect environmental consequences, among other details. An EIS is required for the construction of transit facilities not located within an existing ROW.

Since 2010, FTA has prepared over 50 EA/FONSIs, and over 30 RODs.[167] The ROD is the document that identifies the preferred alternative as determined by the EIS process.

Because NEPA serves as "umbrella" legislation over other federal environmental laws, project sponsors typically need to obtain supplemental federal permits or perform certain project-specific analyses to satisfy various federal environmental statutes (see Table 3).

TABLE 3: FEDERAL ENVIRONMENTAL STATUTES MOST LIKELY TO AFFECT MASS TRANSIT PROJECTS

Original Law	Requirement
Section 4(f) of the Department of Transportation Act	USDOT determination that the project will not jeopardize publicly owned parks, recreation areas, or refuges unless there is no prudent and feasible alternative
Section 106 of the National Historic Preservation Act	USDOT must take into account the effect of any undertaking on historic property (consultation with Advisory Council on Historic Preservation)
Section 404 of the Clean Water Act (Federal Water Pollution Control Act)	Corps of Engineers permit for the discharge of dredged or fill material into the waters of the United States, including wetlands
Sections 9 and 10 of the Rivers and Harbors Appropriations Act of 1899	Corps of Engineers/USDOT permit for construction of a bridge or other obstruction over a navigable waterway
Section 7 of the Endangered Species Act	USDOT determination that the agency action is not likely to jeopardize an endangered species or its habitat (consultation with Fish and Wildlife Service)

4.7.2 NEPA Documentation Requirements as a Cost and Delay Driver

Historically, costs and timelines for processing NEPA reviews have not been tracked in detail for transit or highway projects. Transit agencies and FTA representatives interviewed in a GAO report have indicated that costs associated with NEPA review are not tracked because it can be difficult to discern whether costs are to be attributed to the NEPA process or to the planning and preliminary design phases of project delivery.[168] However, one analysis of environmental costs incurred by State DOTs indicated that while environmental costs may range from two to 12 percent of total project costs, the majority of those costs were likely to be for mitigation actions like stormwater facility construction and erosion control, though the same study listed a number of barriers to tracking environmental costs.[169]

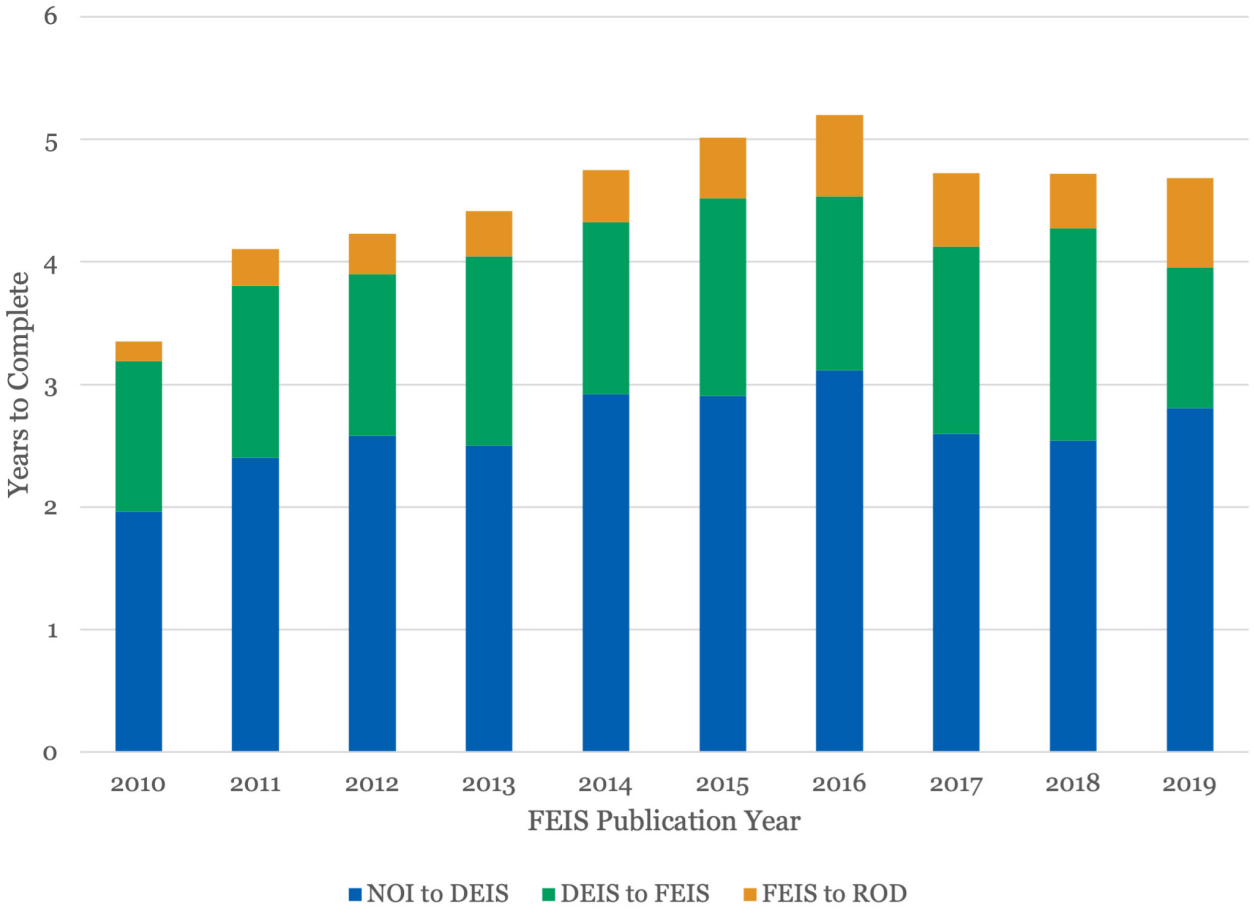
The time and expense needed to conduct environmental review is oft-cited as a challenge in complying with federal requirements.[170] State and local transportation officials have identified limited funding and staffing, responsibilities beyond transportation projects, and difficulty coordinating between multiple government agencies as contributors to increased costs and delays associated with the NEPA process.[171] NEPA review is included in the project budget, and can come from a mix of federal, state, and local funding sources such as FTA New Starts funds, funds from toll road revenues, grant funding, and state transportation fund accounts.[172] Transit agencies frequently rely on contractors to conduct specific elements of NEPA review, such as noise, air quality, and traffic analyses. However, this requires the agency to allocate funds from the project budget toward procuring external assistance. These costs are typically reported among the project management costs.[173] Costs associated with environmental reviews are considered a soft cost (see Section 4.4), though there is not a separate line item in FTA's Standard Cost Categories to

exclusively track NEPA costs. Instead, environmental review is bundled with other design, engineering, and legal activities.

While more complex projects typically require more time to complete NEPA documentation, the length of time from the NOI to the ROD may or may not be directly related to NEPA. For example, there may be starts and stops in the process of documentation due to challenges coordinating with other agencies, changes in agency priorities, lack of staff availability, insufficient funding, community opposition, or engineering requirements.[174]

CEQ studied all 1,161 final EISs across all federal agencies published from 2010 through 2019 and determined that the average EIS completion time from NOI to ROD was 4.5 years, with a median of 3.6 years.[175] On average, the period from the original NOI until the publication of the draft EIS took between two and three years, the period from draft EIS to final EIS took over one year, and the period from final EIS to ROD only took a few months, as shown in Figure 12.

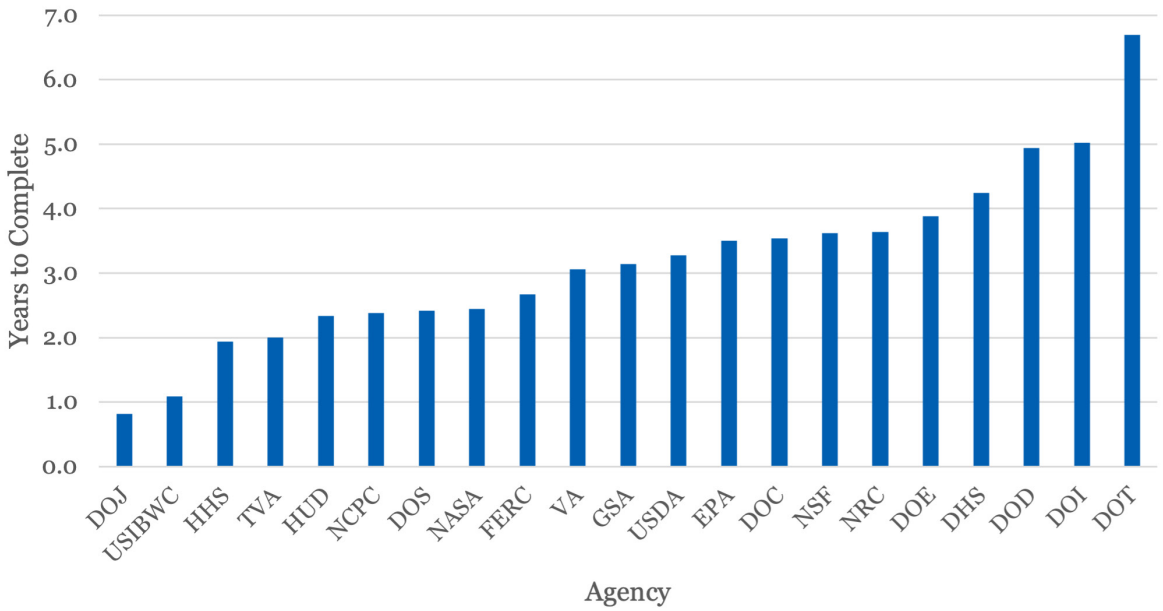
FIGURE 12: AVERAGE EIS PROCESS COMPLETION TIME (NOI TO ROD), ALL EISS AT ALL FEDERAL AGENCIES COMPLETED 2010 - 2019



Source: CEQ 2020

However, the average duration of the EIS process is highly dependent on the type of project being built, and transportation projects are significantly longer than other types of actions. The 319 EIS documents issued by the Department of Agriculture averaged just over three years from start to finish. But the 185 EISs prepared by the Department of Transportation took longer than any other agency—almost seven years, on average, as Figure 13 shows. Thirty-nine DOT projects took longer than 10 years from NOI to ROD (33 of which were FHWA EISs).[176]

FIGURE 13: AVERAGE COMPLETION TIME (NOI TO ROD) FOR FEDERAL AGENCY EISS COMPLETED BETWEEN 2010 AND 2019



Source: CEQ 2020

The CEQ analysis shows that the FTA was the lead agency for 31 of the projects that completed the NEPA process between 2010 and 2019. For those 31 projects, average and median NEPA processing times vary because of two outliers (the Charlotte Lynx light rail and the Maryland Purple Line). The median overall time, start to finish, is 50.2 months, or just over four years, as shown in Table 4.

TABLE 4: NEPA PROCESSING TIME FOR DECISIONS WHERE THE FTA WAS LEAD AGENCY, 2010-2019 (MONTHS)

	NOI to DEIS	DEIS to FEIS	FEIS to ROD	Total, NOI to ROD
Average (mean)	37.4	22.8	3.2	63.4
Median	26.6	18.6	2.7	50.2

Source: CEQ 2020

4.7.3 Efforts to streamline the environmental process

As of 2018 there have been about 30 provisions enacted into law to streamline the NEPA process, with the first provisions enacted in 2005's SAFETEA-LU law. The GAO groups these provisions into four categories:

1. *Accelerated NEPA review*: excluding certain actions from more detailed NEPA review;
2. *Administrative and coordination changes:* changing processes to avoid duplication, establish time frames, and create planning documents;
3. *Assigning NEPA review to states:* except for air quality review, allowing states to review EIS, environmental assessments, and some categorical exclusions;
4. *Advance planning:* provisions such as land acquisition that occur prior to NEPA approval.[177]

The provisions largely encompass expansions of categorical exclusions to different types of projects and situations. In part because transit agencies do not track the costs and delays associated with the NEPA process, and because not all provisions have been used by all agencies, it is difficult to ascertain exactly how these provisions have affected project delivery for transit. The provision that was reported to be used most and to be most successful in speeding project delivery for both highway and transit projects was "Minor Impacts to Protected Public Land", which allows project sponsors to bypass environmental assessment if a project will have minimal effects on historic sites and parklands.[178] For the Chicago Transit Authority, this provision was expected to speed project delivery by several months.[179]

While legislative reforms have led to some gains in streamlining project delivery, they have not been entirely successful. A recent report from the DOT Office of the Inspector General found that of the 42 planned actions listed in MAP-21 to streamline project delivery, only 27 had been completed. Full implementation was delayed because DOT had to revise several actions to comply with the subsequent FAST Act.[180]

Since NEPA was first signed into law, a number of Executive Orders (EOs) have been issued by presidents that have altered the scope of information agencies are to obtain when conducting their environmental reviews (see Table 5). EOs outline the responsibilities of federal agencies when administering environmental permits, thereby altering the information that agencies are required to submit.

TABLE 5: RECENT EXECUTIVE ORDERS ISSUED RELATED TO ENVIRONMENTAL REVIEWS

Number	Year	President	Summary
EO 13274	2002	Bush	Established a Transportation Infrastructure Streamlining Task Force to monitor and assist agencies, review projects, and identify and promote policies that can streamline the NEPA process
EO 13604	2012	Obama	Required the development of a Federal Plan to reduce the aggregate time needed to make federal permitting and review decisions
EO 13807	2017	Trump	Established "One Federal Decision," requiring environmental reviews and decisions for major infrastructure projects to be made by one federal agency and set a government-wide goal of reducing the time needed to complete environmental reviews to two years
EO 13990	2021	Biden	Repeals EO 13807

In 2007, the National Surface Transportation Policy and Revenue Study Commission recommended a number of reforms to reduce project development delays, including eliminating the need to revisit alternatives that were previously rejected in the planning process, revising CEQ regulations to narrow the number of alternatives considered "reasonable", and requiring better coordination between federal agencies.[181] The alternatives analysis required by NEPA often duplicates a similar analysis required by FTA's New Starts program. The Surface Transportation Assistance Act marked up by the House Transportation and Infrastructure Committee in 2009 suggested eliminating the alternatives analysis required in the New Starts program, but this was ultimately not adopted into law.[182]

California has its own environmental review law that is famously more stringent than NEPA. In response, federal law was changed in 2005 to allow U.S. DOT to assign some of its responsibilities under NEPA to states, a provision that is available to both highway and transit projects but to date, has primarily been used for highway construction. Under this law, state DOTs can conduct NEPA reviews and approvals on FHWA's behalf, though FHWA still retains liability for decisions.[183] The NEPA Assignment provision was originally enacted as a pilot in SAFETEA-LU with the goal of speeding up the environmental review process and has since been enacted in seven states through the Surface Transportation Project Delivery Program created in MAP-21.[184] Delegation of NEPA responsibility can also allow states to use their own resources, thus decreasing the likelihood of delays caused by state DOTs needing to obtain project-specific approvals from FHWA.[185]

States must first assume FHWA's responsibility for NEPA compliance for at least one highway project within the state before they can do the same for a railroad, public transportation, or multimodal project. This process for assuming authority can pose challenges, as it may lead to a situation in which a state presides over NEPA review for a highway project while the appropriate federal agency maintains authority over other project elements. Further, states—but not transit agencies—can assume responsibility

for determining whether an activity qualifies for a CE. Given both of these challenges, the potential effects of NEPA Assignment on multimodal projects are unknown.[186]

The few states that have pursued NEPA Assignment have reported cost and time savings. For example, Ohio DOT estimates a 20 percent time savings and $45 million savings in overall program delivery. Texas DOT estimated a reduction in the average time to conduct an EA from three years before state assignment to two years. However, these examples are limited to highway programs and a comprehensive study of nationwide NEPA Assignment cost and time savings has not yet been conducted.[187] Of the states whose NEPA programs have been evaluated, the available information pertains to a limited number of projects and fails to consider how other factors like funding can affect project timelines.[188]

When an EIS is required for a project, the lead agency must coordinate with resource agencies that have purview over the resources potentially affected by a project, such as the Fish and Wildlife Service or the Federal Aviation Administration (FAA). In addition, the requirement that projects comply with all federal, state, and local environmental laws means that the NEPA process necessitates close coordination among a number of agencies at all levels of government.[189]

It is unclear whether recent attempts at better federal coordination have been successful.[190] There is little indication that the "Administrative and Coordination" provisions in recent transportation legislation have led to improvements in project delivery. Rather, most of these provisions have either had no effect or the effects cannot yet be measured, as indicated by state DOTs.[191] Still, efforts specifically aimed at early coordination—between permitting agencies and between planning and environmental staff—might help to mitigate a number of risks that, if unaddressed, may result in time-consuming litigation associated with the NEPA process.[192]

A 2005 report for a working group focused solely on improving analysis of indirect and cumulative impacts, for the agencies that conduct such analyses, indicated that early coordination between agencies would help to foster agreement on issues about the resources most likely to be affected as well as the temporal and spatial boundaries of analysis. The provision of guidance and information resources to support better coordination could help to "avoid misunderstandings and conflicts that can lead to delays in project development".[193]

In 2011, FHWA launched the "Every Day Counts" (EDC) to help find best practices. Through EDC, the FHWA and its regional offices work with state and local agencies as well as private sector firms to collaboratively identify innovative delivery practices and rapidly scale their utilization through regional summits, webinars, and written materials focusing on best practice sharing. EDC innovations include design and construction practices, procurement and delivery models, public outreach, and innovative finance.

Since its inception, 52 discrete and specific innovations have been identified and each state has employed at least one.[194]

4.7.4 Environmental Litigation

Legal issues are often cited as a major source of NEPA-related project delays, though the issues that spur litigation are complex. Of the many types of events identified as potentially inciting litigation, two in particular receive the most attention: use of NEPA to delay or stop a project by interests such as community coalitions or environmental organizations who oppose the project, and lack of agency compliance with NEPA procedures.[195] Across all federal NEPA actions, only 0.22 percent result in litigation.[196] This is because the vast majority (95 percent) of federal actions are evaluated as a CE, with less than one percent of federal actions requiring an EIS. While NEPA litigation has declined since the 1970s, there is concern that the potential for litigation still affects the NEPA process through the extra time and effort expended by project sponsors to prepare legally-sound documentation.[197]

The primary reasons for filing NEPA lawsuits are inadequate NEPA documentation (e.g. the EIS or EA did not include sufficient analysis of all alternatives, did not consider all "reasonable" project alternatives, or did not adequately analyze cumulative or indirect effects) and failure to prepare an EIS rather than an EA (e.g. inappropriate selection of assessment process).[198]

As shown in Table 6, 39 cases were brought against FTA between 2001 and 2013, compared with 96 against FHWA, 46 against the FAA, and 7 against other agencies within DOT.[199] Cases brought against FTA represent just over 2 percent of all NEPA litigation.

TABLE 6: NEPA CASES BROUGHT AGAINST TRANSPORTATION AGENCIES FROM 2001 TO 2013

Agency	Total Cases	Avg. Per Year
FAA	46	3.5
FHWA	96	7.4
FTA	39	3
DOT - OTHER	7	0.5
ALL AGENCIES	**1,499**	**115.3**

Source: Ruple and Race 2020

Public involvement efforts, a fundamental piece of the environmental review process, often provide the forum in which project opposition is addressed. Levels of public involvement vary depending on the type of NEPA review (i.e. EA vs EIS) and the specific agency conducting the review. In general, agencies are required to offer 45 days for the public to comment once a draft EIS is prepared. Two Supreme Court cases have held

that issues must be raised at an early enough point in the process to be "meaningfully considered" unless there is a flaw in the agency's analysis.[200]

The CEQ notes that, "the success of a NEPA process heavily depends on whether an agency has systematically reached out to those who will be most affected by a proposal, gathered information and ideas from them, and responded to the input by modifying or adding alternatives, throughout the entire course of a planning process."[201]

For reviews that warrant an EIS, the project sponsor is required to conduct a "legal sufficiency" review to ensure that the proposal is legally sound and accounts for all available information. Some have expressed that this review is overly risk-averse and may slow down the process.

Commonly cited reasons EISs for transportation projects have been found inadequate in court cases[202]

- Trivial treatment of indirect and cumulative impacts
- Sweeping conclusions unsupported by fact
- Vagueness with respect to important issues
- Internal contradictions
- Disregard for local land use planning requirements
- Failure to include sufficient information on impacts associated with reasonable alternatives
- Failure to make an unbiased comparison of alternatives with the proposed action
- Failure to adequately investigate mitigation measures
- Failure to resolve differences with resource agencies

4.7.5 State and local environmental standards

Twenty jurisdictions (states, territories, regions, and local jurisdictions) in the United States have their own environmental review processes, and other states have laws in place to address specific environmental issues, like wetlands protection.[203] In some cases, as with the California Environmental Quality Act (CEQA), these reviews are considered more stringent and has more substantive requirements and mitigation mandates than federal environmental review.[204]

In these cases, the lead federal agency can authorize states to use their own requirements to meet the federal standard per Section 1309 of the FAST Act. In California, a single combined EIS/EIR (environmental impact report) that bundles the federal and state reviews together is prepared. Some states have indicated that administrative responsibilities associated with NEPA add time to project delivery that would otherwise be prevented if only the state review was required.[205] States can also choose to forego the use of federal funds to save time and costs - thus avoiding

the federal NEPA review process - though time and cost savings may be negated in states with environmental requirements like those at the federal level. However, using nonfederal funds can create problems if the project later uses federal funding and must meet federal requirements.[206]

Individual transit agencies usually have their own environmental review criteria that must be done in conjunction with NEPA review for any project. Typically, this is met by complying with NEPA, though there is some administrative work to put the analysis into agency-specific terms. For example, a transit agency may set its own noise criteria standards in addition to those established by FTA.

Many transit agencies have adopted several other environmental standards for their construction efforts. For example, among the first efforts LA Metro undertook to improve environmental standards in their building practices was the adoption of a Green Construction Policy to reduce emissions from construction equipment in 2011.[207] Since then, the agency has established a Sustainability Plan, Rail Design Criteria, and the Metro Environmental Construction Awareness (MECA) program. Through MECA, contractors and sub-contractors can access video, text, and internet resources specific to environmental regulations and best practices for composing a proposal.[208]

Environmental review is a major element of transit projects and their schedules, though the precise cost of environmental assessments and the extent to which delays are solely attributed to environmental review versus other project development stages can be difficult to pin down. Delays associated with environmental review on projects are primarily a result of the process, rather than the standards themselves. The environmental review process takes an average of seven years to complete for transportation projects, and the potential for litigation can contribute to additional delays. Litigation may result from project sponsors failing to meet NEPA requirements, or from opponents seeking to delay or stop a project. These lawsuits primarily allege inadequate documentation, or failure to consider all reasonable alternatives. Early, proactive coordination among agencies responsible for elements of the environmental review, as well as setting firm geographic and temporal boundaries on the extent of environmental impact analyses have been cited as tools to avoid disagreement and delays during the NEPA process.

4.8 Buy America

Mass transit procurements over $150,000 using FTA grant funds are subject to a “Buy America” requirement first adopted by Congress in 1978. Under 49 U.S.C. §5323(j), all “steel, iron, and manufactured goods used in the project” must be produced in the United States. For rolling stock (including train control, communication, traction power equipment, and rolling stock prototypes), the standard is not quite as high—the cost of all components and subcomponents made in the United States must be at

least 70 percent of the total cost for all rolling stock components, and final assembly must have occurred domestically.[209] The intent of Buy America is to leverage public infrastructure dollars to support and grow domestic manufacturing, but it has some potential cost and timeline consequences for transit projects.

The law gives the U.S. Secretary of Transportation the authority to waive the requirement for transit projects if U.S.-made goods are deemed to be insufficiently available or of insufficient quality, if the domestic content requirement would cause the cost of the overall project to rise by more than 25 percent, or if a waiver is in the public interest. But the issuance of such waivers is always at the discretion of the Secretary, and no waivers have been issued since 2016.

All forms of economic protectionism (whether high tariffs or Buy America requirements) are a statement of principles: that preserving certain kinds of domestic jobs, or certain kinds of industrial or agricultural capacity, are so important to the nation that it's worth requiring U.S. consumers of those products to pay more. The degree to which the costs of mass transit projects are increased by the Buy America requirements are not well documented. However, the few available studies suggest Buy America requirements can lead to costlier procurements for rolling stock given the relatively small size of this domestic market, which cannot achieve lower unit costs from economies of scale. Further, the limited availability of domestically produced versions of specialized products necessary for processes like utility relocation can increase costs through cumbersome compliance processes and the need to request waivers.[210]

Additionally, the higher cost of domestically produced materials can inflate construction costs. For example, the price of hot-rolled band steel milled in the Eastern U.S. is $650 per metric ton as of February 2020, versus $445 per metric ton for equivalent steel milled in China or $491 per metric ton for steel milled in Western Europe. The average world export price is $495 per metric ton at the point of export.[211] The cost of transoceanic shipping may mitigate this differential by as much as $70 per ton, but there is still a sizable difference in the cost of steel used in U.S. transit projects because it cannot be purchased on the world market. A study analyzing the effects of using U.S.-produced steel in highway projects found that Buy America requirements increased construction costs by $2 billion from 2009 and 2011 ($652 million annually).[212]

But perhaps more important than increased costs is the time spent complying. Commonly cited issues with Buy America include lengthy project timelines due to limited domestic availability of specific materials or administrative complications in determining compliance or requesting waivers. These costs include required agency documentation of the national origin of various materials and products; contractor preparation of two separate bids incorporating either domestic or foreign materials for a single project; and preparation of waiver requests.[213]

In New York City, the Second Avenue Subway project was delayed over disagreements about whether a fire suppression system largely manufactured in Finland needed to be Buy America-compliant.[214] The MTA argued that the system was a subcomponent of the subway station and not itself the "end product." However, in 2013 another firm challenged the MTA's interpretation and two years later, the FTA determined that the suppression system itself was an end product, and thus had to comply with Buy America's 100 percent domestic content requirement.[215] This ruling required the MTA to remove the Finnish system and begin the procurement process over again.[216]

The number of U.S. buyers for rail rolling stock is limited and there is little data about the effect of Buy America on contracts. However, a 2015 study estimated that U.S. transit buses cost twice as much as those in South Korea and Japan, and that allowing importation of buses would likely lead to expanded choice, lower prices, and better bus service as a result.[217]

Given their unique supply chain, the application of Buy America requirements for utility relocation is a source of additional complication. Difficulties finding specialized parts, documenting compliance, or requesting waivers have led to delayed relocation and increased project costs for several agencies. An FTA request to review Buy America compliance for a $2.3 million reimbursement agreement for gas relocation in Sacramento delayed the relocation by one year. It was eventually completed at an increased cost of $4.3 million.[218] Another instance there involved the replacement of a lot valve, in which a small number of valves were found to be non-compliant with Buy America. While it would have only cost $100,000 to produce a replacement in the United States, the agency learned that the manufacturing process and safety certification would take at least 62 weeks, likely resulting in a project cost increase more than 10 times the value of the actual part.[219]

Existing research on the effect of Buy America on construction costs primarily identifies costlier procurements of select items, particularly rolling stock, electrical systems, and steel components. Though there is not a comprehensive analysis of Buy America's effect on transit costs, several examples and research suggest that the process by which agencies must determine that a product is compliant or applying for waivers can be cumbersome and result in additional delays and costs. The limited availability of Buy America-compliant specialized parts, particularly for utility relocation, can also lead to delays and cost increases during the procurement process as agency's attempt to find compliant parts or apply for a waiver.

4.9 Planning and Community Engagement

Planning helps decision-makers, elected officials, and the public translate goals and visions into a specific, prioritized projects for a region's transit network. Planners at public agencies work with communities and other agencies to pursue projects that meet their criteria. This involves a multi-step process with frequent interaction with the public and demand models to predict future impacts.

Nearly all models of transportation planning include an element of community vision or engagement. Benefits include gaining knowledge and expertise from local constituents; communicating plans, designs, timelines, and costs early on to avoid later conflict; and in many countries for many types of projects, community engagement is a legal requirement. Requirements often include holding meetings and allowing time for public comment on documents, particularly with the expectation of those comments being addressed in subsequent drafts of plans and policies.

However, this element of the planning process is not always included in an effective, equitable, or transparent manner.[220] Community engagement can take many forms to fully constitute participation, not merely communication or placation.[221] Strategies and practices have changed over time, but the aim of engaging the public in the planning process continues to provide both opportunities and challenges. While planning and community engagement can add time and cost to project delivery, early project planning has been found to decrease construction timelines.[222] Insufficient early planning results in costly additional engineering, consideration of more alternatives during the NEPA process, and inaccurate cost estimation.

Following the expansion of the Executive Branch through the New Deal, Congress passed the Administrative Procedures Act (APA) of 1946 to provide greater accountability through new requirements on announcement and recording of proposed government actions. The APA was further amended with the passage of the Freedom of Information Act (FOIA) in 1966 that requires all agencies and departments in the Executive Branch to announce meetings in advance and state whether or not they are public. It also requires open meetings for most government proceedings, stating that with exceptions for security, privacy, and trade secret, among other reasons, "every portion of every meeting of an agency shall be open to public observation" and mandated the opening of records and ability of the public to request records.[223]

While the APA and FOIA brought about more transparency and accountability to the actions and decision-making of executive agencies, they did not actually engage the public or focus on specific stakeholders. Formal processes and expectations to engage the public changed significantly in the 1960s and 1970s, and some attribute increased project costs to increased engagement.[224] As outlined in Section 4.7, projects that include an EA or EIS as required by NEPA also must provide opportunity for public comment. There are other specific requirements to involve the public in the context of transportation planning as well, such as the requirement that metropolitan planning organizations (MPOs) provide in-person and online comment and participation from the public on their required long- and short-range plans for the region.[225]

In the United States, engagement strategies have changed over time as well. Jane Jacobs painted the picture of citizens making their way to city hall and facing imposing city officials "like rulers" in an overly formal setting prior to 1960, and lamented how out of touch the city planners were with their communities.[226] Since then, public involvement

has become much more local, taking on the form of meetings in the affected neighborhoods, collaboration with local stakeholders, and other means of more direct communication.

Recently, virtual public engagement techniques through websites have become widespread. While shifting to solely virtual public engagement has social equity implications since not everyone has easy online access, making online engagement mobile-friendly has helped bridge gaps. By 2019, about 20 percent of adults in the United States accessed the internet through smartphones only, and 81 percent owned a smartphone. However, there is lower smartphone ownership among vulnerable populations such as older adults, people with lower education levels, people with lower income levels, and people in rural areas.[227] Other new engagement strategies include bringing communities together at projects sites through art, storytelling, or other engaging activities.[228] In 2020, in response to the COVID-19 pandemic, modifications to community engagement ranged from shifting online to canceling meeting or postponing projects.[229] Many agencies have found that online public engagement during the pandemic has drawn significantly higher levels of engagement.[230] While there are still inequities in any singular form of engagement, virtual engagement can reach across platforms, reduce travel time to and from a public meeting, reduce childcare needs, and allow participants to tune in for only the part of a meeting that is directly relevant or of interest to them.[231]

4.9.1 Community Engagement as a Cost and Delay Driver

Community engagement can affect project costs and timelines not necessarily through the engagement itself, but rather the process and its outcomes. If community engagement lengthens a project's timeline, costs may be drawn out, and input can produce changes in project specifications, such as community requests to add more infrastructure.[232] One recent study found higher increases in costs for highway projects in high income areas, possibly due to the fact that people with higher incomes may provide more input given they are more likely to have flexible schedules, able to afford childcare, and more inclined to value spending public money to further enhance transportation projects beyond basic or standard designs. Furthermore, people with higher incomes have a higher willingness to pay for environmental attributes such as air quality and noise.[233] The desires of the community are only communicated and incorporated into plans when the public is involved and listened to. Therefore, involving as much of the public as possible and acknowledging the biases in the community feedback or engagement received will also have an impact on resulting project outcomes and costs.

Public engagement is not often studied and evaluated, especially on a project level.[234] It is therefore difficult to assess its precise impacts.[235] However, research suggests that early, transparent, and effective public participation can help mitigate the costs and delays associated with problems or difficult issues springing up in later project stages. While increasing community participation likely also increases costs, these are likely not high as the costs of large changes partway through a project or litigation, and

engagement can be conducted parallel to other project tasks, limiting potential stoppage due to litigation.

4.10 Architecture and Design

Design specifications are a core element of any transportation project, and agencies often spend a significant amount of money on preliminary design. Design decisions determine whether a project is constructed at-grade, above-ground, or below-ground, along with the depth and size of stations. Other elements of station design include platform size and layout, vertical access (escalators and elevators), construction materials, and aesthetics.[236] These specifications are informed by a range of factors including expected passenger capacity, environmental considerations, physical site characteristics, agency preference, and compatibility with existing systems, among many others.

There is significant debate over the impact of architectural and design elements on project costs. Some research cites large, grandiose, and overly-customized stations as a major cost driver, while examples from Toronto have pointed to station depth—rather than design—as a primary determinant of cost (building deeper can be a result of geological constraints, but also a desire to minimize disruption at surface level).[237] Other research and examples from New York City points to management of the design process and design quality as a potential driver.[238] Projects typically undergo a series of design and constructability reviews to resolve errors and ensure that the project can be built as designed. Poor project design or incomplete design evaluations may require change orders or other modifications if major errors or issues arise during construction, leading to further delays and cost increases. An over-designed project—one whose initial capacity far exceeds its short-term expected capacity—may also incur unusually high construction and operating costs while an under-designed one may result in significant costs down the road in the form of expensive modifications.

4.10.1 Project Design Assessment and Evaluation

Assessment of project design quality is dependent on a variety of factors, including an agency's technical expertise and the contracting method used. Design assessment can be conducted in-house by agency staff, by outside consultants, or by a hybrid team.[239] In a DBB process, projects typically undergo a series of three design reviews during the Final Design phase—sometimes referred to as 30-percent, 60-percent, and 90-percent reviews. The FTA establishes a set of recommended protocols for design quality assessment during each phase.

Some projects undergo a less formal peer review, in which peer agencies or other independent external entities evaluate and offer feedback on a range of possible topics including a project's design, budget, or timeline. While peer review is required for Small Starts projects and for midsize projects funded by the FTA's CIG program, it is not a requirement for larger projects. Such reviews tend to enhance the project development

process and ensure compliance with common standards rather than improving specific project elements.

Flawed project design processes have been cited as a major cost driver in New York City, particularly for the East Side Access and Second Avenue Subway projects. Project design and constructability reviews in New York are often performed by contractors overseen by the agency. During constructability reviews, limited access to construction sites led to incomplete assessment of site conditions, while poor evaluation of initial design documents resulted in alterations and change orders during construction.[240] Analysis by the MTA's Office of the Inspector General found that design errors or omissions were some of the most common causes of frequent change orders.[241] The prevalence of change orders and design-related delays underscores the effect that design review quality and management can have on overall project cost and schedule.

Additionally, extended project planning phases can lead to over-customized specifications that require expensive procurement, complicate construction, and inflate costs. The Second Avenue Subway and East Side Access projects both underwent several rounds of design. When planning phases are extended over several years, there is an increased risk of technology or standards in the initial design becoming outdated before construction starts, leading to change orders, delays, and cost increases.[242] Extended planning phases may also prompt contractors to overdesign projects as a way to manage the potential risk of inadequate design, further inflating construction costs.

DB projects tend to involve unique design evaluation methods viewed through the lens of three variables: cost, schedule, and quality.[243] Under DBB, agencies and project sponsors provide a completed design and desired completion date, leaving bidders to compete over the price needed to complete the project. Under DB, agencies will provide specific performance criteria and project schedule, leaving design and cost as the variables in bidder competition.[244] Agencies who pursue DB often need to define and evaluate design quality in a more detailed and precise manner than they would for a DBB project.

The degree to which project owners utilized these potential design assessment approaches varied greatly. One study's review of DB RFPs indicates that project owners may be insufficiently evaluating design bids. Nearly 30 percent failed to ask for the design/builder's past qualifications, and 43 percent failed to evaluate the bidder's approach to delivering project quality.[245] While a majority of projects required post-award submission of a quality management plan for construction, less than a third required a similar plan for project design. These patterns suggest that project sponsors may be relying solely on review of design submissions to evaluate project quality and missing opportunities to establish quality management plans. While most of the highway and rail projects reviewed included both design and construction quality management plans, transportation projects made up a small portion of the RFPs

reviewed in the study. These findings nonetheless demonstrate the role of design evaluation in the project development process and suggests the need for rigorous design quality assessment practices for DB projects.

4.10.2 Design Specifications as a Cost Driver

Among the design elements frequently cited as a major cost driver are stations, particularly for subway projects. Various elements of transit stations, including size, construction materials, depth (if underground), and tunneling method can contribute to project costs. Larger, deeper, and more complex stations may incur significantly more construction costs than smaller and simpler stations.

Station Depth

Data from projects in the United States, Canada and Europe suggest that station depth may play a significant role in driving construction costs. When compared to projects in Los Angeles, Paris, and London, both the share of total costs borne by stations and per-station costs were unusually high in New York's newer stations. Recent stations in New York are notable for their large, deep, and highly customized features in contrast to older MTA stations. Stations accounted for 60 percent of construction costs for the Second Avenue Subway, 32 percent for East Side Access, and 62 percent for the 7 Line Extension.[246] Stations accounted for only 36 percent of total construction costs for Paris' Line 14 extension despite large intermodal connections required to connect with the existing system, and 27 percent for Los Angeles' Purple Line extension. Per-station costs for the Second Avenue Subway were $507 million compared to $161 million for the Purple Line in Los Angeles and $200 million for the extension of Paris' Metro Line 14.[247]

TABLE 7: STATION COST COMPARISON AMONG NEW YORK, LONDON, LOS ANGELES, TORONTO, AND MADRID[248]

Project	Number of New Stations	Length (miles)	Station Costs	Station's Share of Construction Cost	Cost Per Station
#7 Line Extension – New York	1	1.5	$746 million (not including $114 million for retrofit of existing station)	62% (39% excluding station retrofit)	$746 million
East Side Access – New York (ESA)	1	3.9	$2.3 billion	32%	$2.3 billion
Second Avenue Subway – New York (SAS)	3	8.5	$1.5 billion (not including $209 million for retrofit of existing station)	60% (52% excluding station retrofit)	$507 million
Northern Line Extension – London	3	1.9	$211 million	43%	$70 million
Line 9 Extension – Madrid	2	5.0	$28 million	21%	$14 million
London Crossrail (underground portion)	7	14.3	$3.3 billion	50%	$473 million
Los Angeles Purple Line Extension Phase I	3	3.9	$482 million	27%	$161 million
Line 14 Southern Extension – Paris	6	8.6	$1.2 billion	36%	$200 million
Sheppard Subway – Toronto	5	4.0	$714 million	40%	$143 million
Toronto-York-Spadina Subway Extension (TYSSE)	6	5.3	$957 million - $1.1 billion	33-39%*	$160-183 million

**TYSSE station costs are estimates according to project budgets, final station costs are not reported for all stations*

Stations for the recent New York projects are significantly deeper than those on other subway lines. The Hudson Yards station for the 7 Line Extension is 125 feet below ground while the SAS and ESA stations are nearly 100 feet below ground, compared to roughly 50 feet for LA's Purple Line and Paris Metro's Line 14 extension. In the case of the SAS, the decision to build deep stations was intended to avoid the expense of relocating utility lines, though any savings were likely negated by the significant cost of these stations. In the case of the 7 Line extension, the 100 foot station depth was necessary due to the line's tail-end tracks, which extend beyond the terminal below the existing rail yard, and other deep infrastructure. For the ESA project, the new 100 foot-deep terminal below Grand Central Station was chosen over proposals to bring rail service to the station's existing lower level in part due to concerns associated with excavating the tunnels connecting the station to buildings along Park Avenue.[249]

A similar relationship between station depth and cost was identified in Toronto, though overall construction costs in Toronto are on par with similar projects in Paris and Los Angeles referenced above. The most recent subway project in Toronto—the 5.3 mile Toronto-York-Spadina Subway Extension (TYSSE)—was among the most expensive in recent history at $579 million per mile ($3.1 billion). TYSSE stations are among Toronto's deepest, ranging from 65 to 82 feet below ground, and feature long-escalators, expansive column-less interiors when possible, and high ceilings. The TYSSE project's six stations are estimated to have cost between $957 million to $1.1 billion (roughly $160-183 million per station), nearly 39 percent of the total project cost.[250]

The second most recent subway project in Toronto was the Sheppard Subway (Line 4), a five-station line spanning four miles. Completed in 2002, the project cost $400 million per mile ($1.5 billion total). Stations on Line 4 are 50 to 59 feet below ground, which makes them shallower than the TYSSE stations yet up to twice as deep as older stations on the Toronto subway. The Line 4 stations are simpler and less grandiose than the TYSSE stations and cost $143 million each ($714 million total). While the Line 4 stations were less expensive than those on the TYSSE, they were still two to three times more expensive than older, shallower stations. When compared to the shallower stations (no deeper than 46 feet) on older projects (mostly built using cut-and-cover methods), the TYSSE stations ranged from 4.2 to more than 18 times more expensive. These trends suggest a linear relationship between greater station depth and construction costs in Toronto. Examples from Madrid and Toronto suggest that cut-and-cover methods may be less costly than tunnel boring, though they may also generate other externalized costs and are far more disruptive at the street-level and can require costly relocation of existing utilities along the trench.[251]

Station Customization

While some level of customization is necessary for all projects, the extent to which stations rely on standardized designs and simple construction materials can affect project costs. The New York MTA opted for granite archway entrances for the SAS project, which required custom-produced granite cut at the right size and shape. Buy America regulations limited the MTA to a handful of American granite suppliers capable of producing the custom pieces, though the need for custom granite would have likely still resulted in a similarly complicated and expensive procurement. Stations on the East Side Access project were intended to feature pre-cast walls as finishes for portions of the blasted tunnels. The pre-cast pieces, which were sometimes damaged during transport from the project staging site in Long Island, ultimately did not fit together due to the tunnel's slope and led to workers casting the walls by hand. Researchers noted that leaving the exposed bedrock (like in Stockholm and other European cities) rather than adding finishes likely could have curtailed costs without necessarily sacrificing visual appeal.[252]

Officials in Madrid and Copenhagen cite standardization and simplification of station design as a cost containment strategy for their respective projects. In Madrid, where

subway construction costs are among the lowest in the world (ranging from $134-168 million per mile), stations were kept shallow (55 feet) and primarily built using cut-and-cover methods.[253] The most recent extension of the Madrid Metro—Line 9—featured two new stations that cost an average of $14 million each (21 percent of total project costs), far less expensive than other European and American projects.[254] In addition to cut-and-cover construction and shallow depth, officials stressed the use of standard, uniform designs, wide platforms, and simple materials as key elements to keeping station costs low.[255]

Similar efforts to streamline and simplify station design have been implemented in Copenhagen and Los Angeles. Using a modular "kit-of-parts" approach, officials in Copenhagen and Los Angeles standardized sizes, materials, and components for their stations to minimize costs and streamline construction (see Copenhagen Case Study). In 2018, LA Metro adopted a formal Systemwide Station Design Standards policy that established common materials and parts for all future bus rapid transit (BRT) and rail stations. The policy was initially developed in 2012 in response to rising construction and maintenance costs associated with unique station designs, including challenges in maintaining or replacing custom station features that negatively affect station appearance over time.[256] The standards were produced as a kit-of-parts and specify both the materials and individual components to be used across all stations. These components are primarily made of glass, stainless steel, and concrete, with factory-finished surfaces used in limited cases. Components include glass panels for canopies and entryways; a standardized concrete paving pattern for all station plazas; stainless steel finishes for entrances, gates, railings, and other equipment; and LED lighting. This standardization is intended to allow for customization and variation in station layout—including the integration of public art into glass panels for entryways—while maintaining durability, consistent appearance, and cost-effective construction and repairs across the system.

While station customization can play a role in construction costs, it is difficult to assess the magnitude of its impact compared to station depth. In Toronto, there was minimal difference in stations as a share of total cost between the TYSSE project (with large, ornate stations) and Line 4 (built using a no-frills, minimal design).[257] While the former chief of the Toronto Transit Commission suggested station depth, rather than materials, was the primary determinant of station costs for the Line 4 project, more data is needed to evaluate station cost drivers more precisely. The lack of comprehensive data or studies on station costs makes it difficult to fully isolate the impact of station depth or materials on costs for individual projects. However, cost figures and anecdotal evidence from New York City, when compared to design streamlining efforts in Los Angeles, Copenhagen, and Madrid suggest that station customization, architecture, and depth can all play key roles in driving construction costs.

4.10.3 Design and Safety Standards

Technological advances have improved the ability to monitor, control and manage operational and safety performance of transit systems. However, they have significantly added to the complexity of projects, particularly tunneling projects. For example, a transit line project can have thousands of unique communications points that are transmitted and report in some manner to a remote location, such as a control center. These include train tracking, signaling, emergency communications devices, intrusion alarms, gas monitors, failure monitors on myriad types of equipment, ventilation control and monitoring, fire alarms, and CCTV.

While not expensive as stand-alone elements, their installation, integration, and testing can add significant time to rail projects. Many of these subsystems, like fire alarms, must be connected in order to work. Activation of a fire alarm in a station affects operational functions of elevators, escalators, messaging systems, station ventilation and alarm reporting. Each interface must be tested for each alarm, of which an underground station can dozens.

Further, given the long time to complete rail projects, specifications for advanced communication systems are often obsolete by the time they are ready to be installed toward the end of a project. This can result in change orders with schedule impacts if upgrading to a more modern standard. Many of these technological requirements are driven by fire and safety codes that are unique to rail projects, discussed in detail below.

Fire Safety Standards

Rail transit stations, particularly below ground, are also subject to safety regulations. The U.S.-based National Fire Protection Association (NFPA), an independent global trade group, publishes safety and fire codes for a range of facilities, including rail transit systems under NFPA 130 *Standard for Fixed Guideway Transit and Passenger Rail Systems*.[258] NFPA 130 is not federal law, but it has been formally adopted by many jurisdictions and agencies as part of their fire safety codes for rail transit construction. While some countries like Spain, France, Japan, Italy, Germany and Austria have their own fire safety standards for transit, most agencies around the world follow NFPA 130.[259]

NFPA 130 largely consists of performance-based criteria for ventilation, fire endurance and spread, and evacuation, but also include specific provisions for materials, distances between exits, spacing of stations and cross-passageways, and doors, among others. For example, one part of the code that has direct implications for the scope of subway stations, and thus costs, is riders standing on a platform must be able to evacuate the station within four minutes and reach a safe location within six minutes.[260]

The code also sets parameters for modeling evacuation scenarios. These evacuation times are based on peak service, with trains one headway behind schedule, resulting in twice the normal passenger load on vehicles and twice as many passengers on a

platform.[261] Additionally, evacuation scenarios assume that one escalator on each station level is out of service, and that the escalator chosen must be the one that would most negatively impact passenger exit capacity.[262] Escalators generally cannot make up more than half of a station's egress capacity on each level.[263] This is intended to ensure that evacuation can be completed even in a worst case scenario.

One of the more significant determinants of station platform size are NFPA 130 requirements on the number and width of stairs, as well as the maximum permissible distance from the most remote points of the platform to the nearest exit.[264] As a result, station and platform sizes often comfortably exceed the levels that would be necessary to handle normal passenger flow rates. While intended to ensure space for evacuation, meeting these strict standards can lead to a more comfortable passenger experience.[265]

Other standards that may impact station costs or elements include provisions for the inclusions of cross-passages to allow for passengers to move between tunnels in case of emergency and, for example, if one tunnel has smoke. According to NFPA 130, if the distance between two stations is greater than 2500 feet, cross passages must be built between the tunnels at 800-foot intervals if there are no intermediate shafts to the surface.[266] According to one analysis, cross passages are rare in Europe as well as in Japan.[267] This is likely in part due to the relatively close spacing and travel time between stations that may allow passenger to walk a short distance to evacuate, and reducing the likelihood that a train would get caught in the middle of a tunnel and unable to drive to the next station.[268] Constructing cross-passages can require additional excavation and complexity that may affect construction costs.

Ventilation systems that can bring fresh air to underground passengers during a safety incident is also a major element of underground metro systems. NFPA 130 requires mechanical and passive ventilation systems to become fully operational within 180 seconds, and maintain airflow rates for at least one hour to allow for evacuation of vehicles.[269] Design of ventilation systems also accommodate the maximum number of trains possible between ventilation shafts during an emergency.[270]

Seismic Standards

Transit systems in earthquake prone areas also must comply with seismic safety guidelines. At and above ground systems are particularly vulnerable to ground movement from earthquakes while underground transit systems largely move with soil in the event of an earthquake and are generally safer.[271]

Seismic codes for transit are largely handled at the local or agency level, though there are certain statewide and federal guidelines that agencies may incorporate into their design standards.[272] For example, Seattle's Sound Transit adopted agency-wide seismic standards that take a hazard-based approach to earthquake resilience. These approaches include planning for an Operating Design Earthquake (ODE)

which is a once a 150 year event, with a 50 percent chance of an earthquake exceeding this strength over a facility's 100 year design life. The other is a Maximum Design Earthquake (MDE), which would be expected to occur once every 2500 years, with a 4 percent chance of an earthquake exceeding this level during a facility's design life. Sound Transit's guidelines require light rail facilities to withstand ODE's and resume operations in a "reasonable amount of time," and withstand a MDE without collapsing or risking lives.[273]

Meeting such standards can vary depending on the seismic profile of varying regions. For example, San Francisco's Bay Area Rapid Transit (BART) strengthened its standards over the past decades and are undertaking vulnerability analyses and retrofitting key facilities to enhance their earthquake resilience. These measures include enlarging tunnels that cross through faults to account for potential displacement and incorporating concrete-encased steel ribs.[274] Aerial structures are reinforced with stronger foundations or columns to withstand collapse or poor soil is replaced with non-liquifiable soil to prevent collapse or damage.[275]

Accessibility Standards

Transit stations are also subject to accessibility requirements under the Americans with Disabilities Act of 1990 (ADA). Design specifications for accessibility are outlined under Title II and III of the ADA, also known as ADA Accessibility Guidelines. Enforced by both the federal departments of Justice and Transportation, these guidelines cover vehicles, buildings, transportation facilities, and many other types of facilities. The U.S. Access Board, a federal government agency, writes all code/guidance and has issued supplements to cover different facilities. The ADA guidelines were last updated in 2004 to address usability and format issues, as well as cover new types of facilities. The U.S. DOT formally adopted these new standards in 2006.

Among the DOT-specific guidelines for transit include locating accessible routes in the same area as general circulation paths, including detectable warnings on curb ramps and along platforms that do not have screen doors or platform guards, minimum platform heights, and maximum rail platform slopes.[276] DOT has added to these standards over time. For example, in September 2011, DOT added a provision mandating that individuals with disabilities, including wheelchair users, "must have access to all accessible cars available to passengers without disabilities in each train using the station", to prevent segregating disabled riders in separate vehicles.[277] These standards apply to all new construction, as well as alterations to existing facilities.

The ADA requires that any alterations to existing facilities make them fully ADA compliant, or to the maximum extent feasible in cases where full accessibility is not possible. If making a facility fully accessible would exceed 20 percent of the alteration cost, agencies are only required to incorporate accessibility elements that would not result in a disproportionate cost (under 20 percent).[278]

A U.S. DOT 2016 ruling clarified that any alterations to existing transportation facilities that can impact their usability must incorporate accessibility, including for wheelchair users.[279] The ruling also clarifies that the ADA requirement to incorporate accessibility to the maximum extent possible is primarily intended for rare cases where it is impossible to make an existing facility fully ADA compliant. In these cases, agencies cannot cite disproportionate cost as a limiting factor preventing incorporation of accessibility. The disproportional cost provision applies only in instances where a primary function area of a station (such as a platform) is being renovated.

Coverage of the impact of ADA compliance on construction costs has largely revolved around elevator retrofits on older subway systems. The cost of retrofitting elevators has gained particular attention in New York City. Only 23 percent of New York MTA's subway stations are accessible, and the agency has retrofitted several stations without installing elevators or ramps.[280] A 2019 lawsuit ruled that the agency violated the ADA by not installing elevators as part of a 2013 subway station renovation in the Bronx, and must make stations accessible when renovating future stations.[281] The agency announced a $5.5 billion capital program in 2019 to install elevators in 70 stations in five years.[282] The plan received increased scrutiny for its cost—nearly $78 million per elevator, in contrast to examples from European cities, where station upgrade costs per elevator are as low as $22 million.[283] These costs are also lower in other North American cities like Boston, where the MBTA installed three new elevators and two escalators at a Red Line station for $36 million, and Chicago, where a new station with four elevators cost $75 million ($19 million per elevator).[284]

Accessibility regulations abroad are largely handled at the country level, but generally all stations built in recent decades are designed to be accessible. Transportation systems in Canada are governed by the newly enacted Accessible Transportation for Persons with Disabilities Regulations (ATPDR), as well as the 2018 Accessible Canada Act, which is the first nationwide accessibility act.[285] Provinces also have their own accessibility regulations that apply to public entities, like the Accessibility for Ontarians with Disabilities Act.[286] Public transportation in Australia is similarly governed by the national Disability Discrimination Act of 1992, which includes design and service standards for public transport similar to the ADA.[287]

There are no European Union-wide accessibility standards comparable to the ADA, but rather individual member state regulations. The European Accessibility Act, passed by the European Parliament in 2019, largely focuses on fare payment systems and does not explicitly address system design.[288] Accessibility on European transit systems can vary significantly. In Barcelona, 143 out of 158 metro stations (81 percent) are accessible, while just under 20 percent of stations on the London Underground are accessible.[289] Just three percent of stations on the Paris Metro, for example, are accessible to passengers with disabilities, while the much newer tram system is fully accessible.[290] While France passed a law in 2005 to improve accessibility in public spaces, Paris'

Metro was exempt, and its operator has argued that the system's age would make retrofitting stations extremely costly.

Design and architecture can be significant cost drivers for transit projects in three ways: poor management of the design processes, project design itself, and design standards. Lack of oversight of the design process can result in accepting inadequate or faulty designs that result in issues during construction and require change orders. The design of transit projects themselves, particularly on underground stations, can also raise construction costs. Deep, extravagant stations and the use of bespoke materials have been cited as major cost drivers in cities like New York and Toronto. Lastly, select safety standards can require more complex system design to make a project resistant to natural disasters like earthquakes. Stringent evacuation standards in fire safety codes like NFPA 130 can also result in large subway stations, while the need to install cross-passages and ventilation systems can be an additional source of costs. Accessibility standards, on the other hand, do not appear to be a particularly significant cost driver for new construction, though accessibility retrofits of older station in New York City have received scrutiny for the high costs of elevator installations compared to other cities.

4.11 Labor

Frontline labor is a major cost of any capital project. Workers are needed to prepare and install the materials to ensure a safe and long-lasting infrastructure system. But while labor is a major part of overall construction costs, outside of New York City there is little research comparing transit construction labor costs in the United States to places abroad or whether labor is a major cost driver that can be addressed through responsible changes in public policy. The wages, benefits, and work rules that are negotiated for unionized labor, which makes up the majority of the transit capital workforce, are typically embedded in construction contracts protected by nondisclosure agreements and are notoriously difficult to obtain.[291]

The economic desperation of the Great Depression resulted in widespread labor mobility, with unemployed men willing to relocate almost anywhere to get work and prepared to accept almost any wage offered. In response, Congress enacted a law in 1931, called the "Davis-Bacon Act" after its sponsors, to prevent an influx of cheap outside labor from lowering the wage standards in any given area.[292] The law originally mandated that any contract to construct or improve a federal building had to require that all contractors and subcontractors pay laborers and mechanics a wage "not less than the prevailing rate of wages for work of a similar nature in the city, town, village, or other civil division in the State in which the public buildings are located."[293] Davis-Bacon was expanded in 1935 to cover almost all federal work and in 1956 to federal-aid "highway projects on the Interstate System."[294]

Later, the Federal-Aid Highway Act of 1968 expanded Davis-Bacon applicability to non-Interstate federal-aid highway projects and prevented any mass transit loan or grant from being approved without assurances that all construction workers would be paid prevailing wages.[295]

The Department of Labor maintains a minutely detailed database of the prevailing wage determinations for a wide variety of job types in every U.S. municipality. The database contains wage information for four types of construction projects: building, heavy, highway, and residential.[296] The categorization of a project within the database is often based on the primary structure type rather than on the overall project type. For example, per the DOL guidance document, construction of aboveground "Subway stations" is generally classified under "Building Construction" while "Railroad construction," "Subways (other than buildings)," "Tunnels," and "Viaducts (other than highway)" are categorized under "Heavy Construction."[297]

Obviously, the prevailing wage requirement causes an increase in construction labor costs for some federally-aided mass transit projects.[298] However, the financial effects of Davis-Bacon are difficult to evaluate, because the prevailing wage laws in a majority of states would still apply in the absence of a federal prevailing wage law.[299] According to a 2017 report from the Council of State Governments, 29 states have some kind of prevailing wage law that would still govern federally-funded mass transit construction contracts in the absence of federal Davis-Bacon requirements.[300]

The factors affecting compensation relate to the U.S. healthcare and pension system, which rely heavily on employers to provide those benefits. Such benefits, negotiated by unions, can cost 36 to 62 percent of the prevailing wage rate.[301] Comparable developed economies typically have government-provided healthcare and retirement plans, alleviating huge potential cost burdens on agencies and contractors.[302] Abroad, those costs are paid through general taxation so they do not add to the direct cost of capital projects. Pension contributions at Transport for London are less than half those at New York MTA.[303] Without significant reform in U.S. healthcare and retirement policy, those discrepancies are likely to persist.

The stipulations written into labor contracts that establish the parameters for baseline and additional compensation, are also a potential cost driver. To address safety and health concerns, abuses of excessive time worked, and quality standards, labor unions created a system of rules which prevented management from taking advantage of workers. The inability of work rules to keep up with technology and productivity improvements are cited as one key factor in driving labor costs.[304] Private sector labor are often 20-30 percent below union labor, and according to contractors this is due to differences in work rules not compensation.[305]

Discrepancies in work rules exist between U.S. unionized labor and similar organized workforce abroad. For example, tunnel boring machines (TBMs) and necessary support systems in the United States generally require 20-25 operators, compared to 10 in Poland and Spain 14 in Australia, and up to 20 in the UK.[306] It is unclear whether there are any tangible safety implications related to a smaller worker-to-machine ratio. Higher labor counts are not restricted to TBMs: one detailed investigation found staffing levels on subway projects in New York to be up to four times higher than in other countries.[307]

Laborers sometimes receive high premiums for working nights and weekends, which is when many capital construction projects take place so as to not disrupt existing operations. Complicated accounting for overtime can also create scheduling problems. Modifying rules to add more flexibility to scheduling might appease both labor and agency management, but the General Contractors Association of New York, a labor group, has resisted a more flexible overtime policy.[308]

Some cities have used Project Labor Agreements (PLAs) to establish work rule guidelines prior to construction and final negotiation of the contract. PLAs are collective bargaining agreements designed to avoid worker strife by providing clear arrangements for dispute resolution, per-approved compensation rates and benefits, specific work rules, and—importantly—dispute resolution procedures.[309] They apply to all contractors and subcontractors on a construction project, usually prohibit work stoppages, and include union or non-union workers.

A comprehensive study in Massachusetts found PLAs beneficial for keeping large-scale transportation construction projects on time and on budget due to their ability to avoid labor disputes.[310] A study in New York came to similar conclusions.[311] LA Metro recently renewed its PLA policy based on its previous ability to attract workers in advance of major anticipated construction activity was approved by voters.[312] Nevertheless, they remain contentious. A study of PLAs throughout California suggests the agreements reduce the ability for "flexibility" on the job site.[313] President George Bush issued two Executive Orders restricting the use of PLAs for federal construction projects, which was overturned by President Barack Obama whose Executive Order encouraged their use.[314]

Workforce supply is another potential labor-related cost driver. In Los Angeles, the concurrency of several large-scale public and private construction projects has resulted in a scarcity of skilled workers, increasing costs for the Purple Line Extension.[315] The workforce shortage is expected to become more acute as workers retire and fewer are available and willing to take their place. Workforce development programs and active succession planning can help to retain a productive workforce.[316]

While cost increases associated with the frontline workforce have been documented in New York City, the extent of labor costs on U.S. transit projects have not been fully quantified, nor has there been a comprehensive comparison of labor costs between U.S.

and international projects. The full impact of the Davis Bacon Act is also difficult to assess, as most states have their own prevailing wage requirements that would apply in the absence of federal regulations. However, costs associated with paying workers extra for evening or weekend shifts may be minimized by the use of more flexible working hours. The use of PLAs has also been found to minimize worker strife and avoid delays and costs associated with labor disputes. Other sources of increased labor costs in the U.S. may be attributed to healthcare and pensions being incorporated into the direct capital cost of a project compared to abroad, where nationalized healthcare and pension schemes are paid for through general taxation as opposed to employers.

REGIONAL CASE STUDIES

The case studies in this report examine the facts and background of a project or several projects conducted in a region and examined their approach to governance, processes, and project standards. The research relies on discussions with public and private experts and stakeholders in each region to help identify best practices and problems in delivering projects. The case studies were selected in consultation with the project's advisory panel, and included considerations of project complexity, geographic diversity, modal comparability, and other factors that can help identify cost and timeline drivers along with solutions to improve them.

The following cases are included in this section:

- Los Angeles
- Seattle
- Denver
- Minneapolis-St. Paul
- Copenhagen
- Madrid
- Paris
- Toronto
- Virginia's I-495 HOT Lanes and the Silver Line

THE ROLE OF THE FEDERAL TRANSIT ADMINISTRATION IN PROJECT DELIVERY

The Federal Transit Administration (FTA) is a modal agency under the U.S. Department of Transportation (USDOT) and administers roughly $12 billion annually through its various grant programs. Fixed guideway (rail and bus rapid transit) projects receive approximately $2.3 billion through the agency's Capital Improvement Grants (CIG).

The agency employs 550 full time staff across its Washington, DC headquarters and 10 regional offices. Each regional office includes an Office of Planning and Program Development, as well as an Office of Program Management and Oversight. Some of the larger regional offices with more transit activity like Philadelphia (Region 3) and San Francisco (Region 9) have an Office of Financial Management and Program Oversight that provides additional oversight and assistance. Staff sizes at the regional offices ranges from 15 to 40 employees.

Nearly all large transit infrastructure projects use federal resources as part of their funding package, necessitating interaction with FTA staff and complying with federal regulations. This is done primarily through FTA's regional offices in the early stages of project development. FTA's in-house staff is supported by project management oversight contractors (PMOCs) that are drawn from a nationwide network of private firms, selected by the FTA through a rigorous review, to provide oversight of major capital projects from conception to operation. These contractors focus specifically on project costs, schedules, expenditures, scope, risk, and safety.[317] Transit agencies work closely with FTA staff to secure CIG funding and reach a record of decision on the federal environmental review. The FTA also conducts triennial reviews of grantee agencies, including their procurement practices, capital programs, financials, and compliance with Buy America, civil rights, and other requirements that come with Federal funding. Once funding and NEPA approval are secured, the FTA's role in construction and operations diminishes.

Local agency staff mostly recall positive experiences working with FTA and benefit from their technical expertise. In particular, oversight and reviews by the FTA before the preliminary engineering phase help agencies better identify and resolve staff capacity constraints, third party and intergovernmental approvals and coordination, or other complications like utility relocations in advance, preventing potential delays. Some cited a lack of staff capacity at the FTA regional offices and distances between agencies offices and FTA offices resulting in slower decisions and inability to provide greater technical assistance.

5.1 Los Angeles

Metropolitan Los Angeles is currently undergoing the most ambitious capital expansion plan in the United States. Since 1990, the region has invested more than $20 billion in construction, built more than 104 miles of rail transit, and is currently extending and adding several new lines to its system. Los Angeles Metro's Metro Rail system consists of two heavy rail subway lines and four light rail lines, spanning 98 miles of rail and having 93 stations.

The Los Angeles region provides a useful case study given its robust pipeline of projects and recent experimentation with different delivery methods that has allowed it to build out sizeable in-house management teams. However, cumbersome standards, complicated utility relocations, low tolerance for community disruption, and persistent requests for betterments from municipalities have contributed to delays and challenges in delivering projects.

Governance Overview

The **Los Angeles County Metropolitan Transportation Authority (LA Metro)** is the primary agency responsible for planning and executing the expansion of the region's light and heavy rail system. The agency was formed in 1993 after the legislature merged the LA County Transportation Commission and Southern California Rapid Transit District and serves as a transportation planning, coordinating, designing, building, and operating agency for Los Angeles County.

LA Metro is governed by a 14 member board of directors including members from the county and several local jurisdictions. More than 10 million people are spread out among Los Angeles County's 88 municipalities. These municipalities are stakeholders on projects within their borders and must provide the project sponsor with permits or approvals for design, engineering, or construction work, and can set restrictions on working hours or road closures. As stakeholders, these local governments often request improvements to utilities, streets, or other public infrastructure as part of projects. The municipal representatives on LA Metro's board can help with permitting and other needs from the local jurisdictions.

The **California Department of Transportation's (Caltrans)** role in transit project delivery can vary significantly, but primarily involves the distribution of funds and oversight through the Transit and Intercity Rail Capital Program (TIRCP). While Caltrans does not have a project management role in these projects, its oversight focuses on achieving ridership, greenhouse gas emissions, and connectivity metrics.

Several transit projects have been built by **independent construction authorities** that are separate from LA Metro. These authorities are designed to be temporary

construction bodies with boards that include the relevant jurisdictions and staff with the capacity to manage procurement and construction contracts. In 1995, shortly after LA Metro's founding, a 60-foot deep sinkhole occurred during the construction of the Red Line under Hollywood Boulevard, significantly impacting the agency's credibility.[318] The incident led to the adoption of more conservative tunneling standards and practices to prevent similar incidents, and raised questions about LA Metro's ability to deliver major projects.

In 1998, the California State Legislature created the Gold Line Construction Authority (GLCA)—formerly known as the Blue Line Construction Authority—to take over construction of the initial segment of the Gold Line, which was on the verge of being cancelled.[319] The construction authority was independent from LA Metro and intended to be a smaller, leaner, and more nimble organization with more flexibility in contracting as well as the power of eminent domain. The Exposition Line Construction Authority was also created to deliver both phases of that project and was dissolved after transferring ownership of the line to LA Metro to operate.

The GLCA is currently building Phase 2B of the Gold Line Foothill Extension. Its nine member board of directors include representatives appointed by the cities of Pasadena, South Pasadena, and Los Angeles, as well as by the San Bernardino County Transportation Authority, LA Metro, and a gubernatorial appointee. Additionally, 15 cities are part of a Joint Powers Authority (JPA) to participate in the planning, funding, and construction of the extension. The JPA is also advised by a Technical Advisory Committee, which includes city managers or staff appointees from each city in the JPA. LA Metro also plays a large role in the design review process for the Gold Line extension.

System Overview

TABLE 8: TRANSIT LINES PROFILED IN THE LOS ANGELES REGION

	Year Opened	Time to Construct (months)	Length (miles)	Percent Tunneled	Stations	Primary Delivery Method*	Total Cost	Cost Per Mile
Blue (A) Line Light Rail	1990	57	21.9	3%	22	DBB	$2.2 billion	$100 million
Green (C) Line Light Rail	1995	55	19.5	0%	14	DBB	$1.5 billion	$80 million
Gold (L) Line Light Rail – LA to Pasadena	2003	37	13.7	5%	13	DB	$721 million	$53 million
Gold (L) Line Light Rail – Eastside Extension	2009	64	6.0	28%	8	DB	$887 million	$147 million
Gold (L) Line Light Rail – Foothill Extension Phase 2a	2016	69	11.5	0%	6	DB	$714 million	$62 million
Expo (E) Line Light Rail Phase 1	2012	67	8.6	3%	10	DB	$1.3 billion	$147 million
Expo (E) Line Light Rail Phase 2	2016	56	6.6	0%	7	DB	$1.5 billion	$225 million
Crenshaw (C) Line Light Rail	2021***	Not yet open	8.5	45%	8	DB	$2.1 billion**	$247 million**
Red Line (B) Heavy Rail Phase 1	1993	76	3.3	85%	5	DBB	$3.1 billion	$926 million
Red Line (B) Phase 2 / Purple (D) Line Heavy Rail Initial	1996 and 1999	125	6.6	100%	8	DBB	$3.4 billion	$515 million
Red Line (B) Heavy Rail Phase 3	2000	73	6.4	100%	3	DBB	$2.3 billion	$354 million
Purple (D) Line Heavy Rail Extension Phase 1	2023***	Not yet open	3.9	100%	3	DB	$4.3 billion**	$1.2 billion**
Purple (D) Line Heavy Rail Extension Phase 2	2025***	Not yet open	2.6	100%	2	DB	$2.5 billion**	$967 million**
Purple (D) Line Heavy Rail Extension Phase 3	2027***	Not yet open	2.6	100%	2	DB	$3.6 billion**	$1.4 billion**

**A single delivery method is not always used on an entire project.*
*** Projected costs for unfinished projects*
**** Projected opening dates*

In the Los Angeles region, light rail lines primarily run at-grade within former freight rail rights of way, in highway medians, or along wide city streets. These lines are relatively inexpensive ($53 to $247 million per mile) and are often procured as DB. Both the Gold and Expo lines were delivered using independent construction authorities. Heavy rail lines run in tunnels underneath major boulevards. These lines cost 5 to 20 times more than the at-grade light rail and have all been delivered directly by LA Metro.

It is important to note the unique geological constraints that have contributed to the high cost of Los Angeles' tunneled lines. Geology is not a significant aspect of this

research as it is beyond a region's control, but the underground environment in Los Angeles is particularly challenging and is routinely cited as a source of high costs, project delays, and management headaches. For example, a 1985 methane gas explosion under a downtown department store led to a re-routing of the planned Red Line, while a 1992 methane gas leak required the evacuation of Red Line construction crews.[320] Many portions of Beverly Hills and Century City, which are along the route of the Purple Line Extension, are high-methane zones.[321] Abandoned and often unmarked oil wells add to the challenges. Additional challenges tunneling through the tar pits under La Brea resulted in a $200 million increase to the project budget.[322]

Strong institutions and staff capacity are essential to ensure projects are delivered on-time and on-budget.

Over the last several decades, LA Metro and the independent construction authorities (which have delivered some of the lowest cost projects) invested in capable staff and institutional capacity to deliver major projects. This is largely a result of the steady pipeline of capital projects and the region's voter-approved financial resources for transit. Since 1980, Los Angeles County voters approved four different ½-cent transportation sales tax measures.[323] Measure M passed in 2018 and is expected to raise $120 billion over 40 years, dwarfing all other transit capital expansion programs in the United States. State contributions constitute less than 10 percent of the agency's capital funding, and Los Angeles has been adept at securing federal transit grants due to its local contributions.[324]

The significant stream of revenue is beneficial for the timely delivery of projects, as many regions start planning for transit then use the planning process to help make the case for federal and local resources. With ample revenue streams, Los Angeles is able to continue planning for multiple lines knowing the resources will be available.

LA Metro also attracted new talent and built its internal staff thanks to its long-term capital program and the steady stream of major construction projects. In its early days, the agency retained a small in-house team and relied heavily on outsourced consultants for project planning and management. While LA Metro still relies on external experts for many elements of project delivery, its core group of senior and deputy project management staff bring significant institutional knowledge as well as private sector experience. Building an in-house team is not only less expensive than hiring consultants, but often also leads to better project outcomes since staff can better assess risk for the agency and the project budget when making major decisions.

In the past, the independent construction authorities delivered the lowest cost projects in the region. This is partially a result of simpler alignments in existing ROW (particularly for the Gold Line), though robust community support and more flexible procurement through the construction authorities contributed to lower costs. The two

projects delivered by the GLCA—opened in 2003 and 2016—were completed on-time and under-budget using the design-build delivery method.[325] The authority is currently building Phase 2B and has retained its lean and flat structure, relying on a small core group of less than a dozen senior, in-house management and executive staff. This staff is augmented by external consultants that operate in close coordination with the authority and are treated as in-house staff. The GLCA is also responsible for coordinating and securing buy-in from the numerous jurisdictions and stakeholders along the alignment of the Gold Line. The authority minimized scope changes by discussing ideas and preferences early in the planning process, and by managing the scoping phase tightly.

Another independent construction authority was used to deliver the Expo Line. It had trouble with the first phase of the project, which was delayed and completed $300 million over-budget due to contracting and project management issues (adding about $35 million per mile to that line).[326] In response, LA Metro commissioned an audit to identify key problems, lessons learned, and document steps the authority was taking to mitigate the risk of overruns on the second phase. The construction authority ultimately delivered Phase 2 on time and within budget (see below).

Despite their relative successes, LA Metro is moving away from construction authorities and, with the exception of Phase 2B of the Gold Line, is building all of its current and future projects (many of which are tunneled) in-house. This is in part because the agency has built up institutional capacity learned from challenges on early subway projects. The Purple line extensions, Regional Connector, and Crenshaw Line currently under construction are managed by LA Metro staff.

Staff capacity is also a critical element for properly managing project delivery and various procurement methods. Many of Metro's early projects during the 1990s were built under a traditional design-bid-build procurement, which is generally associated with higher costs and overruns due to the difficulties in managing project scopes and change orders. Since the initial segment of the Gold Line, which was the region's first DB project and delivered on-time and under budget, LA Metro and the construction authorities have utilized design-build for all major projects. However, the DB delivery method can result in delays and cost increases if not executed properly and requires project owners to be disciplined when developing project scopes, design criteria, and performance specifications for the design-builder.

This inexperience with the delivery model and the use of a "negotiated design-build" procurement on Phase I of the Expo Line contributed to significant cost overruns and delays. In lieu of establishing a lump sum, fixed price for the project when awarding the DB contract, the Expo Line Construction Authority negotiated the fixed price for each of its 19 work-packages once they neared final design. This was intended to avoid building risk and uncertainty over incomplete design into the bid.[327] However, the authority found that costs quickly outstripped the initial estimate once it began negotiating

the work packages given the need for additional design and engineering work. This approach ultimately led to the authority requesting an additional $145 million from LA Metro.[328] A more traditional DB procurement was used on Phase II of the Expo Line, which was delivered on-time and on-budget. The authority also hired two firms to develop preliminary design work before selecting one firm to move forward, allowing the authority to own both designs and incorporate features from each into the final product.

It is important to note that neither LA Metro nor the construction authorities physically build the infrastructure with in-house staff. As with other major projects, the design, engineering, and construction is always contracted out to private companies. In Los Angeles, the building trades are employees of private sector companies and unionized, negotiating directly with their private employer. No interviewee suggested that union wages, benefits, or work rules were a major factor in driving the costs or timelines of projects.

Neighborhoods and municipalities often request project enhancements that contribute to higher project costs.

Los Angeles' transit projects run through dense urban environments and through numerous local jurisdictions. Managing their timelines and costs means managing scope additions, also known as betterments, for upgrades to community infrastructure like streets, signals, and utilities. For example, the Crenshaw Line is 45 percent tunneled—much more than other light rail lines in the region—in part to meet community demands.

Addressing community concerns is unquestionably important and betterments are often paid for by the requesting locality, meaning they do not always result in increased direct project costs. However, if they are requested late in planning or during construction, they can add delays and require contract modifications, resulting in additional soft costs for the agency (i.e. administrative costs and legal fees). Under a DB approach any change in scope must be negotiated with the design builder.

Given the lengthy period of time between final design and the start of construction, there are often changes in local political leadership that leads to additional reconsideration of project scope. Interviewees suggested that, in some cases, municipalities may delay or condition approval of permits on whether LA Metro implements their betterment requests. Betterment requests from wealthier and more organized municipalities often compel the agency to consider equity considerations as to whether to apply similar improvements on other parts of a line.

In 2013, LA Metro adopted a policy that formalizes how betterments should be requested and evaluated. It states that third party entities should submit betterment requests as early as they can during the project development phase, and establishes an evaluation process by which LA Metro decides whether to approve a betterment.[329] If

a betterment is deemed unnecessary, it can only be incorporated if the agency receives commitment (and any necessary funding) from the requester in writing that the betterment will not impact the project's schedule and budget. In all other cases, LA Metro's board must authorize any modifications and requests.

Nevertheless, managing betterment requests is a challenge for LA Metro. In some cases, there may be pressure to tolerate increased costs for betterments to secure buy-in from necessary stakeholders. However, there is a strong consensus and effort among officials in the region to conduct more upfront design work, coordinate with stakeholders and all relevant third parties as early as possible in the planning process and provide clarity over what project enhancements LA Metro can and cannot accommodate during the scoping phase.

Permitting authorities also tend not to give final approval until project design is 100% complete. This is incompatible with the design-build delivery method often used by LA Metro. Changes and differing interpretations of planning documents from local jurisdictions compared to the bid documents have often led to modifications as the details of the designs are finalized after the DB contract is awarded. As noted above, the advancement of design to a higher level (particularly for areas impacting local jurisdictions) prior to award of the DB contract has significantly improved outcomes with respect to securing local permits.

In addition to betterments, communities are often sensitive to construction impacts of major transit projects and request accommodations from the agency. Concerns over noise, staging sites, and traffic disruptions can result in restrictions on working hours or construction areas which drive additional costs and lengthen project timelines.

The COVID-19 pandemic afforded an opportunity to demonstrate how these restrictions can lengthen project timelines and increase cost. Prior to March 2020, excavation and decking work for the Beverly Hills station on the Purple Line Extension was conducted only on weekends to limit road closures on weekdays at the request of the City of Beverly Hills.[330] The COVID-19 travel reductions allowed project crews to fully shut down major roads, including Wilshire Boulevard, and work additional shifts six days a week.[331] As a result, the decking work was completed in June 2020, seven months ahead of schedule.[332] This demonstrates how expedited construction timelines may depend on community tolerance for more disruptions over a shorter period of time versus a prolonged schedule with less day-to-day impact. Strong community support for a project can also help clear the way for a smooth construction process, such as in the case of the Gold and Expo Lines.

Project sponsors in the Los Angeles region are also placing a greater emphasis on early, proactive community engagement to facilitate quicker timelines, manage project scopes, mitigate backlash, and secure buy-in. Specific strategies include delineating project area

boundaries on a map to keep community requests for improvements from extending beyond the project's physical scope, as well as allowing the public to visualize and weigh in on potential staging sites for construction to better understand disruptions and tradeoffs inherent in various options.

Lengthy reviews and litigation associated with environmental review add time and cost.

Public transit projects in California are governed by environmental review regulations set forth in the California Environmental Quality Act (CEQA). Projects receiving federal funding are also required to comply with NEPA, and while both laws have significant overlap, there are a few additional requirements in CEQA including more detailed documentation and mitigation of individual significant environmental impacts.[333] The environmental review process for projects in Los Angeles are a cost and timeline driver, primarily due to the threat of litigation, lengthy alternatives analyses, and onerous third-party reviews.

A major source of pre-construction delays and cost increases is CEQA-related lawsuits. While environmental review-related lawsuits are not unique to the Los Angeles region, entire projects can be, and often are, halted as a result. Like NEPA, CEQA lawsuits are primarily procedural and often argue that alternative alignments or scopes were not sufficiently considered. With few restrictions on who can file a CEQA lawsuit, the prospect of litigation results in lengthier environmental review documents and alternatives analyses that cover far more ground. As a result, individuals or organizations who may not live near or be directly impacted by a project are able to file lawsuits in an attempt to delay or block a project.

In addition to avoiding litigation, the need for several levels of internal and external reviews of draft environmental documents can further lengthen the review process. Environmental law and planning rules require getting approval or addressing comments from multiple external agencies and regulatory authorities, as well as internal departments within agencies or cities. These include state historic preservation or environmental protection agencies, local planning and engineering departments, city DOTs, airport authorities, public utility commissions or departments, and Federal agencies like the FTA, FHWA, and EPA. These layers of review can lead to staff being inundated with comments and result in significant back and forth among various stakeholders.

Tight management, early planning, and thorough record-keeping is critically important in expediting the environmental review process for cross-jurisdictional projects. Interviewees suggested keeping checklists that document all necessary approvals and quickly moving on, establishing a clear process and schedule for obtaining approvals, and getting all stakeholders together to iron out feedback and requests whenever possible. In-house expertise, clear documentation of

external approvals and strong project management measures can not only expedite environmental review, but also prevent accusations of inadequate consultation with external or internal regulatory agencies during the community engagement process.

Utility relocation is complicated by legacy agreements and inaccurate maps, driving up costs and timelines.

Utility relocation is one of the most predictable sources of project delays and cost increases. Project sponsors frequently need to coordinate with third parties to relocate utilities, which can introduce additional complications. Third party reviews, permits, and the actual relocation work itself can take a significant amount of time to complete, as utility owners may not have the necessary staff to accommodate major construction projects, or are simply not compelled to follow the project owner's timeline. Legacy agreements between utility owners and public agencies sometimes require a specific entity or department to carry out utility relocation. As a result, project sponsors have little to no choice but to accept the rates provided by the entity and cannot bring in their own contractor to conduct the relocation more quickly or at a lower cost. In many cases, project owners also have little leverage to push back against requests for upgrades or other improvements from utility owners.

While some cities with experienced staff may be able to handle relocation requests, it can be impossible for smaller municipalities to hire enough staff to keep up with a large stream of major construction projects. Additionally, project sponsors often cannot compel cities or utility owners to conform with a project's timeline. For example, on Phase I of the Expo Line, the Los Angeles Department of Water and Power (the public entity responsible for relocating overhead power lines below ground) took longer than anticipated and was under no obligation to conform the construction authority's schedule, leading to a six month delay $29 million claim from the project's contractor.[334] On Phase II of the Expo Line, the construction authority opted to dedicate more staff to third party interfaces and initiate earlier coordination with utility owners and municipalities, which helped prevent similar delays and overruns.

Another major challenge in relocating utilities is the age and inaccuracy of utility maps. For example, when utility identification and relocation work began on the Regional Connector project, crews discovered that many of the utilities under downtown Los Angeles were neither in the location nor condition specified by the utility records, requiring a re-design and replacement work that contributed to a two-year delay and adding significant costs. Optimistic projections of the duration required for utility relocations have also been a contributing factor, while in other instances, project cost and schedules have been impacted by quality issues with contractors in charge of relocation. Recently, LA Metro began conducting advanced relocation work by issuing a separate contract for utility identification and relocation prior to awarding the DB contract. These contracts helped expedite the relocation process and minimize utility-related issues on the Purple Line Extension and have now become standard

practice for mega-projects at Metro. LA Metro continues to place a major emphasis on the importance of utility relocations to maintain project schedules. Metro executives meet at least quarterly with executives from key utilities to review status, schedules, priorities, and issues. This collaboration has been very helpful in being able to resolve issues.

Outdated standards and cumbersome processes can delay projects and add significant costs.

The safety, environmental, and cultural standards in place in California are a net positive. However, interviewees felt that in some cases, the standards might be unnecessary or the process to achieve them might need to be reformed. While this research did not do a comprehensive evaluation of those standards and processes, specific anecdotes regarding safety and historic preservation standards illustrate the frustrations and challenges associated with them.

Projects in Los Angeles follow the National Fire Protection Association's (NFPA) 130 *Standard for Fixed Guideway Transit and Passenger Rail System* requirements (see Section 4.10.3). These standards are ubiquitous on U.S. rail transit systems and set specific design requirements for station evacuation and train separation barriers in tunnels. For example, trains running in opposite directions are required to have a concrete barrier between them to enable passengers to evacuate into a separate, clean air tunnel in the case of a fire. It also limits the application of a single bore tunnel as is more common in Europe. The use of twin bore tunnels and wider stations resulting from NFPA 130 exiting requirements are major factors in tunnel depth and the extensive amount of excavation and structural support required at underground stations, compared to a conventional single bore tunnel.

However, NFPA 130 is not applied in other peer countries, like Spain, allowing international projects to use a smaller, single-bore tunnel whereas in Los Angeles the NFPA 130 standards meant the Red and Purple lines are both twin bore systems, adding cost. Since Los Angeles-specific seismic protection standards require larger tunnel bores, stronger tunnel linings, and additional excavation to protect tunnels from collapsing due to ground movement than most other places, some interviewees suggested that the NFPA 130 standards might be unnecessary.[335]

Similarly, standards to ensure safety for tunnel workers add to project delays. For example, construction of the Purple Line subway requires the deployment of methane gas sensors and robust ventilation systems along the construction site. An alarm sounds when gas levels rise above an acceptable limit, and all equipment is automatically shut down as workers evacuate the construction site and ventilation systems are activated. Once safety officials are able to clear the site, workers can resume construction, a process that generally takes up to an hour. Between October 2019 and March 2020, the Purple Line extension experienced nearly 60 automatic shutdowns, some of which

were false alarms, along the segment from the Wilshire/La Brea to Wilshire/Fairfax stations.[336] The frequency of shutdowns along this line has required deployment of additional gas sensors. While the safety standards are clearly necessary, interviewees felt that there should be a better way to either ventilate or recover from a tunnel evacuation than the current practice.

Another source of delays and cost increases on projects is the frequent discovery of and action related to archaeological items and historic artifacts.[337] CEQA also requires projects to assess and mitigate impacts on historical resources, and as of 2015, requires recipients to consult with California Native American tribes to assess any impacts on Native Cultural Resources.[338] Fossils, burial sites, oil wells, aqueducts, human remains, and Native American artifacts are among the many items that construction crews have discovered when doing site work. While project owners may conduct initial investigations into site conditions and potential impacts on historic or cultural resources, these unexpected discoveries often pause construction, require additional investigation, and in some cases have contributed to significant project delays.

This was a notable issue in 2017 on the Patsaouras Bus Plaza Station in downtown Los Angeles. LA Metro staff conducted extensive consultation and planning work, documented how the agency would mitigate and protect any discovery, and report findings to the FTA.[339] During construction, project crews uncovered additional archaeological remains and Native American artifacts and had to pause construction to bring in archaeological experts and observers from the Native American community. The unexpected findings were initially expected to stop construction for two months but the project was put on hold for nearly a year until the additional reviews, studies, and mitigation efforts could conclude.

The Patsaouras Bus Plaza Station highlights two important challenges. First, the bus station is in the heart of downtown, surrounded by the depressed 101 freeway, the El Monte Busway Bridge, and the Red Line subway. None of those projects reported any historical artifacts during construction. It is likely that when those projects were completed several decades ago, these standards did not exist and such findings were discarded or ignored. There is a general consensus among stakeholders in the region that projects have rightfully become increasingly accountable for their external impacts over the past several decades. But such accountability and care certainly makes building today more challenging. The processes for respectfully handling such findings are in need of reform to better meet both historical and project timeline needs.

5.2 Seattle

Seattle's light rail system serves as a valuable case study since it has significant portions of track that are elevated and tunneled, making it comparable in terms of complexity to other U.S. and international projects. The region's rapid growth and sizeable capital program offer several unique insights into its capacity to manage, oversee, and deliver major projects.

Governance Overview

Sound Transit (ST) is the service name of the Central Puget Sound Regional Transit Authority, a public corporation created in 1993 by King, Pierce, and Snohomish counties to build and operate a regional high-capacity transit system. ST partners with transit providers throughout the region to provide a range of integrated transportation services, including Link light rail, Sounder commuter rail, express buses, Tacoma Link light rail, and bus rapid transit. ST also manages the regional ORCA fare card system. The agency is governed by an 18-member board of directors comprising elected officials from its constituent counties. Representation is determined by county population with one position is held by the Washington State Secretary of Transportation. ST services are funded by sales, property, and motor vehicle excise taxes levied within the ST taxing district as well as by federal grants, fares, and other revenue sources.

Washington State Department of Transportation (WSDOT) primarily funds highway projects, but also coordinates closely with ST. WSDOT has a dedicated 20-person staff with planning, engineering, and construction expertise to support ST's project delivery, and its rail office also has an oversight role over Sound Transit. WSDOT also helps identify opportunities for ST to construct rail within its ROW.

King County Metro is the primary transit operator for the region's most populous county, which contains the city of Seattle. King County Metro operates the region's bus network and is contracted by ST to operate and maintain Link light rail. In 2019, King County Metro and Sound Transit renewed their agreement to continue integrated rail operations and management through at least 2023.[340]

Puget Sound Regional Council is the region's MPO and conducts long-range regional planning for transit, though it has no direct involvement in project delivery.

System Overview

Rail transit in the region consists of the Sounder commuter rail line, three streetcar lines, and a single Link light rail line, the 1 Line. The 1 Line corridor traverses well-developed urban areas and operates in a tunnel between its northern extent at the University of Washington and the International District station in downtown Seattle.

From that point, the line extends southward to SeaTac Airport and its terminus at Angle Lake Station on a combination of at-grade and elevated segments with a short tunnel. The region is currently constructing or planning several major Link system expansions (See Table 9).

TABLE 9: TRANSIT LINES PROFILED IN THE SEATTLE REGION

	Year Opened	Time to Construct (months)	Length (miles)	Percent Tunneled	Stations	Primary Delivery Method*	Cost	Cost Per Mile
1 Line Light Rail (formerly "Central Link" and "Red Line")	2009	68	15.6	15% (1.3 mi of total tunneled length is pre-existing DSTT)[341]	14	DBB	$3.7 billion	$239 million
1 Line Light Rail Angle Lake Extension (formerly "South 200th Extension")	2016	41	1.6	0%	1	DB	$331 million	$207 million
1 Line Light Rail U-Link Extension	2016	84	3.2	100%	2	DBB/CMR	$1.6 billion	$511 million
Northgate Light Rail Extension	2021***	N/A	4.3	81%	3	DBB/CMR	$1.8 billion**	$419 million
Lynwood Light Rail Extension	2024***	N/A	8.4	0%	4	CMR	$2.7 billion**	$321 million
East Link Light Rail Extension[342]	2023***	N/A	13.9	14%	10	CMR/DB/DBB	$ 3.6 billion**	$259 million

Note: the Central Link tunnel used an existing bus tunnel under downtown Seattle, reducing some tunneling costs
**A single delivery method is not always used on an entire project.*
*** Projected costs for unfinished projects*
**** Projected opening dates*

Voters in the Puget Sound region approved three major ballot measures to fund the Link light rail system expansion: Sound Move (ST1) in 1996, Sound Transit 2 (ST2) in 2008, and Sound Transit 3 (ST3) in 2016.[343] Each raised sales tax revenues in the counties in and around Seattle to plan and construct transit expansion across several modes. While analysis found that project scopes and budgets were often adjusted during the course of the projects due to unforeseen cost and schedule issues and did not meet their early targets, each phase of the 1 Line has been completed under the revised budgets.[344] The initial portion was completed $117 million below the $2.44 billion budget. The U-Link extension was completed $200 million under budget and six months ahead of schedule.[345] Similarly, the extension to Angle Lake station was completed for $40 million less than the original $383 million budget.[346]

The Northgate, Lynnwood, and East Link extension projects are funded under ST2 and will expand the system by 27 miles once completed. Under ST3, the agency will add 62 miles of new light rail for a total of 116 miles as well as 37 new stations for a total of more than 80 stations by 2041.[347]

In addition to tunneling in what local engineers and planners called “problematic soils,” projects in the Puget Sound region must conform to rigorous fire, seismic, and public safety standards that can add additional cost to projects. While Washington does not

experience earthquakes as frequently as California, they have historically lasted longer and overall can be more powerful. Seismic safety codes have also become more stringent over the last several years.[348] For example, elevated guideways must be built to a higher standard in areas where certain soils pose earthquake risks. The seismic code also requires a significant amount of rebar for rail lines, which can further add cost.

Despite a growing staff and capital program, capacity constraints can still be a challenge in a complex expansion environment.

ST has grown and changed significantly since its formation in 1993 to deliver the rail and bus projects that voters first approved in 1996. At first, it had a small staff and relied heavily on external consultants. Since then, ST's three major voter-approved capital expansion programs allowed the agency to grow its internal staff and gain experience delivering major projects. As of July 2019, ST has more than 1,000 employees.[349]

The agency's growth has brought both benefits and challenges. Most notably, ST's major capital program has allowed it to build internal experience and capacity delivering projects. The agency now has a sizeable planning and engineering team. While ST is able to do planning work in-house, it contracts out for all of its design work and construction management. Nevertheless, with multiple lines currently in planning or construction, often with varying project delivery methods (DB, DBB, CMR), ST has had challenges managing contracts.[350]

Agencies sometimes employ several different procurement approaches, and there is not always agreement about which approach works best.

ST uses a range of delivery methods for the contracts within its projects and will often use a mix of delivery methods within a single project alignment. The initial Link light rail segment was built using DBB, while the U-Link project included both DBB and CMR (the region calls the CMR delivery method "CM/CG") contracts. The East Link project used DBB, DB, and CMR while the Federal Way project is entirely DB. The Lynwood extension also two civil CMR contracts and one CMR contract.[351] While the agency has a detailed process to evaluate and determine which delivery method should be used on various projects, interviewees suggested three primary challenges with the region's approach to the selection.

First is that the agency is often very involved with design even when using DB. In contrast to DBB, in which project sponsors review designs at 30, 60, and 90 percent completion, a DB procurement typically only requires two quick design reviews to allow the contractor to begin construction as quickly as possible. However, interviewees cited frequent interactions and reviews with DB designs, including a DBB-style approach to the design review process by requiring a 90 percent review, adding additional time. Others noted that the agency's management team may comment too much on the

contractor's design and may not have enough trust that the contractor will meet their desired performance.

DB procurements ideally require less staff and time to oversee so long as an agency places enough trust in the performance criteria it provides to the contractor, and leaves enough room for creativity without being either overly prescriptive or too vague. However, ST has struggled with sufficiently incorporating its preferences and interoperability requirements in its design specifications for DB projects. Interviewees cited anecdotal examples where the contractor's choice of components such as circuit breakers or rail clips met the project's DB performance criteria, but did not match the same brand or style on other parts of the system. In these cases, modifying the desired specifications lead to further contract changes and scope modifications.

Finally, while DB and CMR approaches can save time, their procurements often take much longer than traditional DBB projects, eliminating some of the benefits of these models. For example, the procurement for the Federal Way project took nearly 20 months. While some of this is due in part to ST's procurement process, there are also significant statewide procurement regulations and requirements that the agency is required to comply with, particularly for CMR projects.

Public entities must receive approval to use DB or CMR from Washington State's Project Review Committee (PRC). Approvals can be granted for individual projects, or through a Public Body Certification. The process requires a public body to submit an application and demonstrate that the alternative contracting method will either have a fiscal benefit or help the entity meet its schedule or quality standard. ST received its CMR certification in 2013, and its DB certification in 2015 and both are renewed every three years.[352] Previously, the agency submitted applications to the PRC to use DB and CMR on individual projects.

In order to receive a Public Body Certification, the entity must demonstrate that they have successfully managed at least one DB or CMR project in the last five years, as well as demonstrate that they possess the necessary experience and qualifications to evaluate, choose, and carry out an alternative delivery method.[353] These regulations are a result of the state's relative caution in responding to alternative delivery methods due to concerns from labor groups, contractors, and small businesses around fairness and competition, specifically over the ability to secure subcontracts.

ST's challenges with procurement have created an environment that result in numerous contract change orders. While these technical changes can be relatively minor, if numerous they can quickly become disruptive to a project's cost or schedule. An ST audit of a sample of 12 contracts on five major construction projects (totaling $2 billion) revealed nearly 300 change orders costing $172 million.[354]

Change orders are sometimes the result of site conditions that differ from initial plans and surveys, which are infrequent but have a significant impact. Unexpected underground soil or water conditions were responsible for $79 million in change orders (46 percent of the total). They can also be technical changes that are either a result of design or contract mistakes, which staff sometimes notice or uncover late in construction. More than half of these changes (160) were issued by ST because of mistakes or missing information in project designs or contracts. The audit suggested that increased investment in early underground exploration and a stronger design review process with standardized checklists could help curtail a significant amount of the change orders the agency encounters.

Officials also noted that the process for handling change orders is very regimented, takes too long, and involves too many people. In response, ST's Board of Directors in 2018 changed policy to allow the board's committees to approve up to $50 million (previously $5 million) for contracts, agreements, and land acquisition that fall under their jurisdictions, and raised the CEO's approval authority to $5 million (previously $200,000) for construction, architecture, or engineering services contracts. The change also authorizes the CEO to approve up to $2 million in contracts for materials, technology, and other services.[355]

These changes intend to streamline and balance the number of change orders, contracts, and agreements that require board approval, and free up more time for the board to engage more deeply and productively on policy matters. Though these changes have been helpful, change orders must be reviewed by the contracting staff to ensure they fall within scope, the project controls group to verify they are within budget and timeline, and may also still have to be reviewed by the Board to ensure that the change is one that the agency wants.

Problems with procurements, specifications, and change orders led stakeholders in the region to develop strong opinions on which delivery method is the best for the region. Many believe that DB is the best approach but noted that agency staff need to be better at developing design specifications that are neither too broad nor too prescriptive and should cede more control over the design and design review process to the design-builder.

There is more concern and disagreement over the success of CMR. Some feel strongly that this delivery method had not worked out well for the agency and led to higher costs. CMR contracts can take significant time to negotiate, and lack the competitive pressure of other delivery methods, which can lead to a higher cost compared to DB contracts. Furthermore, CMR requires a different oversight approach than DB or DBB. ST's experiences with multiple procurement approaches has made it difficult for it to understand the varying levels of control and management necessary for different project elements and delivery methods.

Extensive community outreach and planning processes can result in significant requests for betterments, which can be challenging if the agency does not have permitting authority.

Interviewees expressed frustration that the region spends significant time addressing community concerns without a clear and consistent process for constraining requests. One said that the region at large puts a "high value on leaving everyone happy." This includes both during the environmental review and the planning process. The resulting environmental review and planning process typically takes five or more years and is a significant timeline driver, primarily due to threats of litigation, lengthy alternatives analyses, and sequencing. Projects in Seattle are also subject to environmental regulations under NEPA as well as the Washington State Environmental Protection Act (SEPA). While SEPA is not considered any more onerous than NEPA, the local review does include some additional components related to the region's unique habitats.

In terms of sequencing, current FTA regulations state that project sponsors cannot complete final design or begin acquiring ROW until after the agency issues a Record of Decision (ROD). This is intended to prevent a conflict of interest by biasing the project sponsor in favor of a particular alignment. The FHWA, however, does provide project sponsors flexibility to begin early ROW acquisition prior to the completion of NEPA at their own risk.[356]

Additionally, officials expressed frustration that environmental review documents seem to be written to avoid litigation rather than to inform the public. Observers pointed to the alternatives analysis process where projects must analyze many different potential alignments for a project, often to shield agencies from procedural lawsuits and accusations that they failed to consider a certain alternative. For example, on the East Link project, ST identified 36 alternatives during the initial scoping phase, and advanced 27 of those for further review.[357] The Final EIS examined 24 build alternatives.[358] While a major project might warrant the review of many alternatives, the process remains lengthy and can also make it difficult for contractors to begin identifying utilities and subsurface conditions before the final alignment is chosen.

On earlier projects, there was a tendency for staff to avoid controversial questions about scope or alignments until later in the project planning phase, which would ultimately take longer and cost more to resolve. One example is the at-grade section of Line 1 that runs through the primarily lower-income and non-white Rainier Valley neighborhood. ST had initially ruled out the idea of putting that segment below ground but had to revisit the issue at the request of the community during the design phase.[359] This required the agency to conduct additional studies, host public hearings, produce new cost estimates, and essentially prepare a mini EIS for the tunnel, leading to a nine-month delay until the agency ruled out the option.[360]

Bellevue also raised concerns over the East Link project's alignment and requested that ST consider either an elevated or tunneled segment, after the agency had already completed the initial design.[361] This led to nearly four years of discussions, studies, and negotiations over the alignment.[362] A tunneled segment was eventually included as part of the project's final EIS in 2011, and further modifications were finalized in 2013, requiring a SEPA addendum to the project's EIS.[363] While Bellevue ultimately put forth $100 million in funding to support construction of the tunnel, it is a clear example of how projects can be slowed down by years of negotiations and potentially contentious debates over scope elements, especially after initial designs have been completed.[364] Officials also noted the increase in community expectations for project elements like finishes and artwork.

The root of the problem, according to many in the region, is that ST needs to secure permits from the 84 local jurisdictions in and around Seattle. While ST cannot legally be denied permits given its status as a public entity, localities can drag the process out for a significant period of time. The permitting process was frequently brought up as uniquely time consuming, contentious, and onerous, especially for transit lines that run through several jurisdictions. Many suggested that it's often cheaper for ST to accept and pay for a betterment request rather than absorbing a project delay.

ST has attempted to develop a more formal method to evaluate requests for betterments and decide whether to pay if the requesting entity is not reimbursing the agency.[365] However, there remains a lack of prioritization of betterment requests and clear boundary setting to establish which requests can or cannot be granted. This is attributed to a persistent culture of not moving ahead on a project until all parties are satisfied, and a sense of obligation among agency staff to be a good neighbor and grant these requests to secure buy-in from stakeholders.

As the region prepared for its third major ballot initiative, ST3, in 2016, an expert review panel assembled for the initiative recommended engaging stakeholders and jurisdictions as early as possible in the planning process.[366] Proactive, early conversations around alignments and design options can minimize mid-stream changes and allow for more focus on constructing the project on-time and on-budget. Strategies include letters of concurrence with the early proposed project scopes from jurisdictions and coordinating on environmental review documents with jurisdictions and third parties as early as possible. The proposed timelines for ST3 projects were, on average, six months shorter than those on ST1 and ST2.[367] However, even with the emphasis on early engagement, regional stakeholders expressed pessimism over whether projects can be completed any faster than they already are.

Skyrocketing real estate values and a booming local economy are key cost drivers.

The transit construction labor market in the Puget Sound region is strained by the rapid expansion of the system coupled with competition for housing construction labor. Finding engineers and construction staff is difficult and has led private firms to increase employee wages to attract and retain talent. Similarly, housing prices have increased dramatically over the past decade, making it difficult for workers to find affordable places to live.

In addition, the real estate a transit line needs is also much more expensive than ten or more years ago. To build a transit line, an agency needs to purchase real estate in the ROW, one of the most time consuming and costly elements of a project. Property acquisition can take as long as two years, particularly when condemnation is required. ST spends a considerable amount of time and money on administrative settlements to avoid property condemnations compared to peer cities like Portland. One interviewee suggested that ROW costs and mitigation associated with certain above-ground alignments can rival the cost of building a tunnel. Some attributed high property acquisition costs to the agency's desire to avoid conflict and offer owners a settlement that will make them more than satisfied, while others felt the high prices reflected NIMBYism or strong resistance on the part of property owners to accept lower compensation amounts.

Project sponsors could pay less for property if ROW acquisition was not such a major schedule driver and was less time sensitive. While ST has begun initiating early discussions with property owners that may be affected by a project, it is unable to discuss actual prices or make any deals due to the FTA's prohibition on beginning the ROW acquisition process prior to receiving a ROD.

During the COVID-19 pandemic, real estate costs continued to rise while ST's revenue fell. This led to significant price escalations and affordability challenges on several ST3 projects currently in the development and cost estimation phase, including the West Seattle and Ballard Link Extensions, Tacoma Dome Link Extension, and the Link Operations and Maintenance Facility South.[368] Across these projects, there has been a cumulative cost increase of 40 percent ($4.8 billion to $6.2 billion) over original estimates.[369] While rising real estate costs are cited as the largest contributor to the cost escalation, design work on these projects has uncovered additional sources of cost increases as project scopes are further developed, including: challenging site conditions, increased property acquisition needs, more complex utility relocation and stormwater infrastructure upgrades, and putting previously at-grade segments of select projects above ground to minimize impacts to environmentally and culturally sensitive sites.[370]

Under ST3, the agency is required to undergo a realignment process if any element of the program is found to be unaffordable. The ST Board of Directors will assess how

the timelines and plans for affected ST3 projects can be modified to address financial constraints. This will include seeking new state and federal revenue sources, as well as considering options like delaying projects to allow the agency more time to collect revenue, split projects into phases, or reduce project scopes.[371] The board also retains a last-resort option of suspending or deleting projects altogether if necessary. The realignment process began in January 2021, and a final realignment plan is expected to be produced in summer 2021 after public consultation and board deliberation.[372]

5.3 Denver

Denver's first light rail project (the D Line) opened in 1994, and two major regional investments since then have significantly expanded the system. The first was the Transportation Expansion Project (T-REX), which added 19 miles of track and 13 stations to the region's light rail system, and the second was FasTracks, which added 25 miles of light rail track and 53 miles of commuter rail to the system. All of the projects discussed in this case study are part of the FasTracks initiative due to their recency and because a portion of the initiative was the first major rail construction project in the United States to use a public-private partnership delivery method. However, both T-REX and FasTracks showcase relatively low construction costs for U.S. rail projects, and the early success of T-REX established momentum for the buildout of FasTracks several years later.

Governance

Denver's **Regional Transportation District (RTD)** was established in 1969 by the Colorado General Assembly. The agency serves over 3 million people located within 2,342 square miles and provides service in eight of the twelve counties of the Denver-Aurora-Boulder Combined Statistical Area. Services include bus, rail, shuttles, ADA paratransit services, demand responsive services, special event services, and vanpools. RTD is governed by a 15-member, publicly elected board of directors. Each of these members is elected to a four-year term and represents a specific district of roughly 180,000 constituents with varying degrees of density. The board has influence over issues like bus service planning but relatively less over rail capital project delivery.

The region's MPO, the **Denver Regional Council of Governments (DRCOG)** approves financial plans and vehicle technology for RTD rapid transit projects. The **Colorado Department of Transportation (CDOT)** coordinates with DRCOG and RTD to coordinate and administer funding from the state to rail projects. CDOT and RTD partner to coordinate construction for rail infrastructure that crosses state or federal highways and co-produce the relevant EIS.

RTD also coordinates with local governments and private entities for ROW. For example, the University of Colorado A Line crosses ROW belonging to the Union Pacific Railroad, private property, the shared city and county of Denver, and the city of Aurora.[373] The agency must also coordinate with private utility companies for ROW.

System Overview

TABLE 10: TRANSIT LINES PROFILED IN THE DENVER REGION

	Year Opened	Time to Construct (months)	Length (miles)	Percent Tunneled	Stations	Primary Delivery Method*	Cost	Cost Per Mile
Southeast Light Rail Extension	2019	36	2.3	0%	3	DB	$183 million	$80 million
R Line Light Rail (Also known as I-225 Rail)	2017	47	10.5	0%	8	DB	$591 million	$56 million
W Line Light Rail ("West Rail" during construction)	2013	71	12.1	0%	12	CMR	$661 million	$55 million
G Line Electric Commuter Rail ("Gold Line" during construction)	2019	92	11.2	0%	7	DBFOM	$455 million	$41 million
A Line Electric Commuter Rail (Officially "University of Colorado A Line", and "East Corridor" or "East Rail" during construction)	2016	68	23.4	0%	7	DBFOM	$1.2 billion	$52 million
B Line Electric Commuter Rail ("Northwest Rail Line" during construction)	2016	Data not available	6.2	0%	7	DBFOM	$393 million	$63 million

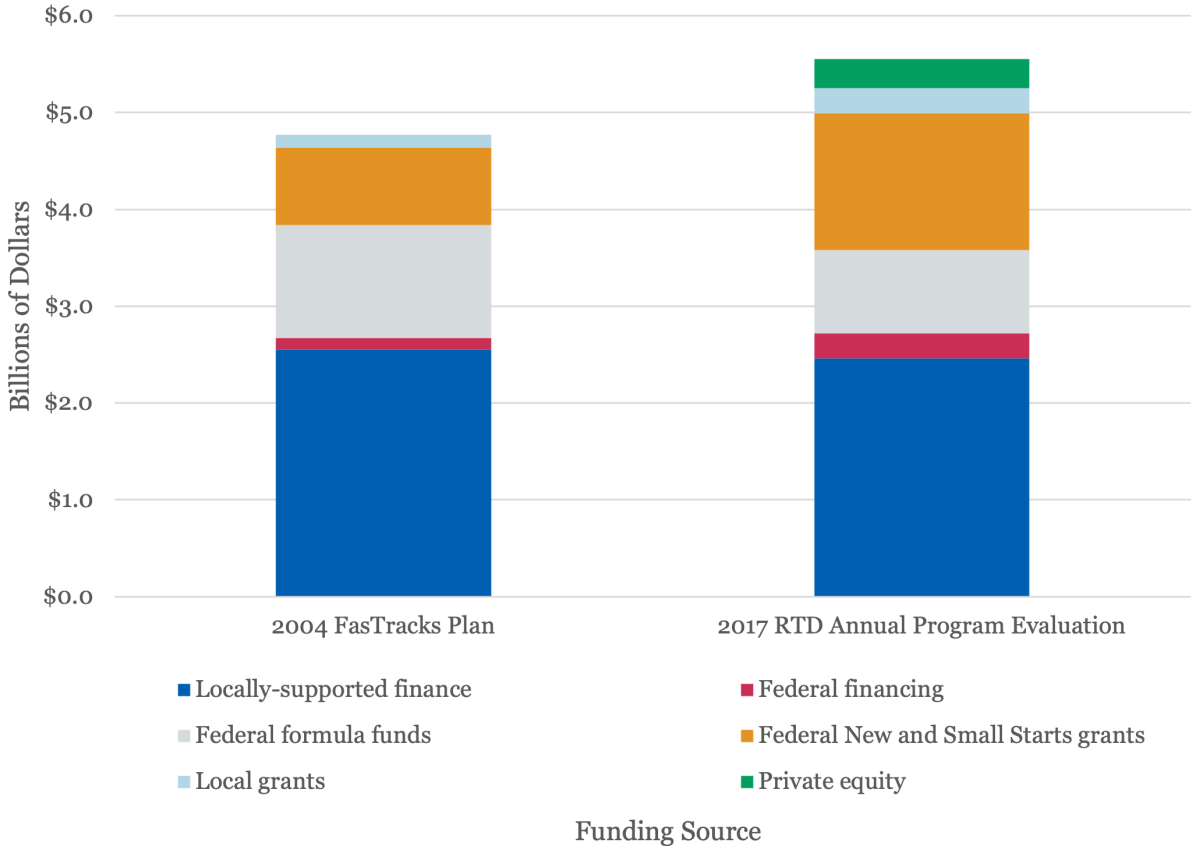
**A single delivery method is not always used on an entire project.*

The region currently has four commuter rail lines (University of Colorado A Line; B; G; N) powered by overhead electric lines and seven light rail lines (C; D; E; F; H; L; R; W).[374] Commuter rail was introduced with the University of Colorado A Line in April 2016. All of the lines in Denver's system are at-grade or elevated, and there was no major tunneling required for construction. As a result, RTD avoided some of the physical construction and engineering challenges of other regions. Additionally, much of the rail construction is through highway medians or existing freight ROW, simplifying the construction process.

Across all projects, local sales tax bonds and federal grants were the primary sources of funding. Additional funding sources and an increase in federal grants received added $900 million to the funding committed to the capital buildout of FasTracks through 2020.[375]

In 2007 the FTA selected three FasTracks lines—the East Rail, the G Line, and the first segment of the B Line to Westminster—for federal funding through the Public-Private Partnership Pilot Program (Penta-P). These three projects (along with a commuter rail maintenance facility) eventually became known as the Eagle P3. In 2011, the Eagle P3 received a $1.03 billion FFGA from the FTA and $486 million in private financing and RTD sales taxes. The agency refers to this funding model as the "Three-legged Financing Stool."

FIGURE 14: FASTRACKS PROJECT FUNDING COMPARISON BY SOURCE



Note: Adapted from information found in RTD's FasTracks Program Overview Executive Summary from June 29, 2018.
The chart compares the original 2004 funding plan to the actual and committed funding through 2020 as stated in the 2017 Annual Program Evaluation.

Effective project management helps move projects forward.

The completion of the T-REX program ahead of schedule and under budget helped increase public support for FasTracks several years later.[376] T-REX was an RTD/CDOT joint effort which allowed the project to benefit from existing institutional capacity at CDOT. For example, the ROW acquisition process used in-house CDOT appraisers and existing CDOT ROW forms.[377] T-REX was also a successful example of DB project delivery, in part attributed to bidder input on the contract to identify potential cost drivers and on the use of experts with experience in the legal aspects of DB work. Projects that predated FasTracks had minimal overlap in the timing of the environmental review process, which allowed RTD staff to focus attention on the various phases of project delivery in sequence. During FasTracks, staff were simultaneously carrying out various phases of project delivery and managing different consultants across multiple projects.[378] FasTracks was projected to be completed in 2017 at an estimated cost of $4.7 billion. However, the project is still underway and projected costs have risen to $5.2 billion as of 2020.[379]

Because RTD used a range of procurement methods across FasTrack's various projects, having strong leadership and delegated decision-making helped to keep projects moving forward and frequent reflection through lessons learned documents enabled the agency to learn from its missteps. RTD filled senior and key staff management positions with professionals that were highly-experienced in P3s.[380] RTD also created separate project management positions for planning and engineering. This was particularly beneficial in allowing both perspectives to contribute to the environmental review process, and encouraging both managers to benefit from each other's expertise on technical or planning issues.

As part of FasTracks, RTD also adopted a delegated authority approach for management, which allowed major decisions to be approved by designated managers rather than going through a chain of command (i.e. approval by all levels of managers within the organization). This delegated authority approach led to faster turnarounds on key decisions and thus fewer project delays, though this approach is rare. In addition, change orders did not require board approval unless the amount exceeded the overall project budget. This practice, in place since the T-REX project, enabled quick decision making and expedited the work.

In its post-completion evaluation of FasTracks, RTD indicated that several project delivery models were used on FasTracks projects, a departure from the agency's original plan to use DBB for all corridors.[381] The evaluation found that the DB method used for the Southeast Rail Extension and N Line and DBFOM used for the Eagle P3 maximized contractor innovation and helped the projects get completed faster. The CM/GC method used for the W Line required early buy-in from RTD as the designer, but in practice RTD and the contractor were not always in agreement about project details. This may have been a side effect of these entities working in separate locations and on different contracts. RTD also indicated that the negotiations for this contract were challenging and that "there is no substitute for the discipline of the marketplace under a competitive bidding environment." For its part, DBB was found to be best used for smaller projects or those that involve high levels of risk.

Just after the FasTracks vote but before construction was set to begin, RTD realized that revenues would be lower than originally anticipated due to declining sales tax revenues as a result of the economic recession, and that a P3 may also make it easier to deliver multiple corridors at once.[382] In 2009, RTD issued a request for proposals and later entered into a 34-year agreement with Denver Transit Partners (DTP), for which it agreed to pay DTP to operate and maintain the system.[383] By using this approach, RTD let the private partner determine how to bundle the most valuable lines together, which allowed the Eagle P3 projects to be delivered faster as a result, though they were not without implementation and operations challenges later on.

Transit P3s can expedite delivery, but if not structured carefully they can cause problems in the future.

The use of a P3 approach can also alleviate some of the schedule constraints under a DBB procurement. Project owners retain a higher degree of control under DBB, which can require multiple procurements and handoffs between the design and construction contractors, potentially slowing progress. On the other hand, P3 models transfer much of the control over project details to the private consortium, which may help expedite procurement and delivery.

Much of a project's risk is inherently transferred to the private sector with a P3, but project sponsors must still do their due diligence to understand the level of risk transfer and provide proper oversight. Since the Eagle P3 was the first full DBFOM public-private partnership for transit in the United States, there were many processes for which RTD had little prior experience or lessons to gather from peer projects and the agency took many steps to have pre-construction meetings with stakeholders like vendors, financiers, and railcar providers to get a better understanding of the project's risk. While some risk was transferred to the private sector for the Eagle P3 project, responsibility for other elements like compliance with railroad regulations and design changes were less clear and more risk could have been transferred to the private sector.

The concession agreement with the selected P3 entity resulted in capital costs that were over $300 million less than RTD's estimate.[384] This savings enabled RTD to jump start other projects. Since project specifications were largely performance based (rather than prescriptive), the concessionaire was able to balance the risk of project design elements against the long-term operation.[385] The concession agreement specified a 29-year operating agreement, over which availability payments would be made to the concessionaire, partially based on operational performance parameters during that period.[386]

Therefore, in its bid, the concessionaire performed numerous life-cycle, cost-benefit analyses to determine whether specific capital items would impact operational performance and thus risk future availability payments. In some cases, elements such as double tracking and additional crossovers were determined not to provide a positive cost-benefit ratio and were deleted. In others, items such as the incorporation of a redundant substation were retained.

This analysis of cost and benefits performed by the concessionaire when preparing their bid, was significantly more extensive than anything typically done by project owners who tend to use long standing criteria and personal experiences of project personal and consultants.

The Eagle P3 project had a formal process in place for design criteria conformance in which review and approval of checklists by Safety and Security Working Groups produced a Certificate of Conformance for each project segment, but RTD stated that the process "was not always scheduled in a timely manner" and in some instances, that resulted in construction beginning prior to completion of that process, which resulted in cost and schedule overruns. Ultimately, any delays or cost increases were risks borne by the contractor, though RTD was responsible for reviewing project schedules and milestones to verify that various activities are included in Design Criteria Conformance Checklists.[387]

RTD oversight of design reviews for structures could have been improved, given that a number of bridge structure deficiencies arose, requiring the demolition and re-design of one bridge, two bridge deck retrofits, and other structural changes like girder replacements. According to the agency, the structures design oversight team should have identified unique or challenging design elements and ensured that the design engineers understood the relevant codes during the design review phase, rather than focusing only on contract compliance.[388] However, because RTD used the P3 delivery model, the concessionaire performed the necessary structural modifications without any cost impacts to the agency.

Among the lessons learned, RTD determined that a strong legal and financial counsel team was a necessary component of a P3 since "it is at the core a business deal rather than a traditional construction contract.".[389] Some contractors are increasingly reluctant to accept public rail projects due to the potential risk involved. If they do pursue projects, their bid prices incorporate significant contingencies. From RTD's perspective, construction companies' legal teams and strategies have grown over time. One interviewee expressed that "rather than doing business with a construction company that occasionally experiences legal issues, the transit agency is doing business with a legal firm with a construction wing," since there is a robust legal strategy built into construction companies' business because of increasing project complexity and the risk of litigation.

Coordinating with third-party entities can create challenges.

In numerous instances across the FasTracks projects, challenges involving third parties—such as federal regulators, local jurisdictions, and utility companies—surfaced that were not accounted for in the original contract negotiations.

For example, RTD experienced challenges getting approvals from local governments on the North Metro project. Interviewees expressed that local jurisdictions see the rail construction process as a way to extract upgrades to other adjacent infrastructure that jurisdictions may not be able to pay for due to local budget limitations. These can include upgrades to drainage infrastructure, streets, and other elements that extend

beyond the project's scope. Since the local jurisdictions cannot see the fully completed designs in a DB contract, they may request more change orders than they otherwise would have. For example, for North Metro, RTD tried to streamline the design-review process in inter-governmental agreements, but differing processes within a jurisdiction (e.g. between the design and planning entities and the public works entity) sometimes created situations where certain departments were aware of design plans and others were not. In some cases, this dynamic led to change orders and finger-pointing.

Similarly, contracts do not always account for ambiguous regulatory practice. The P3 approach for the Eagle P3 projects allowed RTD to shift significant risk to the private sector, but there was a "legal gray area" when complications arose concerning compliance with freight rail regulations. RTD was the first transit agency to deploy positive train control (PTC) technology during construction of FasTracks.[390] PTC refers to technologies that automatically stop trains before collisions and incidents occur. PTC was part of the original designs for the Eagle P3, which was viewed as an innovative aspect of the project, but one that resulted in confusion about risk and responsibility when regulatory challenges arose.

Because RTD's commuter rail lines were designed to operate using electrified service, the traditional form of crossing gate warnings was not available. In early agreements, it was decided that PTC would include some technologies that could provide constant warning times. Federal Railroad Administration (FRA) regulations vaguely state that any "electromagnetic, electronic, or electrical" device at each crossing warning system be maintained in accordance with the system's limits for any warning system apparatus.[391] As for gate arms, regulations state that gates should close no less than three seconds after flashing lights appear and remain positioned no less than five seconds prior to any train.[392]

Once testing began, the Colorado Public Utilities Commission and FRA were not satisfied with the warning times, but did not have a specific regulation to challenge, as the design followed industry standards. After the University of Colorado A Line was opened for service a software glitch in the at-grade safety gates at vehicle crossings caused the gates to open and close at static times that did not account for potential train delays or early arrivals.[393] This error required the agency to operate under a waiver from the FRA.[394]

The regulators' primary experience prior to this project had been on rural freight projects, and there was general agreement across all stakeholders—including the regulators, RTD, and DTP—that the regulation of crossing gates for passenger rail in an urban setting was uncharted territory. Under current FRA policy in Section 255, a minimum of 20 seconds is required for grade crossing warning systems to signal an oncoming train, however no maximum number has been imposed.[395]

RTD's contract indicated that the agency was responsible for regulatory compliance, since they are the Railroad of Record. However, the lack of clarity over interpretation of the regulation ultimately left DTP responsible for additional costs incurred, as they were the concessionaire for the Eagle P3 and RTD believed they would comply with the regulations. The proposed solution while the issue was sorted out was to deploy crossing gate guards ("flaggers") at each gate on the University of Colorado A and G lines.[396] DTP filed a lawsuit for $122 million for the cost of crossing guards, and RTD filed a countersuit of $120 million for bridges that were not designed to the proper standard and had to be rebuilt, which left less time for testing of crossing gates.[397]

This issue does highlight a somewhat unique regulatory risk with rail transit projects. These projects generally require the final approval of some independent regulatory body before service can commence. The risk allocation for this factor and how much contractors would apply to this risk (if so allocated) is an important consideration.

RTD also experienced challenges with water and utility regulators and operators. Water management policies in the intermountain west have created the notion that "water is king" which presents challenges for major projects whose alignments run next to water infrastructure. In the case of the North Metro line, the project is adjacent to a large wastewater treatment plant, crosses the Platte River three times, and parallels an irrigation canal. Acquiring land from the entities that manage these assets was a challenge and ultimately, RTD negotiated five major agreements with third parties that were not originally in place when they issued the notice to proceed to contractors.

Further issues arose when coordinating utility relocation. RTD was the party of record in agreements with utility companies, and the agency considered coordination with utilities as an area that needs improvement. Despite RTD being the party of record, there was originally no clear delineation of who—RTD or DTP—would provide reports on testing activities to utility companies. For example, reports of a breaker tripping were never reported to Xcel Energy, which strained relationships between RTD, DTP, and Xcel Energy. As a result, RTD indicated that rather than relying on contractors to provide utility companies with reports of test activities, the agency itself should be responsible for these notifications as the party of record.[398]

Early coordination between internal and external stakeholders can help to mitigate unanticipated challenges. Bringing entities that are not directly party to the contract but that are otherwise affected by a project into negotiations sooner rather than later can avoid delays or costly changes later in the project.

5.4 Minneapolis-St. Paul

Transit project delivery in the Twin Cities is characterized by an evolution in approaches that the region has refined to fit its needs. In developing mega-projects roughly once per decade, officials have placed more emphasis on community engagement and increased the amount of control retained by public agencies over project details. This and several other factors have resulted in per-mile costs increasing from an average of $83 million on the Blue Line in the early 2000s to an estimated $138 million on the extension currently under construction.

Governance Overview

The Minneapolis-St. Paul region has a unique governance structure for building and operating rail transit that involves multiple state and local entities. The **Metropolitan Council** is the region's MPO, planning agency, and transit operator. The Met Council is controlled by the Governor of Minnesota, who appoints each of its 17 board members. However, its members must reside in and represent regional districts that are sized based on population, effectively adding a local element to the agency's governing body. **Metro Transit** is a division of Met Council and is responsible for operating commuter rail, light rail, and most regular-route bus service in the region. It is also the primary agency responsible for delivering major transit capital projects. The agency receives the bulk of its operating funds from state and county sources, and most of its capital construction funds from county and federal sources.

The Twin Cities metropolitan area includes seven counties, all of which play a major role in planning and funding transit capital projects. In 1980, the Minnesota Legislature passed the Regional Railroad Authorities Act which required counties to create "**regional railroad authorities**" to acquire, plan, tax, and execute rail projects across the state.[399] This was partly in response to freight railroads abandoning lines as well as a desire for the state to consider developing passenger rail corridors. For transit, the counties coordinate with the Met Council to create a plan for light rail lines and are responsible for beginning the planning and environmental review process. Once those documents are drafted by county staff, they are handed over to Metro Transit to deliver the project. The counties are also able levy taxes to pay for a portion of the construction of those lines. The county regional railroad authority boards are the same as the county boards of commissioners.

The **Minnesota Department of Transportation (MnDOT)** is actively involved in transit corridor construction in several ways. Transit lines often cross or run parallel to state roadways, so MnDOT staff assist in project designs that affect their assets. Given its expertise, MnDOT handled the purchasing of ROW on behalf of Metro Transit for the first lines, and now supports Metro Transit's in house staff. Although not directly from MnDOT, the state provided some of the funding to the Green and Blue lines.

System Overview

Rail transit in the Minneapolis-St. Paul region consists of a two-line light rail system that has been built out over the past two decades, with an extension to one of the lines currently under construction. The light rail network interfaces with the region's bus network, commuter rail line, and several bus rapid transit lines. The system is mostly at grade, and the costs per mile of the two projects are roughly in line with other at-grade rail projects elsewhere in the country.

The evolution of the approach to project delivery is evident through the differences between the two light rail lines (shown in Table 11) that have been constructed.

TABLE 11: TRANSIT LINES PROFILED IN THE MINNEAPOLIS-ST. PAUL REGION

	Year Opened	Time to Construct (months)	Length (miles)	Percent Tunneled	Stations	Primary Delivery Method*	Cost	Cost Per Mile
Blue Line Light Rail	2004	41	12	15%	19	DBB	$951 million	$79 million
Green Line Light Rail	2014	45	9.8	0%	23	DB	$1.2 billion	$118 million

**A single delivery method is not always used on an entire project.*

Scope changes can be kept to a minimum through effectively-run DB procurement methods.

The Blue Line, also called the Hiawatha Line, was the first light rail line delivered by the Met Council. The project broke ground on January 17, 2001 and began partial service in June 2004.[400] The 12 mile long line consists of 19 stations, connecting the Minneapolis central business district, the Minneapolis St. Paul International Airport, and the Mall of America in Bloomington.[401] While officials hoped to complete the line in 2003, opening was delayed by a year mainly due to route modifications and cost escalations due to inflation. The line began full service on December 4, 2004, 27 days ahead of the revised opening date after its initial delay.

Despite being on the planning books for years, the Blue Line did not move forward until it had completely secured its funding. Several political factors helped the project sponsors assemble the funding sources that enabled the project to become a reality (see Table 12). The governor and state legislature were in favor of the project and contributed over $120 million in state funding. The Hennepin Regional Railroad Authority put forth $84 million and the airport provided $87 million to provide transit access underneath its terminals. Lastly, Metro Transit was able to secure over 50 percent of its funding from federal sources.

TABLE 12: BLUE AND GREEN LINE FUNDING SOURCES

	Blue Line		Green Line	
Funding Source	**Amount (2001 dollars)**	**Share**	**Amount (2010 dollars)**	**Share**
Hennepin County Regional Railroad Authority (HCRRA)	$84.2 million	12%	$28.2 million	3%
Counties Transit Improvement Board (CTIB)			$284 million	30%
Ramsey County Regional Railroad Authority (RCRRA)			$66.4 million	7%
Metropolitan Airports Commission Grants	$87 million	12%		
State of Minnesota	$120.1 million	17%	$91.5 million	10%
Federal Transit Administration (FTA)	$374.2 million	52%	$478.5 million	50%
Federal Surface Transportation Program and Congestion Mitigation and Air Quality Improvement Program	$49.8 million	7%		
City of St. Paul			$5.2 million	<1%
TOTAL	**$715.3 million**	**100%**	**$956.9 million**	**100%**

Source: Federal Highway Administration, 2020; Lucy Thompson, City of St. Paul. 2010

Once the funding package was complete, a new Hiawatha Office was created at Metro Transit to manage the project's final design and delivery. The office brought in planners and project managers from Met Council, the airport, and MnDOT, among others.

The 1.8 miles segment of rail underneath the airport partially utilized an existing tunnel and used TBMs for the remainder. According to engineers, the tunnel boring conditions at the airport are ideal: a limestone cap with sandstone underneath. Such geology made the tunneling both easier and faster. The project also utilized existing ROW and bridges, which further reduced complexity and cost. Metro Transit decided to deliver the Blue Line using a DB procurement, which made design changes more difficult and costly to make, minimizing the number scope modifications. Some of the limits on betterments were tied to the route: much of the project's ROW is on either an industrial corridor or airport property, limiting impacts on the local community and minimizing the need to acquire private property.[402]

Metro Transit also had success relocating utilities, despite legal action by some companies. For example, when constructing the Blue Line in downtown Minneapolis, the electric utility company, Xcel Energy, agreed to move their utilities at their own expense, as required by state law. Metro Transit worked with MnDOT given their expertise in utility relocation but when MnDOT took control of the project's ROW to help with relocation, Xcel argued that they did not have enough access to some of their other facilities. A lawsuit ended up in the Minnesota Supreme Court, which ruled that the electric company had no ability to change its previous agreement with Metro Transit.[403] Creating smart agreements early on in the process benefited Metro Transit and reduced project costs.

DBB allows for more public sector control over the design process.

The Green Line was the region's second rail transit line, connecting the Blue Line in downtown Minneapolis, the University of Minnesota and downtown St. Paul by adding 11 miles of new track. In 2008, the Met Council approved the project and the project's final EIS, FTA approved the project's final design in May 2010, and construction began in December 2010. Revenue service began in June 2014.[404]

The region made several changes to its project delivery approach with the Green Line. First, it relied more heavily on county funding, with the counties contributing nearly 40 percent of the project costs. Increased funding from local sources allowed the project to proceed without securing as much political support from the state legislature as was necessary for the Blue Line.

Metro Transit and the counties decided to use a DBB procurement method, despite the timeline and budget success it had using DB on the Blue Line. This decision was mostly because the project sponsors wanted to retain more control over the design of the project and its stations.

Metro Transit also decided to dedicate multiple staff to community engagement, particularly given the line runs through several immigrant communities. These staff worked with residents and business owners and often spoke the languages that were common among nearby residents. Metro Transit surveyed the community, conducted focus groups with key constituencies, and posted online maps where people could call out specific complaints or suggestions and pin them to the map. When soliciting feedback, staff made it a priority to respond to every comment they received.

This thorough community engagement led to many changes and additions to the project scope, with many interviewees characterizing the betterment process on the Green Line as having "blossomed," "intense," and, in some cases, "out of control." The project ultimately became more than just a light rail project, but an opportunity to redo the entire streetscape and underground utilities across the project's alignment. The University of Minnesota also had several demands, including the inclusion of "floating slab" track sections to mitigate vibrations and noise. These requests resulted in additional costs, which were absorbed by the project.

Despite the increased costs, community engagement did result in enhancements that greatly improved the project. For example, the outreach teams learned that the proposed stations in the heavily minority and immigrant communities along the line were too far apart. Planners changed the design and added new stops to serve these communities, elevating their voices and allowing them to communicate with Metro Transit. These modifications and design decisions made the Green Line project 18 percent more expensive on a per mile basis than the Blue Line, even though the Blue Line involved tunneling.

The designers also made several decisions that positively affected the project timelines and costs, including the retrofit of the existing Washington Avenue Bridge across the Mississippi river to accommodate light rail tracks instead of constructing a new bridge, which saved at least $75 million and 2 years of construction. They also ran underground utilities, like water lines, on both sides of the tracks so future utility work would not affect rail service. Learning from the challenges with the Blue Line, utility companies negotiated from a stronger position up front and received some reimbursement for relocation. One interviewee noted that utility upgrades and relocation often remain the responsibility of private companies or utilities, but it is often easier for the project team to assume this responsibility to save time, and thus money.[405]

The region is currently extending the Green Line 14.5 miles southwest of downtown Minneapolis as part of the Southwest LRT Extension project. The approximately $2 billion project is being delivered using a DBB procurement. While Metro Transit is still utilizing a DBB procurement, any betterment proposal is paid for by the requesting entity, which is either a locality, utility, or MnDOT.

While projects are constructed relatively quickly, planning often takes decades to complete.

One of the successes of the Twin Cities' project delivery approach is the largely on-time and on-budget completion of the Green and Blue lines. However, interviewees consistently mentioned that the projects had been in planning for years, if not decades prior to the official start of the project. As a result, the region has taken significant time to build out its light rail network, and the years in between projects made it difficult for the agency to retain its project delivery staff. These costs and timelines are not considered in assessing transit project delivery.

Met Council began exploring light rail networks and working with the community on alignments in the 1980s. This involved myriad studies, community engagement, and exploring of alternatives. Much of this time was spent in "analysis-paralysis" mode and arguing over the merits of light rail in general. By the time funding was complete and the project was ready to begin, many of the major issues and alternatives had been worked out. As a result, the Twin Cities has a strong culture and involved process for community engagement manifested in frequent public meetings and staff dedicated to working with the community and resolving issues during design and construction.[406]

However, several interviewees complained that in the Twin Cities region, Metro Transit must seek municipal consent from local jurisdiction on alignment and station locations. While the agency can override a local rejection of the preliminary plan, the project would face challenges in the form of non-cooperation during construction. Therefore many of the routes chosen for light rail are those that are most politically expedient and cause the least disruption—such as along freight rail or highway corridors—rather than

dense areas where transit would make the most sense for future riders. The region's high emphasis on community engagement can also absolve leaders of their responsibility to make tough decisions. This dynamic can undermine support for future extensions, as the resulting transit lines are not as useful as they could be.

THE ROLE OF THE EUROPEAN UNION IN PROJECT DELIVERY

Public transportation projects in Europe are largely planned, funded, and delivered at the national and local levels. However, the European Union plays a limited role in funding and overseeing select projects, as well as setting guidelines for environmental assessments. This funding and oversight role is handled by the European Commission, the EU's executive branch. The Commission is organized into multiple departments and executive agencies according to policy area.[407] The Directorate General for Regional and Urban Policy oversees the segment of the EU budget that funds urban transportation projects, and consults with other DGs, including the DG of Mobility and Transport.[408]

The EU sets some high-level transportation policies aimed at meeting specific goals like decarbonization, adoption of new technology, and reducing disparities in economic development between member states.[409] Among the more specific goals of the EU is the completion of the Trans-European Transport Network (TEN-T).[410] The EU provides funding and financing assistance to member states for TEN-T projects which are primarily cross-border rail and road projects. There are, however, some public transit projects that receive funding under this program. For example, Metro line 8 in Madrid, which provides a connection from the city center to the Madrid Airport, which is deemed an international connecting point for the TEN-T network. As a result, the European Union covered 76 percent of the project cost through its Cohesion Fund.[411]

The EU also sets general standards for formatting, processes, and environmental impacts to be considered through its Environmental Impact Analysis (EIA) directive (Directive 2014/52/EU).[412] The EIA directive details the selection criteria that should be used to determine whether or not to prepare an environmental impact statement, including project characteristics, location, and the anticipated extent of potential impacts. The directive also requires public notices and consultation opportunities during various stages of the project development and environmental assessment phase.

While this directive specifies the general structure, form, and content of environmental impact statements, each member state is responsible for adopting its own law and process. The most recent amendment of this directive in 2014 instructed member states to streamline environmental reviews, enact time limits on the environmental assessment process, and simplify language to make EIA reports more accessible to the public.[413]

5.5 Copenhagen

Copenhagen opened its first rapid transit system for service in 2002 with the completion of the initial segment of the 12.7 mile M1 and M2 lines, which serve 22 stations (the remaining stations were opened in 2007).[414] Since 2007, the region has expanded its system by 11 miles and 19 new stations through two new lines, with additional extensions underway. Among the unique features of the Copenhagen Metro are compact, standardized station designs and short but frequent fully-automated trains, which help to keep costs low without sacrificing capacity during peak hours.

The Metro was funded largely using "value capture," (using increases in land values due to new infrastructure being built) as part of a larger urban redevelopment effort, which is unique for transit projects of this scale, and is touted as helping to revive the region's economy. Surplus revenues from operations funded nearly half of the construction costs for the initial segment of the Metro. Additionally, the Copenhagen Metro is operated by a state-owned corporation owned jointly by the national government and municipalities, which has been able to successfully build up an experienced project delivery staff in a short amount of time.

Governance Overview

Major infrastructure projects in the region are primarily carried out by privately managed corporations often owned jointly by the national government and relevant municipalities. The **Ørestad Development Corporation** was the state-owned, special purpose corporation created in 1993 to redevelop Ørestad, a former military training ground in Central Copenhagen owned jointly by the Danish Ministry of Finance (45 percent) and Municipality of Copenhagen (55 percent).[415] The Corporation was also tasked with building the initial phase of the Metro (the M1 and M2 lines), which was funded using value capture from the redevelopment of Ørestad.[416] In 2007, the transit and urban redevelopment arms of the Ørestad Development Corporation were spun off into two separate entities: Metroselskabet and the Copenhagen City and Port Development Corporation.[417]

Metroselskabet is responsible for both constructing new lines and operating and maintaining the Metro. Ownership of the Metro is split between the Municipality of Copenhagen (50 percent), Municipality of Frederiksberg (8.3 percent), and the national Ministry of Transportation and Housing (41.7 percent).

Metroselskabet is governed by a nine-member Board of Directors. The Danish Government and Municipality of Copenhagen each appoint three members, and the Municipality of Frederiksberg appoints one member (along with one alternate member). The remaining two members are elected by the employees of Metroselskabet. All board members serve four year terms.[418] Metroselskabet's day-to-day affairs are managed by

a CEO and a four-person group of directors. It contracts out the day-to-day operation of the Metro to *Metro Service A/S*, a joint venture between Azienda Tranporti Milanesi (Milan's public transit operator) and Hitachi Rail STS.

A similar state-owned enterprise model is used for the Greater Copenhagen Light Rail project, which is being delivered by **Hovedstadens Letbane**, a publicly-owned company that shares its staff and CEO with Metroselskabet. This light rail corporation is owned by 11 suburban municipalities as well as the Capital Region (the Copenhagen regional government). All municipalities and the regional government have a representative on the company's Board of Directors, which meets six times a year.[419]

In addition to serving as a partial owner of the Metro, the **national government**'s role is primarily to approve projects through the passage of construction acts in parliament, approving environmental review documents, and granting safety approvals, though the national government was responsible for granting building permits for the City Ring line. The Danish Parliament approves the national construction acts, which are required for all major infrastructure projects of national significance. The construction acts detail the alignment and proposed stations of a project, and delineate the roles and responsibilities of various authorities on the project (i.e. the Minister of Transportation, Metroselskabet, and the municipalities).[420] Specific processes for handling land acquisition, construction notices, utility relocation, and complaints are also outlined in the construction act. Additional elements like working hours or acceptable noise levels are included in either the construction act or the project's environmental impact report, which is adopted as part of the act. One the act is passed, it carries the weight of parliamentary approval, and all parties and stakeholders are bound to its terms and rules, providing an efficient way to hammer out all concerns and questions, as well as formally establish agreement on the rules and authorities of all parties.

The region's **municipalities** serve as the authority for granting building permits for most major projects as well as helping prepare environmental review documents. Leaders and staff from the national government and municipalities also meet annually with Metroselskabet's Board as part of a partnership meeting of the company's owners, allowing public sector staff and representatives to stay aware of project developments and influence high-level decisions.[421] The Municipality of Copenhagen retains dedicated technical staff to support companies in which the municipality has either a full or partial ownership stake. This staff works closely and frequently with the leadership of the state-owned companies (like Metroselskabet), which are often run by political leaders. When political officials on the board have new proposals or questions about projects or major decisions, they are able to request analysis and answers from the technical staff at the municipality.

With the exception of certain holidays, there are few national labor regulations in Denmark. Wages, sick pay, pensions, parental leave, and other **labor** elements are

largely established through collective bargaining agreements between employees and employers at the industry level. Collective agreements among industry associations and trade unions are typically negotiated every three years. Most trade groups involved in Metro construction, like concrete workers and bricklayers, have their own collective agreements at the industry level. There is a strong relationship between Metroselskabet, its contractors, and the various trade unions, and that labor is a stable element of project delivery in the region.

While political officials have sizeable influence and power over publicly-owned companies like Metroselskabet, there does not appear to be a significant politicization of these entities. The close relationship between civil servants and technical experts at the municipalities and political leadership of the Board was cited as playing a large role in keeping political influence away from the decision-making process, and allowing Boards to utilize public sector expertise.

System Overview

TABLE 13: TRANSIT LINES PROFILED IN THE COPENHAGEN REGION

	Year Opened	Time to Construct (months)	Length (miles)	Percent Tunneled	Stations	Primary Delivery Method*	Cost	Cost Per Mile
Initial Segment (M1 and M2 light metro lines)	2002 (extension to airport opened in 2007)	72 (initial segment), 30 (airport extension)	13.0	48%	22	DB	$2.3 billion	$176 million
City Ring Light Metro Line (M3)	2020	106	9.6	100%	17	DB	$3.8 billion	$393 million
M4 Light Metro Line	2020	63	1.4	86%	2	DB	$492 million	$350 million
M4 Line Light Metro South Extension	2024***	N/A	2.8	100%	5	DB	$1.3 billion**[422]	$466 million
Greater Copenhagen Light Rail	2025***	N/A	17.4	0%	29	DB	1.2 billion**[423]	$69 million

**A single delivery method is not always used on an entire project.*
*** Projected costs for unfinished projects*
**** Projected opening dates*

The M1 and M2 Lines share a common 4.8 mile section through central Copenhagen and include a mix of both tunneled, elevated, and at-grade segments. These lines were delivered using a DB procurement. An international consortium known as Copenhagen Metro Construction Group (COMET) was awarded the contract for civil works and the international firm COWI provided project management and engineering consulting services. Ansaldo STS (Now Hitachi STS) served as the systems contractor, and Rambøll served as the systems consultant. The M1 and M2 lines were the region's (and the country's) first major rapid rail transit project, and were built at a cost-per-mile comparable to several U.S. light rail projects despite being tunneled for nearly half of their alignment.

The M3 line of the Copenhagen Metro, known as the City Ring line, runs in a fully-tunneled loop around Central Copenhagen and is one of the largest construction projects ever undertaken in Denmark.[424] The City Ring was approved by the Danish Parliament in 2007 and construction sites were set up in 2011, with tunneling beginning in 2013. A joint venture was awarded a contract for civil works and design while a separate contract was awarded for architectural finishes on the stations.[425] The project was delayed by nine months and completed $400 million over budget.[426] Despite this delay and cost overrun, it was tunneled at a cost significantly less than comparable projects in the United States.

A two-station, 1.4 mile extension of the City Ring line from Østerport to North Harbor was completed in 2020, and branded as the M4 line.[427] Metroselskabet is currently building a 2.8 mile, five station extension of the M4 Line from Copenhagen Central Station to serve the South Harbor district. The extension was approved by Parliament in 2015, and is expected to be complete by 2024.[428] Once complete, the M4 line will share much of its track with the City Ring Line.

Hovedstadens Letbane is currently building the Greater Copenhagen Light Rail project, a 17.4 mile light rail line expected to be completed in 2025. The light rail line will serve 29 stations in suburban Copenhagen, and interface with the region's commuter rail (S-Bahn) system. The light rail line will largely run along its own grade-separated track, but share ROW with vehicular traffic in a few segments due to space constraints. This project has also been procured as a DB project, though it is split up into several smaller packages. The LRT is split into eight major contracts: five of which are civil works contracts, representing different sections of the project alignment, and one each for systems and rolling stock.[429] Breaking up the contracts in this way was intended to attract more competition and allow for the participation of local and small businesses.

As a relatively new system that was constructed at a cost-per-mile in line with comparable projects in Europe and the United States, albeit with some delays and cost overruns, the Copenhagen Metro offers valuable lessons learned regarding project management and design.

The City Ring line is a particularly useful example to highlight both positive and negative cost and timeline drivers given construction delays and challenges, as well as positive coverage of its engineering methods and architecture. The Greater Copenhagen Light Rail project, though currently under construction, is projected to be completed at a relatively low cost-per-mile relative to both European and U.S. light rail lines.

Standardization, small stations and automated trains can keep project costs down without sacrificing capacity.

The Copenhagen Metro is notable for compact yet spacious stations with ample natural light, and small but frequent automated trains that run at high frequencies to handle rush-hour demand without overdesigning stations. This approach was part of a deliberate desire to avoid over-designing stations to meet peak service, which would leave station space largely underutilized during non-peak hours.

The Metro uses standard, automated trains produced by Hitachi Rail Italy that span a total length of 128 feet and contain just three cars, considerably shorter than trains on other European and U.S. metro systems. The system compensates for the reduced train capacity by running trains as often as every two minutes, which is possible due to the system's automation. This also enabled stations to be designed with shorter platforms and compact footprints that span just 210 by 65 feet. These cut-and-cover stations fit comfortably within the existing urban fabric of the city, and are often located above existing or new parks and plazas to minimize land acquisition and street disruption.[430] They have an average depth of 65 to 98 feet, with the exception of the City Ring station located just outside the entrance of the 18th century Marble Church.[431]

Using a modular "kit-of-parts" approach, the architects of the Metro also standardized sizes, materials, and components for their stations to minimize costs and allow for easy repairs.[432] Architects designed as many parts as possible—including wall cladding, platforms, and screen doors—to be either 18 feet wide or tall, allowing for easy replacement of damaged parts and less expensive maintenance.[433] One of the few custom elements of the stations on the new City Ring line are colors and materials of the wall cladding, which are intended to give each station its own unique look while still retaining standard sizes.

Architects were also encouraged to challenge and find new methods to meet fire and safety regulations and streamline designs. Among these solutions are dual-purpose features like skylights that allow natural light onto the platforms while doubling as NFPA 130-compliant ventilation devices in the event of a fire, reducing the need for mechanical ventilation devices or equipment rooms in the stations. This approach cut the number of necessary escape shafts by 30 percent.[434] Architects also pushed heavily for the inclusion of platform screen doors, which can not only protect riders from falling onto the tracks but also make it easier to ventilate stations by isolating and sealing off the platform from the tunnels in the event of a fire.

Innovative funding structures can keep costs down, better integrate land use with transportation, and galvanize public and political support to help speed up project delivery.

The Copenhagen Metro is unique in being funded entirely through value capture and the redevelopment of publicly owned lands through state-owned, but privately managed, corporations. During the late 1980s and early 1990s, both the municipality of Copenhagen and Denmark faced a stagnant economy and high unemployment. As part of a major effort to re-invigorate the capital region, the national and local governments partnered to identify ways to boost the city's tax base, attract new residents, and spur economic development.

A national subcommittee proposed new transportation options and identified value capture as a financing mechanism that did not involve raising taxes. The subcommittee recommended developing a new district anchored by Ørestad, a 0.58 square mile area of undeveloped military training ground in South Copenhagen jointly owned by Denmark and the City of Copenhagen, with a Metro system as its backbone.[435] The Metro was intended to not only connect centers and neighborhoods across Central Copenhagen, but also spur new development and increase land values in Ørestad, which would in turn help fund the Metro and other new infrastructure.

In 1991, the concept of developing Ørestad and Metro were presented to the Danish Parliament, which passed the Ørestad Act in 1992.[436] This act officially authorized and created the Ørestad Development Corporation and tasked it with selling land and developing Ørestad, as well as building and operating a new mass transit system. The Ørestad Development Corporation took out low-interest, state-backed loans against projected future fare revenue and the sale of publicly owned land, ensuring long-term financial stability over the 40 year-long development of the new region and Metro system.

A significant amount of revenue from recent redevelopment projects carried out by the CPH City & Port Development company have been transferred to Metroselskabet to finance new Metro projects. While the M1 and M2 lines were primarily funded by the redevelopment of Ørestad, the City Ring Line has been largely funded by the redevelopment of Copenhagen's North Harbor.[437] To help generate additional land for this redevelopment project, surplus soil and muck from the metro tunnels are deposited into a concrete structure along the water. Nearly 3.1 million tons of muck from the City Ring tunnels have been used to create new land in the North Harbor. Redevelopment of the North Harbor has generated nearly $15 billion in new value, with $5.8 billion redirected to the Copenhagen Metro ($2 billion of which was dedicated for the construction of the City Ring line).[438]

Metroselskabet has also reported an annual profit for much of its operational history, and receives most of its revenue from fares, which are used to repay construction loans.[439]

The ability for Metro to run an operating surplus has largely been attributed to the lack of overhead costs from having a driverless system.

In contrast to the Metro, which is funded through land value capture, the city's light rail is funded directly by the cities, as it operates on existing ROW through suburbs that are already fully built out. While the national government does not have an ownership stake in the light rail corporation, it is covering 40 percent of the project cost. The municipalities are jointly responsible for 34 percent of construction costs, while the Capital Region will cover the remaining 26 percent.[440] The municipalities' share of construction costs is calculated according to population, the number of stations in each municipality, and projected growth rates.

Like the Metro, the municipalities all share ownership of the light rail project, including all risk, construction costs, and operating expenses. As a result, any cost overruns on the light rail project will be shared amongst the municipalities. By requiring all stakeholders to have a direct stake in the project outcome (and final cost), this governance and financing structure was cited as helping keep all 11 stakeholders focused on the communal benefits of the project and preventing municipalities from attempting to extract as many concessions from the project as possible.

Institutions with appropriate staff and legal authority can deliver projects effectively, but lack of coordination can slow down delivery.

As a publicly-owned, privately managed corporation, Metroselskabet has substantial legal authority to complete major projects, which is codified in law by the passage of construction acts in parliament. Metroselskabet has also developed the in-house capacity needed to deliver projects effectively. Given the wide mandate of the Ørestad Development Corporation, Metroselskabet's predecessor, to both develop a new region as well as build and operate a new rapid transit system, the corporation had to stand up a team of experts in a short amount of time.[441]

While the M1 and M2 lines relied heavily on outside consultants, Metroselskabet has since brought a significant amount of work in-house, including project management. This is both a result of Metroselskabet gaining significant project delivery experience (and growing popularity as an employer) from the M1 and M2 lines, but also due to the shortcomings of overreliance on consultants. There was a consensus among interviewees that consultants are very helpful in providing specific, technical expertise but are often not good at making major decisions. This became problematic on the M1 and M2 lines, and was one of the reasons why Metroselskabet opted to build an internal staff for future projects and instead rely on consultants for specific technical expertise it could not afford to retain in-house.

There is not a major salary disparity between Metroselskabet and the private sector, making it much easier for the company to attract and retain qualified staff. Additionally, Metroselskabet is able to offer unique and interesting roles for prospective employees that allow them to gain more diverse work experience than they would otherwise gain as private contractors. Many jobs at Metroselskabet also allow technical specialists to gain significant knowledge in their field and become experts, which has also helped attract talented staff. Many of the staff that worked on the City Ring project have transferred to working on the Greater Copenhagen Light Rail project. As a result, the light rail corporation has been able to rely almost exclusively on in-house staff with consultants limited to design and technical analysis.

While Metroselskabet has been successful in building out an experienced team, both the M1 and M2 lines as well as the City Ring line experienced schedule delays and were completed over-budget. To minimize disruptions and delays on the M1 and M2 lines, the project team identified a "critical path" of major milestones and potential bottlenecks that had to be receive close attention in order to move the project along.[442] One contractor, however, noted that this heavy emphasis led to the project team paying less attention to elements that did not seem to pose an urgent threat to the project timeline or progress, but ended up causing headaches and requiring more time to resolve.[443]

The M1 and M2 lines were delivered two years later than planned, largely due to issues and delays during the preliminary stages of the project.[444] Delays were mostly attributed to slow design review turnarounds from the Metro staff, communication delays given that designers and specialists were stationed across Europe, rather than in Copenhagen, as well as insufficient time allocated for coordinating design documents.[445] There were also at least $385 million worth of claims filed by the contractors on the M1 and M2 lines against the project.[446] While most of these claims were due to the early delays on the project, others were a result of instances where the contractors' decisions on architectural appearances and other functional elements of the project conflicted with the specific wants or desires of the project owners.[447]

To prevent similar conflicts between contractor's design decisions and Metroselskabet's preferences, Metroselskabet bid the architectural finishes on the City Ring stations separately from the tunneling and civil works contract. This approach was intended to attract firms with specific expertise in each area, but also allow Metroselskabet to retain more control over station architecture. Metroselskabet eventually migrated the station contract into the larger DB contract, though this approach introduced unnecessary legal complexity, with some feeling it would have been better to manage both contracts separately.

Tunneling beneath a dense, historic, low-lying city is uniquely challenging.

Both the M1 and M2 lines as well as the City Ring experienced successes and challenges tunneling through dense, historic, and geologically sensitive areas within Central Copenhagen. The contract for the M1 and M2 lines explicitly noted that no damage could be done to any of the historic buildings along the alignments. These lines also ran through portions of Central Copenhagen that were incredibly sensitive to groundwater lowering.[448]

Strict environmental regulations posed further engineering challenges. On the one hand, the project team was required to minimize the use of chemicals underground to prevent contamination of the groundwater supply. On the other hand, contractors were limited in their ability to draw down the water table below the city center.[449] Contractors cited early environmental assessment and multidisciplinary cooperation between geologists, engineers, and environmental scientists as critical elements for overcoming these geotechnical complexities.[450]

The City Ring faced similarly complex tunneling conditions given its proximity to much of the city's historic, Medieval architecture. Prior to the tunneling work on the City Ring line, archaeologists discovered artifacts from the late Viking age underground, including a 16th century shipwreck and city gates dating back 1,000 years.[451] The project team further deployed thousands of sensors on buildings and used computer monitors to mitigate potential disruptions due to construction.[452] In some cases, nearby buildings had to be lifted by pipes to mitigate disturbances.[453] Over 22,000 monitoring stations provided 200,000 readings each day during construction.[454]

Construction work on the twin-bored tunnels for the City Ring line was divided into southern and northern portions to account for different ground conditions.[455] Whereas the southern portion of the City Ring had similar soil conditions to those of the M1 and M2 lines, the northern portion was slated to run through a mix of clay and sand, rendering it more liable to settlement of buildings than the southern portion, which involved tunneling through chalk.[456] During the geotechnical surveying phase, the anticipated 350 boreholes needed to assess the ground conditions grew to 500 due to scarce information gathered from the original 350 drillings.

Noise complaints during construction of the City Ring line introduced further challenges and resulted in one of the few high-profile instances of major project pushback and work disruption. During the peak of the line's construction in 2013, Metroselskabet requested extensions to working hours into the evenings, arguing that the additional hours would speed up construction and allow for less overall disruption. The project's standard working hours were between 7:00 am and 6:00 pm on weekdays.[457]

The municipalities granted Metroselskabet's request and allowed them to carry out construction activities that would surpass normal noise levels during this time. Metroselskabet's request and the city's justification stated that the collective noise pollution impact would not be affected by these construction activities and would comply with the noise limits outlined in the EIA report. Once evening construction began, however, an increasing number of noise complaints were filed by residents. Several resident associations filed complaints, arguing that the noise levels generated by evening construction violated the permissible levels in the EIA and construction act.

Eventually, the Nature and Environmental Board of Appeals ordered a stop to evening construction in July 2013. The complaints resulted in a seven-month delay on the project as Metroselskabet, municipalities, and Transportation Ministry negotiated a solution. Eventually, the Construction Act was amended in 2014 to clarify permissible noise levels, detail processes for adjudicating complaints or appeals, and allow residents impacted by the construction to be relocated or receive compensation if they remained (a maximum of $3,200 a month).[458] While these complaints and negotiations resulted in a lengthy delay, the amendment and compensation procedures successfully resolved the issue and allowed for construction to resume with minimal disruptions or complaints.

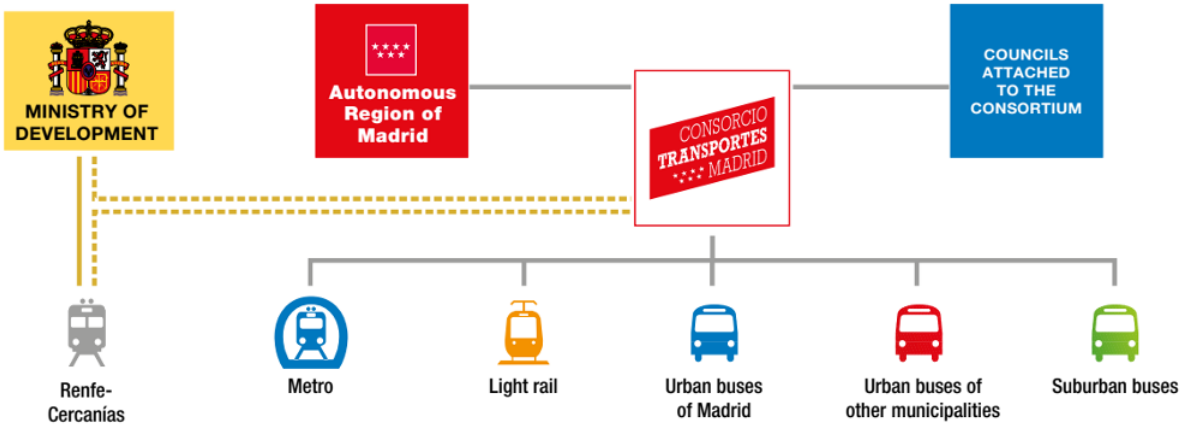
5.6 Madrid

Madrid is home to one of the most extensive networks of metro and light rail networks in the world: the Metro system alone includes 242 stations on a 179-mile long network, which connects to an extensive light rail and commuter rail network. The region experienced a building boom from 1995 through 2008 that more than doubled the size of its metro, tram, and commuter rail transit network. This rapid expansion was in large part because it was able to build some of the least expensive tunneled transit lines in history.

Expansion of the region's rail transit system has slowed markedly since 2008, with only 4.7 miles of track completed since then. This is largely because the system has been built out, and the region has been financially constrained since the European Debt Crisis of the early 2010s.

Governance Overview

FIGURE 15: PRIMARY TRANSIT INSTITUTIONS IN MADRID.



While the governance of rail transit in Madrid includes many organizations, the structure is straightforward. The **Ministry of Development** is a national agency responsible for intercity and commuter rail lines throughout the country. It funds and manages infrastructure development through a ministry-owned public company, ADIF (Administrador de Infraestructuras Ferroviarias), including the Chamartín-Atocha Tunnel under Madrid completed in 2008. The Ministry also owns the public company RENFE, which operates trains on ADIF infrastructure. RENFE Cercanías is the commuter rail subsidiary owned by RENFE. While the Ministry supports intercity and commuter rail, it rarely funds metro or light rail projects.

Urban transit systems are funded and managed through the **Autonomous Region of Madrid**. Autonomous communities are the first-level political and administrative divisions in the Spanish government. The Autonomous Region of Madrid contains the city of Madrid and 178 other municipalities.[459] The Region plans, funds, constructs,

and operates transit infrastructure through its subsidiaries, municipalities, and other organizations in which it has a stake.

The **Consorcio Regional de Transportes de Madrid (CRTM)** is a centralized transportation authority charged with organizing and coordinating all public transit modes in the region. Specifically, it plans transit infrastructure, establishes an integrated fare and information system, and coordinates transit services as well as distributes funding and resources to operating entities.[460] CRTM oversees the Madrid Metro, the light rail networks, the urban buses of Madrid (EMT), urban buses of other municipalities, and suburban buses. It also coordinates with RENFE-Cercanías. The CRTM Board of Directors consists of 20 members including 12 local and regional representatives but also two each from the national government, trade unions, and the business community. One member is appointed from the riders' union.[461] CRTM requires a majority plus one to approve plans or changes within their jurisdiction, but almost all decisions are done through consensus to ensure complete buy-in from all regional stakeholders.

Madrid Metro owns, maintains, and operates the subway infrastructure. Most of the network is within the city of Madrid, but several lines extend into surrounding jurisdictions. It has a nine person board of directors, all of whom hold offices in the regional government or the CRTM.[462] Staff at Madrid Metro work with CRTM planners to develop infrastructure plans and designs when necessary. Public funding for Madrid Metro comes from the regional government, flowing through CRTM.

MINTRA is a public company chartered and managed by the regional government and tasked with financing and building the subway expansions in the late 1990s and early 2000s.[463] Formed as a SPDV, MINTRA was responsible for designing and bidding out construction of the subway segments. It originally rented the track to Madrid Metro, but eventually transferred ownership of the lines altogether. MINTRA was dissolved in 2011.[464]

The Madrid region has 4 light rail lines (ML-1, ML-2, ML-3 and ML-4), which all opened between 2007 and 2008. They were all constructed using DFBOM public-private partnerships, with 30-to-40-year concessions to operate and maintain the lines after construction. The concession contracts are managed by either CRTM or Madrid Metro (in some cases by both), supported by funding through the CRTM and farebox revenue.

The governance structure in Madrid—with multiple operators structured like companies and a regionally-owned consortium charged with unifying planning, branding and fares—proved useful in executing construction projects. At least 20 regions around Spain have since emulated the model.[465]

System Overview

TABLE 14: TRANSIT LINES PROFILED IN THE MADRID REGION

	Mode	Year Opened	Time to Construct (years)	Length (miles)	Percent Tunneled	Primary Delivery Method*	Cost	Cost Per Mile
ML1	Light Rail	2007	31	3.3	69%	P3	$547 million	$163 million
ML2	Light Rail	2007	31	5.4	30%	P3	$559 million	$104 million
ML3	Light Rail	2007	29	8.5	10%	P3	$565 million	$67 million
Parla Tram (ML4)	Light Rail	2008	32	5.2	0%	P3	$270 million	$52 million
1995-1999 Extension Program	Heavy Rail	1999	43	34.7	68%	DBB	$4.2 billion	$121 million
1999-2003 Extension Program	Heavy Rail	2003	43	46.3	77%	DBB	$7.5 billion	$162 million
Line 2 Extension	Heavy Rail	2011	28	2.9	100%	DBB	$556 million	$195 million
Line 9 Extension	Heavy Rail	2015	66	1.9	100%	DBB	$333 million	$179 million
Chamartín-Atocha Tunnel	Commuter Rail	2008	48	4.7	100%	DBB	$1.1 billion	$234 million

**A single delivery method is not always used on an entire project.*

The subway extension programs between 1995 and 2003 represent some of the most impressive transit expansion projects in modern history. Itemized cost data on individual lines or stations is difficult to determine, in part because the projects were bundled as part of larger programs. Given that the expansions were completed nearly two decades ago, this case study presents them, along with the light rail build-out in the mid-2000s, as a portfolio of projects and intends to understand the governance and processes in place to make them a success.

Part of Madrid's ability to keep tunneling costs low is that the region has relatively consistent and soft soils that are conducive to efficient construction using TBM.[466] Spain was one of the first countries to have widespread use of TBM, with project leaders requiring their use over other, more traditional approaches like cut-and-cover and the New Austrian tunneling method.[467] Further cost savings were achieved by using single bore tunnels rather than twin bores, which are used in the United States.[468] Spain also has much lower labor costs and incomes compared to other countries, including in Northern Europe and the United States. Employers in Spain also do not have to pay for healthcare costs, an expense that American projects need to absorb.

Strong political alignment to build transit brings widespread public support to speed projects along.

Since the creation of the CRTM in the mid 1980s, the regional government had been planning to expand the region's transit system. Then led by the Spanish Socialist Workers Party, it created planning and environmental documents for new lines and

extensions. The expansion of the subways became a primary campaign issue in the 1995 regional government elections, with political factions competing on how much transit they could deliver. In 1995, the conservative People's Party won the majority of seats in the regional parliament.[469] A major campaign promise was to build 31 miles of new subway lines in the region during their 4-year term, out-promising the Socialist party opponents.[470] The People's Party made good on their commitment, constructing and opening 35 miles of new lines during their first term. During the 1999 elections, the party doubled down on the issue, promising to build an additional 47 miles during their next 4-year term. After winning an even larger majority, the People's Party led the construction of 46 miles of subway over four years.

Though the subways were built by the conservative government, the projects had broad support across the political spectrum. This shifted the political debate to how much transit should be built, rather than if it should be built at all. While there were multiple factors behind the success of the subway build-out between 1995 and 2003, the political agreement on the need for transit investment is seen as crucial to enabling rapid development of the region's network. Among other things, it led the regional government to acquire the financial resources necessary to deliver on its promise. To do so, it borrowed heavily, in some cases funding 80 percent of a line through debt. However, after the delivering the first expansion program from 1995-1999, the regional government's infrastructure ministry did not have enough financing capacity to bond directly for future expansions. Instead, the regional government created publicly owned companies and used an SPDV and P3s to enable it to borrow without the debt appearing in the government's budget.[471]

In 1999, the regional government created MINTRA, a state-owned company designed to deliver the subway expansion projects. As a governance tool, this structure was useful in delegating the specific task of project delivery to a government owned, third-party SPDV. SPDVs are often used to deliver projects, then either continue on as owners who rent access to the infrastructure, or transfer ownership over to an operator. As an independent unit, they can help staff focus on the delivering the project and managing contracts. To this end, MINTRA was created a high quality, single focus team that was successful in building out Madrid's network.

Similarly, the Madrid region used PPPs to design, build, finance, operate, and maintain its light rail lines over a 30- to-40-year period. The regional government manages three different P3 contracts, each of which involves a consortium of private sector companies. The private companies are tasked with the short-term responsibility of delivering the light rail project and the long-term task of running the line efficiently. They receive regular base payments from the regional government and a variable payment based on how many passengers they carry in a certain month. The P3s were successful at delivering 22 miles of light rail at relatively low costs, despite some lines with significant

tunneling. However, the P3 structure might not accurately portray the full upfront construction costs as some items are paid for over the life of the multi-decade contract.

However, the other reason that the regional government used MINTRA and P3s to deliver their rail lines was for clever accounting. Technically, MINTRA was considered a private entity, so its massive debt was not on the government's books. Yet being owned by the regional government made holders of MINTRA's debt confident that it had government backing, allowing MINTRA to borrow money at competitive rates. Similarly, the P3 consortia borrowed from the private market based on the availability of government payments that it would receive upon revenue service. Even though the P3 contract for the light rail lines pledge government support throughout the 30- to-40-year life of the agreement, these payments do not legally count as government debt.[472]

Using MINTRA and P3s, the regional government was able to indirectly borrow billions of Euros to rapidly fund and build its rail transit network. This debt undoubtedly helped move projects forward, but was also a major contributor to the European debt crisis that began in 2009.[473] Governments struggled to fulfill their contractual agreement to support debt service of these entities and many others across sectors, and the resulting debt crisis exposed the extent of this hidden borrowing. This fallout is a large reason why Madrid has only built 4.7 miles of new subway extensions since 2008, most of which was in the planning and construction phase before the crisis hit.

Straightforward environmental standards and processes for transit projects in urban areas is a sensible approach.

In part due to the widespread political and public support for transit expansion, most experts and stakeholders in the Madrid region remarked about the relatively straightforward environmental standards and process. Like most of Europe, Spain has high environmental protection standards, but accounting for these impacts is straightforward given the top-down approach to these processes and a friendly political environment.

Environmental review in Europe and Spain works similarly to the United States. Following EU directives, the Spanish government requires large projects to prepare a document that evaluates various environmental impacts based on a series of project alternatives and requires some level of community engagement and feedback. Once satisfied, the national and local authorities grant approval and construction can begin. Despite these similarities, a few unique factors make the Spanish environmental review process simpler and faster than in the United States.

The scope of environmental impacts assessed is limited for transit projects. Given that most of these projects run through areas that are already developed, they are not required to evaluate their impact on the natural environment, such as wetlands and

endangered species. Environmental assessments are mostly limited to construction noise, vibrations, construction air pollution and site water runoff, as well as some requirements to evaluate impacts on historical artifacts.

Additionally, permits for transit projects are simple and do not require multiple levels of review. The permitting process is unified so the regional government, CRTM, or other publicly-owned company has the ability to secure permits only once. For example, if a civil servant at MINTRA approved a design, it was not necessary for that design to be reviewed again by a civil servant at the city of Madrid. Not only does this make the permitting process faster and more controlled, but also makes it easier for the projects to avoid having to accept project betterments from localities.

Other elements like the discovery of historical artifacts are also handled in a streamlined, process-oriented fashion. If a project encountered artifacts or unearthed human remains, they became property of the national Ministry of Culture. The items are moved to a parallel area where the ministry conducts further studies, and the construction project is allowed to proceed. These processes are built on relationships between the public agencies and the construction managers, which helps foster trust among all parties.

Projects with minimal construction limitations and restrictions reflect widespread public support.

Community engagement for transit construction in Madrid is fairly limited. In Spain, the environmental review and design processes happen concurrently, and community engagement is mostly a top-down affair. The general perception around community engagement is that the government—in this case the regional government, who is planning and funding the projects—represents the will of the community and is thus empowered to make planning decisions.

Planners and designers hold public meetings to inform residents about project plans and solicit feedback. Neighbors do request changes, including the location of entrances and construction phasing sites, and if the majority of residents want a change, the plans are often modified. In cases where a change results in a cost increase, project staff can (and regularly do) deny the request. With widespread ideological support for subway and light rail expansion, the judicial system is not amenable to stopping projects over a dispute.

Such expediency and reliance on top-level planners to make major decisions about projects results in utilitarian stations, with no elegant architecture or expensive finishes.[474] The subway network focuses on simple construction, wide escalators, and shallow stations to encourage rapid movement of people.[475]

While the narrowly focused environmental review and expedited community engagement helped move projects along and likely reduced costs, many of the experts interviewed believed that the Madrid system was built too quickly and with too little community engagement. Projects were effectively pushed onto neighborhoods with little concern for their particular needs or desires in a rush to meet project deadlines. This suggests that a more thorough community engagement process might have yielded more expensive but perhaps better projects.

Related, most subway projects were incredibly disruptive to neighborhoods during their construction periods. The tunneling operation was conducted around the clock and construction shut down roads for extended periods of time. This is in contrast to typical projects in the United States, where noise limitations restrict work hours for certain construction activities, and projects have limited ability to shut down traffic. The fact that Madrilenians were willing to accept construction disruption as a tradeoff for quicker completion inevitably saved the project region significant costs.

While construction was disruptive in the short term, work moved so quickly that an impacted neighborhood was back to normal again in a matter of months or weeks. For the 1995-2003 subway expansion projects, the tunnel boring machines averaged 282 feet per day, resulting in minor disruptions over the long term.[476] For comparison, the tunnel boring machines under Los Angeles in the current Purple Line extension project currently average 70 feet per day, and because the line is twin bored, the TBMs have to pass twice, causing additional disruption.[477] The slow pace of tunneling in Los Angeles is in part due to work hour restrictions and roadway access limitation imposed by local communities.

Competent in-house teams that manage multiple small contracts can effectively push major projects forward.

For the subway expansion projects, MINTRA and the regional government relied on a small team of highly qualified engineers and project managers to oversee the design and construction consultants.[478] The project managers used consultants for discrete tasks but did not use outsourced labor for managing the overall project. The strong investment in institutional capacity at the public agency or publicly owned company overseeing construction was important to the region's overall success in delivering low-cost projects.

The in-house talent was first developed at the regional government, and their skills were honed during the 1995-1999 expansion program. Much of this staff then moved to MINTRA during the 1999-2003 program, where approximately 150-200 in-house staff helped manage contracts and plans.[479] The fact that MINTRA was technically a private company also allowed it to offer higher salaries than comparable public-sector positions, attracting top talent to the firm. In addition, with promises of significant expansion and

widespread public support, national and international construction firms staffed up and were ready to quickly put together proposals.

For subway procurement, MINTRA used a DBB method. Project managers and engineers wanted significant control over tunneling methods and felt that DBB was important to keeping risks low for private bidders given the unknowns with the underground environment. Though the entire project cost billions of Euros, the subway lines were bid out in smaller, more manageable packages with contracts that rarely exceeded €200 million ($241 million).[480]

While breaking up large projects into smaller packages required managers to oversee many contracts as opposed to a single, multi-billion-euro contract, this approach held a few distinct advantages. First, if there was an issue with a contractor, the managers could focus on resolving that issue while construction continued elsewhere. Second, the discrete contracts fostered more competition and allowed small, newer firms to compete and win projects. These firms diluted the power of larger firms, avoiding situations where a few large companies dominate decision making. This competition helped keep costs down while also creating a homegrown field of experienced contractors that now work all over the world.

5.7 Paris

Paris's rail transit network is one of the largest in the world, consisting of 16 metro lines, 10 tram lines, seven commuter rail lines, five hybrid commuter-rapid rail lines (RER), and 58 bus lines. Much of the recent network extension has occurred in the city's suburbs, but still in a dense environment.

The Île-de-France region –the administrative region that includes Paris—is currently in the midst of constructing an additional 124 miles of railway tracks, 90 percent of which will be built underground, and 68 stations to primarily connect the region's suburbs.[481] This initiative is formally known as the Grand Paris Express (GPE). In recent years, the region has expanded its transit network by extending heavy rail lines and by building out its tram system, which has been in operation since 1992. This case study focuses primarily on these recently-completed buildouts, but also incorporates some takeaways from the GPE and other ongoing metro and tram construction projects.

While the recently-completed transit projects primarily represent short extensions of existing lines, Paris was chosen as a case study due to its dense urban environment and its buildout of tram lines. Because transit expansion in Paris has been limited to minor heavy rail extensions and light rail buildouts outside of the inner-city limits, this case study is aimed more at understanding the key policy and institutional factors that influence transit capital project delivery in that region than specific technical or engineering elements.

Project delivery in Paris is characterized by a robust public participation process, stringent environmental review, and strong public sector staff capacity to manage projects. Recent concerns over project timelines and costs have led project sponsors to consider alternative procurement models, like DB, that allow for more contractor input on design and increased risk transfer between public and private partners.

Governance Overview

Project delivery in the Paris region requires coordination among a diverse array of governing bodies. Funding is shared by a mix of national, regional, departmental, and local governments and some lines have also relied on borrowing. Project ownership also varies by line.

The **national government (i.e. the state)** provides financial support for some projects, and denies or grants environmental permits.[482] Through a series of decentralization laws in the early 2000s, control of transit planning and operations in Île-de-France shifted from the state to the region, though the state regained some control in transportation planning in 2010 by creating the Société du Grand Paris to execute the GPE program.[483]

The devolution of national control coincided with major investments in transit starting in 2000. France uses a six-year planning document known as a State-Regional Plan Contract (CPER) to coordinate on priorities for infrastructure planning and development between the state and the regions. The plan for 2000-2006 CPER included several major investments in tram and metro lines, many of which were completed in the following decade.[484]

Paris sits in the **Île-de-France region**, which is the most populated of the 18 subnational regions. The region provides funding for transit infrastructure and operations and manages the regional transit system.[485] Within Île-de-France there are eight administrative departments (e.g. Hauts-de-Seine to the west of Paris) or cities (e.g. Paris) that also contribute funding toward projects.[486]

Project management is handled by urban transportation organizing authorities (AOTUs).[487] A series of laws passed throughout the 1990s and early 2000s merged transportation policymaking with urban planning and environmental considerations at the local and regional levels.[488] The AOTU for the Paris region is **Île-de-France Mobilités (IDFM)**. As the integrated public transport authority for the region, IDFM designs projects to expand and improve the public transportation system, carries out preliminary project studies, conducts public outreach, manages construction contractors, and owns transit infrastructure.[489] IDFM also organizes the day to day operations of the public transportation system by creating and administering ride passes, financing operations and rolling stock purchases, and overseeing network operation by contractors like the RATP Group, Transdev, and SNCF.[490] IDFM conducts and oversees the bidding process for consulting firms and issues contracts for construction companies.

IDFM is governed by a council of 31 elected regional council members (16 representing the Île-de-France region, 5 representing Paris, 7 representing the region's departments, and one each representing the Île-de-France Chamber of Commerce, the presidents of public intermunicipal cooperation establishments, and public transportation rider associations), and has a regional council president and a separate chief executive.[491]

The **RATP Group** is a state-owned company that operates and maintains trams, metro lines, buses, and regional trains in Paris. Their main responsibility is to operate transit service, though RATP manages project extensions for existing rail lines on behalf of IDFM. RATP does not manage new project buildouts.[492] RATP has an engineering staff that conducts prospective studies for future projects and modernization work on the existing rail network.[493] RATP has a 29-member board of directors comprised of nine representatives of the state, two individuals chosen for their transportation expertise, three that represent diverse socio-economic groups, two from transit rider organizations, two elected officials from towns or regions affected by RATP service, nine

elected staff, and two other board members.[494] Together with SNCF and French banks, RATP owns 43 percent of the consulting and engineering firm SYSTRA. The company is responsible for project management across all phases of the GPE.[495]

The GPE is being delivered through a special purpose delivery vehicle, a separate state-owned corporation known as the **Société du Grand Paris (SGP)**. SGP is owned 100 percent by the French government, and was created after the passage of the GPE law in June 2010.[496] The SGP and IDFM infrastructure projects are being constructed concurrently but independently. RATP is the technical manager for the GPE.[497] The SGP has built out a team of over 800 employees, primarily concentrated in procurement and contract management.[498] As a state-owned company, SGP is able to provide starting salaries comparable to those offered in the private sector, and the company has attracted many of its current staff from private firms.

System Overview

TABLE 15: TRANSIT LINES PROFILED IN THE PARIS REGION

	Year Opened	Time to Construct (months)	Length (miles)	Percent Tunneled	Stations	Primary Delivery Method*	Cost	Cost Per Mile
Metro Line 14 Olympiades Extension	2007	73	0.4	100%	1	DBB	$189 million	$434 million
Metro Line 13 to Courtilles	2008	40	1.2	100%	2	DBB	$251 million	$213 million
Metro Line 8 to Pointe-du-Lac	2011	55	0.8	0%	1	DBB	$127 million	$157 million
Metro Line 12 to Front Populaire	2012	62	0.9	100%	1	DBB	$443 million	$476 million
Metro Line 4 to Montrouge	2013	80	0.9	100%	1	DBB	$278 million	$299 million
Metro Line 4 to Bagneux	2021***	N/A	1.1	100%	2	DBB	$526 million**	$471 million
Tram 1 Initial Segment	1992	39	5.6	0%	21	DBB	$255 million	$46 million
Tram 2 – Initial	1997	46	7.1	11%	13	DBB	$190 million	$27 million
Tram 1 – Extension to Noisy-le-Sec	2003	56	1.8	0%	5	DBB	$56 million	$31 million
Tram 3a – Initial	2006	30	4.9	0%	17	DBB	$516 million	$105 million
Tram 4 – Initial	2006	29	5.0	0%	11	DBB	$77 million	$15 million
Tram 2 – Extension to Porte de Versailles	2009	51	1.4	0%	4	DBB	$147 million	$103 million
Tram 1 – Extension to Gennevilliers	2012	40	3.0	0%	1	DBB	$222 million	$73 million
Tram 2 – Extension to Pont de Bezons	2012	64	2.6	0%	7	DBB	$335 million	$129 million
Tram 5	2013	70	4.1	0%	16	DBB	$239 million	$58 million
Tram 7	2013	52	6.9	0%	18	DBB	$432 million	$62 million
Tram 8	2014	54	5.3	0%	17	DBB	$359 million	$68 million
Tram 6 (initial + extension)	2016	68	8.7	11%	21	DBB	$561 million	$65 million
Tram 11	2017	96	6.6	0%	7	DBB	$1.6 billion	$242 million
Tram 1 – Extension to Asnieres Quatre-Routes (Phase 1)	2019	25	0.6	0%	1	DBB	$50 million	$90 million
Tram 4 – Extension	2019	38	4.1	0%	11	DBB	$364 million	$89 million

**A single delivery method is not always used on an entire project.*
*** Projected costs for unfinished projects*
**** Projected opening dates*

Projects with multiple funding sources and institutional actors can lead to lengthy bureaucratic reviews and delays.

Similar to the United States, projects in France receive a mix of national, regional, and local funding. At the same time however, project managers (e.g. IDFM and RATP) sometimes provide financing for parts of a project. IDFM receives funding from national, regional, and local governments, as well as passenger fares, and taxes on employers (which is the primary source of funding, at between 40-45 percent of IDFM's overall budget), and some gasoline taxes.[499] Whereas most of its budget is allocated to operations, a portion is dedicated to capital projects, and that amount is funded by the state, regions, and individual departments.[500]

Project ideas come about as a result of studies funded by the Île-de-France region and the French state, and carried out by the operator (typically, RATP) in close collaboration with the city. The project then moves to the Commission Nationale du Débat Public (National Commission for Public Debate—CNDP), which initiates the public consultation process in the affected jurisdictions. A consultation report is then composed to summarize the main themes of the public consultation.[501]

In 2017, France elected to integrate the disparate environmental assessments into one coordinated evaluation (requiring one application, one contact person, and one environmental permit).[502] The permit application is submitted to the prefect (i.e. the national government's representation in a given region), and the prefect conducts a review, public inquiry, and administers a decision.[503] Interviewees expressed that this environmental review process is hard to understand and the efforts to streamline it have only made it more complicated. The decision to create a unified evaluation system was intended to simplify the environmental clearance process, but has created new challenges for transit megaprojects. One interviewee noted that the full environmental impacts of construction may not be fully known until a construction contractor is selected, and the contractor's choice of digging methods can influence, for example, impacts on groundwater movement. Project sponsors may need to hire a contractor and keep them waiting for up to two years until the environmental review is complete, or risk submitting a partially incomplete assessment. With all of the tests combined into one environmental review, more extensive review is required that can add length to the project's timeline, though the ultimate effect of this coordination is still unknown since the change was only recently adopted.

Similar to the United States, projects in France face potential delays due to lawsuits brought by constituent groups that want to delay or obstruct a project. However, unlike in the United States, transportation-related lawsuits tend to be brought mostly against road projects, though pushback against transit projects does occur. The financial risk that results from litigation, opposition, and other forms of risk on average amounts to seven percent of total project costs.[504] Other interviewees felt

that political leaders often set unrealistic timelines for megaprojects, particularly in advance of elections. As a result, projects can be expected to have a six to nine month delay already baked into their timeline.

Opposition to projects are primarily based on environmental concerns. These objections may target specific impacts on species in the ROW, or focus on procedural elements or inadequacy of the environmental review process. In contrast, the GPE is generally viewed in a positive light by the public as it is seen as providing an acute need for providing improved connections between the suburbs and the city of Paris. Currently, residents living along the periphery have fewer transit options to commute between suburbs, but rather have to travel into central Paris and transfer lines.

While there was a broad consensus in favor of the GPE, one notable exception involved Line 17, which will run through the suburbs of northern Paris and serve both Le Bourget and Charles De Gaulle Airports. Line 17 was the subject of significant environmental opposition, specifically with regard to the station serving Triangle de Gonesse, a 2.9 square mile greenfield north of Le Bourget airport. As part of the GPE, the French government proposed developing 1.1 square miles of the greenfield, including a dense, 0.3 square mile commercial and retail center called EuropaCity.[505] EuropaCity, and consequently Line 17, was subject to significant pushback over the impact of development on the area's natural farmland. The project also received opposition from groups that were against the project's commercial, private nature and viewed the project as a symbol of consumerism.[506]

In a January 2018 report, the national department overseeing environmental review of transportation and urban development—the General Counsel for Environment and Sustainable Development—determined that there were significant gaps in the environmental assessment of Line 17, particularly on the impact of the project on water resources, species, and other habitats in Gonesse.[507] The report also found that the EIA did not adequately distinguish between the impacts of the metro line itself with the proposed urban development, and called for additional studies and revision and inclusion of alternative scenarios.

Citing similar inadequacies in its environmental assessment, a court in Montreuil ordered the suspension of all work on Line 17 near Gonesse for one year in November 2019 pending additional study and development of mitigation measures for the line's potential impacts on protected avian breeding sites.[508] Amid continued opposition, President Emmanuel Macron formally cancelled the EuropaCity project in November 2019, and while an alternative plan is in the works, the future of the development zone is uncertain.[509]

The suspension of work on Line 17 was ultimately overturned by a court of appeals in Versailles in November 2020, ruling that the project fell under the jurisdiction of

the administrative court in Paris, which had authority over public projects associated with the 2024 Olympics.[510] Construction on the rest of Line 17 resumed shortly after, and while the segment serving Le Bourget airport is expected to open by 2024, other elements of the line will likely be delayed as a result of the suspension.[511]

Alternative delivery methods help transfer risk between public and private partners and increase collaboration with contractors.

Transit projects in Paris have traditionally been delivered using DBB due to strict national regulations that, with few exceptions, require design and construction to be procured separately.[512] Amid legal uncertainty over whether SGP would be able to seek authorization to use DB, France modified its procurement laws to explicitly allow the company to enter into DB contracts.[513] Additional reforms to French procurement law have expanded authority to design-build in other public sectors (namely the Interior, Justice, Defense, and Health ministries), for social housing projects, and for projects that will have a net positive impact on energy efficiency.[514] As a result, there is recent interest in utilizing alternative delivery methods like DB that allow more risk to be transferred to the private sector, as well as allow for more collaboration with contractors.

In addition to a tradition of using DBB, the French and EU governments also encourage public entities to break construction contracts into multiple packages to allow for more competition. In some cases, there can be up to six contracts for a single station. While this arrangement can be convenient and help keep project timelines in check, it also requires project sponsors to be very accurate when specifying their design needs. Having a large number of contracts for individual project components can lead to contractors blaming one another for project delays and demanding compensation, with the project sponsor ultimately footing the bill.

SGP issued its first DB procurement on the East and West segments of Metro Line 15 in September 2020, which will form a 47 mile loop around the periphery of Paris as part of the GPE.[515] Technical challenges associated with the proposed La Defense and Mairie d'Aubervilliers stations on Line 16 introduced additional design and engineering complexity.[516] As a result, a DB procurement was used on this project to preserve schedule and budget while achieving the architectural goals of these complex stations.[517] DB was also attractive to SGP as a means of preventing midstream project changes and scope creep.

As part of its aim to better handle risk on major projects, SGP is also employing the use of competitive dialogues with contractors.[518] This is intended to allow for earlier contractor input on design and provide opportunities to negotiate design, risk transfer, and management on major projects with potential bidders. One of the areas where interviewees felt significant risk often cannot be transferred to a private partner is geotechnical or underground work, particularly when there are uncertainties about

the site conditions that may be encountered when tunneling. However, in cases where project sponsors have a clear understanding of site conditions, there are opportunities to transfer a sizeable portion of risk to the private contractor.

RATP is also aiming to incorporate more contractor involvement in design by modifying its procurement model. Rather than procuring a project after conducting initial design, RATP intends to put projects out for competitive bidding first, then work with the selected contractor on project design.

5.8 Toronto

Toronto is home to an extensive, 48 mile long subway network, consisting of four lines that serve 75 stations. The region is currently in the process of constructing two new light rail lines that will expand the system by 31 mile and 39 new stations.

Project delivery dynamics in the region are characterized by significant political interference and a fraught governance structure. Amid rising costs on major projects, some researchers have raised questions about the depth of subway stations and tunnels. In addition, rising construction costs have compelled the region to utilize public-private partnerships, with mixed results. The provincial (statewide) government has also recently taken steps aimed at cutting timelines on major projects, most notably by creating a separate, expedited environmental review process for transit and giving public entities considerably more power over utility relocation, property acquisition, and ability to utilize municipally-owned ROW.

Governance Overview

In metropolitan Toronto, transit planning, delivery, operations, construction, and finance are largely handed at the provincial level. Per the Canadian constitution, responsibility for intra-province transportation is delegated to the provinces, while the national government primarily oversees international and inter-province transportation services.

The provincial government has been the primary funder of rapid-transit infrastructure since the 1970s, though the federal government has become increasingly involved in transit in recent years. Amid cost overruns on the Toronto-York-Spadina subway extension (TYSSE), the province has taken over rapid-transit planning, project delivery and construction, which were traditionally handled by municipalities. The Toronto Transit Commission operations, which had received a provincial subsidy for about a quarter century beginning in the early 1970s, are city responsibilities in full.

Most recent projects are funded using provincial and local funds, though the national government contributed just under 19 percent ($579 million) to the TYSSE subway project through the Build Canada Fund, and 13 percent ($275 million) to the Finch West Light Rail project.[519] Nationally, the Build Canada Fund provided $7.2 billion towards individual infrastructure projects (contributing between 25 to 50 percent of project costs) between 2007 and 2014 and the national government is becoming increasingly more involved in the funding of major projects through programs like the Investing in Canada Infrastructure Program, in which the Canada Infrastructure Bank has committed nearly $17 billion to transit.[520] In May 2021, the federal government announced it would provide nearly $10 billion in funding—amounting to 40 percent of project costs—for the next wave of major transit projects in Toronto: the Ontario Line,

Scarborough Rapid Transit replacement, Eglinton Crosstown light rail line, and the Yonge-North subway extension.[521]

Metrolinx is a provincial agency that serves as the regional transportation authority for the Greater Toronto and Hamilton Area (GTHA).[522] It was created by the province of Ontario in 2006 to design the region's first-ever transportation plan. That plan—dubbed the Big Move—was released 2008 and set out a new $42 billion transportation program and series of major investments for the region.[523] In 2009, Metrolinx was merged with GO Transit, Ontario's regional transit system. GO Transit functions as an operational division of Metrolinx, but only operates commuter trains and commuter buses.

In 2018, the mandate of Metrolinx was amended to give it authority over transit planning, rather than wholly focusing on *transportation* planning. Responsibility for regional transportation planning was transferred to the Ontario Ministry of Transportation.[524] Today, Metrolinx has sole responsibility planning and implementing the numerous major transit expansion projects and initiatives in the region, along with other responsibilities like developing a common regional fare system. Metrolinx is governed by a board of up to 15 citizen members who must be recommended by the Ontario Minister of Transportation and approved by the Province. Prior to 2009, the board was largely made up of mayors and other elected officials from the region. After the merger of Metrolinx and GO Transit, the board's structure changed, and elected officials were removed.

The **Toronto Transit Commission (TTC)** is the exclusive local public transit operator for the city, and accounts for the about 85 percent of all public transit trips in the region. It is governed by a 10-person board, appointed by the Toronto City Council (four are public members and six are City Councilors). The TTC was the lead agency responsible for project delivery until 2015, when control was transferred to Metrolinx amid cost overruns on the TYSSE project.

Infrastructure Ontario (IO) is a state-owned enterprise (referred to in Canada as a Crown agency) overseen by the Ministry of Infrastructure and serves as the primary procurement lead for major public infrastructure projects using public-private partnerships. IO also manages the province's real estate portfolio, provides long-term infrastructure loans to public sector clients, and provides assistance for commercial projects. IO has taken on a greater role in public transit projects amid the region's shift towards utilizing P3s. IO is currently delivering the Eglinton and Finch West light rail projects using DBFM procurements. While IO and the P3 approach was intended to help the region deliver transit projects more cost effectively, construction costs have continued to rise, with cost estimates for the next wave of proposed subway lines far outpacing the TYSSE project on a per-mile basis.[525]

System Overview

TABLE 16: TRANSIT LINES PROFILED IN THE TORONTO REGION

	Year Opened	Time to Construct (months)	Length (miles)	Percent Tunneled	Stations	Primary Delivery Method*	Cost	Cost Per Mile
Line 4 – Sheppard Subway	2002	101	3.4	100%	5	DBB	$1.5 billion	$440 million
Line 1 – Toronto-York-Spadina Subway Extension (TYSSE)	2017	113	5.3	100%	6	DBB	$3.1 billion	$579 million
Eglinton Crosstown	2022***	Not yet open	12	51%	25	DBFM	$4.3 billion**	$358 million
Finch West LRT	2023***	Not yet open	6.8	0%	18	DBFM	$2.1 billion**	$300 million
Eglinton Crosstown West	2030***	Not yet open	5.7	65%	7	N/A	$3.9 billion**	$684 million
Ontario Line	2030***	Not yet open	9.6	50%	15	N/A	$9 billion**	$942 million
Scarborough Subway Extension	2030***	Not yet open	4.7	100%	3	N/A	$4.5 billion**	$971 million
Yonge North Subway Extension	2030***	Not yet open	4.6	68%	6	N/A	$4.6 billion**	$1.1 billion

**A single delivery method is not always used on an entire project.*
*** Projected costs for unfinished projects*[526]
**** Projected opening dates*

The Toronto subway is part of a larger public transportation network, including streetcars, buses and light rapid transit, run by the TTC. The subway was the nation's first, opening in March 1954. Since then, it has grown from a single, 12-station line running 4.6 miles beneath Yonge Street to a four-line system encompassing 75 stations over 47 miles. In 2019, the TTC recorded 236 million passenger trips on the Toronto subway.[527]

The Sheppard Subway line was completed in 2002 and it continues to be owned and operated by the TTC. It consists of four new stations and one reconstructed station—Sheppard-Yonge—where Line 4 intersects with Line 1. The Sheppard Subway is less than 4 miles from beginning to end, is completely tunneled, and was constructed using a mix of cut-and-cover (for the stations) and bored tunnel. It was completed using a conventional DBB contracting method.[528]

In 2017, Toronto completed a major extension of its busiest subway line, Line 1, known as the Toronto-York-Spadina Subway Extension (TYSSE). The TYSSE is a short 5.3 mile extension consisting of twin bored tunnels and six new stations constructed using cut-and-cover methods. The TYSSE was projected to cost about $1.7 billion but wound up costing $3.1 billion an overrun of 82 percent.[529]

The recently completed subway projects in Toronto are the most expensive ever built in the region. An April 2020 study analyzed a variety of potential cost drivers amid escalating transit construction costs in the region, finding that tunnel and station depth had major impacts on cost, though are not the only contributing factor.[530] Though subways cost more to build, interviewees noted that there is significant pressure in

the region to put transit underground to not only avoid surface disruption, but also because of a persistent perception that subways are inherently "better" than above-ground options. In particular, many political officials feel that subways will spur more development and place a suburb or neighborhood "on the map."

Two new light rail lines are currently under construction. The Eglinton Crosstown (Line 5) will serve 25 stations along 12 miles of track, of which 6.2 miles will be below ground. Originally expected to open in September 2020, the line has been delayed to 2022. The project is estimated to cost $4.3 billion ($358 million per mile).[531] The Finch West LRT (Line 6) will serve 18 stops (16 above grade) along 7 miles is expected to be completed in 2023 at a cost of $2.1 billion ($300 million per mile).[532]

Planning is also underway for four new proposed subway projects—the 9.6 mile Ontario Line, 4.7 mile Scarborough Subway Extension, 5.7 mile Eglinton Crosstown West extension, and 4.6 mile Yonge North Subway extension. As illustrated in Table 16, current construction cost estimates proposed lines based are significantly higher on a per-mile basis than the TYSSE project.[533]

Fraught transit governance that is subject to significant political interference can result in expensive low priority projects and significant delays, cancellations, and change orders.

Over the last decade, significant changes in governance—particularly the creation of Metrolinx—affected the region's capacity to deliver projects. The region's two most recent subway projects were largely built due to political pressure from suburban officials, and against the technical advice of experts.

The Sheppard Subway is the newest subway line in Toronto. It was initially proposed by the TTC in 1985, but rising cost estimates for the project and changes in provincial leadership led to its consistent delay and near-cancellation.[534] Much of the political impetus for its eventual passage was from Toronto Mayor Mel Lastman, who previously served as Mayor of North York (a suburban district in northern Toronto served by the Sheppard Subway) from 1973 to 1997 when it was its own municipality. Lastman successfully lobbied the province and TTC to fund the Sheppard subway even though the agency's technical studies found the line would be best served as light rail.[535] The mayor and other political supporters were heavily in favor of a subway to help spur commercial development that would make part of North York into a "second downtown."

The TYSSE project has a similar origin story. Political leaders wanted the city of Vaughan to be served by a subway line, not only to raise the profile of that area but to also spur development and raise property values around York University. Both the city and York University lobbied the province to fund an extension of Line 1 to Vaughan which, at that time, was not the priority of the TTC or other local officials in the region.

In fact, the extension was deemed unjustified by the TTC due to low densities along the proposed route and modest projected ridership.[536] However, Greg Sorbara, the former Minister of Finance for Ontario who represented Vaughan in the provincial parliament, successfully lobbied the provincial and federal government to push ahead with the project.[537]

Political influence and interference in major projects have persisted in the region, despite governance changes. Metrolinx was originally intended to serve as an independent, regional organization at an "arm's length" from local and provincial politics, but its financial and governance structure made the agency largely captive to the political dynamics of the province. Reports and interviewees have documented a lack of political legitimacy and accountability around transit decision-making.

While Metrolinx is tasked with developing and executing regional transit plans, it does not have the authority to raise its own revenues. There is also no regional governing body in the GTHA that lies between the municipalities and the province to whom Metrolinx can be held accountable.[538] Rather, Metrolinx reports solely to the Province of Ontario, who retains the final say in all decisions. The projects included in Metrolinx's first regional transit plan in 2008 were also largely already decided upon by Toronto (through Transit City) and the Province of Ontario (through its MoveOntario 2020 plan for 52 rapid transit lines).[539]

Metrolinx itself is subject to significant political interference. Changes in political leadership can lead to projects getting modified or canceled even after construction has begun. The 2007 "Transit City" proposal put forth under former Mayor David Miller called for the creation of seven new light rail lines in Toronto.[540] Initial studies for many of the lines were underway and construction had already begun on the Sheppard East line when newly-elected Mayor Rob Ford cancelled Transit City on his first day in office.[541] Ford pushed instead to extend the Sheppard subway to Scarborough and replace the aging Scarborough RT line with an extension of the Bloor-Danforth subway line.[542] Despite this cancellation, the Toronto City Council ultimately voted to resume work on Transit City in 2012, specifically on the Eglinton and Finch lines, which are now under construction.[543]

Similarly, the Province of Ontario approved $800 million in funding for a 9 mile light rail line in Hamilton (22 miles southwest of downtown Toronto) in 2015 under Ontario Premier Kathleen Wynne.[544] The Hamilton LRT was one of Metrolinx's priority projects under the Big Move, and was expected to be opened in 2024.[545] However, after an independent cost estimate showed project costs rising from $800 million to $4.5 billion, Conservative Premier Doug Ford, who succeeded Liberal Premier Wynne, canceled the project in 2019, before procurement was complete.[546]

The cancellation sparked significant backlash from opposition parties and debate between officials from the province and Hamilton, specifically over the accuracy and timing of the cost estimate used to justify cancellation. The $4.5 billion cost estimate also included operating and maintenance costs that were not included as part of the original $800 million estimate, which only covered capital costs.[547] Debate surrounding cost overruns on the project were further complicated after a report by the Ontario Auditor General (AG) found that Metrolinx and the Ministry of Transportation knew, but failed to disclose, that the project would cost more than the initial $800 million as early as 2016.[548] In February 2021, the province recommitted to a slightly shorter version of the project, offering $830 million in funding if the federal government agrees to commit $1.2 billion.[549]

Persistent political interference casts significant uncertainty over transit planning and decision-making in Toronto. The frequency by which political officials can cancel, modify, or otherwise interfere with projects that have already been approved or even under construction makes it difficult for the public and business community to assess the stability of any decision or plan introduced by Metrolinx. A 2018 report by the Ontario AG found that politically motivated project changes and cancellations have amounted to nearly $104 million in sunk costs for the agency.[550]

The lack of a standard, transparent process by which projects are proposed or evaluated was cited as one of the reasons why Metrolinx is susceptible to political influence. Despite formal business case analyses and other evaluations carried out by Metrolinx and IO, stakeholders and politicians propose a variety of different projects, with little to no structure on how to evaluate and vet these proposals.

Metrolinx has institutionalized a policy to require business case analyses for major capital projects over $42 million (50 million CAD).[551] These analyses evaluate the rationale, value for money, and impacts of major investments during various stages of project development. These business cases also analyze the viability of various alignments and modes, deliverability of a project, and the level of expected project risk, among others.

However, what appears to be a streamlined and robust process for decision-making from the outside masks the largely political decision-making process that happens behind-the-scenes. This process was characterized by one interviewee as “decision-based evidence making” with political officials making a decision to move ahead on a given project, and planners or consultants being tasked with justifying the decision. While interviewees acknowledged that there are some sound technical reports and analyses prepared by Metrolinx, they expressed doubt over whether they are actually read or taken into account by political officials who have the ultimate say in approving projects.

Reports from the Ontario AG identified several instances of Metrolinx undermining its own decision-making and technical analysis process. As part of the Transit City project, Toronto, Metrolinx, and Ontario had already agreed to build the seven proposed projects as light rail lines, and Metrolinx's 2009 business case analyses of these seven corridors did not assess the viability of alternate modes like BRT. When updating its business cases for the Finch West, Sheppard East, and Hamilton LRT lines in 2014, Metrolinx found that BRT service may be able to achieve similar benefits at a lower cost, and called for additional study of the cost-effectiveness of BRT versus LRT.[552] However, the agency did not ultimately conduct any additional analysis. In January 2020, Metrolinx voted to move ahead with an eastern extension of the Scarborough subway and westward extension of the Eglinton Crosstown line despite receiving a cost-benefit-analysis report that found the projects would cost nearly $10 billion to build, but only result in $4.2 billion in benefits.[553]

Similarly, when assessing the overall benefit of LRT versus BRT in Hamilton, Metrolinx found that light rail would offer the most benefits under a high intensity land use intensification scenario, while BRT would perform best under moderate land use intensification.[554] However, while Metrolinx modeled the benefits of LRT under low, medium, and high land use intensification scenarios, BRT was only studied under the medium intensification scenario. Metrolinx recommended conducting an updated business case before a final decision was made, though no additional study was conducted before the province approved the LRT project in 2015.[555]

In another case, Metrolinx overruled its own recommendation against building two new GO Transit stations after receiving pressure from the province and Toronto.[556] As part of a planned expansion of the GO commuter rail system, Metrolinx conducted a business case evaluation of 17 proposed GO stations in 2016. The analysis did not recommend building stations in Kirby and Lawrence East (among five other rejected stations), finding that their inclusion would increase travel time and thus reduce ridership, lead to an increase in automobile use, and decrease overall system fare revenue.[557]

However, the agency subsequently modified its evaluation of the stations to make the Kirby and Lawrence East appear to score better and overrode their own recommendation to approve them after the then-Minister of Transportation and the city of Toronto pressured the agency to include the stations.[558] The Kirby station resided within the electoral district represented by the then-Minister of Transportation in the Ontario Parliament, while Lawrence East was one of the proposed stations under the Toronto Mayor's signature SmartTrack commuter rail expansion plan.[559]

Pursuing public-private partnerships for major projects just to save money produces mixed results.

In response to cost overruns and delays on major public works projects, the region moved towards using public-private partnerships for large infrastructure projects, largely managed by IO. The provincial government requires all public infrastructure projects over $83 million ($100 million CAD) to be screened as potential P3 candidates by IO.[560] Under the Ontario P3 model, referred to as alternative finance and procurement (AFP), Metrolinx establishes project scope, budget, and purpose, while a private consortium finances and carries out construction (in some cases also the maintenance and operation).

IO was primarily used to deliver infrastructure like hospitals, schools and courthouses until 2009, when it began managing roadway and transit projects. After the completion of the TYSSE, project delivery was handed over to Metrolinx, which used IO to help deliver three light rail lines using P3s (primarily using a combination of design-build-finance-operate and/or maintain), including the Eglinton Crosstown, Finch West LRT, Hurontario line, and several expansions of the region's commuter rail network.

The recent embrace of P3s is driven by a perception that they can alleviate many of the cost and schedule issues on projects and lead to more efficient project delivery. However, many interviewees were skeptical that the shift to P3s has done much to address the region's cost issues for transit, despite IO's previous success with other building projects. For example, the final bids on the Hurontario LRT, which runs in Mississauga, Ontario west of downtown Toronto, came in nearly $500 million (12 percent) higher than the original cost estimate of $4.1 billion, despite Metrolinx reducing the project's scope through a shorter alignment and fewer vehicles.[561] The increasing cost could be a result of shifting such significant amounts of risk to the private sector, which ultimately becomes priced into their bids through higher contingency budgets. Other interviewees suggested that the region may ultimately revert back to using more traditional forms of project delivery.

A major 2014 report by the Ontario AG found that IO's methodology for calculating project risk and comparing the value-for-money between traditional and AFP procurements almost always favored the use of AFPs.[562] As part of its cost comparisons, IO assessed how much project costs would be reduced if project risk was transferred from the public sector to the private sector under AFP. According to IO's methodology, project risks were nearly five times higher under traditional procurements than AFP. In nearly all of the projects reviewed by the AG, it was only the assessment of risk transfer that led to AFP scoring better than public sector procurement. For example, IO estimated that delivering the four approved Transit City LRT lines as an AFP would cost $12.5 billion, versus $10.7 billion, a difference largely explained due to higher cost of

private sector financing.[563] This higher cost was offset by an estimated savings of $4.9 billion in risk that the public sector would not be responsible for.[564]

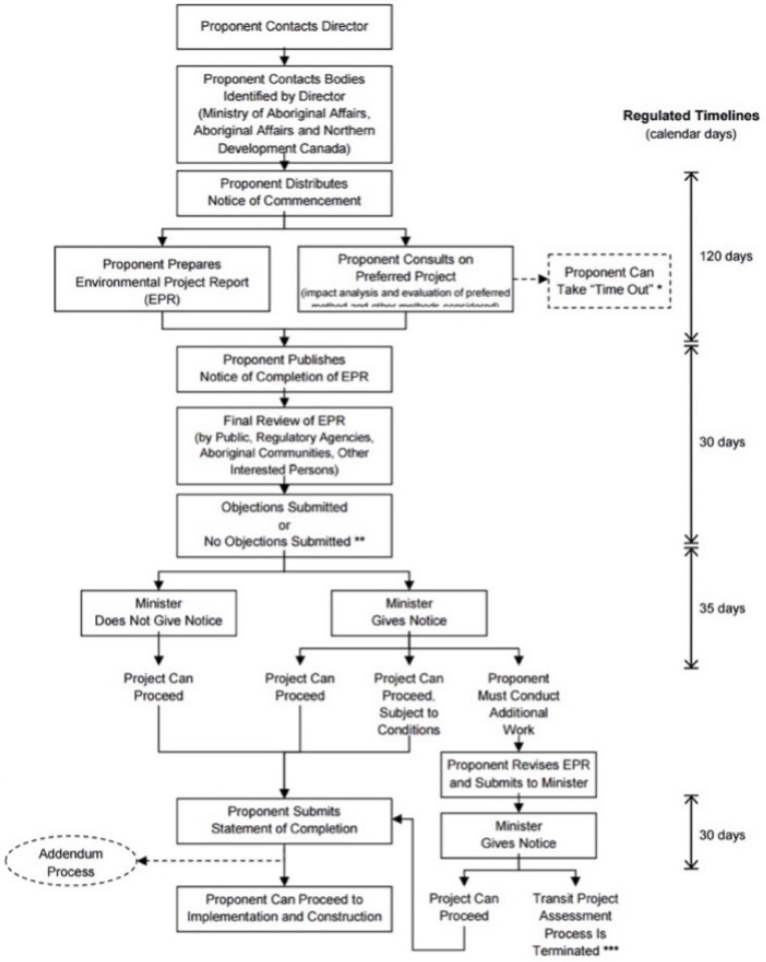
However, the AG's report also found that IO did not use empirical data to back its assumptions of risks, and often painted public sector procurement in a bad light. For example, IO estimated that a traditional public sector procurement would result in a 29 percent cost overrun risk for the Transit City LRT lines, while an AFP procurement would have just a 2.5 percent overrun risk, an estimate the AG found unjustified by any evidence. While the report included recommendations and changes that are currently underway for future procurements, interviewees cited continued issues with risk assessment and alleged cost savings under P3s. All of IO's transit projects are currently under construction or in development, so their performance relative to public sector procurements has yet to be fully evaluated.

Cost and timeline issues have been the subject of increased coverage on the Eglinton Crosstown LRT. The project fell behind schedule in 2017, but under the AFP contract, Metrolinx had limited ability to hold the private consortium accountable for delays discovered early in the project as long as the consortium could certify it would meet the September 2021 opening target.[565] Remedies for delays could only take effect if the consortium itself, rather than Metrolinx, declared it could not meet its target opening date.

Additionally, the Ontario AG found that the risk of cost and timeline overruns were not entirely transferred to the private sector for the Eglinton Crosstown LRT, despite the premium paid for the P3 structure. In February 2018, the consortium filed a claim against Metrolinx requesting compensation and a deadline extension, arguing that Metrolinx did not provided the assistance necessary to address the delays.[566] Metrolinx and IO reached an agreement to pay the private consortium $200 million—nearly half of the project contingency—in order to retain a September 2021 opening date. However, the auditor found that neither Metrolinx nor the consortium could provide detailed documentation that justified the settlement amount and the consortium's claim that Metrolinx was partially responsible for not offering assistance to overcome the delays.[567] In February 2020, Metrolinx announced the project would not be completed until well into 2022, noting that the private consortium had only achieved 84 percent of its target completion.[568]

Subjecting transit projects to their own, streamlined environmental assessment process speeds delivery.

FIGURE 16: TPAP PROCESS AND TIMELINE [569]



Public transit projects in Ontario are no longer subject to the full environmental assessment act. Instead, they are subject to a specific, expedited environmental review process designed in 2008 specifically for transit, called the Transit Project Assessment Process (TPAP).[570] The TPAP serves as a self-assessment for transit projects and is primarily driven by the project sponsor.

The TPAP does not require project sponsors to conduct an alternatives analysis, but rather begins with a selected project. The TPAP guidance includes recommendations for project sponsors to conduct as much early planning work as possible to establish project scope and secure support from stakeholders, but this planning work is not a formal part of the TPAP.[571]

The TPAP also does not specify any technical studies that must be carried out for a project, though other regulatory agencies may request that project sponsors conduct specific studies (i.e., noise and vibration analysis, cultural heritage assessments, financial analysis, etc.). These studies can vary based on the project type and characteristics. The Ministry of Environment recommends project sponsors contact regulatory agencies early in the project planning phase to determine their specific information needs.

Once a project sponsor identifies a project and issues its notice of commencement, it has 120 days to complete a draft Environmental Project Report (EPR). During this period, project sponsors consult with affected parties, regulatory agencies, and Aboriginal groups. If the project sponsor encounters an issue that requires additional study or could jeopardize the 120 day time limit, it may utilize a "time out" provision to temporarily pause the clock. Time outs can be utilized in two cases: negative impacts on a matter of provincial importance, or potential negative impacts on a constitutionally protected Aboriginal or treaty right.

After completion of the EPR, the public has 30 days to review the document and submit comments and objections in writing to the Minister of the Environment. Objections must be submitted in writing and include description of why further study is needed, documentation of negative impacts on matters of provincial importance or affecting Aboriginal rights that were not identified in the EPR, and a summary of how the person(s) submitting the objection has been involved in the project's consultation process.

After the public consultation phase, the Minister has 35 days to review feedback and consider whether the project will have a negative impact on either a matter of provincial importance or constitutionally protected Aboriginal or treaty right. After this period, the Minister can issue one of three notices: 1) a notice to proceed with the project as planned in the EPR; 2) a notice to require the project sponsor to take further steps like additional studies or consultation; or 3) a notice to allow the project sponsor to proceed with the transit project subject to specific conditions. When the Minister issues a notice requiring additional steps to be taken, the project sponsor must prepare a revised EPR. If the Minister still feels that a project does not appropriately address negative impacts, they can terminate the TPAP and require the project to comply with the full Environmental Assessment Act. If the Minister does not issue any notices within the 35-day period, the project may proceed as planned.

Ontario has taken further steps to streamline the environmental review process, including through 2020's Building Transit Faster Act.[572] The act applies only to the province's four priority transit projects—the Ontario Line, Eglinton West LRT, Scarborough subway extension, and the Yonge North subway extension—and includes several provisions aimed at speeding up project timelines. For example, it eliminates "hearings of necessity" for property acquisition. These non-binding hearings were

previously required to determine whether a property acquisition was fair and necessary for a given public project.

The new law also provides for an "enhanced process" to order companies to relocate utilities. Once ordered to relocate, utility companies must enter into negotiations with Metrolinx "reasonably promptly," and make a reasonable effort to acquire all necessary permits. If the utility company does not comply, Metrolinx may ask the Ontario Superior Court to consider ordering the company to carry out the relocation. The provision also requires utility companies to reimburse Metrolinx for losses or expenses that result from their non-compliance with a relocation order.

It also addresses permitting by granting officials the ability to enter transit corridor lands to remove obstacles without the consent of property owners, as long as proper notice and compensation is provided. The Minister of Transportation is allowed to grant Metrolinx the authority to close streets or access city services (i.e. water or sewers) if an agreement cannot be reached with the municipalities. And in an attempt to minimize conflicts between transit projects and private construction work, private property owners living within 98 feet of a corridor designated for one of the four priority transit projects must receive a permit from Metrolinx to carry out any construction work, including home repairs.[573]

The province also issued a separate regulation creating a streamlined environmental review process for the Ontario Line. The process is largely similar to the TPAP, but allows select early works—like utility relocation, station construction, bridge replacement, or rail corridor expansion—to be carried out before the completion of the full environmental assessment.[574] This regulation created a separate category of "Early Works Reports" narrowly tailored at evaluating the scope, alternatives, and potential environmental impacts of these activities.

Several interviewees felt that these reforms to the environmental review process have helped minimize conflict and expedite project approvals, with environmental clearance and community consultation being completed within two years. These reforms have operated under the general premise that transit is inherently beneficial for the environment, and therefore should not be subject to a lengthy and potentially contentious environmental clearance process. However, these reforms—along with other proposed changes to province-wide environmental review—have come under scrutiny from environmental groups concerned that they have excessively curtailed opportunities for the public to comment or raise concerns over projects.[575] Others expressed concern that the Building Transit Faster Act may erode the environmental review and stakeholder engagement process, which is already streamlined for transit projects under the TPAP.[576]

THE ROLE OF THE FEDERAL HIGHWAY ADMINISTRATION IN PROJECT DELIVERY

The Federal Highway Administration (FHWA) provides assistance and funding for states to design, build, operate, and maintain the national highway system (Federal-aid Highway Program).[577] The agency is headquartered in Washington, D.C. and has a division office in every state, the District of Columbia, and Puerto Rico, employing roughly 2700 staff in total.[578] Division offices are often located in state capitals, where most state DOTs are also headquartered.

The total federal-aid highway budget is $41 billion per year and is largely distributed to state DOTs under existing formulas in federal law. Unlike transit CIG grants, most FHWA grants for large projects are not discretionary and state DOTs are responsible for selecting and evaluating projects that will receive federal funding.[579] To be eligible, projects must be included in a state's Statewide Transportation Improvement Program (STIP) and the MPO's Transportation Improvement Program (TIP or RTIP), which lists the major transportation projects across all modes that are expected to need federal funding or approval.[580]

FHWA uses a risk-based methodology to determine which projects to dedicate additional oversight and technical assistance, including size, cost, schedule, and complexity.[581] For these major projects, division offices develop a project-specific plan that documents the justification for and scope of the division office's involvement. The division office will often embed its own staff into a project to provide technical assistance across multiple project phases. FHWA division offices are able to lend in-house expertise on ROW acquisition, environmental reviews, engineering, operations, freight, and finance. The co-location of state DOTs and FHWA division offices in the same city allows for regular meetings, knowledge-sharing, and cooperation between state and federal teams.

Under federal law, the Surface Transportation Project Delivery Program also allows states to assume NEPA review and approval authority (known as NEPA assignment).[582] This eliminates the need for FHWA review and approval on specific projects, and help streamline the environmental review process. States may apply for NEPA assignment and, if approved, are bound by a memorandum of understanding with FHWA that must be renewed every five years. Seven states currently have NEPA assignment agreements with FHWA: Alaska, Arizona, California, Florida, Ohio, Texas, and Utah.

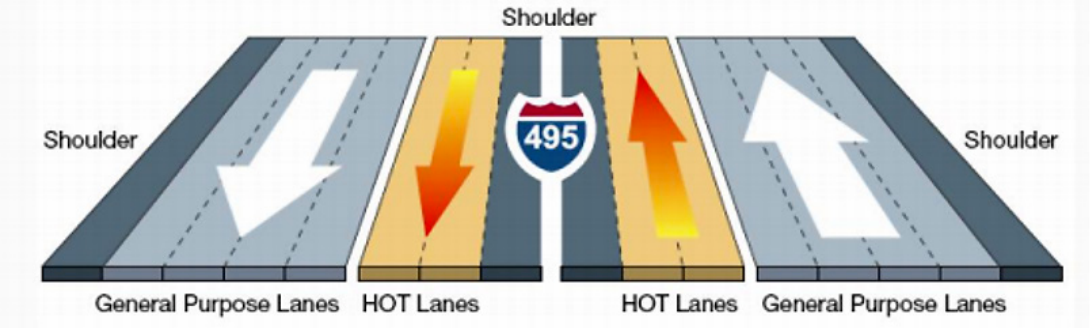
5.9 Virginia I-495 HOT Lanes and Silver Line Extension

The I-495 high occupancy toll (HOT) lanes project and the Silver Line extension of the heavy rail system in Northern Virginia provide a useful comparison of project delivery practices for highways and transit. In addition to their geographic proximity, both projects largely run along highway medians and were delivered at similar costs per mile using tolling revenue and unique delivery methods.

Each project also had its own complexities. For example, Silver Line required the construction of large stations, included tunneled and aerial segments, and the necessary systems for operation. The HOT Lanes project alignment covered a wider footprint, included many interchanges, and required deployment of a new tolling system. The HOT Lanes project also had the benefit of greater institutional knowledge and staff support for its planning and delivery.

I-495 HOT Lanes Governance and Project Overview

FIGURE 17: I-495 HOT LANES CONFIGURATION



Through a design-finance-build-operate-maintain (DFBOM) procurement, Interstate I-495 (the Capital Beltway) was expanded from eight to 12 lanes along a 14 mile stretch from the Springfield Interchange to north of the Dulles Toll Road.[583] The project added two new HOT lanes in each direction and reconstructed the existing general purpose lanes. It also featured $260 million worth of infrastructure upgrades, including over 50 new bridges and overpasses, new carpool ramps, upgrades to 11 interchanges, and 80,000 square feet of sound walls.[584] The project was completed in November 2012 at a cost of $2.07 billion, or $148 million per mile.

Several organizations were closely involved in the execution of this project, led by the **Virginia Department of Transportation (VDOT)**. The agency is overseen by the **Commonwealth Transportation Board (CTB)**, whose 17 members are appointed by the governor. VDOT also has separate specialized divisions including the **Office of Public-Private Partnerships**, which provides much of the procurement, management, and technical support for P3 projects, and a Mega Projects Office which

offers design and engineering support. **FHWA's Virginia Division Office**, located in Richmond, works collaboratively with VDOT and assists with the development of projects, including environmental reviews, land acquisition, procurement, and construction. **Capital Beltway Express, LLC (CBE)**, is a private consortium formed by Fluor and Transurban to design, finance, construct, and operate the I-495 HOT Lanes. The consortia is 90 percent owned by Transurban and 10 percent owned by Fluor.[585]

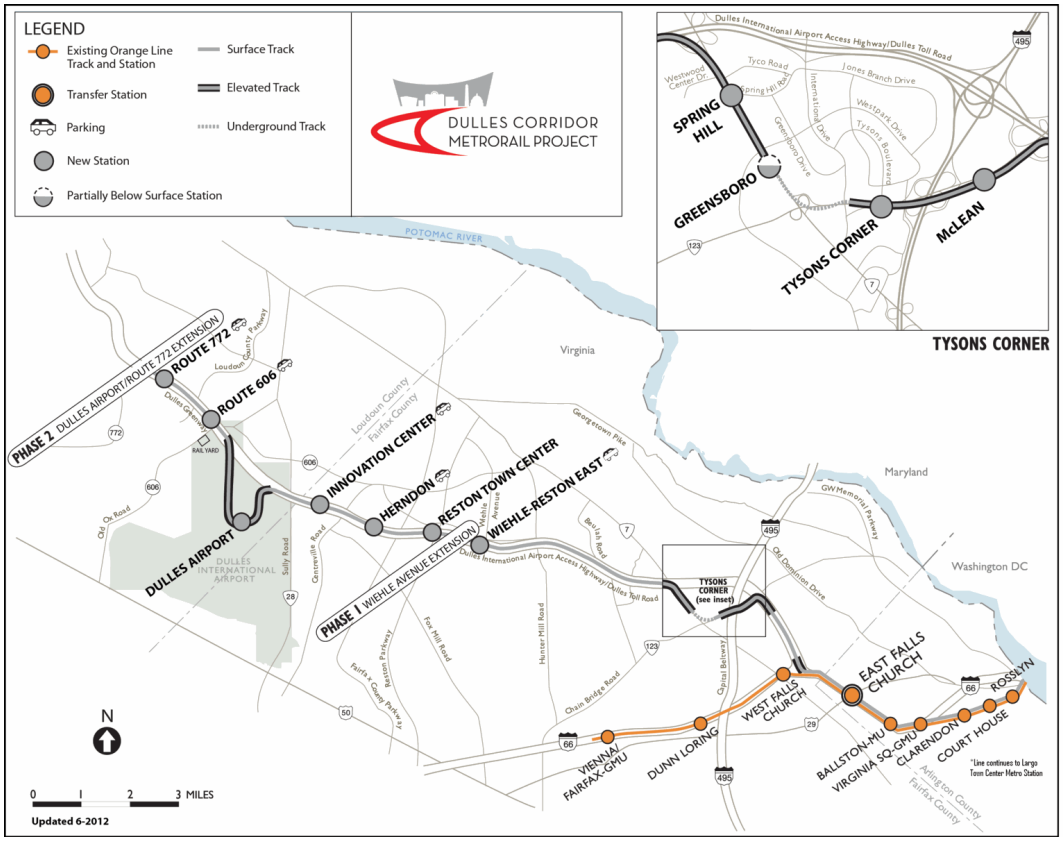
Chronic traffic congestion on the Capital Beltway led VDOT to consider ways to address travel demand. A 1997 Major Investment Study conducted by VDOT recommended the use of high occupancy vehicle (HOV) lanes and expanding I-495 by up to four lanes, though an eight lane expansion was considered and ruled out.[586] Public hearings on the Draft EIS were held in 2002, but the estimated $2.6 billion in construction costs and potential displacement of nearly 350 homes led to significant pushback from local officials, the public, and communities in the corridor and prompted VDOT to modify the project.[587]

In 2002, under the authority of Virginia's Public-Private Transportation Act of 1995, Fluor and Transurban submitted an unsolicited proposal to expand I-495 to 12 lanes. The proposal solved two of the main problems facing the highway project: funding and scope. It would be paid for and financed in part by tolls, which the consortium would be able to retain during the life of the DFBOM contract. By minimizing shoulders, limiting the scope of interchange improvements, and utilizing painted strips in lieu of physical lane barriers, reducing the expansion from eight to four new lanes, the proposal kept the expansion largely within the existing ROW and resulted in only seven displacements.[588]

After inviting a formal solicitation for competing proposals and receiving none, the CTB approved the proposal for further evaluation in 2003 and entered into an initial development agreement with Fluor-Transurban.[589] The Record of Decision was signed in 2006 and further negotiations over project scope and details took place until 2007, when the partners officially signed the Comprehensive Agreement as Capital Beltway Express, LLC.[590] The contract spans 85 years, including 5 years for construction and 80 years of operation. Construction began in July 2008 and the HOT lanes opened in November 2012, one month ahead of schedule.

Silver Line Extension Governance and Project Overview

FIGURE 18: SILVER LINE EXTENSION MAP



Source: MWAA

TABLE 17: SILVER LINE PHASES

	Year Opened	Time to construct (months)	Length (miles)	Percent Tunneled	Stations	Primary Delivery Method*	Cost	Cost Per Mile
Silver Line Heavy Rail phase 1	2014	64	11.7	4%	5	DB	$3.3 billion	$279 million
Silver Line Heavy Rail phase 2	2022***	N/A	11.3	0%	6	DB	$2.4 billion**	$211 million

**A single delivery method is not always used on an entire project.*
*** Projected costs for unfinished projects*
**** Projected opening dates*

The Silver Line is an extension of the Washington Metro's heavy rail system intended to connect Washington, DC to the employment districts along the Dulles Toll Road, Dulles International Airport, and the Dulles Greenway. The project was split into two 12 mile phases: the first connecting the existing heavy rail network to Tysons and Reston, and the second phase extending the project to the airport and beyond. The rail yard and maintenance facility is being built on more than 90 acres of airport land. Phase 1 runs

primarily along highway medians and includes both below ground and aerial segments. Four percent of the 12-mile, five station Phase 1 portion is tunneled, and 23 percent is elevated. Phase 2 contains no tunneled portions but 27 percent is elevated.

Several organizations are heavily involved in the execution of this project, which is led by the **Metropolitan Washington Airports Authority (MWAA)**. MWAA was established in 1987, and is in responsible for the ownership and operation of Reagan Washington National and Dulles International Airports. The authority is governed by a 17-member board appointed by the mayor of Washington, D.C., the President of the United States, and governors of Maryland and Virginia. The authority is not funded with taxpayer dollars. Operations are funded by landing fees and rents/revenues from airport concessions, while capital improvements are paid for using bonds issued by MWAA, federal and state Airport Improvement Program funds, and Passenger Facility Charges. MWAA is managing the construction of the Silver Line.

The **Washington Metropolitan Area Transit Authority (WMATA)** is the primary rail and bus operator in the Washington region. It did not build the Silver Line but will own and operate it when completed. MWAA still has ownership and care of the facility as WMATA begins operational testing. Only after successful completion of testing, which has no set time, will the project be turned over to WMATA ownership. Passenger services commences several months thereafter.

The **Virginia Department of Rail and Public Transportation (DRPT)** is responsible for planning freight and passenger rail service. It is a separate entity from VDOT and is overseen by the CTB. DRPT supports capital improvements and operation of Virginia's rail system through three major grant programs. DRPT served as project sponsor for the Silver Line before transferring control to MWAA. The **FTA's Region 3 office** is located in Philadelphia, PA, and assists local and state transit officials with developing and managing federal grants. The Silver Line received a $900 million grant from the FTA.

Dulles Transit Partners, LLC. is a private consortium between Bechtel Infrastructure and Washington Group International (now URS) contracted to build the Silver Line's Phase 1. **Capital Rail Constructors**, a joint venture of Clark Construction Group and Kiewit Infrastructure South is contracted to build Phase 2. Both contracts are structured as a DB procurement, as is the contract for the rail maintenance facility being built by **Hensel Phelps Construction Company**.

The Silver Line extension is notable for its unique delivery structure, as it is being delivered by an entity other than a transit agency and, in this case, an airport authority. DRPT was the project sponsor for the Silver Line from 2000 until 2008, when ownership and oversight was transferred to MWAA as part of a larger governance change and agreement that granted the Airports Authority responsibility

over operating the Dulles Toll Road and building the Silver Line, with a portion of toll revenue being used to finance the project.[591] DRPT retains an oversight role on the project and serves as a funding partner, while WMATA was the technical lead during the NEPA process, and will be the owner and operator of the line after construction.[592]

Phase 1 was completed six months after initially scheduled and $220 million over budget.[593] A number of challenges contributed to the project's delays, including a three-year dispute over the tunneling style to be used and MWAA's indication that DTP failed to meet construction criteria in seven of 12 critical areas.[594] Phase 2 has been delayed due to issues concerning compliance with state and federal stormwater management regulations enacted midway during the project's construction (instead of grandfathering the project under the previous rules); tunneling for cable work; construction challenges; malfunctioning equipment; flawed concrete; and a U.S. Department of Justice investigation into a subcontractor. Project officials have not yet calculated costs associated with delays and change orders.[595]

Both projects had stalled until the project sponsors decided to use tolling to help secure long term debt to complete the funding packages. The repayment of the federal loan programs for the HOT Lanes and the private equity component will all come from future tolls, which amount to nearly three-quarters of the total project's initial costs.[596] Nearly half of the funding for both phases of the Silver Line is from revenue from the Dulles Toll Road. MWAA, Fairfax County, and Loudon County also utilized federal credit assistance to raise the necessary funds for construction.[597] Fairfax and Loudon counties' loans will be repaid using annual appropriations and special taxing districts around Silver Line stations.[598] MWAA's loan has been repaid early with other Airports Authority's bonds.

TABLE 18: I-495 HOT LANES AND SILVER LINE FUNDING SOURCES

I-495 HOT Lanes	Amount	%	Silver Line	Phase 1	%	Phase 2	%
Federal Private Activity Bonds	$589,000,000	28.5%	Federal grant	$900,000,000	30.2%		
Federal TIFIA Loan	$589,000,000	28.5%	Commonwealth of Virginia	$252,000,000	8.5%	$323,000,000	11.6%
Commonwealth of Virginia	$409,000,000	19.8%	Fairfax County	$400,000,000	13.4%	$527,000,000	19.0%
Private Equity	$348,000,000	16.8%	Loudon County			$276,000,000	9.9%
VDOT Change-order funding	$86,000,000	4.2%	MWAA Funds from Aviation			$236,000,000	8.5%
Interest Income	$47,000,000	2.3%	MWAA Funds from Toll Revenue	$1,430,000,000	48.0%	$1,415,000,000	51.0%
TOTAL	$2,068,000,000		TOTAL	$2,982,000,000		$2,777,000,000	

Source: FHWA Project Profiles, 2020; MWAA

While both the HOT Lanes and Silver Line were led by public agencies and private consortia with internal expertise for delivering large projects, there was more institutional capacity and knowledge to support the team delivering the HOT Lanes. This was most notable in the level of resources at VDOT versus DRPT and MWAA, as well as between FHWA and FTA.

Highway projects in general benefit from more public staff that are experienced at delivering large, complex projects. VDOT employs nearly 7,500 professional staff, with specialties ranging from engineering and procurement to planning and environmental review.[599] Its separate divisions to support public-private partnerships and megaprojects provide additional sophisticated support and as a result of their sizeable team, VDOT is able to provide in-house expertise across all phases of project delivery. VDOT also has nine district offices across the state—including in northern Virginia—whose staff handle permitting and help coordinate with third parties and local stakeholders as needed.

By contrast, the DRPT employs just 65 staff and relies more heavily on consultants, particularly for engineering oversight. MWAA employs fewer than 20 in house staff in its rail division, primarily concentrated in leadership roles, and relies on contractors for construction management and design on the Silver Line.[600] While consultants are useful for their specialized expertise, they are often risk-averse, which leads to project delays due to unnecessary back and forth discussions between staff, supervisors, and contractors over relatively minor decisions.

Similar differences in institutional capacity and support are apparent at the federal level . While both FTA and FHWA conduct programmatic and project-specific reviews for implementing agencies, FHWA is able to provide more depth and breadth than FTA. FHWA's Virginia Office and VDOT are also located just a few blocks away from each other in downtown Richmond. As a result, VDOT staff work closely alongside the same FHWA division staff and their in-house engineers on a daily basis. While FTA staff is certainly capable, the Region 3 office is located in Philadelphia and grantees mostly interface with the FTA's PMOCs who may be located in a different part of the country.[601] Interviewees also felt that the geographic proximity of FHWA division offices allows VDOT staff more regular, in-person access to FHWA staff on short notice for issues that implicate the federal government, while transit staff may have to wait until the next time the PMOCs or FTA field staff are on site.

The staff capacity is important because although both projects were subject to similar environmental standards, the highway project process was much more routine and straightforward. The rules set forth under NEPA meant both projects had to complete an EIS, the highest class of environmental review. However, with a nearly $1 billion federal-aid highway program and over 500 projects subject to NEPA each year, VDOT has developed a routinized and structured process by which it handles highway projects, including the environmental review. Officials had straightforward answers on how the navigate the processes with an engineering-like methodology. VDOT's P3 office conducts preliminary work and studies on various project configurations to help determine the class of environmental review necessary (EA versus EIS). These inputs and preliminary analyses are then handed over to the environmental staff at VDOT, who make a determination on whether to prepare an EA or EIS and take the lead on conducting the appropriate review.

On the other hand, transit projects are neither common nor routine. MWAA had never conducted a major capital investment off its property, so the Silver Line represented a new process that staff had to learn. Interviewees familiar with the process at MWAA suggested that the environmental review and planning process was complex and convoluted in large part because of fewer routine processes and experience in preparing and guiding projects through the various stages of project delivery, including the environmental review. FTA's Region 3 office and DRPT provided additional assistance, but transit project themselves are much less common and their uniqueness brings huge challenges.

Lastly, the segments of both the HOT Lanes project and the Silver Line in highway medians had limited challenges with utility relocation and business disruptions. Unlike the HOT Lanes, however, the Silver Line had to contend with strong public sentiment about the value of transit. Interviewees felt that a significant amount of energy was spent to justify not only the value of the Silver Line investments, but also the existence of transit in the region. In one example, DRPT had to commission a statewide study of the economic impact of transit investment in order to garner legislative support for more investment, a process that would likely not be necessary for highway funding.[602]

Highway projects, of course, can still spark strong community reaction. This was the case with the originally proposed expansion of I-495. As a result of the needed land acquisition and the project's location within a dense, fully-developed corridor, the project garnered significant public interest and received a higher than normal volume of comments and pushback on the draft EIS. The reduced scope helped facilitate a relatively smooth preparation of the final EIS.

The fact that the Silver Line runs within existing highway medians simplified the project and helped keep costs low compared to other transit projects. However, Phase 1 required more coordination with VDOT given its interfaces with the agency's roadways, which required additional VDOT design reviews and approvals. Because most of the ROW for Phase 2 was owned by MWAA, it handled its own permitting and code compliance.

6.0 Takeaways and Recommendations

The preceding data, analysis, and case studies reveal major challenges with public transit cost and project delivery in the United States, outlined below. Especially at a time of economic and fiscal uncertainty as well as environmental and social anxiety, it is critically important we get the most out of our existing public investments and that those projects we do undertake are successful both during the planning, design, construction, and implementation phases.

However, this work also makes it clear that there is no silver bullet to cutting the costs and timelines of critical transit projects. It also finds that the responsibility for doing so does not rest solely on federal reforms, fixes at the agency level, or with private sector practice. Rather, the challenges are acute, complex, and multi-faceted and therefore the solutions are too. The recommendations below are based on that fundamental premise. They are organized around the governance/process/standards themes discussed in Section 2 and, similarly, there is overlap among the recommendations as well as their intended targets.

6.1 We need to get the institutions, oversight, and decision-making right. Governance does not usually garner the most attention, but it is paramount to the success of a project both at public agencies as well as with the private sector.

Project sponsors, the public institutions charged with leading the delivery of a project, need authority, staff, and good governance to move projects forward. Special purpose delivery vehicles are often the best way to achieve that.

Today, in the United States, transit projects are delivered almost exclusively through existing entities. Public transit agencies are institutions that were designed as operating entities often to pick up the operation of struggling bus lines from private companies decades ago. As such, they rarely have the structure, authority, or experience to deliver a major transit construction project, which requires unfettered support from local jurisdictions, the ability to acquire land as necessary, secure local permits to close streets and relocate utilities, and flexibility to hire top talent to lead the project.

Given this complexity and the limited reach of most agencies, project sponsors both domestically and abroad have turned to SPDVs to deliver projects, whether using DBB, DB, P3 or other procurement method. The build-out of the subway system in Madrid relied on MINTRA, an independent SPDV, to manage construction before handing the ownership and operation back to Madrid Metro. Denmark and the Municipality of Copenhagen created the Ørestad Development Corporation to build their subway system and has since transitioned it to an operating agency. European SPDVs are often structured as publicly-owned corporations and their single-mission purpose of building a transit

system with flexibility in contracting and setting salaries fosters a businesslike approach and culture. Some of the lowest cost lines in the United States, including the Gold Line in Los Angeles, were similarly constructed using an independent construction authority.

While the success of a project cannot be explicitly tied to a governance model, **states or regions need to create a temporary, independent SPDV with the necessary authorities (outlined below), or modify an existing institution in the same way, to deliver a project.** In either case, this can require the transit agency and local jurisdictions to cede some of their control over project delivery. But careful organization through board representation and sharing of staff can help to ameliorate those concerns.

Project sponsors should have authorization to be self-permitting. For example, if a street needs to be closed for construction activities for a transit project, a project-specific permit allows work to begin without the need to request another permit from a locality to proceed. This requires localities ceding some control but will facilitate speedier projects and help the project sponsor manage betterment requests. **Project sponsors should also be able to issue debt (if necessary), use eminent domain to acquire land, relocate utilities, as well as enter into contracts and agreements with public and private entities.**

Project sponsors should have a governing board that is made up of funders and the relevant other stakeholders that are necessary to push the project forward. Inclusive board representation not only allows the project sponsor to secure buy-in from relevant parties but can also help manage delays and scope additions. Project delays or major change orders will reflect poorly on the board, and if a delay is associated with a particular jurisdiction, they will be naturally incentivized to resolve the issue quickly. Having local officials on the governing board will also help alleviate concerns associated with ceding control over permitting and other decisions.

Since one of the most significant problems associated with project delivery is the ability of public-sector staff to directly manage projects, **the project sponsor should have the ability to set its own salaries to attract and hire top project management talent** and **borrow staff from existing institutions**. Compensation that is reflective of market rates will help the public sector compete with private sector consultants for top level staff. Instead of building the entire team from scratch, the entity should bring in staff from other agencies with project oversight and management experience, like state departments of transportation (DOTs). They can temporarily join the project sponsor payroll or relocate to the project sponsor's office, adding expertise to help navigate regional project complexities.

While these authorities, abilities, and governance structures could be achieved by reforming and existing public transit agency or other existing institution in most cases,

a temporary SPDV will be necessary to achieve those authorities given the complexities associated with reforming an existing institution for the purpose of delivering a project.

For its part, **the FTA should encourage project sponsors to reform governance, authorizations, and other factors as part of receiving federal funds**. The federal government should help support project sponsors set up SPDVs or reform governance of existing institutions through preferential treatment for competitive grants by adding a governance review and score as part of the CIG application process. The FTA can also develop more detailed information, best practices, lessons learned and other guidance about how to organize and create effective SPDVs.

Project sponsors need to understand, manage, and commit to whatever project delivery method is most appropriate for the project.

Anecdotally, many project delivery experts have a preferred method for delivering projects. Some swear by the traditional DBB approach, which was used to successfully deliver the huge buildout of subways in Madrid. Others cite time savings and innovation realized through DB, which is increasingly used in regions like Paris and Copenhagen. The P3 arrangements in Denver created tangible project savings on some parts of the project, and project managers in Seattle use a combination of DB, DBB, and CMR.

Our work makes clear that no single delivery method on its own is a panacea for cost and timeline issues. But agencies' commitment to the method and understanding of how to manage it is essential. Each delivery method has its own benefits and tradeoffs depending on the project. In DBB, most of the risk for cost overruns lie on the public sector side. While DB can transfer risk to the private sector and often yields a faster (but not necessarily cheaper) project, a poorly written DB contract, deferred planning decisions, or delays in obtaining public permits can result in change orders and lawsuits, with the public sector still responsible for cost increases. DB contracts require a different type of oversight than traditional contracts and require a much longer and more intensive procurement process.

In order to sort out these differences, **project sponsors need to adopt a formal evaluation process to determine the appropriate procurement method on a project-by-project basis**. As part of this process, risks must be identified, their probabilities and impacts assessed, and mitigation measures must be identified and implemented.

Similarly project sponsors need to consider the level of involvement and *control* they would like to have over the project design, among other factors, before deciding on a procurement method. On a DBB project, the public sector is heavily involved in overseeing the project design process and conducts multiple design reviews. Under DB, the public sector provides the contractor with high-level specifications and performance

criteria and allows the design-builder to develop the specifics as it simultaneously designs and constructs the project. This requires the project sponsor to cede control over the design process but allows it to benefit from potential innovations and efficiencies from having the builder design the project. Agencies that are too heavily involved in the design process of a DB can eliminate its benefits. In Seattle, a tendency to manage DB contracts as DBB on certain projects by requiring the design-builder to submit to the traditional 30, 60, and 90 percent design reviews was cited as a significant reason for delays and inability to realize the benefits of the delivery method.

Additionally, **project sponsors must avoid developing design or procurement criteria that are either too prescriptive or too vague**. Overly prescriptive specifications can restrict the design-builder's creative freedom over the design process, which is one of the notable elements of the DB method. An overly vague spec sheet that fails to specify desired finishes or compatibility requirements, for example, can result in agencies receiving an unsatisfactory or flawed final product. To remedy this requires expensive change orders, which were common in all the domestic case studies reviewed in this research.

Once a project sponsor chooses a specific procurement method, they should commit to it and manage it accordingly. For example, the first light rail project in the Twin Cities region was delivered primarily using a DB approach. This yielded a project that came in under budget and ahead of schedule. But when building their second line, the project sponsor opted to go with a DBB procurement given its desire retain more control over the project design. Officials in Copenhagen similarly wanted to retain control over the architecture of stations on the City Ring Line (which was delivered using DB) and thus opted to procure the stations separately.

Projects need to be developed smartly so contracts are not too large to be effectively managed, procurement goals are realistic, and the best value is returned for public dollars.

After selecting the procurement method for a particular aspect or section of a transit line, project sponsors in the United States tend to make several mistakes that contribute to delays and increased costs.

For one, project sponsors often attempt to simplify projects by bundling its discrete elements into one mega contract that can exceed $1 billion in value. Bundling can have benefits: a single procurement and single contract helps a single contractor coordinate activity and, in theory, cut costs and timelines. But examples from abroad shows that single contracts are rare, and agencies often disaggregate segments, so contract values do not exceed about $300 million. While this is in part attributed to the limits of the private bidders to secure insurance and bonding capacity, this approach yields several benefits to the project. Notably, smaller contracts invite more competition and reduce

the chance that a contract or contractor will jeopardize progress on other segments of a project. **U.S. agencies should similarly break up construction projects into manageable sections and cap contracts at $300 million to $500 million**.[603] The project sponsor must execute these smaller contracts strategically and clearly to ensure seamless interfacing and coordination.

Project sponsors also regularly include rules in the procurement specifications that help achieve other public goals, such as requirements that a certain minimum percentage include disadvantaged businesses. The percentage is usually set locally and can be problematic for a project both in meeting the target and the process for compliance. **Project sponsors should consult with construction firms prior to procurement to ensure that the DBE goal is both aspirational yet achievable, and to increase it on future procurements as the local market develops.**

Similar approaches apply to other procurement specifications like local hiring requirements or Buy America. While it is unclear whether these add significant costs in themselves, the arduous process of complying with the requirements is the key cost and timeline driver rather than the requirement itself. Existing research focuses on how the Buy *American* law applies to several federal agencies, but not Buy *America* which applies to highway or transit projects conducted by state and local project sponsors. **GAO needs to evaluate how Buy America specifically increases costs and timelines for transit projects, both in terms of materials and compliance.** More research on Buy America and its effect on transit projects would help identify potential reforms to improve the processes for compliance.

Another problem is that most state or agency policies dictate that public procurements must go to the lowest bidder. The intention for prioritizing low bids is to save public dollars but in practice they often result in cost overruns or change orders because of problems both on the public and private sector side. Nevertheless, the practice continues in the United States despite international best practices of using a blended scoring process that place greater weight on the quality and past performance of the contractor, rather than cost as the primary driver. For example, when scoring construction bids for the 1999-2003 metro extensions in Madrid, 30 percent of the final score was based on bid price, 20 percent on schedule considerations, and 50 percent on the technical qualifications of the bidder and their proposal. Other evaluation factors might include design, delivery schedules and timelines, quality of proposed personnel, past performance, and management plan.

Examples from Europe demonstrate how best value procurement keeps construction costs low and projects on schedule by prioritizing technical expertise and preventing under-qualified contractors from receiving contracts. **State and local procurement regulations should be reformed to allow transit agencies to apply best value selection rather than lowest bid.** The federal government does not mandate any

specific evaluation factors, but for best value procurement, it does require the criteria to be disclosed in its solicitation. But since most agencies do not have significant expertise in conducting best value procurement, **the FTA should develop guidance and technical assistance to share best practices on standards and models, including formulas that agencies can use to evaluate proposals**. A best practices manual with standards and implementation guidelines would provide agency staff with confidence of conformance with federal and state laws.

Agency staff need appropriate training in order to manage projects, construction staff, and consultants.

Overburdened and undertrained public agency staff have trouble coordinating environmental review and planning documents, creating discrete and clear procurement plans, writing smart and effective contracts, and ensuring adherence to contract terms during construction. These all lead to problems with litigation, change orders, and delays throughout a project. **Project sponsors need to invest in better training and support for front office staff** who are responsible for overseeing, monitoring, and managing projects from inclusion to operation. They should be well-versed in the type of delivery mechanism employed (e.g., DB, DBB, P3). Experienced staff with strong oversight is associated with fewer project delays.

Project sponsors should also invest in a small, multidisciplinary team of high-quality, experienced executives with control over on-the-spot decisions, and enough junior staff to support them. The team needs to consist of employees from the public sector to ensure no conflicts of interest and proper oversight of outsourced staff. Project sponsors can and should use consultants to bolster in-house staff for specific expertise and discrete tasks, but those consultants need to be overseen by strong public sector management.

The FTA needs to work with project sponsors to more precisely determine their workforce needs for project delivery management and oversight. The FTA should invest in and develop training institutes and provide other resources to help agencies address these needs.

In addition, this research found that the unionized, frontline construction workforce is not a primary target for cost or timeline efficiencies on major projects domestically or abroad.[604] Due to competition with other industries for construction labor, the workforce is typically paid above the prevailing wage, and given that nearly all workers are employees of private construction firms, they do not have public sector pensions or other benefits associated with public sector agencies. Labor is a significant portion of project costs, but outside certain markets like New York, reforms to work rules and regulations will not have much effect.

Project sponsors should, however, **establish equitable project labor agreements (PLAs)** as a valuable way to avoid worker strife by providing clear arrangements for dispute resolution, pre-approved compensation, and work rules. Labor leaders should be at the table at the beginning of the project development in order to address potential concerns early, create flexibility in work rules, overtime, shared understanding about conflict resolution, and scheduling to keep projects moving efficiently and safely.

6.2 Some of the processes, procedures, and practices that public and private actors must undertake in order to build transit projects—from conception to final completion—are often too slow, cumbersome, or outdated. We need to make it easier to build more and better transit projects.

The NEPA statute does not need to be reformed, but the processes by which federal agencies reach a record of decision does.

Large, linear transit construction projects almost always require a comprehensive EIS. This is the most detailed type of analysis required by federal environmental review process, and one that can take several years to complete. The federal NEPA process is required of projects that use federal funds, but components of it often apply even if no federal funding is used.

NEPA is an important part of making sure that projects are transparent about their potential impacts to the built and natural environment, air quality, and the communities affected. They are intended to be clear and transparent in order for stakeholders to understand what will happen and mitigate unintended consequences. These federal regulations also help protect communities from negative effects to their health, resiliency, and vitality, especially communities of color, which often bear a disproportionate burden of negative impacts. It can give others impacted by the project—including labor—a voice in the decision-making process. Along with the federal metropolitan transportation planning requirements, it is one of the few mandated opportunities for the historically underrepresented to provide input.

The NEPA review process also extends beyond the statutory confines of the law itself. Environmental review for a project can involve more than 30 different federal authorizations, including NEPA, the Clean Air Act, the National Historic Preservation Act, and others. Layered on top of that are myriad state and local authorizations necessary for a project to move forward. The result is an uncoordinated, duplicative, and convoluted process that takes a long time given the different pace and experience among the agencies. Project sponsors usually do not know which of these authorizations will apply before they enter the environmental review phase. For each, a separate agency must prepare and review the authorization, under the loose guise of a lead agency that is tasked with overseeing the process. For example, the FTA is typically the lead agency for transit projects, but if a project crosses through an

endangered species habitat, the Department of Interior must also review compliance with the Endangered Species Act.

In this way, the U.S. approach is fairly consistent with how other countries approach their environmental reviews. But although the rules, regulations, and requirements in some European countries are as just as elaborate, the environmental review processes are generally better streamlined, and approval is obtained faster than in the United States. They offer several potential reform ideas that will help to make demonstrable improvements in environmental review efficiency without affecting environmental and community protections.

Other countries limit what is required for certain types of projects, including alternatives and types of impacts. In Madrid, transit projects in urban areas are brownfields, and thus are exempt from many of the environmental laws that, for example, an intercity high-speed rail or highway project in a greenfield site would require. Subway projects in Madrid primarily focus on construction impacts such as noise, NOx, and vibrations along with historical preservation. Ontario's Transit Project Assessment Process (TPAP) has allowed transit projects to be exempt from the provincial environmental assessment and to use their own condensed environmental review process that takes less than two years. Recent legislative changes have further exempted transit projects from select requirements and allowed certain early works like utility relocation to be evaluated through their own environmental assessment and carried out before completion of the larger environmental review.

Following the lead of places like Toronto, **Congress should create a pilot program to allow the federal transportation secretary to exempt select public transportation projects from NEPA if they are able to meet certain criteria.** To qualify for a place in the pilot program, a public transit project sponsor must demonstrate that it conducted robust community engagement and evaluated alternatives through the planning process. Projects in the pilot program will still need to work through other state and federal environmental authorizations outside of NEPA, such as historic preservation requirements and the Clean Air Act. The secretary should not allow more than three projects per year to be accepted into the pilot program. After five years, the FTA should evaluate the pilot to determine whether it had demonstrable benefits to costs and timelines or unintended consequences on the community or environmental resources.

For projects outside of the pilot, improved coordination, collaboration, and understanding of the federal permitting process among agency staff is critical to improving timelines. The better federal coordination promulgated through the One Federal Decision (OFD) Executive Order, was a good first step. Although there is general agreement that OFD will likely not make a significant impact on the actual timelines, better coordination between agencies on the status and timeline of the

varying federal authorizations is sensible. However, the mandatory time limits on EAs and EISs imposed by OFD failed to take into account the separate timelines and review processes mandated by other laws, like the Endangered Species Act, Clean Air Act, or National Historic Preservation Act. Likewise, mandatory page limits did little to restrict the scope of the document as a whole, because those pages ended up being displaced to appendices.

The Biden Administration revoked the OFD EO, **but it should be reissued and focus on better coordination and consolidation of the disparate timelines and processes among the various regulations that fall under the umbrella of NEPA**. Some aspects of OFD, such as page or time limits should not be included in the new EO. Once issued, **the FTA should execute an agreement with relevant federal agencies** such as the Army Corps of Engineers, EPA, United States Coast Guard, and others as appropriate and commit to working together to achieve the goals of the reissued EO and collaboratively work to coordinate each agency's processes.

Misunderstandings and conflicts between agencies lead to significant delays in the development of documents associated with environmental review. Early and consistent coordination between agencies during planning and environmental assessment helps foster agreement on issues. **The Council on Environmental Quality (CEQ) should require more regular face-to-face meetings of federal agency field staff involved with preparing environmental documents.** The goals of these in-person meetings are to discuss the project, the respective processes, potential barriers and to form relationships between staff that are concurrently working on environmental review. The deliberate creation of professional relationships can lead to a greater understanding among permitting staff on how other agencies conduct their respective analyses, enable better problem-solving, and ultimately result in faster decision-making.

Congress needs to level the playing field between highways and transit when it comes to NEPA review. Federal law allows states to assume NEPA review and approval authority for highway projects. This eliminates the need for the federal government to directly review and sign off on NEPA documents for specific projects, which could save time. **U.S. DOT should closely evaluate NEPA Assignment outcomes in the states that have adopted the program** to determine whether it makes sense for Congress to expand the program's statutory applicability to transit projects.

But large transit projects are much less common than highway projects in the United States, and the agencies tasked with environmental review often take a risk averse and inefficient approach. The local project sponsor typically does not have longstanding experience in project delivery or NEPA. In addition, the FTA has fewer staff since field offices cover multiple states—in contrast to FHWA, where each state has a field office—and the uniqueness of transit projects often results in more complex analyses. **Congress should dedicate more resources to the FTA to increase staffing in**

their regional offices and help assist transit agencies with preparing and coordinating environmental documents. As part of an overall coordination effort, requiring agencies to share environmental documents will help cut down on duplicative tasks and ensure greater communications between agencies. **Federal agencies and CEQ should explicitly require sharing of environmental documents between permitting agencies to cut down on duplicative tasks.**

Since the federalist reforms at streamlining are new and ongoing, **CEQ should set up an annual environmental permitting conference**. The event should cover federal, state, and local elements and bring public and private, federal and local environmental permitting staff together to learn and share best practices on transit project delivery. Training materials (e.g., print, video, and/or presentation materials) should be made available online or provided in person each year. Such an initiative could be modelled on parts of "Every Day Counts" (EDC) from the FHWA.

States and project sponsors also need to invest in the staff and processes for their own permitting and environmental review.

Through the course of this work, it was striking how mundane and straightforward highway projects navigate the environmental review process. With an engineering approach and methodical culture, highway projects interact with the environmental review process regularly since the United States routinely builds roadway projects. The public sector has experienced staff at state DOTs, and the FWHA has similarly experienced staff in nearby field offices in each state to guide projects through the environmental review process and other project phases. While officials seek to avoid NEPA-related litigation, it occurs regularly enough that agencies recognize it as part of the process, have the documents and staff ready to face these lawsuits, and regularly win such challenges. Along with continuing to leverage expertise from FTA, **transit project sponsors should borrow staff from state DOTs, MPOs and FHWA to assist with preparing environmental documents**. Transit project sponsors can lean on the deep experience and understanding that already exists within the highway environmental review industry by bringing on temporary staff, or working directly with staff at a state DOT or FHWA.

Since state laws and regulations are often as complicated and suffer from the same siloed nature as federal permits, **states should set up their own permitting councils similar to the Federal Permitting Improvement Steering Council**. If structured correctly, they would help local agencies navigate state environmental regulations and coordinate between various state and federal staff.

Lastly, transit projects are often subject to the study of several, if not dozens, of potential alternatives to determine the locally preferred option. In 2020, CEQ revised the federal regulations to no longer require the evaluation of "*all* reasonable alternatives" and

instead now allows applicants to only examine those alternatives deemed feasible. **Transit project sponsors should take advantage of this provision and exercise constraint in their alternatives and only examine those within their purpose and need.** While exploring alternatives is undoubtedly important, project sponsors and federal agencies should only explore viable alternatives so as to limit the scope and size of the EIS.

The planning and community and stakeholder engagement process needs greater investment and more attention.

During the environmental and planning process, project sponsors spend many hours communicating with the public and municipal governments about plans, soliciting input, and changing design in response to feedback. Plans and disruptions are similarly communicated to residents and business to help them handle the construction phase. In addition to being a required component of NEPA review and the federal planning process, community engagement is also an important part of major infrastructure projects around the globe.

But despite their efforts, agencies generally invest too little in public outreach and employ outdated tools. The resulting community anxiety and uncertainty can wind up slowing down project delivery. While some agencies like the Metropolitan Council in the Twin Cities stand out by having multiple, dedicated, full-time staff assigned to various portions of their projects' alignments, most agencies use a standard public meeting approach to communicate plans and listen to feedback. A lack of early planning and dedicated staff that can meet the community members where they are, listen to their concerns, and find ways to address them is a common shortcoming. **Project sponsors need to dedicate more staff and resources to working directly with communities during the early planning process. They should also employ non-traditional forms of public engagement**, such as opportunities to provide virtual feedback, smaller meetings in communities (rather than the standard, large auditorium public meeting), and hosting meetings at non-traditional hours to accommodate shift workers, can play a major role in creating a more equitable and effective outreach program.

At the same time, project sponsors often defer too much to community input and place high value on the path of least resistance. While it is important to listen and absorb input, it can result in scope creep, runaway betterment requests from localities, and escalating costs. Public agencies and the officials on their boards are intended to represent the public, and **agency staff need to be more empowered to make tough decisions on project scope and requests** during planning and construction. In doing so, **project sponsors need to transparently document their community engagement** to ensure that those decisions are socially equitable. A transparent process, where public sector planners can document all comments and demonstrate how they feed into the final decisions, is critical. Staff should take care to

ensure that outreach is representative, respond to every comment, track major decisions and why options were taken off the table, and show how decisions were made with the public input in mind.

Community engagement in international peer regions often emphasizes transparency early in the process. For the Grand Paris Express, project designs were open to public comment for several months and once construction started, numerous events were held where the public could interact with construction employees at the worksites. A similar approach was used in Copenhagen, where there is extended public outreach about the proposed designs and an opportunity for the public to provide input into the scope of the environmental review. **Project sponsors should invest time and resources into securing scope agreement as early as possible during the project planning stage** to prevent disagreements and issues from causing further delays and issues further into the project.

Without a doubt, most transit construction projects are disruptive to local businesses, residents, and roadway traffic. To minimize the impact, project sponsors amend their work schedule to avoid generating noise during the evening and night hours. Projects also have to enable traffic to flow around or through construction sites. Accommodating these interests is a major driver of project timelines in the United States while international examples suggest other countries much more tolerant of disruption.

COVID-19 created a natural experiment in Los Angeles to demonstrate these tradeoffs. When tunneling for the Purple Line's Beverly Hills station, LA Metro's original plan was to excavate Wilshire Boulevard over a months-long series of weekends, and deck over the excavation so traffic could resume during the work week. With stay-at-home orders in effect, the community agreed to close the road and let construction continue throughout the week. The result was that the station excavation was completed *seven months sooner* than anticipated. **Project sponsors should work with the community to recognize these trade-offs and push for greater short-term disruption to advance construction faster**.

Policy and practice reforms are needed to address significant shortcomings related to utility relocation and land acquisition.

The need to relocate utilities and acquire land are major cost and timeline drivers for both domestic and international projects. Utility relocation involves not only identifying which are affected by construction work, but also coordinating the actual relocation with utility companies, which may be publicly or privately owned. Issues with utility identification can become particularly complicated when relocating subsurface utilities. Old and inaccurate maps have led to project sponsors finding utilities below ground that were never documented, are in unexpected locations,

or are in worse condition than documents had indicated. These result in additional relocation work and change orders that further adds costs and delays.

While utility companies are technically responsible for the relocation, it is the subject of frequent litigation, and courts do not always force utilities to cover the full cost. In some cases, existing agreements between utility companies and public agencies govern any relocations, giving project sponsors little to no ability to bring an outside contractor in to complete the relocation or push for a specific relocation timeline. Some of these agreements may give a municipality (but not necessarily a transit project sponsor) the power to order relocation. Additionally, the need to conduct third party reviews, acquire permits, and physically relocate the utilities can take significant time to complete.

It is critically important to begin the utility relocation process as early as possible. After a series of delays and claims associated with relocation work on Phase I of the Expo Line, LA Metro dedicated more staff to handling third party interfaces on major projects, and initiated earlier contacts with utility owners and municipalities. On the Purple Line Extension, the agency awarded a separate contract for utility identification and relocation prior to awarding the full design-build contract to prevent relocation issues from impacting the larger, multi-billion project contract. In Ontario, Canada, major legislative changes to the approval and environmental assessment process for transit projects have given project sponsors the legal authority to order utility relocation, and if utility companies refuse to comply, they are legally required to re-imburse the project sponsor for any relocation costs.[605]

Project sponsors need to dedicate staff with expertise in utility relocation since quick, and responsible processes lead to substantial cost savings. These staff should be brought on early, in the planning phase, and remain through the duration of construction. **Project sponsors and utilities should sign agreements early in the process and relocate or identify as many utilities as practical prior to construction.** Early identification and relocation yield significant benefits later in a project's construction. On the other hand, misidentification of utilities can lead to significant costs due to change orders.

Similar challenges exist with the land acquisition process. Rising real estate costs in major U.S. cities along with hesitancy on the part of property owners have led to lengthy, expensive property acquisition negotiations. In Seattle the process can take nearly two years, and Sound Transit often spends a significant amount of time and money to compensate owners for their property to avoid condemnation. To address this, the agency began launching early discussions with property owners and brought in experienced ROW acquisition staff from the Washington State DOT. The DOT conducts land acquisition on a much more regular basis and can provide additional expertise and assistance in both acquiring land and making the most of the state's

existing ROW. This is a good model and transit **project sponsors should work with staff at state DOTs to bring on experience in utility relocation and land acquisition.**

6.3 Building more and better transit demands a new framework for how we think about projects, the standards that are applied, and the policy environment in which they operate.

Customization should be deemphasized in favor of updated standardization to save on construction costs and speed up delivery.

Undeniably, transit investments—especially stations—help shape communities, neighborhoods, and define a place's character. Given how infrequent these projects take place, there is a natural and understandable tendency to tailor designs and materials to a locally preferred aesthetic. In other cases, agencies have highly specific and unique standards for equipment and systems which are not visible to the public. By relaxing these kinds of standards and imparting lessons and practices from international and domestic cases, projects can achieve better economies of scale.

The Copenhagen example is illustrative. When that city built its first tunneled metro system, it opted for an off-the-shelf automated train from an Italian manufacturer, which provided significant cost savings. The Copenhagen Metro also uses small, 3 car trains, that dramatically reduce the size and excavation footprint of their stations. The automated nature of the system allows for trains to run once every 100 seconds, effectively increasing capacity and boosting service without significant operational costs. Along with reducing the footprint of their stations, architects of the Copenhagen Metro standardized as many parts on their stations as possible to reduce costs and allow for easy, inexpensive maintenance. **U.S. project sponsors, particularly those constructing new systems, should adopt vehicle and station designs from peer agencies to simplify design and trim costs.**

In addition to the overly customized nature of U.S. rolling stock and station design, the lack of incorporation of international examples and best practices is problematic. There could be significant benefits to standardization and adoption of other systems' designs and approaches. The terms and conditions of transit construction contracts in Europe use the International Federation of Consulting Engineers (FIDIC) standards and are mostly uniform. The framework for tunneling provides guidance for how to address risk sharing between project sponsors and contractors and has resulted in fewer legal disputes.[606] **The United States should establish standardized terms and conditions for transit construction contracts**, perhaps using existing resources like the FIDIC Emerald Book.

Further, the longstanding U.S. approach to safety standards should be revisited. Other countries have been able to meet or exceed American safety using a different approach than the NFPA 130 standards. For example, skylights in stations on the Copenhagen Metro not only allowed for natural light to reach the platform, but also doubled as NFPA-compliant ventilation devices, reducing the need for escape shafts and expensive ventilation equipment. The United States' approach to safety standards would benefit from an update, along with additional study of other international standards. **Project sponsors, the FTA, UITP, and APTA should review existing construction standards to see if they can be more performance-based and useful in ways that can maintain safety but open avenues for more creative ways to meet them.**

The FTA and project sponsors should establish dedicated programs to exchange best practices on project delivery and station design, including but not limited to regular study tours. Through its International Public Transportation Program, the FTA currently engages in trade missions, capacity building, and technology transfer initiatives with agencies abroad. The FTA should expand its international collaboration by establishing a program dedicated to the exchange of best practices and capacity building for project delivery. Regular study trips and formal information exchanges would help U.S. planners, leaders, and designers to better understand the best practices and innovations in governance, planning, standards, and processes of transit project delivery around the world. Such exploration should expand beyond Western Europe and Canada to include other low cost countries in Asia and elsewhere.

Transit projects in the United States need to maximize their public benefits.

When faced with escalating costs and community resistance, project sponsors in the United States often select routes along freeways or industrial freight rail rights of way because they are significantly less expensive, do not interface with communities, nor require the intensive utility relocation often necessary for at-grade options along boulevards or other urban roadways. However, the international examples explored in this research include trams constructed at-grade in the median of existing arterials (if not buried), taking existing lanes from cars and putting routes through the denser parts of the region. These projects are delivered at a similar cost to U.S. projects that choose a path of less resistance but provide far more utility and benefit to the communities they serve.

The U.S. approach leads some stations to be located in sub-optimal locations and less likely to meet ridership or accessibility goals or serve the most useful routes, ultimately undermining the project's success. While ensuring proper stewardship of public dollars for construction is laudable, **project sponsors should weigh the tradeoffs between cost, complexity, and ridership when considering alignments**. While running transit through existing rights-of-way can minimize interfaces with existing

communities, reduce complexity, and lower costs, it may also come at the expense of system ridership and utility if the line does not serve population centers.

Project sponsors are often responsible for covering the costs of betterments and other scope changes requested by local jurisdictions. Betterments can enhance a project and its surrounding community but can become problematic when requested after a project is already underway, leading to costly change orders, or require the project sponsor to increase project budgets to cover the cost of betterments. As has been done in Los Angeles and Minneapolis, project sponsors should **enact a policy that clearly outlines when and how stakeholders can request betterments, include a process to evaluate whether or not to grant the request, and require the requesting entity to cover the cost in most circumstances**. Sponsors can define instances in which a requester must pay for the betterment, and outline any exemptions (i.e. for equity or safety reasons, or for any betterments necessary to comply with the law, standards, or other policies) but project sponsors should be primarily responsible for funding just the transit elements of the overall project. **Community benefit agreements (CBA) or other formal agreements, should be used to address community concerns and are useful when made early in the process.**

Federal incentives are another powerful tool to enable project sponsors to increase the overall standards of their transit projects. **The federal Capital Investment Grants program needs to require minimum zoning densities or level of development around stations as a condition for federal funding.** Similarly, **federal evaluation needs to de-emphasize ridership as a key component of a project's success and rely on accessibility metrics more often.** The FTA should investigate new metrics that better leverage federal dollars.

7.0 Conclusions

Our thorough review of project delivery reveals that inadequate governance, cumbersome processes, and outdated standards cost U.S. transit project dearly. While there is no single cause for high costs and long timelines, the compounding effects of these underlying issues creates an environment of inefficiency that results in fewer projects being built, shorter transit lines, and sub-optimal routing decisions that leave many systems underutilized. Implementing the changes necessary to tackle this problem will require a concerted effort at the federal, state, and local levels.

A common thread across the recommendations in this report is the lack of underlying political will to implement best practices. The United States suffers from a political climate that does not uniformly see investment in transit infrastructure as net positive. Instead, transit project sponsors spend much of their public outreach effort simply justifying their existence and the value of transit, rather than engaging on the details of a project. Public skepticism of transit investments results in broad community pushback, increased willingness to sue to delay or block projects, and more judges that are sympathetic to those lawsuits. The lack of broad public acceptance for transit also results in communities demanding mitigation for negative construction impacts rather than demanding faster timelines.

This stands in stark contrast to peer countries, where support for transit is much greater and often cuts across partisan lines. The successful subway expansion in Madrid was a product of socialist and conservative parties out promising each other on how much transit could be built in the region. The conversative party won regional elections on their promise to build more subway lines and were reelected due to their ability to meet their goals. While there are always detractors, broad support for transit allows communities to clamor and compete for projects, rather than trying to block them.

Changing the national mindset on transit investment is a monumental task and one that will take significant effort. Luckily, there are several important opportunities to help change the narrative on transit investments. Increasing environmental consciousness and a global need to cut greenhouse gas emissions are already expanding political support for transit investments, as is the growing focus on combatting racial and socioeconomic inequality. But most importantly, as more localities use their own funds to expand and invest in their transit networks, there will be a strong financial incentive for regions to change their approach to project delivery. By implementing best practices and making the changes necessary to effectively deliver major projects, project sponsors will be able to deliver more and better transit projects to the communities that need them.

Appendix A: Transit Construction Cost Database

The following is a select subset of the Eno Transit Construction Cost Database.
The full construction cost database is available for download at https://projectdelivery.enotrans.org/

Country	Region	Project	Mode	Opening Date	Time to Construct (months)	Length (miles)	Percent Tunneled	Stations	Final Cost (million US$)	Cost per Mile (million US$)
US	Boston	Green Line Extension	Heavy Rail	December 2021	90	4.3	0%	6	**2346**	**548**
US	Charlotte	Blue Line	Light Rail	November 2007	33	9.6	0%	15	**674**	**70**
US	Charlotte	Blue Line Extension	Light Rail	March 2018	54	9.3	1%	11	**1309**	**141**
US	Dallas	DART Green Line Extensions to Buckner and North Carrollton	Light Rail	December 2010	41	28.5	1%	16	**2369**	**83**
US	Dallas	Blue Line Extension to Rowlett	Light Rail	December 2012	44	4.6	0%	1	**386**	**84**
US	Dallas	Orange Line Phase 1 to Irving	Light Rail	July 2012	37	5.4	0%	3	**622**	**115**
US	Dallas	Orange Line Phase 2 to Belt Line	Light Rail	December 2012	42	3.9	0%	2	**498**	**128**
US	Dallas	Orange Line Phase 3 to DFW	Light Rail	August 2014	28	4.7	0%	1	**469**	**100**
US	Dallas	South Oak Cliff/UNT Blue Line Extension	Light Rail	October 2016	24	2.6	0%	2	**219**	**84**
US	Denver	W Line	Light Rail	April 2013	71	12.1	0%	12	**661**	**55**
US	Denver	A Line	Commuter Rail	April 2016	68	23.5	0%	7	**1231**	**52**
US	Denver	R Line	Light Rail	February 2017	47	10.5	0%	8	**591**	**56**
US	Denver	Gold G Line	Commuter Rail	April 2019	92	11.2	0%	7	**455**	**41**
US	Denver	Southeast Extension	Light Rail	May 2019	36	2.3	0%	3	**183**	**80**
US	Houston	Red Line (Original)	Light Rail	January 2004	34	7.5	0%	16	**546**	**73**
US	Houston	Red Line Extension	Light Rail	December 2013	53	5.3	0%	8	**940**	**178**
US	Houston	Green Line	Light Rail	May 2015	70	3.2	0%	7	**711**	**223**
US	Houston	Purple Line	Light Rail	May 2015	70	6.7	0%	11	**997**	**149**

Country	Region	Project	Mode	Opening Date	Time to Construct (months)	Length (miles)	Percent Tunneled	Stations	Final Cost (million US$)	Cost per Mile (million US$)
US	Hudson County	Hudson-Bergen light rail	Light Rail	January 2011	165	17.0	5%	24	**3647**	**215**
US	Los Angeles	Blue Line	Light Rail	July 1990	57	22.0	3%	22	**2189**	**100**
US	Los Angeles	Green Line	Light Rail	August 1995	55	19.5	0%	14	**1555**	**80**
US	Los Angeles	Red (B) Line Phase 2A and 2B	Heavy Rail	June 1999	125	6.6	100%	8	**3413**	**515**
US	Los Angeles	Red (B) Line Phase 3	Heavy Rail	June 2000	73	6.4	100%	3	**2281**	**354**
US	Los Angeles	Expo Line Phase 1	Light Rail	April 2012	67	8.6	2%	10	**1264**	**147**
US	Los Angeles	Expo Line Phase 2	Light Rail	May 2016	56	6.6	0%	7	**1482**	**225**
US	Los Angeles	Gold Line - LA to Pasadena	Light Rail	July 2003	37	13.7	5%	13	**1244**	**91**
US	Los Angeles	Gold Line - Eastside Extension	Light Rail	November 2009	64	6.0	28%	8	**1256**	**210**
US	Los Angeles	Gold Line Foothill Extension Phase 2A	Light Rail	March 2016	69	11.5	0%	6	**844**	**74**
US	Miami	AirportLink metrorail	Heavy Rail	July 2012	38	2.4	0%	1	**629**	**267**
US	Minneapolis	Metro Blue Line (light rail)	Light Rail	June 2004	41	12.0	15%	19	**951**	**79**
US	Minneapolis	Metro Green Line (light rail)	Light Rail	June 2014	45	11.2	0%	23	**1160**	**104**
US	New York	7 extension	Heavy Rail	September 2015	93	1.0	100%	1	**3010**	**3034**
US	New York	Second Avenue Phase 1	Heavy Rail	January 2017	117	1.7	100%	3	**5939**	**3548**
US	Norfolk	Hampton Roads Tide Light Rail	Light Rail	August 2011	44	7.4	0%	11	**367**	**50**
US	Phoenix	Central Mesa Extension	Light Rail	August 2015	38	3.1	0%	4	**227**	**73**
US	Phoenix	Northwest Extension Phase 1	Light Rail	March 2016	38	3.2	0%	3	**368**	**115**
US	Phoenix	Gilbert Road Extension	Light Rail	May 2019	31	1.9	0%	2	**188**	**99**
US	Pittsburgh	North Shore Connector	Light Rail	March 2012	66	1.2	43%	3	**671**	**560**
US	Portland	Westside/Hillsboro MAX	Light Rail	September 1998	62	17.7	17%	20	**1673**	**95**
US	Portland	Airport MAX Red Line	Light Rail	September 2001	28	5.5	0%	4	**453**	**83**
US	Portland	Interstate MAX	Light Rail	May 2004	42	5.7	0%	10	**444**	**77**

Country	Region	Project	Mode	Opening Date	Time to Construct (months)	Length (miles)	Percent Tunneled	Stations	Final Cost (million US$)	Cost per Mile (million US$)
US	Portland	Green Line light rail	Light Rail	September 2009	31	4.0	0%	8	**527**	**131**
US	Portland	South Corridor/Portland Mall MAX	Light Rail	September 2009	31	8.4	2%	20	**645**	**77**
US	Portland	Orange Line light rail	Light Rail	September 2015	52	7.3	0%	10	**1767**	**243**
US	Sacramento	Blue Line Extension South Corridor Phase 1	Light Rail	September 2003		6.3	0%	7	**291**	**46**
US	Sacramento	Gold Line Extension Folsom Corridor	Light Rail	October 2005		12.9	0%	10	**388**	**30**
US	Sacramento	Riverfront Green Line	Light Rail	June 2012	32	1.0	0%	2	**55**	**55**
US	Sacramento	Blue Line Extension - South Corridor Phase II	Light Rail	August 2015	45	4.3	0%	4	**319**	**74**
US	Salt Lake City	Blue Line (Original)	Light Rail	December 1999	32	15.0	0%	16	**422**	**28**
US	Salt Lake City	Red Line (Original)	Light Rail	December 2001	16	2.3	0%	8	**167**	**73**
US	Salt Lake City	Green Line (West Valley Extension)	Light Rail	August 2011	38	5.1	0%	4	**474**	**93**
US	Salt Lake City	Red Line (Mid-Jordan Extension)	Light Rail	August 2011	39	10.6	0%	9	**463**	**44**
US	Salt Lake City	Blue Line Draper Extension	Light Rail	August 2013	31	3.8	0%	3	**173**	**46**
US	Salt Lake City	Green Line (Airport Extension)	Light Rail	August 2013	58	6.0	0%	6	**435**	**73**
US	San Francisco	BART - SFO Extension	Heavy Rail	June 2003	67	8.6	67%	4	**2635**	**307**
US	San Francisco	Coliseum-Oakland International Airport Line	Heavy Rail	November 2014	49	3.2	2%	2	**587**	**184**
US	San Francisco	BART Warm Springs	Heavy Rail	March 2017	90	5.4	16%	1	**886**	**164**
US	San Francisco	eBART	Commuter Rail	May 2018	91	10.1	0%	1	**604**	**60**
US	San Francisco	Central Subway	Heavy Rail	2022		1.7	100%	3	**1685**	**1007**
US	Seattle	1 Line - Initial Segment	Light Rail	July 2009	68	15.6	15%	14	**3723**	**239**
US	Seattle	Angle Lake Extension	Light Rail	September 2016	41	1.6	0%	1	**331**	**207**
US	Seattle	U-Link	Light Rail	March 2016	84	3.2	100%	2	**1614**	**511**

Country	Region	Project	Mode	Opening Date	Time to Construct (months)	Length (miles)	Percent Tunneled	Stations	Final Cost (million US$)	Cost per Mile (million US$)
US	Trenton	Southern NJ Light Rail Transit System	Light Rail	March 2004	46	28.0	0%	21	**977**	**35**
US	Washington, DC	Red Line Wheaton to Glenmont	Heavy Rail	July 1998	59	1.6	100%	1	**421**	**268**
US	Washington, DC	Green Line Mid-City Segment U Street to Fort Totten	Heavy Rail	September 1999	76	2.9	100%	2	**1195**	**411**
US	Washington, DC	Green Line from Anacostia to Branche Avenue	Heavy Rail	January 2001	64	6.7	70%	5	**1442**	**217**
US	Washington, DC	Silver Line phase 1	Heavy Rail	July 2014	64	11.7	4%	5	**3258**	**279**
US	Washington, DC	Silver Line phase 2	Heavy Rail	2022		11.4	0%	6	**2398**	**211**
AT	Vienna	Line 2 extension	Heavy Rail	October 2013		2.6	0%	3	**477**	**183**
AT	Vienna	Line 1 extension	Heavy Rail	September 2017	62	2.9	57%	5	**845**	**290**
AU	Canberra	Canberra Metro	Light Rail	April 2019	33	7.4	0%	13	**474**	**64**
AU	Sydney	Metro NW	Heavy Rail	May 2019	92	22.3	42%	13	**5949**	**267**
CA	Calgary	Blue Line West Extension	Light Rail	December 2012	58	5.1	29%	6	**1575**	**310**
CA	Calgary	Northeast LRT Extension to Saddle Ridge	Light Rail	August 2012	35	1.8	5%	2	**124**	**69**
CA	Calgary	Northwest LRT Extension to Rocky Ridge/Tuscany	Light Rail	August 2014	52	1.4	0%	1	**111**	**80**
CA	Edmonton	Metro Line	Light Rail	September 2015	73	2.0	27%	3	**648**	**317**
CA	Montreal	Laval extension	Heavy Rail	April 2007	61	3.2	100%	3	**930**	**288**
CA	Ottawa	Confederation	Light Rail	September 2019	77	7.8	20%	13	**1899**	**245**
CA	Toronto	Sheppard	Heavy Rail	November 2002	101	3.4	100%	5	**1501**	**440**
CA	Toronto	Spadina Subway Extension	Heavy Rail	December 2017	113	5.3	100%	6	**3089**	**579**
CA	Vancouver	Millennium Line - Initial	Heavy Rail	August 2002	34	12.7	5%	10	**1750**	**138**
CA	Vancouver	Canada Line	Heavy Rail	August 2009	46	11.8	47%	16	**2335**	**198**
CA	Vancouver	Millennium Line Evergreen Extension SkyTrain	Heavy Rail	December 2016	55	6.8	20%	4	**1338**	**197**

Country	Region	Project	Mode	Opening Date	Time to Construct (months)	Length (miles)	Percent Tunneled	Stations	Final Cost (million US$)	Cost per Mile (million US$)
CA	Waterloo	Ion Light Rail	Light Rail	June 2019	58	11.8	0%	19	**757**	**64**
DE	Berlin	U5-U55 connection	Heavy Rail	December 2020	128	1.4	100%	3	**759**	**556**
DE	Dusseldorf	Wehrhahn Line	Heavy Rail	February 2016	99	2.1	100%	6	**1430**	**678**
DE	Hamburg	U4 to HafenCity U	Heavy Rail	November 2012	63	2.4	100%	2	**520**	**215**
DE	Hamburg	U4 to Elbbrücken	Heavy Rail	December 2018	44	0.8	100%	1	**210**	**261**
DE	Leipzig	City Tunnel	Heavy Rail	December 2013	125	2.2	100%	4	**1589**	**712**
DK	Copenhagen	Metro Initial	Light Rail	September 2007	130	13.0	48%	23	**2297**	**176**
DK	Copenhagen	City Circle Line	Light Rail	March 2020	106	9.6	100%	17	**3779**	**393**
DK	Copenhagen	M4 to North Harbour	Light Rail	March 2020	63	0.9	86%	2	**491**	**565**
ES	Barcelona	Tram Line 11	Light Rail	December 2003	35	1.4	100%	5	**195**	**137**
ES	Barcelona	Trambaix Network (T1, T2, and T3 Lines)	Light Rail	April 2007	70	9.4	0%	29	**623**	**66**
ES	Barcelona	L3 Metro Extension to Trinitat Nova	Heavy Rail	October 2008	60	1.2	100%	2	**298**	**253**
ES	Barcelona	Trambesos Network (T4, T5, and T6 Lines)	Light Rail	June 2008	65	8.7	11%	27	**547**	**63**
ES	Barcelona	L2 Metro Extension to Badalona	Heavy Rail	July 2010	57	0.4	100%	1	**131**	**302**
ES	Barcelona	L5 to Vall d'Hebron	Heavy Rail	July 2010	40	1.6	100%	3	**587**	**379**
ES	Barcelona	Terrassa tunnel	Heavy Rail	July 2015	88	2.8	100%	3	**699**	**251**
ES	Barcelona	Metro Line 9 - Southern Segment to Airport	Heavy Rail	February 2016	161	10.5	100%	15	**5317**	**507**
ES	Barcelona	Sabadell tunnel	Heavy Rail	July 2017	123	2.7	100%	4	**750**	**275**
ES	Bilbao	Line A Tram	Light Rail	December 2002	43	3.5	0%	14	**96**	**28**
ES	Bilbao	Line 3	Heavy Rail	April 2017	93	3.7	95%	7	**489**	**134**
ES	Madrid	1995-98 program	Heavy Rail	March 1999	43	34.7	68%	34	**4197**	**121**
ES	Madrid	1999-2003 program	Heavy Rail	March 2003	43	46.3	77%	39	**7523**	**162**

Country	Region	Project	Mode	Opening Date	Time to Construct (months)	Length (miles)	Percent Tunneled	Stations	Final Cost (million US$)	Cost per Mile (million US$)
ES	Madrid	ML1	Light Rail	May 2007	29	3.3	69%	9	**547**	**163**
ES	Madrid	ML2	Light Rail	July 2007	31	5.4	30%	13	**559**	**104**
ES	Madrid	ML3	Light Rail	July 2007	31	8.5	10%	14	**565**	**67**
ES	Madrid	Chamartin-Atocha tunnel	Heavy Rail	July 2008	48	4.7	100%	3	**1086**	**234**
ES	Madrid	Parla Tram	Light Rail	May 2008	32	5.2	0%	15	**270**	**52**
ES	Madrid	Line 2 extension	Heavy Rail	March 2011	28	2.9	100%	4	**556**	**195**
ES	Madrid	Line 9 extension	Heavy Rail	March 2015	66	1.9	100%	2	**333**	**179**
ES	Malaga	Lines 1-2	Light Rail	July 2014	97	7.0	81%	17	**1535**	**219**
ES	Murcia	Line 1	Light Rail	May 2011	61	10.9	0%	28	**484**	**45**
ES	Seville	Sevilla Tram	Light Rail	October 2007	18	1.4	0%	5	**102**	**75**
ES	Seville	Line 1	Light Rail	April 2009	67	11.3	64%	22	**1762**	**156**
ES	Tenerife	Line 1 Tram	Light Rail	June 2007	36	7.6	0%	21	**506**	**66**
ES	Tenerife	Line 2 Tram	Light Rail	May 2009	14	2.2	0%	6	**101**	**45**
ES	Vitoria	Vitoria Tram	Light Rail	December 2008	32	4.5	0%	18	**193**	**43**
ES	Zaragoza	Zaragoza Tram	Light Rail	April 2011	20	7.9	0%	25	**706**	**89**
FR	Lyon	Line T1	Light Rail	January 2001	28	5.9	0%	22	**347**	**59**
FR	Lyon	Line T2	Light Rail	January 2001	28	6.2	0%	20	**394**	**64**
FR	Lyon	Line A to Vaulx	Heavy Rail	October 2007	27	0.6	100%	1	**86**	**139**
FR	Lyon	Line B to Oullins	Heavy Rail	December 2013	53	1.1	100%	1	**328**	**311**
FR	Montpellier	Line 1	Light Rail	July 2000	35	9.4	0%	29	**733**	**78**
FR	Montpellier	Line 2	Light Rail	December 2006	22	12.4	0%	33	**771**	**62**
FR	Nantes	Line 3	Light Rail	August 2000		2.9	0%	12	**157**	**55**
FR	Orleans	Line 1	Light Rail	November 2000	25	11.0	0%	24	**619**	**56**
FR	Paris	Tram 1 Initial Segment	Light Rail	July 1992	39	5.6	0%	21	**255**	**46**
FR	Paris	Tram 2 - Initial	Light Rail	July 1997	46	7.1	11%	13	**190**	**27**
FR	Paris	Line 14 - Madeleine to	Heavy Rail	October 1998	107	5.4	100%	7	**2418**	**448**

Country	Region	Project	Mode	Opening Date	Time to Construct (months)	Length (miles)	Percent Tunneled	Stations	Final Cost (million US$)	Cost per Mile (million US$)
FR	Paris	Line 14 - Madeleine to Francois Mitterand Library	Heavy Rail	October 1998	107	5.4	100%	7	**2418**	**448**
FR	Paris	Line 14 - St. Lazare Extension	Heavy Rail	December 2003	65	0.4	100%	1	**217**	**540**
FR	Paris	Tram 1 - Extension to Noisy-le-Sec	Light Rail	December 2003	56	1.8	0%	5	**56**	**31**
FR	Paris	Tram 3a - initial	Light Rail	December 2006	30	4.9	0%	17	**516**	**105**
FR	Paris	Line 14 - Olympiades Extension	Heavy Rail	June 2007	73	0.4	100%	1	**189**	**434**
FR	Paris	Line 13 to Courtilles	Heavy Rail	June 2008	40	1.2	100%	2	**251**	**213**
FR	Paris	Tram 2 - Extension to Porte de Versailles	Light Rail	November 2009	51	1.4	0%	4	**147**	**103**
FR	Paris	Line 8 to Pointe-du-Lac	Heavy Rail	October 2011	55	0.8	0%	1	**127**	**157**
FR	Paris	Line 12 to Front Populaire	Heavy Rail	December 2012	62	0.9	100%	1	**443**	**476**
FR	Paris	Tram 1 - Extension to Gennevilliers	Light Rail	November 2012	40	3.0	0%	1	**222**	**73**
FR	Paris	Tram 2 - Extension to Pont de Bezons	Light Rail	November 2012	64	2.6	0%	7	**335**	**129**
FR	Paris	Line 4 to Montrouge	Heavy Rail	March 2013	80	0.9	100%	1	**278**	**299**
FR	Paris	Tram 5	Light Rail	July 2013	70	4.1	0%	16	**239**	**58**
FR	Paris	Tram 7	Light Rail	November 2013	52	6.9	0%	18	**432**	**62**
FR	Paris	Tram 8	Light Rail	December 2014	54	5.3	0%	17	**359**	**68**
FR	Paris	Tram 6 (initial + extension)	Light Rail	May 2016	68	8.7	11%	21	**561**	**65**
FR	Paris	Tram 11	Light Rail	July 2017	96	6.6	0%	7	**1592**	**242**
FR	Paris	Tram 1 - Extension to Asnieres Quatre-Routes (Phase 1)	Light Rail	October 2019	25	0.6	0%	1	**50**	**90**
FR	Paris	Tram 4 - Extension	Light Rail	December 2019	38	4.1	0%	11	**364**	**89**
FR	Rennes	Metro Line A	Heavy Rail	March 2002	62	5.9	79%	15	**1028**	**175**
FR	Rennes	Metro Line B	Heavy Rail	September 2021	108	8.7	78%	9	**1792**	**205**
FR	Strasbourg	Line B	Light Rail	September 2000	26	7.8	0%	24	**557**	**71**

Country	Region	Project	Mode	Opening Date	Time to Construct (months)	Length (miles)	Percent Tunneled	Stations	Final Cost (million US$)	Cost per Mile (million US$)
FR	Strasbourg	2007-08 Extension (Extension of Line B, C, and D)	Light Rail	May 2008	25	7.9	0%	22	**633**	**80**
FR	Toulouse	Line A - Initial	Heavy Rail	June 1993		6.0	90%	15	**1020**	**170**
FR	Toulouse	Line A - Extension	Heavy Rail	December 2003	40	1.4	64%	3	**359**	**263**
FR	Toulouse	Line B	Heavy Rail	June 2007	70	9.3	100%	20	**1640**	**176**
FR	Toulouse	Tram T1 - Initial	Light Rail	December 2010	41	6.8	0%	18	**324**	**48**
FR	Toulouse	Tram T1 - Extension	Light Rail	December 2013	22	2.5	0%	6	**167**	**68**
FR	Toulouse	Tram T2	Light Rail	April 2015	16	1.5	0%	3	**105**	**71**
GB	Croydon	Tramlink	Light Rail	May 2000	40	17.4	0%	35	**513**	**30**
GB	London	Jubilee line extension	Heavy Rail	December 1999	72	9.9	80%	13	**9838**	**992**
GB	London	Battersea	Heavy Rail	Autumn 2021		2.0	100%	2	**1781**	**898**
GB	Manchester	Eccles Line	Light Rail	September 2000	38	4.0	0%	11	**410**	**103**
GB	Manchester	"Big Bang" Extension	Light Rail	February 2017	88	37.2	0%	57	**2549**	**69**
GB	Nottingham	Nottingham Tram Line 1	Light Rail	March 2004	46	8.9	0%	23	**450**	**51**
GB	Nottingham	Nottingham Tram Line 2	Light Rail	August 2015	41	10.9	0%	28	**939**	**87**
GB	Tyne-and-Wear	Tyne and Wear Metro (Initial Phase, 1991 Extension, and 2002 Extension)	Light Rail	2002		47.7	8%	57	**1407**	**29**
IT	Brescia	Metro	Light Rail	March 2013	110	8.5	76%	17	**1597**	**188**
IT	Milan	Passante Railway	Commuter Rail	May 2008		4.8	60%	10	**2298**	**475**
IT	Milan	Line 5 phase 1	Light Rail	February 2013	67	3.8	100%	9	**924**	**244**
IT	Milan	Line 5 phase 2	Light Rail	November 2015	60	4.0	100%	10	**1276**	**317**
IT	Rome	Line B1 (Bologna to Conca d'Oro)	Heavy Rail	June 2012	80	2.5	100%	3	**876**	**353**
IT	Rome	Line B1 extension to Jonio)	Heavy Rail	April 2015	65	0.9	100%	1	**324**	**349**
IT	Turin	Line 1 (initial)	Heavy Rail	February 2006	62	5.9	100%	15	**1212**	**206**
IT	Turin	Line 1 (First extension)	Heavy Rail	March 2011	60	2.3	100%	6	**512**	**223**

Country	Region	Project	Mode	Opening Date	Time to Construct (months)	Length (miles)	Percent Tunneled	Stations	Final Cost (million US$)	Cost per Mile (million US$)
IT	Turin	Line 1 south extension	Heavy Rail	April 2021	101	1.1	100%	2	**295**	**280**
NL	Amsterdam	North-South Line	Heavy Rail	July 2018	195	6.1	61%	8	**4657**	**766**
NO	Oslo	Løren Line	Heavy Rail	April 2016	34	1.0	100%	1	**151**	**152**
SE	Malmo	Citytunneln	Heavy Rail	December 2010	69	10.5	35%	3	**1186**	**113**
SE	Stockholm	Citybanan	Commuter Rail	July 2017	102	4.6	81%	2	**2544**	**554**

Endnotes

[1] Yonah Freemark, "Too Little, Too Late? A Decade of Transit Investment in the U.S.," The Transport Politic, 2020.
[2] Future iterations of this database could include examples beyond these regions, and Eno intends to draw lessons from peer countries in Asia, Oceania, Africa, and South America.
[3] "Data", Transit Costs Project—NYU Marron Institute, 2020; Freemark, 2020.
[4] Note that these 11 cost and timeline drivers cover only controllable variables in project delivery. Many factors that make some projects more expensive than others result from the current costs of raw materials or the underlying geology, which cannot be changed. While these factors are important to consider, they cannot necessarily be controlled by public policy and thus are not the focus of this review.
[5] One exception is Los Angeles, where several projects were delivered by independent construction authorities but are owned and operated by the region's lead transit agency, LA Metro.
[6] A separate study of project delivery in New York City is forthcoming.
[7] See: Bent Flyvbjerg, "Cost Overruns and Demand Shortfalls in Urban Rail and Other Infrastructure," *Transportation Planning and Technology*, 30(1): February 2007, pp. 9-30.
[8] OECD, "PPPs and Exchange Rates," OECD National Accounts Statistics (database), 2021.
[9] The CCI is in line with other price indexes that measure construction inputs as well as investments in transportation, except for the Bureau of Economic Analysis; (BEA) price index for state and local government investments in transportation. The price indexes for transportation investments, construction, and consumer goods grew at a somewhat similar rate from 1980 until 2004, when the BEA's cost index for transportation investments began to outstrip the increase in the cost of consumer goods. While there was a global increase in the cost of key construction materials, such as steel, in the mid-2000s, it is unclear whether the BEA's transportation index is capturing rising construction cost inputs or reflecting construction cost issues that are endemic to the United States. As a result, the BEA index was not chosen as the inflation adjuster for this database.
[10] "Standard Cost Categories for Capital Projects," Federal Transit Administration, July 27, 2017.
[11] Nasri Munfah and Paul Nicholas, "Why Tunnels in the US Cost Much More Than Anywhere Else in the World," *Tunnel Business Magazine*, August 18, 2020.
[12] Note: The New York City projects were excluded from the plot given their outlier status to allow for a clearer view of the trendline and individual projects below the $500 million per mile threshold.
[13] The trendlines are not intended to represent or be interpreted as a linear regression, but rather to illustrate the general direction of construct costs as they relate to a project's grade alignment.
[14] Cost obtained via FOIA request to Sound Transit, 2020.
[15] Los Angeles Metro Program Management Dashboard.
[16] ibid.
[17] ibid.
[18] ibid.
[19] Mike Clark-Madison, "From Light Rail to a Downtown Tunnels: The Parts of Project Connect," Austin Chronicle, September 25, 2020.
[20] For extensions of existing lines, the total length of a project's alignment was divided by the total number of stations. For new lines, the total length of the alignment was divided by the number of stations minus one to account for terminal stations at the end of the line.
[21] Four outlier international projects are excluded.
[22] New York projects are excluded from this plot, along with the Hudson Bergen Light Rail, whose cost reporting and timeline includes the initial segment and several extensions completed between 1997 and 2011. Projects that have not been opened are also excluded from this chart. Month-level groundbreaking information was not available for seven completed lines.
[23] See: Los Angeles County Metropolitan Transportation Authority Office of the Inspector General, "Capital Project Construction Management Best Practices Study," Report No. 16-AUD-01, February 26, 2016; George Kaparos and Pantoleon Skayannis, "Dealing with Context and Uncertainty in the Development of the Athens Metro Base Project," *Interface: Planning Theory & Practice*, 15(3): 2014; A. Walsh and Patrick Walker, "Looking Beyond Time and Cost Influences in Megaprojects," University of Salford, 2020; Christy Gomez and Muhammad Gambo, "Evaluation of Special Purpose Vehicle Organisation Skill Sets Taxonomy for Effective Public-Private elivery," *Journal of Construction in Developing Countries*, 21(1): 2016.
[24] William Tucker, "Crossrail Project: the Execution Strategy for Delivering London's Elizabeth Line," Proceedings of the Institution of Civil Engineers, 2015.
[25] Simon Wright and others, "Crossrail Programme Organisation and management for Delivering London's Elizabeth Line," Proceedings of the Institution of Civil Engineers, 2017.
[26] Manuel Melis Maynar, "Introduction: Madrid Metro and Railway Infrastructure 1995-2003," Metrosur 2, April 2003.
[27] Kaparos and Skayannis, 2014.
[28] Richard Barone and others, "Building Rail Transit Projects Better for Less," Regional Plan Association, 2018.

[29] Daniel Pulido and others, eds., The Urban Rail Development Handbook, World Bank, 2018.
[30] Specifically, LA Metro notes that "Board reports by staff must be completed 4-5 weeks before the Board meeting; so writing of the report must commence 1-2 weeks before that, resulting in taking up to 6 weeks before proceeding on a matter. Depending on the significance of a project change, a quicker, timely review and approval by the Board may be necessary for these changes in order to avoid delays and/or increased costs to the project." LA Metro, 2016.
[31] Mendel Giezen and others, "Adaptive Capacity Within a Mega Project: A Case Study on Planning and Decision-Making in the Face of Complexity," European Planning Studies, 2014.
[32] Maynar, 2003.
[33] Stephanie Lotshaw and others, "A Bid for Better Transit," Eno Center for Transportation and TransitCenter, 2017.
[34] Pulido and others, 2018.
[35] Mendel Giezen, "Keeping it Simple? A Case Study into the Advantages and Disadvantages of Reducing Complexity in Mega Project Planning," *International Journal of Project Management*, 30: 2012.
[36] Giezen and others, 2014.
[37] Ali Touran and Ildefonso Burgos, "Project Delivery Method Selection Tool for Transit Projects," TR News, 316: July-August 2018.
[38] Mark Konchar, "A Comparison of United States Project Delivery Systems," Computer Integrated Construction, Technical Report No. 38, December 1997; Ali Touran and others, "Selection of Project Delivery Method in Transit: Drivers and Objectives," *Journal of Management in Engineering*, 26(4): 2010.
[39] Randall Park and Doug Gransberg, "Leveraging Early Contractor Involvement: Construction Manager–General Contractor Project Delivery" TR News, 316, July-August 2018.
[40] Mary Jane Breinholt and others, "Partnership Financing," Eno Center for Transportation 2014.
[41] Park and Gransberg, 2018.
[42] Center for Innovative Finance, "State P3 Legislation," Federal Highway Administration, 2020; Jenn Goodman, "Design-Build Takes Hold in All but 2 States," *Construction Dive*, February 10, 2020.
[43] Breinholt and others, 2014.
[44] Park and Gransberg, 2018.
[45] Pulido and others, 2018.
[46] Frank Beckers and Uwe Stegemann, "Open Interactive Popup A Risk-Management Approach to a Successful Infrastructure Project," McKinsey & Company, 2013.
[47] Svante Mandella and Jan-Eric Nilssonb, "A Comparison of Unit Price and Fixed Price Contracts for Infrastructure Construction Projects," Swedish National Road and Transport Research Institute, and CTS Stockholm, 2010.
[48] Debra K. Rubin and others, "Fixing Construction's Fixed-Price Conundrum," *Engineering News-Record*, November 20, 2019.
[49] Park and Gransberg, 2018.
[50] Pulido and others, 2018.
[51] Douglas D. Gransberg and others, "A Framework for Guaranteed Maximum Price and Contingency Development for Integrated Delivery of Transportation Projects," Iowa State University, 2011.
[52] Maynar, 2003.
[53] George Lowden and John Thornton, "The Special Challenges of Project Management Under Fixed-Price Contracts," Project Management Institute, 2015.
[54] Robert Lewis Bostwick, "Project Delivery Systems- How they Impact Efficiency and Profitability in the Buildings Sector," McGraw Hill 2014; Eric Scheepbouwer and Bryan Pidwerbesky "Alliance Contracting: Advancing Collaboration and Integration in International Project Delivery," *TR News* 316, 2018.
[55] LA Metro, 2016.
[56] Touran and others, 2010.
[57] ibid.
[58] Nancy C. Smith and Stephanie W. Kam, "Risk Sharing and Transfer Using Alternative Project Delivery Methods and Contracting" *TR News* 316, July-August 2018.
[59] Mounir El Asmar, "Transportation Project Delivery, Alternative Contracting Methods Research," *TR News* 316, July-August 2018.
[60] Touran and others, 2010.
[61] LA Metro, 2016.
[62] Smith and Kam, 2018; Touran and others, 2010.
[63] Touran and Burgos, 2018; Touran and others, 2010.
[64] LA Metro, 2016.
[65] Maynar, 2003.
[66] While there is no strict definition for "large" or "complex" its application for transit capital projects typically mean that it costs more than $100 million and/or involves tunneling or several miles of elevated track
[67] Mounir El Asmar, "Transportation Project Delivery, Alternative Contracting Methods Research," TR News 316, July-August 2018.

[68] "Eagle P3 Project Procurement Lessons Learned," Denver Regional Transportation District, August 31, 2011.
[69] ibid.
[70] U.S. Government Accountability Office, "Rail Transit. Federal Transit Administration Could Improve Information on Estimating Project Costs," GAO-19-562, 2019.
[71] Pulido and others, 2018.
[72] ibid.
[73] Smith and Kam, 2018; Park and Gransberg, 2018.
[74] Pulido and others, 2018.
[75] ibid.
[76] GAO, 2019.
[77] Pulido and others, 2018.
[78] FTA Circular 4220.1F is the primary document governing third-party contracting for federally funded projects. See: Federal Transit Administration, "Best Practices Procurement & Lessons Learned Manual," 2016.
[79] ibid.
[80] One study found they are likely to result in low quality work. See: Carey Barr and Scott Baker, "Successful Methods to Acquire and Oversee the Outsourcing of Tasks and Projects Related to State DOT Management of Transit Grant Programs," NCHRP Project No. 20-65, Task 46, 2014.
[81] American Public Transportation Association, "Transit Procurement: A Guide for Transit Board Members," 2010.
[82] Symeon Christodoulou and others, "Qualifications-Based Selection of Professional A/E Services," *Journal of Management in Engineering*, 20(2): 2004.
[83] APTA 2010.
[84] Christy Veeder, "Empirical Analysis of USDOT's Local Labor Hiring Pilot Program," Jobs to Move America, 2021; American Public Transportation Association, "Procurement Handbook: A Guide for Transit Industry Executives," 2014; and Jerry Hsu and Scott Baker, "Assessment of State DOT Transit Vehicle Procurement Models," NCHRP 20-65 Task 57, 2016
[85] Maynar, 2003; LA Metro, 2016.
[86] Maynar, 2003.
[87] Note the literature on state regulations is primarily focused on highway projects. See, e.g., Sidney Scott and others, "Best-Value Procurement Methods for Highway Construction Projects," NCHRP Report 561, 2006.
[88] Daniel Tran, and others, "Implementing Best-Value Procurement for Design-Bid-Build Highway Projects," *Transportation Research Record*, 2573, 2016.
[89] ibid.
[90] "History of the DOT DBE Program," U.S. Department of Transportation, January 5, 2015.
[91] Dakshina De Silva and others, "Disadvantaged Business Enterprise Goals in Government Procurement Contracting: An Analysis of Bidding Behavior and Costs," Federal Reserve Bank of Cleveland, Working Paper 11-02, 2011; Adjo Amekudzi-Kennedy and others, "Effective Utilization of Disadvantaged Business Enterprises" (DBE) in Alternative Delivery Projects: Strategies and Resources to Support the Achievement of DBE Goals," Georgia Institute of Technology, 2016.
[92] David Keen and others, "Current Practices to Set and Monitor DBE Goals on Design-Build Projects and Other Alternative Project Delivery Methods," NCHRP Synthesis 481: 2015.
[93] Ali Touran and others, "A Guidebook for the Evaluation of Project Delivery Methods," TCRP Report 131, 2009.
[94] Amekudzi-Kennedy and others, 2016.
[95] Keen and others, 2015.
[96] Keen and others, 2015.; Amekudzi-Kennedy, and others, 2016.
[97] Federal Transit Administration, "New Starts Standard Cost Categories Workbook (Rev. 21)," 2019.
[98] Justin Antos and others, "What Determines Soft Costs in Major Public Transit Fixed Guideway Projects? Examining Four Decades of Experience," *Transportation Research Record* 2143(1): 2010.
[99] ibid.
[100] Donald Schneck and others, "Estimating Soft Costs for Major Public Transportation Fixed Guideway Projects," TCRP Report 138, 2010.
[101] Antos and others, 2010.
[102] ibid.
[103] Ye Zhang and Ali Touran, "Are Soft Costs Increasing in Transit Projects?" Construction Research Congress, 2012.
[104] ibid.
[105] Federal Transit Administration, "Project and Construction Management Guidelines," 2016.
[106] Barone and others, 2018.
[107] Schneck and others, 2010.

[108] Peter Love and others, "Cost Performance of Public Infrastructure Projects: The Nemesis and Nirvana or Change- Orders," *Production Planning & Control* 28(13): 2017.
[109] Ali Touran, "Probabilistic Model for Cost Contingency," *Journal of Construction Engineering and Management*, 129(3): 2003.
[110] Love and others, 2017.
[111] ibid.
[112] Barone and others, 2018.
[113] ibid and Brian M. Rosenthal, "The Most Expensive Mile of Subway Track on Earth," *New York Times*, December 28, 2017.
[114] Rosenthal, 2017.
[115] Barone and others, 2018; and Rosenthal, 2017.
[116] Love and others, 2017.
[117] ibid.
[118] Maynar, 2003.
[119] ibid.
[120] Barone and others, 2018.
[121] Cesar Quiroga and others, "Practices for Utility Coordination in Transit Projects," TCRP Synthesis 118, 2015.
[122] ibid.
[123] LA Metro, 2016.
[124] Barone and others, 2018.
[125] LA Metro, 2016.
[126] Dennis Keck and others, "Accelerating Transportation Project and Program Delivery: Conception to Completion," NCHRP Report 662, 2010.
[127] "Memorandum of Law: Utility Relocation," San Diego City Attorney, August 19, 1999.
[128] *Pine Belt Chevrolet v. Jersey Cent. Power*, 132 N.J. 564, 1993.
[129] Quiroga and others, 2015.
[130] LA Metro, 2016.
[131] Barone and others, 2018.
[132] Federal Transit Administration and Charlotte Area Transit System, "South Corridor Light Rail Project Draft Environmental Impact Statement," 2002.
[133] LA Metro, 2016.
[134] FTA, 2016.
[135] Quiroga and others, 2015.
[136] LA Metro, 2016.
[137] Carlos Caldas, "Synthesis of Best Practices in Right-of-Way Valuations and Negotiations," Texas Department of Transportation, Project 0-5379, 2006.
[138] Ming Zhang, "Bus Versus Rail Meta-Analysis of Cost Characteristics, Carrying Capacities, and Land Use Impacts," *Journal of the Transportation Research Board*, 2110, 2009.
[139] Larry Smith and others, "Over and Under: A Practical Guide to the Condemnation of Aerial Guideway Easements and Tunnel Easements," Graham & Dunn PC, 2015.
[140] Smith and others, 2015.
[141] GAO, 2019.
[142] Eno Capital Cost Database, 2021
[143] Federal Transit Administration, "Real Estate Information."
[144] Compensatory mitigation can entail restoring, establishing, or preserving existing or new natural habitats. Gian- Claudia Sciara and Elizabeth Stryjewski, "Saving Money When Safeguarding Species and Habitats: Conventional vs. Advance Land Acquisition for Transportation Mitigation," *Research in Transportation Economics*, 52: 2015.
[145] ibid.
[146] Property owners may wish to seek their own appraisal and make a counteroffer. See: "Program Management Lessons Learned," Denver Regional Transportation District, December 2014.
[147] Sciara and Stryjewski, 2015; Caldas, 2006.
[148] Limited exceptions are granted for circumstances involving: 1) hardship acquisitions, 2) protective acquisitions, or 3) acquisition of railroad ROW. Federal Transit Administration, "Property Acquisitions and Relocations".Also see: Lucy Garliauskas, Dear Colleague Letter, Federal Transit Administration, January 5, 2016.
[149] Federal Transit Administration, "Final Guidance on the Application of 49 U.S.C. § 5323(q) to Corridor Preservation for a Transit Project," February 27, 2020.
[150] Garliauskas, 2016.
[151] Caldas, 2006.

[152] David Jeong and others, "Barriers to Right-of-Way Acquisition and Recommendations for Change," Minnesota Department of Transportation Report 2016-28 2016.
[153] Caldas, 2006.
[154] Shadi Hakimi and Kara Kockelman, "Right-Of-Way Acquisition and Property Condemnation: A Comparison of U.S. State Laws," *Journal of the Transportation Research Forum* 44(3): 2005.
[155] ibid.
[156] Xiaoxia Xiong and Kara Kockelman, "The Cost of Right-Of-Way Acquisition: Recognizing the Impact of Condemnation Via a Switching Regression Model," *Journal of Infrastructure Systems*, 20(4): 2014.
[157] Paul Lewis and others, "Lessons Learned from the Utah Transit Authority System Expansion," Eno Center for Transportation, 2013.
[158] Congressional Research Service, "The National Environmental Policy Act (NEPA): Background and Implementation," January 10, 2011.
[159] See, e.g., U.S. Government Accountability Office, "National Environmental Policy Act: Little Information Exists on NEPA Analyses," GAO-14-369, 2014; Linda Luther, "The Role of the Environmental Review Process in Federally Funded Highway Projects: Background and Issues for Congress," Congressional Research Service, 2012; Kelsey Owens, "Federal Environmental Review and Permitting 101," U.S. Department of Transportation, October 22, 2019.
[160] Natural Resources Defense Council, "Never Eliminate Public Advice: NEPA Success Stories," February 1, 2015.
[161] Environmental Protection Agency, "What is the National Environmental Policy Act?" n.d., 40 CFR § 1508.18, "Major Federal Action."
[162] U.S. Government Accountability Office, "Highway and Transit Projects: Evaluation Guidance Needed for States with National Environmental Policy Act Authority," GAO-18-222, 2018; U.S. Government Accountability Office, "Highway Projects: Some Federal and State Practices to Expedite Completion Show Promise," GAO-12- 593, 2012."

[163] See, e.g. Nossaman LLP, "NEPA Rules Rewrite: Potential Impacts on Federal-State Environmental Reviews and Studies," August 28, 2020.
[164] Federal Transit Administration, "What Should Project Sponsors Consider When Initiating an Environmental Review of a Transit Project?" U.S. Department of Transportation, n.d.
[165] Federal Transit Administration Office of Planning and Environment, "Alternatives: Standard Operating Procedures No. 5," U.S. Department of Transportation, 2019.
[166] For a complete set of examples, see: U.S. Environmental Protection Agency, "National Environmental Policy Act Review Process," n.d.
[167] Federal Transit Administration, "Environmental Decision Documents."
[168] GAO, 2018; Environmental review is not tracked separately as part of the FTA's Standard Cost Categories.
[169] TransTech Management, Inc., "Costs Related to Compliance with Federal Environmental Laws: Case Studies in the Federal-Aid Highway Program," Federal Highway Administration, 2006.
[170] U.S. Government Accountability Office, "Clear Federal Role and Criteria-Based Selection Process Could Improve Three National and Regional Infrastructure Programs," GAO-09-219, 2009.
[171] U.S. Government Accountability Office, "Federal Requirements for Highways May Influence Funding Decisions and Create Challenges, but Benefits and Costs are Not Tracked," GAO-09-36, 2008.
[172] See, e.g. the list of funding secured to date in the Final Environmental Impact Statement for the Dulles Corridor Rapid Transit Project, December 2004.
[173] Schneck and others, 2010.
[174] Luther, 2007; Tanya Snyder, "Are Environmental Reviews to Blame for Infrastructure Project Delays?" *Streetsblog USA*, February 15, 2011.
[175] Council on Environmental Quality,"Environmental Impact Statement Timelines (2010-2017), December 14, 2018; Council on Environmental Quality, "CEQ EIS Timeline Data," June 12, 2020.
[176] CEQ's 2020 report on EIS timelines recognizes that timelines depend on several factors, including variation in project scope and complexity, pre-NOI activity, delays or suspensions in EIS activity, and cooperating and co- lead agencies' involvement.
[177] Note: The final provision category, Advance Planning, does not apply to transit and occurs outside of the environmental review process. GAO, 2018.
[178] GAO, 2018.
[179] ibid.
[180] U.S. Department of Transportation Office of the Inspector General, "Vulnerabilities Exist in Implementing Initiatives Under MAP-21 Subtitle C to Accelerate Project Delivery," 2017.
[181] Report of the National Surface Transportation Policy and Revenue Study Commission, 2007.
[182] "Public Transit New Starts Program: Issues and Options for Congress," Congressional Research Service, 2010.

[183] Kelly Dunlap and others, "Lessons Learned from State DOT NEPA Assignment," American Association of State Highway and Transportation Officials, 2016.
[184] GAO, 2018.
[185] Dunlap and others, 2016.
[186] Eric Beightel, "Multimodal NEPA—Existing Procedural Challenges and How the FAST Act Could Help," American Association of State Highway and Transportation Officials, 2016.
[187] Dunlap and others, 2016.
[188] GAO, 2018.
[189] GAO, 2008.
[190] Charles Hughes, "Streamlining Infrastructure Environmental Review," Manhattan Institute, June 18, 2018.
[191] GAO, 2018.
[192] Parsons Brinckerhoff, Inc., "Guidance for Managing NEPA-Related and Other Risks in Project Delivery, Volume 1," Transportation Research Board, 2012.
[193] ICF Consulting, "Executive Order 13274 Indirect and Cumulative Impacts Work Group Draft Baseline Report," March 15, 2005.
[194] Federal Highway Administration, "Every Day Counts Fact Sheet," undated.
[195] Luther, 2007.
[196] John Ruple and Kayla Race, "Measuring the NEPA Litigation Burden: A Review of 1,499 Federal Court Cases,", *Environmental Law*, 50(2): 2020.
[197] Luther, 2007.
[198] Ruple and Race, 2020.
[199] ibid.
[200] Council on Environmental Quality, "A Citizen's Guide to the NEPA: Having Your Voice Heard," December 2007.
[201] Council on Environmental Quality, "The National Environmental Policy Act: A Study of its Effectiveness After Twenty-Five Years," January 1997.
[202] ICF International, "Effective Project Management for NEPA," American Association of State Highway and Transportation Officials, 2008; Charles H. Eccleston, "The NEPA Planning Process: A Comprehensive Guide with Emphasis on Efficiency," John Wiley and Sons, 1999.
[203] Council on Environmental Quality, "States and Local Jurisdictions with NEPA-Like Environmental Planning Requirements," n.d; GAO, 2008.
[204] States with NEPA-like environmental planning requirements include: California, Connecticut, District of Columbia, Georgia, Hawaii, Indiana, Maryland, Massachusetts, Minnesota, Montana, New Jersey, New York, North Carolina, Puerto Rico Environmental, South Dakota, Virginia, Washington State, Wisconsin Act, as well as the Tahoe Regional Planning Compact, and New York City Environmental Quality Review Council on Environmental Quality, "States and Local Jurisdictions with NEPA-Like Environmental Planning Requirements," n.d
[205] GAO, 2008.
[206] ibid.
[207] As part of its 2012 Rail Design Criteria, six agency-wide environmental policies were listed: Metro Environmental Policy; Metro Construction and Demolition Debris Recycling and Reuse Policy; Metro Water Use and Conservation and Policy; Metro Green Construction Policy; and the Metro Renewable Energy Policy. Los Angeles Metro, "Green Construction Policy," July 21, 2011.
[208] Los Angeles Metro, "Metro Environmental Construction Awareness (MECA) Program," n.d.
[209] The statute was amended in December 2019 to add a general prohibition against using FTA funds for purchasing rolling stock from companies owned or subsidized by the government of the People's Republic of China and a financial penalty for transit agencies that use their own funds to purchase such rolling stock. This law will take effect in December 2021 and will "grandfather" in transit agencies that had ongoing contracts. See Jeff Davis, "Final Defense Bill Bans New Purchases of Mass Transit Vehicles from Chinese Companies—After 2-Year Delay," *Eno Transportation Weekly*, December 9, 2019, and Jeff Davis and Robert Puentes, "The Implications of the Federal Ban on Chinese Railcars," Eno Center for Transportation, 2018.
[210] Michaela Platzer and William Mallett, "Effects of Buy America on Transportation Infrastructure and U.S. Manufacturing," Congressional Research Service, 2019.
[211] SteelBenchmarker Report #332.
[212] Platzer and Mallett, 2019 cites: Gary Clyde Hufbauer, and others, Local Content Requirements: A Global Problem, Peterson Institute for International Economics, 2013.
[213] Platzer and Mallett, 2019.
[214] Timothy R. Wyatt, "Updated Guide to Buy America Requirements—2015 Supplement," TCRP Legal Research Digest 49, 2017.
[215] Federal Transit Administration, "Buy America Investigation Decision: Second Avenue Subway Project's Water Mist Fire Suppression System," January 6, 2015.
[216] Platzer and Mallett, 2019.

[217] Shanjun Li and others, "Public Transit Bus Procurement: The Role of Energy Prices, Regulation, and Federal Subsidies," *Journal of Urban Economics*, 87: 2015; also Philip Rossetti and others, "Buy America Regulations May Raise Cost of Subsidized Infrastructure." American Action Forum, July 7, 2017.
[218] Quiroga and others, 2015.
[219] See: Federal Transit Administration, "Buy America Investigation Decision: Sacramento Regional Transit District," July 10, 2014; and Quiroga and others, 2015.
[220] Phillip Summers and others, "Influencing Public Transportation Policy Through Community Engagement and Coalition Building: Process and Preliminary Outcomes," *Progress in Community Health Partnerships*, 14(4): 2020."
[221] Sherry R. Arnstein. "A Ladder of Citizen Participation," *Journal of the American Planning Association*, 35(4): 1969.
[222] Carole Voulgaris, "Trust in Forecasts? Correlates with Ridership Forecast Accuracy for Fixed-Guideway Transit Projects," *Transportation* 47: 2020.
[223] The Administrative Procedure Act, Pub.L. 79–404, 60 Stat. 237, Enacted June 11, 1946.
[224] Leah Brooks and Zachary Liscow, "Infrastructure Costs," 2019.
[225] 23 CFR 450.316
[226] Jane Jacobs, The Life and Death of Great American Cities, Knopf Doubleday, 1961
[227] Pew Research Center, "Mobile Fact Sheet," June 12, 2019.
[228] American Planning Association, "Community Engagement: How Arts and Cultural Strategies Enhance Community Engagement and Participation," 2011.
[229] Kittleson & Associates, "Moving Public Workshops Online: Tools & Examples for Responding to COVID-19," 2020.
[230] Tim Harlow, "Minnesota Department of Transportation's Online Meetings About Construction Draw Surprising Number of Viewers," *Star Tribune*, June 21, 2020.
[231] Marta Goldsmith, "Virtual Engagement: A Springboard for Inclusive Community Planning," Smart Growth America, May 18, 2020.
[232] Brooks and Liscow, 2019.
[233] Bengt Kriström and Pere Riera, "Is the Income Elasticity of Environmental Improvements Less than One?" *Environmental and Resource Economics*, 7(45): 1996; Udo Ebert, "Environmental Goods and the Distribution of Income." *Environmental Resource Economics*, 25(4): 2003.
[234] Peter Balint and others, Wicked Environmental Problems: Managing Uncertainty and Conflict, Island Press, 2011.
[235] Mark Reed and others, "A Common Standard for the Evaluation of Public Engagement with Research," *Research for All*, 2 (1): 2018.
[236] Pulido and others, 2018.
[237] ibid; Barone and others, 2018; Stephen Wickens, "Station to Station: Why Subway-Building Costs Have Soared in the Toronto Region," Residential and Civil Construction Alliance of Ontario, 2020.
[238] MTA Inspector General, "Misclassification of Design Errors and Omissions at NYC Transit," MTA/OIG Report #2011-15, 2011; and Douglas Gransberg and Keith Molenaar, "Analysis of Owner's Design and Construction Quality Management Approaches in Design/Build Projects," *Journal of Management in Engineering*, 20(4): 2004.
[239] Pulido and others, 2018.
[240] Barone and others, 2018.
[241] MTA, 2011.
[242] Guelda Voien, "Inside the Effort to Design a Better Subway for New York City," *Architectural Digest*, September 19, 2018.
[243] Gransberg and Molenaar, 2004.
[244] U.S. Secretary of Transportation, "Report to Congress on the Costs, Benefits, and Efficiencies of PublicPrivate Partnerships for Fixed Guideway Capital Projects," 2007
[245] Gransberg, and Molenaar, 2004.
[246] Barone and others, 2018.
[247] ibid.
[248] ibid.; Wickens, 2020.
[249] For this paragraph: Barone and others, 2018.
[250] For this paragraph: Wickens, 2020.
[251] Alon Levy, "Cut-and-Cover is Underrated," Pedestrian Observations, February 25, 2021.
[252] For this paragraph: Barone and others, 2018.
[253] ibid.
[254] Maynar, 2003.
[255] ibid.
[256] Los Angeles Metro Board Report, "Systemwide Station Design Standards Action: Adopt Systemwide Station Design Standards Policy," January 17, 2018.

[257] Wickens, 2020.
[258] National Fire Protection Association, "Standard for Fixed Guideway Transit and Passenger Rail Systems," 2020.
[259] WTCB, "Fire in Tunnels," 2001.
[260] NFPA 130, 5.33: Capacity and Location of Means of Egress.
[261] Mineta Transportation Institute, "Passenger Flows in Underground Railway Stations and Platforms," MTI Report 12-43, 2015.
[262] NFPA 130 Section 5.3.5 Stairs and Escalators.
[263] ibid.
[264] MTI, 2015.
[265] ibid.
[266] NFPA 130 Section 6.3.1 Location of Egress Routes.
[267] Japan International Cooperation Agency, "JICA Preparatory Survey on Greater Cairo Metro Line No.4 In the Arab Republic of Egypt," Egypt Ministry of Transport, 2010; and WTCB, 2001.
[268] ibid.
[269] NFPA Section 7.2 Design.
[270] ibid.
[271] "Earthquake Effects on Tunnels," Tunnelling and Tunnel Mechanics, Springer, 2008.
[272] Sound Transit has incorporated WSDOT guidelines, as well as the following Federal standards: Technical Manual for Design and Construction of Road Tunnels—Civil Elements, FHWA-NHI-09-010, 2009; CH2M Hill, "Seismic Analysis and Design of Retaining Walls, Buried Structures, Slopes, and Embankment," NCHRP Report 611, 2008.
[273] Sound Transit, "Design Criteria Manual," Revision 5, Amendment 10, 2021.
[274] Youssef Hashash and others, "Seismic Design and Analysis of Underground Structures," *Tunneling and Underground Space Technology*, 16(4): 2001.
[275] Bay Area Rapid Transit, "Earthquake Safety Program Technical Information," n.d.
[276] Federal Transit Administration Circular, "Americans With Disabilities Act (ADA): Guidance," FTA C 4710.1, 2015.
[277] 49 CFR § 37.42
[278] FTA, 2015.
[279] Carolyn Flowers, Dear Colleague Letter, Federal Transit Administration, September 9, 2016.
[280] TransitCenter, "Access Denied: Making the MTA Subway System Accessible to All New Yorkers," 2019.
[281] Elizabeth Kim, "Judge Rules MTA Should Have Installed Elevators When It Renovated Bronx Subway Station," *Gothamist*, March 7, 2019.
[282] Emma Fitzsimmons and Rebecca Liebson, "M.T.A. Pledges $5 Billion for Subway Elevators. Guess How Many," *New York Times*, October 7, 2019.
[283] Annie Mcdonough, "Why is Subway Accessibility So Expensive?" *City and State New York*, October 8, 2019.
[284] "Wollaston Station Improvements," Massachusetts Bay Area Transportation Authority, 2020; "New Washington/Wabash Station," Chicago Transit Authority, 2020.
[285] Canadian Transportation Agency, "Accessibility and the Canadian Transportation Agency," n.d.
[286] "Accessibility for Ontarians with Disabilities Act, S.O. 2005, c. 11, 2005.
[287] "Disability Standards for Accessible Public Transport 2002," Subsection 31 (1) of the Federal Register of Legislation, Australia.
[288] "European Accessibility Act," Fact Page, European Commission, 2020.
[289] Nick Van Mead, "Access Denied: Wheelchair Metro Maps Versus Everyone Else's," *Guardian*, September 21, 2017.
[290] Clothilde Goujard, "Will Paris's Metro Adapt to Disabled Riders Before the 2024 Olympics?" *Bloomberg*, October 26, 2018.
[291] See: Brianne Eby and Paul Lewis, "Delivering Better Outcomes: Recommendations to Improve the Governance and Oversight of DC Circulator and Streetcar," Eno Center for Transportation, 2019. Barone and others, 2018 found that "data on labor and material costs … are wholly unavailable to public scrutiny."
[292] The Davis Bacon Act, March 3, 1931, 46 Stat. 1494.
[293] ibid.
[294] Federal-Aid Highway Act of 1956, 70 Stat. 374.
[295] Public Law 88-365
[296] The database is accessible at beta.SAM.gov
[297] U.S. Department of Labor, Employment Standards Administration, Wage and Hour Division. All Agency Memorandum No. 130, March 17, 1978.
[298] See e.g., Clifford Winston, "Efficient Transportation Infrastructure Policy Revisited: A Thirty-Year Update Motivated by Brooks and Liscow," National Bureau of Economic Research, 2020.

[299] An analysis from the Congressional Budget Office found that repealing Davis-Bason would save the federal government $12 billion in outlays over a ten-year period. The reduction would come almost entirely from worker wages and benefits and, in turn, those workers would have lower incomes and work quality could suffer. Congressional Budget Office, "Options for Reducing the Deficit: Repeal the Davis-Bacon Act," 2018.

[300] Dexter Home and Jennifer Burnett, "Trends in Prevailing Wage Laws," Council of State Governments, 2017. States with their own prevailing wage laws are Alaska, Arkansas, California, Connecticut, Delaware, Hawaii, Illinois, Maine, Maryland, Massachusetts, Michigan, Minnesota, Missouri, Montana, Nebraska, Nevada, New Jersey, New Mexico, New York, Ohio, Oregon, Pennsylvania, Rhode Island, Tennessee, Texas, Vermont, Virginia, Washington, Wisconsin, and Wyoming.

[301] Barone and others, 2018.

[302] Irene Papanicolas and others, "Health Care Spending in the United States and Other High-Income Countries," *Journal of the American Medical Association*, 319(10): 2018.

[303] Barone and others, 2018.

[304] McKinsey & Company, "Improving Construction Productivity," July 18, 2017.

[305] Barone and others, 2018.

[306] It is important to note that the number of workers for TBMs varies greatly depending on complexity. Tunnel Insider, "How Does A Tunnel Boring Machine (TBM) Work?" n.d.; Rail Projects Victoria, "Introducing our TBMs," 2021, *Transport News*, "HS2's Tunnel Boring Machines arrive in London," December 16, 2020; Rosenthal, 2017.

[307] Rosenthal, 2017; Barone and others, 2018.

[308] Barone and others, 2018.

[309] Elizabeth Ann Chimienti, "Breaking Down Barriers, Building Up Communities: Implementing Project Labor Agreements With Targeted Hiring Goals," Massachusetts Institute of Technology, 2010.

[310] Commonwealth of Massachusetts Special Commission Report on the Use of Project Labor Agreements in Road, Bridge and Rail Projects, "Analysis and Key Findings," 2014.

[311] Fred Kotler, "Project Labor Agreements in New York State: In the Public Interest," Cornell University, 2009. The Citizens Budget Commission in New York City recently called for an evaluation of PLAs there.

[312] *Mass Transit*, "L.A. Metro Board Approves Renewal of the Agency's Projected Labor Agreement and Construction Career Policy," February 7, 2017.

[313] Kimberly Johnston-Dodd, "Constructing California: A Review of Project Labor Agreements," California Research Bureau Report CRB 01-010, 2001.

[314] Federal Transit Administration, "Project Labor Agreements" October 23, 2015.

[315] GAO, 2019.

[316] LA Metro, 2016.

[317] "Project Management Oversight (PMO)", Federal Transit Administration, December 15, 2020.

[318] Richard Finno and others, "Metro Red Line, Segment 2, Contract B251: Investigation of Tunnel Collapse and Sinkhole," October 17, 1995.

[319] "California Senate Bill No. 1847, Chapter 1021."

[320] Mark A. Stein and James Rainey, "Red Line Tunnel Closed by Methane Gas Release," *Los Angeles Times*, March 19, 1992

[321] Los Angeles County Metropolitan Transportation Authority, "Century City Area Tunneling Safety Report," November 30, 2011 (Rev 1).

[322] This cost increase was covered by reallocating unspent funds from construction of the Expo Line. See: Los Angeles Metro Board, "2020-0351 Westside Purple Line Extension Section 1 Project Informational Report", August 20, 2020.

[323] Michael Manville, "Measure M: Lessons from a Successful Transportation Ballot Campaign," Eno Center for Transportation, 2019.

[324] "Los Angeles County Metropolitan Transportation Authority Annual Agency Profile," National Transit Database, 2019.

[325] While these segments were delivered on-time and on-budget, the GLCA experienced a funding shortfall for Phase 2B due to an inaccurate cost estimate, which failed to account for the impacts of changing economic conditions on the construction industry. The resulting bids for the project far exceeded the estimated cost.

[326] Los Angeles Metropolitan Transportation Authority, "Audit of the Phase 1 Expo Construction Project," April 19, 2013.

[327] ibid.

[328] ibid.

[329] "Supplemental Modifications to Transit Projects Policy," Los Angeles Metro Planning and Programming Committee, November 20, 2013.

[330] "Stay-at-Home Order Helps Metro End Purple Line Road Closure in Beverly Hills Ahead of Schedule," *ABC7*, June 25, 2020.

[331] Dave Sotero, "Metro Statement on Purple Line Extension Construction in Beverly Hills," Los Angeles Metro - The Source, April 2, 2020.

[332] *ABC7*, 2020.

[333] "NEPA and CEQA: Integrating State and Federal Environmental Reviews," Council on Environmental Quality and the California Governor's Office of Planning and Research, February 2014.
[334] LA Metro, 2013.; "Expo Light Rail Phase 1," McMillen Jacobs Associates, undated.
[335] Los Angeles Metropolitan Transportation Authority, "Century City Tunneling Safety Report," November 30, 2011.
[336] Richard Clarke, and others, Memorandum to Los Angeles Metro Board of Directors, "CAL/OSHA Reclassification of WPLE Section 2, Reach 2 Tunnels," March 5, 2020.
[337] Projects typically account for impacts on historic and archaeological resources as part of Section 106 of the federal National Historic Preservation Act.
[338] Andrea P. Clark and Lisa Westwood, "Legal and Practical Considerations Regarding Cultural Resources and AB 52," League of California Cities, October 7, 2016.
[339] Clarke and others, 2018.
[340] "King County Metro, Sound Transit Reach Agreement to Continue Integrated Rail Operations and Maintenance through 2023," King County, April 29, 2019.
[341] Sarah Rupp, "Seattle History: A Look Back at Construction of Downtown Seattle Transit Tunnel," Metro Matters, March 21, 2019.
[342] Note: The East Link percentages are estimates based on the FEIS. Of the 14 percent categorized as "below grade," only 3 percent of the total alignment is tunneled. Approximately 9 percent of the total alignment is built on the I-90 floating bridge, and another 2 percent of the total alignment is built on the bridge between Mercer Island and Bellevue.
[343] Sound Transit, "History of Voter-Approved Plans", undated.
[344] Bob Pishue, "Sound Transit Officials Continue to Move the Goal Posts," Washington Policy Center, March 21, 2016.
[345] "Sound Transit Opens Seattle Light Rail Extension Ahead of Schedule, Under Budget," *AASHTO Journal*, March 25, 2016.
[346] Mike Lindblom, "Angle Lake Light-Rail Station Opens Saturday with party," *Seattle Times*, September 22, 2016.
[347] Sound Transit, "Sound Transit 3: The Regional Transit System Plan for Central Puget Sound," June 2016.
[348] David Wagman, "Seattle Revises Building Code to Account for Stronger Quakes," *Engineering 360*, January 9, 2019.
[349] Paxtyn Merten, "Growing Sound Transit Leases Nearly 341,000 Square Feet in Seattle," *Puget Sound Business Journal*, July 8, 2019.
[350] Office of the Washington State Auditor, "Improving Sound Transit's Project Planning and Design to Reduce Costs," June 18, 2020.
[351] Presentation by Ted Lucas and others, "Public Works Delivery Methods and Use at Sound Transit," Sound Transit, December 2019.
[352] ibid.
[353] "Revised Code of Washington 39.10.270 Project Review Committee—Certification of Public Bodies," Washington State Legislature, 2013.
[354] Washington State Auditor, 2020.
[355] Sound Transit Board of Directors, "Resolution No. R2018-40 Procurement, Agreements, and Delegated Authority Policy," September 27, 2018.
[356] Federal Transit Administration, "Frequently Asked Questions FTA Real Property Acquisition and the National Environmental Policy Act (NEPA)," January 2021.
[357] Sound Transit, "Chapter 2 Alternatives Considered - East Link Project Final EIS," July 2011.
[358] ibid.
[359] Alex Fryer, "Showdown in Rainier Valley—Despite One Group's Signs, Some Others Favor Street-Level Rail." *Seattle Times*, October 4, 1999.
[360] "Public Meeting and Hearing on Link Light Rail Rainier Valley Tunnel Study Thursday, Feb. 11, 1999," Sound Transit, February 2, 1999.; David Schaefer, "High Cost May End Rainier Tunnel Plan -- Some Neighbors Want Light- Rail Line to Go Underground," *Seattle Times*, January 22, 1999.
[361] Joshua Adam Hicks, "Sound Transit Board Makes Light-Rail Decision, Exchanges Barbs with Bellevue Mayor," *Bellevue Reporter*, July 23, 2010.
[362] Nat Levy, "Bellevue Council Votes for More Study of its Preferred Light-Rail Route," *Bellevue Reporter*, October 04, 2010.; Nat Levy, "Council Continues Analysis on Railway Corridor Route for Bellevue Light-Rail," *Bellevue Reporter*, September 14, 2010.
[363] Mike Lindblom, "Sound Transit Signs Off on Bellevue's Light-Rail Route," *Seattle Times*, April 25, 2013.
[364] Sound Transit, "Sound Transit, Bellevue Moving Forward with East Link," April 23, 2015.
[365] Sound Transit Board, "Resolution No. R2009-24 Scope Control Policy," December 10, 2009.
[366] Sound Transit 3 Expert Review Panel, "Final Report of ST3 Expert Review Panel," September 26, 2016.
[367] Sound Transit, "System Expansion Implementation Plan," December 2017.
[368] Kimberly Farley Memorandum to Peter Rogoff, "Capital Program Cost Estimate Growth and Response Actions," Sound Transit, January 5, 2021.

[369] ibid.
[370] ibid.
[371] Sound Transit, "Program Realignment Board Briefing Book," January 2021.
[372] ibid.
[373] Denver Regional Transportation District, "East Corridor Record of Decision," November 2009.
[374] The University of Colorado A Line is so named because the school system obtained naming rights for five years starting in 2015, with the potential to renew for another five years. The deal brought in $5 million for RTD over five years in exchange for the University's ability to place ads on the interior and exterior of trains and buses. All revenue was allocated to operating expenses.
[375] Denver Regional Transportation District, "FasTracks Program Overview—Executive Summary," June 29, 2018.
[376] Steve Moler, "Colossal Partnership: Denver's $1.67 Billion T-REX Project," *Public Roads* 65(2), 2001; Denver Regional Transportation District, "T-REX Transit Oriented Development Lessons Learned Report," September 2007.
[377] Federal Transit Administration, "Lessons Learned: The T-REX Mega-Project Experience," June 2007.
[378] Denver Regional Transportation District, "FasTracks 2009 Lessons Learned Report."
[379] Denver Regional Transportation District, "Eagle P3 Project Procurement Lessons Learned," August 2011.
[380] ibid.
[381] Denver Regional Transportation District, "FasTracks 2009 Lessons Learned Report," p. 25.
[382] Bill Van Meter, "The Lessons of a PENTA-P: RTD FasTracks," Denver Regional Transportation District, 2009.
[383] Denver Regional Transportation District, "Eagle P3 Project At a Glance," undated.
[384] Denver RTD, 2011.
[385] ibid.
[386] ibid.
[387] Denver Regional Transportation District, "Eagle P3 Project: Design-Build Final Lessons Learned Report," undated.
[388] ibid
[389] ibid.
[390] Andy Bosselman, "With G Line Opening, Has RTD Figured Out Positive Train Control?" *Streetsblog Denver*, April 23, 2019.
[391] See CFR 49, Section 234.205.
[392] ibid.
[393] Tom McGhee, "Feds Give RTD Another 90 Days to Fix A-Line Crossing Problems," *Denver Post*, February 1, 2017.
[394] Jesse Paul, "RTD Will Not Open G-Line or R-Line Before End of Year as Planned," *Denver Post*, November 18, 2016.
[395] "Grade Crossing Warning Times on the Denver RTD Commuter Rail System," Legal Memorandum to the Federal Railroad Administration, November 2018. p. 16.
[396] Meg Wingerter, "RTD: Long-Delayed G-Line from Denver to Wheat Ridge will Open April 26," Denver Post, April 1, 2019; John Aguilar, "Flaggers to Once Again Be Relieved of Duty on RTD's A-Line, B-Line Crossings," Denver Post, December 21, 2018; Jon Murray, "RTD and Contractors Start Trial in $111 Million Case Over Commuter Rail Crossing Problems," *Daily Camera*, September 23, 2020.
[397] Nathaniel Minor, "RTD Countersues Commuter Rail Operator, Says it Attempted to 'Retroactively Shift Blame'," *CPR News*, October 11, 2018.
[398] Denver RTD, undated.
[399] "Regional Railroad Authorities Act," Chapter 398A, Minnesota Statues 1980.
[400] Federal Highway Administration, "Project Profile: Hiawatha Light Rail Transit (METRO Blue Line)," Center for Innovative Finance Support, 2020.
[401] ibid.
[402] "Hiawatha Avenue Light Rail Transit Line," Minnesota State Auditor, Financial Audit Division, February 26, 2003
[403] "Northern States Power Company, d/b/a Xcel Energy, Respondent, vs. Minnesota Metropolitan Council, Appellant, Minnesota Department of Transportation, Appellants," C4-03-67, Minnesota Supreme Court, August 5, 2004.
[404] "Project Timeline: Central Corridor [Green Line]," Metropolitan Council, undated.
[405] "Green Line Light Rail," AECOM, undated.
[406] The social contract related to this community engagement has historically been strong in the Twin Cities region, but interviewees suggested that the killing of George Floyd might significantly erode the public trust in the engagement process and institutions.
[407] "Departments and Executive Agencies," European Commission, undated.
[408] "Special Report: Effectiveness of EU-supported public urban transport projects," European Court of Auditors, 2014.
[409] "Urban Mobility and Accessibility—Strategies and Policies," European Commission, undated.
[410] "Regulation (EU) No 1315/2013 of the European Parliament and of the Council," December 11, 2013.
[411] "Madrid Metro Line—Access to Barajas Airport," Centre for Innovation in Transport, Barcelona and Centre for Industrial Studies, Milan, September 5, 2012.

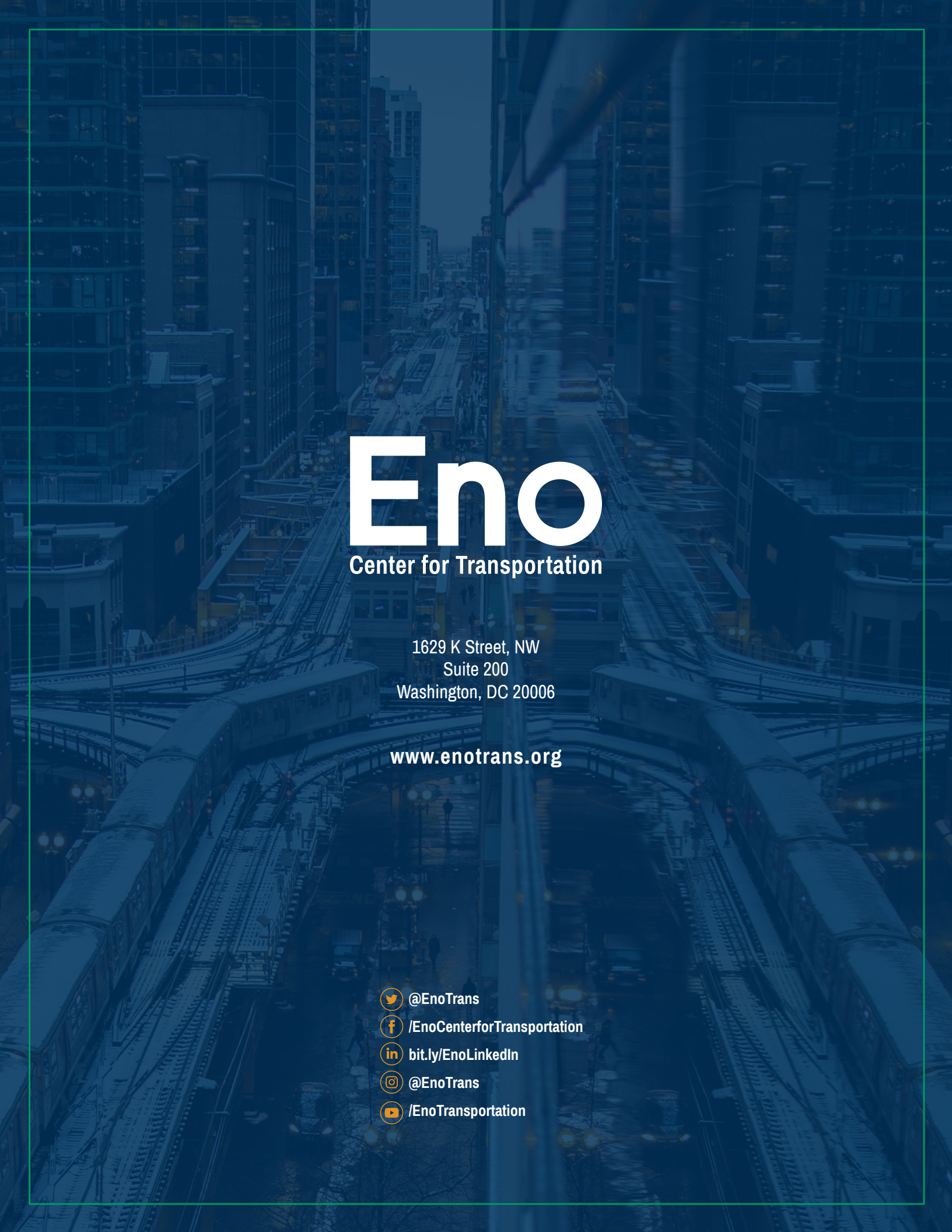
[412] "Directive 2014/52/EU of the European Parliament and of the Council of 16 April 2014 amending Directive 2011/92/EU on the assessment of the effects of certain public and private projects on the environment," April 16, 2014.
[413] "Review of the Environmental Impact Assessment (EIA) Directive," European Commission, undated.
[414] Copenhagen's urban/suburban commuter rail-style hybrid S-bahn trains have been in operation since the 1930's.
[415] Bruce Katz and Luise Noring, "The Copenhagen City and Port Development Corporation: A Model for Regenerating Cities," Brookings Institution, 2017.
[416] Katz and Noring, 2017.
[417] The 1992 national law that established the Ørestad Development Corporation required that it develop the area of Ørestad in order to raise funds for construction of the Metro. In 2007, the corporation merged with the Port of Copenhagen to become the CPH City & Port Development Corporation. Katz and Noring, 2017.
[418] "Annual Report 2019," Metroselskabet, 2019.
[419] "About Us," Hovedstadens Letbane, undated.
[420] See "City Ring Act," Denmark Legislature, and the Amendment to City Ring Act authorizing M4 Line to North Harbor, Denmark Legislature.
[421] "Ejerstruktur og interessentskabsmøder," Metroselskabet ("Ownership structure and partnership meetings" in Danish)
[422] "Metro Profile, Copenhagen Metro, Denmark," Global Mass Transit, 2018.
[423] Cost estimate provided by Metroselskabet.
[424] "The Copenhagen Metro, Denmark," COWI, undated.
[425] ibid.
[426] "Cityringen Metro, Copenhagen," *Railway Technology*, 2018.
[427] Kevin Smith, "Copenhagen Opens Nordhavn Metro Extension," *International Railway Journal*, March 31, 2020.
[428] "Metro to Sydhavn," Metroselskabet, undated.
[429] Kevin Smith, "Suburban Saviour—Light Rail to Plug Gap in Copenhagen Network," *International Railway Journal*, April 16, 2018.; "Tender," Hovedstadens Letbane, undated.
[430] "Cityringen: an Architectural Vision for Copenhagen's Next Generation Metro," ARUP, undated.
[431] Given this historically sensitive site and tight space constraints, tracks on the Marmorkirken station are located on separate floors 131 feet deep rather than side-by-side, making it the deepest station on the Metro. Tony Evans and others, "Cityringen Metro, Copenhagen, Denmark," *Arup Journal*, January 2020.
[432] ibid.
[433] ARUP, undated.
[434] ibid.
[435] Anne-Grethe Foss, "An Idea Becoming Reality," Copenhagen Metro Inaugural Seminar, 2002.
[436] ibid.
[437] COWI, undated.
[438] Katz and Noring, 2017.
[439] "Annual Report 2019," Metroselskabet, 2019.
[440] "About Us", Hovedstadens Letbane, undated.
[441] Arne Steen Jacobsen, "From Vision to Specifications," Copenhagen Metro Inaugural Seminar, 2002.
[442] ibid.
[443] Anders Odgård, "The Consultant's View," Copenhagen Metro Inaugural Seminar, 2002.
[444] ibid.
[445] ibid.
[446] Peter Reina, "Copenhagen Prepares for Metro Tunnels," *Engineering News-Record*, September 16, 2009.
[447] Odgård, 2002.
[448] Peter Jackson, "Environment Issues During Construction," Copenhagen Metro Inaugural Seminar, 2002.
[449] ibid.
[450] ibid.
[451] COWI, undated.
[452] ibid.
[453] ibid.
[454] Evans and others 2020.
[455] Reina, 2009.
[456] ibid.
[457] Ellen Skodborggaard and Søren Stenderup Jensen, "Expansion of Copenhagen Metro: Noise Pollution Prompts Complaints," International Law Office, September 2013.

[458] ibid; "Lov om ændring af lov om en Cityring og ligningsloven", Folketing, June 26, 2014. (Act amending the Act on a City Ring and the Tax Assessment Act, Danish Parliament)
[459] Consorcio Regional de Transportes de Madrid 2018 Annual Report.
[460] ibid.
[461] ibid.
[462] "2018 Annual Report," Madrid Metro, 2019.
[463] Center for Innovation in Transport, "Madrid Metro Line—Access to Barajas Airport," Ex-Post Evaluation of Investment Projects Co-Financed by the ERDF, European Commission, 2012.
[464] "El Gobierno regional disuelve Mintra, la empresa que construye el metro," El Pais, 2011.
[465] Center for Innovation in Transport, 2012.
[466] Maynar, 2003; Center for Innovation in Transport, 2012.
[467] *Tunnel Business Magazine*, "Understanding the New Austrian Tunnel Method (NATM)," December 5, 2018.
[468] Maynar, 2003.
[469] Carles Lozano and José Luis Manchobas, "Elecciones Autonómicas a la Asamblea de Madrid—1983-2019," historicalelectoral.com, 2020.
[470] Benjamin Villanti, "Subway Lessons from Madrid," *City-Journal*, Spring 2010.
[471] ibid.
[472] Ryan Holeywell, "Public-Private Partnerships Are Popular, But Are They Practical?" Governing, November 2013.
[473] Samuel Carpinteroa and Matti Siemiatycki, "The Politics of Delivering Light Rail Transit Projects Through Public-Private Partnerships in Spain: A Case Study Approach," *Transport Policy* 46: 2016.
[474] Maynar, 2003.
[475] ibid.
[476] ibid.
[477] "Purple Line Extension Transit Project Section 2: Tunneling Fact Sheet," Los Angeles Metro, 2019.
[478] Maynar, 2003.
[479] Approximate range given by interviewees who worked with or for MINTRA.
[480] See, for example, various project profiles of OHL: "Railway Infrastructures: Monograph," OHL, 2014 Edition.
[481] Grand Paris Express, "Grand Paris Express, The Largest Transport Project in Europe," undated.
[482] Jean-Pierre Boivin and Anthony Emorine, "Environmental Law and Practice in France: Overview," Thompson Reuters, 2021.
[483] Odile Heddebaut, "The Evolution of Public Transport Contracts in France," OECD, 2017.
[484] Marc Leroy, "Les Contrats de Plan État-Régions en France: Quelles Leçons Pour le Développement des Territoires," Gestion et Finances Publiques, #6, 2017.
[485] Heddebaut, 2017.
[486] ibid.
[487] Yves Boquet, "The Renaissance of Tramways and Urban Redevelopment in France," *Miscellanea Geographica*, 21(1): 2017.
[488] ibid.
[489] Ile-de-France Mobilités, "Ile-de-France Mobilités (Aa2/P-1): Organising Authority for Public Transport and Sustainable Mobility in Ile-de-France," 2020.
[490] ibid.
[491] ibid.
[492] RATP Group, "Infrastructure Management."
[493] RATP Group, "Engineering: International Expertise in Mobility".
[494] RATP Group, "The Board of Directors: Activity and Sustainable Development Report," 2017.
[495] Systra, "Grand Paris Express (Lines 15, 16, 17, and 18)".
[496] Railway Technology, "Grand Paris Express."
[497] RATP Group, "Financial and CSR Report," 2019.
[498] Société du Grand Paris, "Identité et Organisation," March 23, 2021.
[499] Île-de-France Mobilités, "Funding", January 2021.
[500] "Île-de-France Mobilités (Aa2/P-1): Organising Authority for Public Transport and Sustainable Mobility in Ile- de-France", Île-de-France Mobilités, October 2020.
[501] Syndicat des transports d'Île-de-France, "Désaturation de la Ligne 13 Par le Prolongement de la Ligne 14," July 2010.
[502] European Commission, "The Environmental Implementation Review 2019: Country Report France," 2019.
[503] ibid.
[504] Geneviève Zembri-Mary, "Risques, Incertitudes, et Flexibilité du Processus de Décision et de Planification des Projets d'Infrastructures de Transport," *Habilitation à Diriger des Recherches, Université de Lille*, p. 640.

[505] Antoine Boudet and David Barroux, "EuropaCity ne veut pas être victime d'une «instrumentalisation politique d'activistes écologistes», Les Echos, October 24, 2019.
[506] Clémence Pèlegrin, "EuropaCity: a "Hyper-Place" for a Globalised Europe?" *Green European Journal*, January 20, 2020.
[507] "Avis délibéré de l'Autorité environnementale sur la création de la ligne 17 Nord du Grand Paris Express entre la gare Le Bourget - RER (non incluse) et la gare Le Mesnil-Amelot (93, 95, 77)", Autorité environnementale du Conseil général de l'environnement et du développement durable, January 10, 2018.
[508] "Val d'Oise - La Justice Suspend les Travaux de la Ligne 17 du Grand Paris Express," France3, June 11, 2020.
[509] "Emmanuel Macron Enterre le Projet EuropaCity, Mégacomplexe Commercial Controversé Censé Naître à Gonesse," France3, November 6, 2020.
[510] Justin Teste, "Seine-et-Marne. La ligne 17 du Métro Avance (Très) Doucement Jusqu'au Mesnil-Amelot," La Marne, December 9, 2020.
[511] ibid.
[512] Todd Wetmore and Simon Elliot, "France: Construction & Engineering Laws and Regulations", ICLG, November 8, 2020.
[513] ibid.
[514] Flora Aubert, "La Conception-Réalisation: Une Mutation Profonde du Secteur de la Construction", Annales de Mines—Gérer et comprendre, 2017; Basile Delacorne, "Relance: l'ouverture à la Conception-Réalisation Retoquée par le Conseil Constitutionnel," Batiactu, January 5, 2021.
[515] Société du Grand Paris, 2020.
[516] Société du Grand Paris, "2018 Activity Report", 2018.
[517] ibid.
[518] "Competitive Dialogue," Procurement Journey, undated.
[519] "Toronto-York Spadina Subway Extension (TYSSE) Project Profile," Metrolinx, undated.; "Finch West Light Rail Transit (LRT) Project FAQs," Metrolinx, undated.
[520] "Infrastructure Canada Funding Programs," Infrastructure Canada, April 29, 2021; "Building Canada Fund," Infrastructure Canada, October 26, 2011.
[521] Samantha Beattie, "Federal Government to Spend $12B on Toronto, Hamilton Transit", CBC News, May 11, 2021.
[522] Originally known as the Greater Toronto Transportation Authority.
[523] "The Big Move," Metrolinx, 2008.
[524] "Bill 57, Restoring Trust, Transparency and Accountability Act, 2018", Legislative Assembly of Ontario, December 6, 2018.
[525] Wickens, 2020.
[526] ibid.
[527] "2019 Operating Statistics," Toronto Transit Commission.
[528] Carolyn Ruhland, "Allocating Risk in Transportation Megaprojects: The Case of the Canada Line," Thesis: University of Calgary, 2010.
[529] Wickens, 2020.
[530] ibid.
[531] "Eglinton Crosstown Backgrounder", Metrolinx, Undated.
[532] "Finch West Light Rail Transit", Infrastructure Ontario, undated.
[533] Wickens, 2020.
[534] Aaron Adel and James Bow, "The Sheppard Subway," Transit Toronto, July 20, 2017.
[535] Adrian Morrow, "Lessons from Toronto's Sheppard Subway Line," *Globe and Mail*, November 16, 2012.
[536] Oliver Moore and Jeff Gray, "Next Stop, Vaughan: Inside the Toronto Subway's Big Move Beyond the City Limits," *Globe and Mail*, December 14, 2017.
[537] Royson James, "Ours is to Question Why, and Why Again," *Toronto Star*, May 5, 2015.
[538] Ann Golden, "Governance of Regional Transit Systems: Observations on Washington, New York, and Toronto," The Wilson Center, June 2014.
[539] "2018 Annual Report Section 3.07 Metrolinx—LRT Construction and Infrastructure Planning," Office of the Auditor General of Ontario, December 5, 2018.
[540] James Bow, "Toronto's Transit City LRT Plan," Transit Toronto, April 27, 2021.
[541] Tess Kalinowski and David Rider, "'War on the Car is Over': Ford Moves Transit Underground,", *Toronto Star*, December 2, 2010.
[542] "Rob Ford: 'Transit City is Over'," *CBC News*, December 1, 2010.
[543] Marcus Gee, "It Was Alive, it Was Dead and Now Transit City is Back to Life, Maybe," *Globe and Mail*, April 25, 2012.
[544] *Hamilton Spectator*, "Hamilton to Get a New LRT and GO Train Station," May 26, 2015.
[545] "Hamilton B-Line LRT, Ontario," *Railway Technology*, undated.
[546] Matthew Van Dongen, "'A Betrayal of Hamilton': Ontario Pulls out of LRT Project," *Toronto Star*, December 16, 2019.

[547] Mischa Wanek-Libman, "Calls for Investigations; Accusations of Betrayal Among Fall Out from Hamilton LRT Cancellation," *Mass Transit*, December 23, 2019.
[548] Office of the Auditor General of Ontario , "Value-for-Money Audit Metrolinx Operations and Governance," December 2020.
[549] Matthew Van Dongen, "LRT is Back on the Table (along with BRT) Just Months after Ontario Cancelled Hamilton's Ongoing Light Rail Project," *Hamilton Spectator*, April 9, 2020.
[550] "2018 Annual Report Section 3.07 Metrolinx—LRT Construction and Infrastructure Planning," Office of the Auditor General of Ontario, December 5, 2018.
[551] "Business Case Manual Volume 1: Overview," Metrolinx, December 2017.
[552] "2018 Annual Report Section 3.07 Metrolinx—LRT Construction and Infrastructure Planning," Office of the Auditor General of Ontario, December 5, 2018.
[553] Oliver Moore, "Costs of Major Transit Projects Will Far Exceed Their Benefits, According to Metrolinx Reportsm," *Globe and Mail*, February 28, 2020.
[554] "BRT Deserved More Study in Hamilton: Ontario's Auditor General," *Hamilton Spectator*, March 2, 2020.
[555] "2018 Annual Report Section 3.07 Metrolinx—LRT Construction and Infrastructure Planning," Office of the Auditor General of Ontario, December 5, 2018.
[556] Ben Spurr, "Metrolinx Improperly Approved GO Stations Under Political Pressure, Ontario's Auditor General Finds," *Toronto Star*, December 5, 2018.
[557] "2018 Annual Report Section 3.06 Metrolinx—GO Station Selection", Office of the Auditor General of Ontario, December 5, 2018.
[558] ibid.
[559] Spurr, 2018.
[560] Office of the Auditor General of Ontario, 2020.
[561] ibid.
[562] Office of the Auditor General of Ontario, "2014 Annual Report Section 3.05 Infrastructure Ontario—Alternative Financing and Procurement", December 9, 2014.
[563] Office of the Auditor General of Ontario, "2018 Annual Report Section 3.07 Metrolinx—LRT Construction and Infrastructure Planning", December 2018.
[564] Ibid.
[565] Office of the Auditor General of Ontario, "Annual Follow Up on Value-for-Money Audits Section 1.07 Metrolinx—LRT Construction and Infrastructure Planning," December 2020.
[566] ibid.
[567] ibid.
[568] Ben Spurr, "Eglinton Crosstown Faces Another Setback, Delayed until 2022," *Toronto Star*, February 18, 2020.
[569] Ontario Ministry of the Environment, "Guide: Ontario's Transit Project Assessment Process," January 2014.
[570] "Ontario Reg. 231/08: Transit Projects and Metrolinx Undertakings," April 1, 2021.
[571] Ontario Ministry of the Environment, 2014.
[572] ibid.
[573] Ben Spurr, "Live Next to the Ontario Line? You'll Soon Have to ask Metrolinx Permission to Build a Deck," *Toronto Star*, March 29, 2021.
[574] "Ontario Regulation 341/20: Ontario Line Project", June 20, 2020.; "The Ontario Line—Environment," Metrolinx, undated.
[575] "Briefing Note; Need for Environmental Assessment Reform for Ontario," Canadian Environmental Law Association, MiningWatch Canada, CPAWS Wildlands League, and Wildlife Conservation Society Canada, June 2016.; Steve Munro, "Doug Ford's Ontario Line Headed Down the Wrong Track," *Now Toronto*, February 3, 2020.
[576] Ontario Society of Professional Engineers, "Province Moves Forward with the Building Transit Faster Act," March 10, 2020.
[577] "Federal-aid Essentials for Local Public Agencies: Federal-aid Highway Program," Federal Highway Administration, undated.
[578] "Federal Highway Administration Statistics," FederalPay.org, 2018.
[579] "Fixing America's Surface Transportation Act or 'FAST Act' Fact Sheet," Federal Highway Administration, February 8, 2017.; "Federal-Aid Highway Program Authorizations Under the Fixing America's Surface Transportation (FAST) Act," Federal Highway Administration, undated.
[580] "Statewide Transportation Improvement Program (STIP)," Federal Transit Administration, March 11, 2019. 581 "FHWA Risk-based Project Involvement Guidance," Federal Highway Administration, September 25, 2020. 582 "Environmental Review Toolkit: NEPA Assignment," Federal Highway Administration, undated.
[583] "Project Profile: Capital Beltway High Occupancy Toll (HOT) Lanes (I-495)," Federal Highway Administration Center for Innovative Finance Support, undated.
[584] "VDOT Capital Beltway (I-495) EXPRESS Lanes," Fluor, undated.
[585] "I-495 HOV/HOT Lanes, Northern Virginia Project Overview," U.S. Department of Transportation Build America Bureau, September 9, 2014.

[586] Lisardo Bolaños and others, "U.S. Surface Transportation Public-Private Partnerships: Objectives and Evidence," George Mason University Center for Transportation Public-Private Partnership Policy, 2017.
[587] Thomas Jennings and others, "Traveling the Capital Beltway Is Now E-Zier," *Public Roads*, 77(5): 2014.
[588] Bolaños and others, 2017.
[589] "Virginia HOT Lanes Project Timeline: A Decade of Study, Review & Public Input," Virginia Department of Public Transportation, March 2008.
[590] Nobuhiko Daito and others, "Implementing Public Private Partnerships During Challenging Economic Times: Case Study of the 495 Express Lanes on the Virginia Portion of the Washington Capital Beltway Project (USA)," *Case Studies on Transport Policy*, 1(1): 2013.
[591] "Dulles Corridor Metrorail Project, Northern Virginia," NCHRP Report 827 Appendix A Case Study, 2016.
[592] ibid.
[593] Lori Aratani and Paul Duggan, "Why Second Phase of Metro's Silver Line Has Been More Problem-Plagued Than the First," *Washington Post*, July 20, 2019.
[594] Metropolitan Washington Airports Authority, "Airports Authority Statement Regarding Status of Silver Line Phase 1 Construction," February 24, 2014.
[595] Aratani and Duggan, 2019; Lori Aratani, "Crews Resume Some Girder Work on Silver Line, Phase 2," *Washington Post*, August 27, 2015; Lori Aratani, "New Audit Faults Lack of Effective Oversight, New Problems With Phase 2 of Silver Line," *Washington Post*, March 5, 2020.
[596] PABs and TIFIA Loans are federal programs that allow private borrowers to access lower interest rates. The private equity investment will be repaid through future tolls.
[597] NCHRP Report 827, 2016.
[598] "Loudoun Closes on TIFIA Loan for Dulles Rail Project; Officials Praise Financial Benefits," Loudon County Virginia, December 2014.; "Fund 40120 Dulles Rail Phase II Transportation Improvement District," Fairfax County, 2020.
[599] "VDOT's Organization," Virginia Department of Transportation, November 20, 2019.
[600] Estimated staff size for MWAA rail division from interviewee.
[601] "Project Management Oversight (PMO)," Federal Transit Administration, December 15, 2020.
[602] Cambridge Systematics, "Economic Impacts of Public Transportation in the Commonwealth of Virginia," Prepared for Virginia Department of Rail and Public Transportation, February 2020.
[603] The $300 million baseline is flexible, but in line with general international best practice.
[604] One possible exception is the case of projects in New York City. Multiple resources and reports cited specific issues with the construction workforce there, particularly related to work rules and overtime. Future Eno work will investigate this in more detail.
[605] "Bill 171, Building Transit Faster Act," Legislative Assembly of Ontario, 2020.
[606] Fabian Bonke, "Provisions of the new FIDIC 'Emerald Book'," *International Tunneling Journal*, June/July 2019.



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