

Rail Line Prioritization

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"In space, no one can hear you think."

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1 Rail Line Prioritization

1.1 Introduction and Definition of Rail Line Prioritization

Rail line prioritization stands as one of the most consequential yet often overlooked processes in transportation planning, shaping the movement of people and goods across continents for nearly two centuries. At its core, rail line prioritization represents the systematic process through which transportation authorities, governments, and private entities determine the sequence of investments, improvements, and developments within rail networks. This complex decision-making framework balances competing demands, limited resources, and strategic objectives to create efficient, equitable, and sustainable transportation systems. Whether determining which existing rail corridor should be electrified first, which new high-speed line will offer the greatest economic return, or which rural branch line warrants preservation despite low ridership, prioritization decisions fundamentally alter the transportation landscape and influence patterns of human settlement, commerce, and environmental impact for generations.

The conceptual framework of rail line prioritization encompasses both the enhancement of existing infrastructure and the development of new corridors. When considering existing lines, prioritization typically involves determining upgrade sequences—whether to improve signaling systems, increase track capacity, enhance station facilities, or electrify routes. For instance, the decision by European nations to prioritize the electrification of major corridors during the mid-20th century revolutionized rail efficiency and environmental performance. Conversely, new line development prioritization involves route selection, alignment decisions, and the sequencing of construction phases. The development of Japan's Shinkansen network exemplifies this approach, with planners initially prioritizing the Tokyo-Osaka corridor before strategically expanding to connect other major population centers. These prioritization processes do not occur in isolation but fit within broader transportation planning frameworks that consider multimodal integration, urban development patterns, and long-term demographic shifts.

Historically, rail line prioritization has been shaped by the imperatives of its era. During the 19th century railroad boom, prioritization often followed simple economic logic—connecting major industrial centers, ports, and resource extraction sites. The transcontinental railroads in the United States, for example, were prioritized based on their potential to unify markets and facilitate westward expansion. As rail networks matured, prioritization methodologies evolved to incorporate more sophisticated analyses of demand, cost-benefit ratios, and strategic importance. The nationalization of rail systems in many countries during the 20th century further transformed prioritization processes, shifting from purely market-driven decisions to those incorporating public service obligations and regional development goals.

The importance of strategic rail line prioritization cannot be overstated in its economic significance. Efficient rail networks serve as the circulatory system of national economies, enabling the movement of raw materials to manufacturing centers and finished goods to markets. The prioritization of the Rhine Railway corridor in Germany, for instance, facilitated industrial integration across Europe and remains a critical artery for European commerce. Beyond direct economic impacts, rail prioritization decisions influence patterns of investment, with improved rail access often triggering commercial and residential development along corri-

dors. The prioritization of the Paris-Lyon high-speed line in France not only transformed travel between these cities but also stimulated economic growth in intermediate cities like Mâcon and Le Creusot, demonstrating how rail infrastructure can redistribute economic opportunity across regions.

Social impacts of rail line prioritization extend deeply into questions of accessibility, equity, and community connectivity. When transportation authorities prioritize urban commuter rail systems over intercity routes, as occurred in many metropolitan areas during the late 20th century, they fundamentally reshape commuting patterns, housing markets, and social mobility. The prioritization of rail connections to underserved communities can reduce transportation costs for lower-income residents, improve access to employment opportunities, and strengthen social cohesion. Conversely, the decision to deprioritize certain lines—often rural or less populous routes—can isolate communities and accelerate economic decline. The Beeching cuts in Britain during the 1960s, which prioritized profitability over service coverage, resulted in the closure of thousands of miles of railway and numerous stations, fundamentally altering the social and economic geography of many rural regions.

Environmental considerations have increasingly become central to rail line prioritization decisions. Rail transport typically produces significantly lower greenhouse gas emissions per passenger-kilometer or ton-kilometer compared to road or air transport, making rail prioritization a critical tool in climate change mitigation strategies. The prioritization of rail freight corridors in Switzerland, including the construction of the Gotthard Base Tunnel, was motivated in large part by environmental concerns, aiming to shift freight from roads to more environmentally friendly rail transport. Similarly, the prioritization of electrified rail lines over diesel-operated routes in many European countries reflects environmental objectives alongside operational efficiency considerations.

Rail line prioritization also carries strategic importance for national security and resilience. The prioritization of double-tracking and capacity improvements on key military transport routes during the Cold War in both the United States and Soviet Union underscored rail's role in national defense. Contemporary prioritization frameworks increasingly emphasize system resilience, considering how investments might enhance network redundancy and reduce vulnerability to disruptions from natural disasters, accidents, or security threats.

This article explores the multifaceted nature of rail line prioritization through an interdisciplinary lens, examining historical development, fundamental principles, economic factors, governance frameworks, methodological approaches, technological considerations, environmental implications, social dimensions, and future challenges. The analysis draws on case studies from across different continents, governance structures, and developmental contexts to illustrate how prioritization decisions are made and their far-reaching consequences. Key concepts such as cost-benefit analysis, multi-criteria decision analysis, stakeholder engagement, and scenario planning will be examined in detail, providing readers with a comprehensive understanding of this critical transportation planning function.

As we delve into the historical development of rail line prioritization in the following section, we will trace how decision-making frameworks have evolved from the simple economic imperatives of early railroad builders to today's complex, multi-dimensional approaches that balance economic efficiency, social equity, environmental sustainability, and strategic resilience. This historical journey reveals not only changing

methodologies but also shifting societal values and priorities that continue to shape the future of rail transportation worldwide.

1.2 Historical Development of Rail Line Prioritization

The historical evolution of rail line prioritization reveals a fascinating journey from simple economic imperatives to sophisticated multi-dimensional decision frameworks that continue to shape transportation networks worldwide. During the early developmental period of railroads from the 1820s to 1870s, prioritization decisions emerged primarily from practical considerations of topography and economic opportunity. The pioneering Stockton and Darlington Railway in England, opened in 1825, established a precedent for route selection based on connecting coal mines with river transport, demonstrating how resource extraction and industrial needs would drive initial railroad development. Similarly, the Baltimore and Ohio Railroad, chartered in 1827 as America's first common carrier railroad, prioritized routes that would overcome the geographical barriers of the Appalachian Mountains to connect the agricultural Midwest with eastern port cities. These early prioritization approaches were largely intuitive, driven by entrepreneurs seeking to connect existing economic centers rather than following systematic planning methodologies.

The economic imperatives of industrialization profoundly influenced early railroad expansion and prioritization. In Britain, the Railway Mania of the 1840s saw competing companies rush to construct lines between major cities, with Parliament increasingly called upon to arbitrate between competing proposals. The prioritization of routes during this period often reflected the influence of powerful industrial interests and the potential for immediate profit rather than long-term network integration. Across the Atlantic, American railroad development prioritized westward expansion, with the Pacific Railway Act of 1862 establishing the framework for constructing the first transcontinental railroad. This monumental prioritization decision was driven by national unity concerns during the Civil War and the desire to connect eastern markets with western resources, fundamentally altering the economic geography of North America.

Competition between private railroad companies significantly impacted network development patterns during this era. In the United States, the race to construct transcontinental lines led to the prioritization of parallel routes that created redundancy in some areas while leaving other regions underserved. The Union Pacific and Central Pacific railroads' race to meet in Utah in 1869 exemplifies how competitive pressures could accelerate construction but sometimes resulted in suboptimal route selection. Similarly, in Britain, the competition between the Great Western Railway and other companies led to the prioritization of multiple routes to the same destinations, creating an inefficient network structure that would later require rationalization.

Government involvement through land grants, subsidies, and regulatory frameworks played a crucial role in shaping early railroad prioritization. The United States government awarded enormous land grants to railroad companies, effectively prioritizing certain corridors by making them financially viable through the sale of adjacent lands. This approach prioritized a transcontinental route that would encourage settlement and development of the West. In continental Europe, governments took a more direct role in prioritization, with Prussia's state railway system deliberately prioritizing lines that would support military mobilization alongside economic development. These early government interventions established patterns of public-private

partnership that would continue to influence rail prioritization for generations to come.

As rail networks entered their golden age from the 1870s to 1940s, prioritization methodologies became increasingly sophisticated. The maturation of networks necessitated more systematic approaches to investment decisions, moving beyond the simple connective logic of early development. In the United States, the consolidation of the railroad industry under figures like J.P. Morgan led to more coordinated network planning, with systems like the Pennsylvania Railroad prioritizing mainline improvements that would enhance efficiency and competitiveness. The introduction of scientific management principles by railroads during this period represented a significant evolution in prioritization approaches, as operators began systematically analyzing traffic patterns, operating costs, and investment returns to guide their decisions.

National railroad unification during this period transformed prioritization frameworks in many countries. Germany's nationalization of major railroads in the 1920s created the Deutsche Reichsbahn, which adopted a more holistic approach to network prioritization that balanced regional development with operational efficiency. Similarly, the creation of Canadian National Railways in 1919 through the amalgamation of several financially troubled companies represented a state-led prioritization of network integration and rationalization over competition. These national systems developed more sophisticated criteria for investment decisions, considering factors like strategic importance, regional equity, and long-term economic development rather than short-term profitability.

The World Wars and economic crises of the first half of the twentieth century profoundly influenced rail line prioritization decisions. During World War I, railroads in combatant nations were placed under government control, with prioritization focused on military logistics and the movement of troops and supplies. The Great Depression that followed forced railroads to prioritize maintenance and survival over expansion, leading to widespread deferral of improvements and the abandonment of marginal lines. The rise of totalitarian regimes in Germany, Italy, and the Soviet Union during this period saw rail prioritization increasingly subordinated to state ideology and military preparedness, with monumental projects like the German Breitspurbahn (broad-gauge railway) planned but never completed due to the exigencies of World War II.

Standardization of engineering practices and economic assessment approaches during this era provided more rigorous foundations for prioritization decisions. The development of consistent methods for calculating construction costs, operating expenses, and revenue potential allowed for more systematic comparisons between competing projects. The American Railway Engineering Association, founded in 1899, developed standard practices that influenced prioritization by establishing consistent criteria for evaluating infrastructure investments. Similarly, the emergence of traffic forecasting techniques enabled planners to better assess the potential demand for new lines or improvements, adding a quantitative dimension to prioritization processes that had previously relied more heavily on intuition and political influence.

The decline of railroads in many countries following World War II, coupled with the rise of automobile and air travel, fundamentally reshaped rail line prioritization frameworks. In the United States, the Interstate Highway Act of 1956 represented a massive prioritization of highway infrastructure over rail, contributing to the decline of passenger rail service and the rationalization of freight networks. The bankruptcy of Penn Central in 1970 and the subsequent creation of Conrail through the merger of several bankrupt northeastern

railroads exemplified the crisis facing the industry and the need for new approaches to prioritization that could ensure the survival of essential rail services while allowing the discontinuation of unprofitable routes.

Nationalization of rail systems in many countries during this period dramatically altered investment decision processes. In Britain, the creation of British Railways in 1948 brought most rail operations under state control, with prioritization decisions increasingly influenced by public service obligations and political considerations rather than pure market forces. The 1963 Beeching Report represented a landmark in rail prioritization, systematically evaluating the economic viability of thousands of route miles and stations, ultimately leading to the closure of approximately one-third of the network. While controversial, this approach established a precedent for evidence-based prioritization that would influence rail planning decisions globally.

The emergence of high-speed rail beginning with Japan's Shinkansen in 1964 introduced a new dimension to rail line prioritization. Japan's initial focus on the Tokyo-Osaka corridor reflected a prioritization approach that emphasized connecting the country's largest population and economic centers, achieving dramatic reductions in travel time that transformed intercity transportation. France's subsequent development of the TGV network similarly prioritized the Paris-Lyon

1.3 Fundamental Principles and Criteria for Rail Line Prioritization

France's subsequent development of the TGV network similarly prioritized the Paris-Lyon corridor, which carried approximately 40% of all intercity passenger traffic in France at the time. This strategic decision exemplifies how fundamental principles of rail line prioritization translate into concrete action, setting the stage for our exploration of the core principles and criteria that guide such consequential decisions across different contexts and governance structures.

The core principles underlying rail line prioritization form a philosophical foundation that transcends specific methodologies or temporal contexts. Efficiency and optimization principles stand paramount among these, seeking the greatest public benefit from limited resources. This principle manifests in the prioritization of investments that yield the highest returns in terms of capacity enhancement, travel time reduction, or service improvement. The Swiss Railways' application of this principle through their "Rail 2000" initiative in the late 20th century systematically prioritized improvements that would create an integrated, clock-face schedule system across the entire network, dramatically improving connectivity and transfer efficiency while minimizing incremental investment costs.

Equity and accessibility considerations represent another fundamental principle in rail line prioritization, ensuring that transportation systems serve diverse populations rather than merely maximizing ridership or revenue. This principle has gained prominence as societies increasingly recognize transportation as a fundamental right rather than a market commodity. The prioritization of cross-suburban rail connections in Stockholm, for instance, deliberately improved access to employment opportunities for residents of outer suburbs with lower incomes, demonstrating how equity considerations can shape investment decisions even when pure economic metrics might suggest alternative priorities.

Sustainability and long-term thinking constitute a third core principle that has grown increasingly influential in contemporary rail prioritization. This principle emphasizes investments that provide enduring value rather than merely addressing immediate needs, considering environmental impacts, resource consumption, and adaptability to future challenges. Denmark's approach to rail prioritization exemplifies this principle, with the country's decision to prioritize electrification of its entire rail network reflecting a commitment to reducing carbon emissions and decreasing dependence on fossil fuels over decades rather than focusing solely on short-term operational savings.

A systems approach to network development represents a fourth fundamental principle, recognizing that rail lines function not as isolated segments but as interconnected components of a larger transportation system. This principle encourages prioritization decisions that enhance overall network performance rather than merely improving individual corridors. Japan's JR East has applied this principle masterfully, prioritizing investments that strengthen critical transfer points and ensure seamless integration between its Shinkansen high-speed network and conventional regional services, creating a system where the whole truly exceeds the sum of its parts.

Adaptive management and flexibility form the fifth core principle, acknowledging that conditions change over time and that prioritization frameworks must accommodate evolving needs, technologies, and societal values. This principle has been particularly evident in the Netherlands' rail prioritization processes, which have evolved from focusing primarily on passenger mobility to incorporating freight considerations, environmental impacts, and land use planning as societal priorities have shifted over recent decades.

These core principles translate into specific criteria that transportation planners and policymakers use to evaluate and rank rail line investments. Demand and ridership potential typically constitute the primary criterion in most prioritization frameworks, reflecting the fundamental relationship between usage and justification for investment. The prioritization of the Northeast Corridor in the United States, carrying approximately 12 million passengers annually between Washington D.C., New York, and Boston, demonstrates how high-demand routes naturally rise to the top of prioritization lists due to their potential for immediate impact on large numbers of travelers.

Economic development impact represents another critical criterion, considering how rail investments might stimulate business growth, job creation, and property value increases. The prioritization of the Channel Tunnel Rail Link (now High Speed 1) in the United Kingdom was heavily influenced by projections of economic regeneration in areas along the route, particularly in East London, where the line's terminus at St. Pancras International helped catalyze the transformation of surrounding neighborhoods into thriving commercial and residential districts.

Connectivity and network benefits form a third essential criterion, evaluating how proposed investments enhance overall transportation system performance by improving transfers, filling network gaps, or creating new connections. Germany's prioritization of the Stuttgart-Ulm high-speed line as part of the broader "Magistrale for Europe" initiative illustrates this criterion, as the project not only improves travel between these two cities but also strengthens the Paris-Budapest high-speed corridor, enhancing connectivity across multiple national boundaries.

Social equity and accessibility considerations have increasingly become formal criteria in many prioritization frameworks, explicitly evaluating how investments serve disadvantaged populations, reduce transportation costs for lower-income travelers, or improve access to essential services. The prioritization of the Transmilenio bus-rapid transit system with integrated rail feeder services in Bogotá, Colombia, exemplifies this approach, deliberately focusing improvements on serving lower-income neighborhoods that had previously suffered from inadequate public transportation options.

Environmental considerations constitute the fifth primary criterion in contemporary rail prioritization, assessing potential impacts on carbon emissions, air quality, land consumption, and ecosystem preservation. The prioritization of the Gotthard Base Tunnel in Switzerland was driven substantially by environmental concerns, with the project designed to shift freight traffic from environmentally damaging road transport to more sustainable rail alternatives, thereby reducing Alpine pollution and contributing to Switzerland's climate goals.

These criteria are applied through various methodological approaches that have evolved to handle the complexity of rail line prioritization. Multi-criteria decision analysis frameworks have emerged as particularly valuable tools, allowing planners to systematically evaluate projects across numerous dimensions that may be measured in different units or valued differently by various stakeholders. The European Union's use of multi-criteria analysis in evaluating TEN-T (Trans-European Transport Network) priorities demonstrates this approach, considering factors such as accessibility, safety, environmental impact, and economic development alongside more traditional metrics of cost and demand.

Cost-benefit analysis methodologies remain fundamental to rail prioritization processes, providing a standardized framework for comparing projects by quantifying all significant impacts in monetary terms. The United Kingdom's Department for Transport has developed sophisticated cost-benefit analysis approaches that incorporate factors like time savings, reliability improvements, accident reduction, and environmental impacts, enabling consistent evaluation of diverse rail projects from commuter line upgrades to intercity high-speed rail proposals.

Scenario planning approaches have gained prominence as recognition of uncertainty in future conditions has grown. This methodology involves evaluating how different investment priorities might perform under various future scenarios, such as differing population growth patterns, economic conditions, or climate change impacts. The Dutch Ministry of Infrastructure and Water Management has employed scenario planning extensively in its rail prioritization processes, considering how investments might perform under scenarios ranging from strong economic growth to climate-induced disruptions.

Deliberative and participatory methods incorporate stakeholder input directly into prioritization processes, recognizing that technical analyses alone cannot capture all relevant values and perspectives. Germany's "Federal Transport Infrastructure Plan" development process exemplifies this approach, incorporating extensive consultation with states, municipalities, businesses, environmental organizations, and citizen groups to inform prioritization decisions, thereby enhancing legitimacy and addressing diverse concerns.

Comparative assessment techniques provide frameworks for evaluating different types of rail projects on a consistent basis, enabling meaningful comparisons between, for instance, urban metro extensions, regional

rail improvements, and intercity high-speed lines. Sweden's Transport Administration has

1.4 Economic Factors in Rail Line Prioritization

Sweden's comparative assessment techniques, while sophisticated in their methodological approach, ultimately hinge on the economic factors that form the bedrock of most rail line prioritization decisions. These economic considerations extend far beyond simple profit-and-loss statements, encompassing complex calculations of direct financial returns, broader economic impacts, cost structures, funding mechanisms, and the interplay between public investment and market forces. The prioritization of rail lines represents, at its core, an allocation of scarce capital resources with the expectation of generating economic returns—whether measured in direct revenue, wider economic benefits, or strategic advantages that contribute to national prosperity.

Direct financial metrics typically serve as the initial filter in rail line prioritization processes, with projects evaluated on their ability to generate sufficient revenue to cover operating costs and provide an acceptable return on investment. The Japan Railway Construction, Transport and Technology Agency (JRJT) employs rigorous financial modeling to prioritize Shinkansen extensions, focusing on projected farebox recovery ratios—the percentage of operating costs covered by passenger revenue. The Hokuriku Shinkansen extension to Kanazawa, for instance, was prioritized after demonstrating a projected farebox recovery ratio exceeding 100%, indicating operational self-sufficiency while simultaneously delivering significant time savings for passengers traveling between Tokyo and the Sea of Japan coast. This financial viability assessment becomes particularly crucial in contexts where rail operators function as commercial entities rather than purely public services, as seen in Japan's privatized railway structure where individual JR companies must justify investments to shareholders and financial markets.

Cost-benefit analysis represents a more comprehensive economic framework that has become standard in many countries' rail prioritization processes. Unlike pure financial metrics that focus on monetary returns to the rail operator, cost-benefit analysis attempts to monetize the full spectrum of economic impacts, including time savings for passengers and freight, reduced road congestion, lower accident rates, decreased environmental damage, and broader economic development effects. The United Kingdom's Department for Transport has developed one of the world's most sophisticated cost-benefit analysis frameworks for rail projects, assigning monetary values to factors such as time savings (valued at approximately £12 per hour for leisure travelers and £18 per hour for business travelers in 2023), accident reductions, and carbon emissions. This approach was instrumental in prioritizing the electrification of the Great Western Main Line, which demonstrated a benefit-cost ratio of 2.2—meaning £2.20 of economic benefits for every £1 invested—primarily through reduced journey times, lower operating costs, and decreased carbon emissions.

Economic development impact assessments have increasingly become central to rail line prioritization, particularly for new lines or major upgrades that might catalyze regional growth. These evaluations examine how rail investments might stimulate business expansion, attract new industries, increase property values, and create employment opportunities both during construction and through enhanced accessibility. The prioritization of the Channel Tunnel Rail Link (High Speed 1) in the United Kingdom was heavily influenced

by economic regeneration projections, particularly for East London. The decision to route the line through Stratford and terminate at St. Pancras International was driven by forecasts that the improved rail connections would transform these areas into major business districts, attracting investment and creating thousands of jobs. These projections proved remarkably accurate, with Stratford becoming the centerpiece of London's Olympic Park development and the area around St. Pancras experiencing significant property value increases and commercial development following the line's completion in 2007.

Funding mechanisms and budget constraints fundamentally shape rail line prioritization decisions, as even the most economically beneficial projects cannot proceed without adequate financing. The European Union's Trans-European Transport Network (TEN-T) program demonstrates how funding availability influences prioritization, with projects evaluated not only on their economic merits but also on their readiness for implementation and the availability of co-financing from member states. The Rail Baltica project, which will create a continuous north-south rail connection from Poland through the Baltic states to Finland, was prioritized for TEN-T funding partly because of its clear economic rationale but also because the participating countries demonstrated strong financial commitment and political will to deliver the project. Conversely, many economically promising rail projects in developing countries remain lower priorities due to limited access to capital markets, competing development priorities, and concerns about debt sustainability.

Public-private partnerships (PPPs) have emerged as an important economic model for rail line development, particularly for high-cost projects that might exceed public financing capacity. These arrangements bring private sector efficiency and capital into rail development while allowing public authorities to maintain strategic control over service levels and fares. The privatization and subsequent development of Britain's High Speed 1 under a PPP arrangement illustrates this approach, with private companies financing, constructing, and maintaining the infrastructure while the government provides availability payments based on performance metrics. This economic arrangement influenced the project's prioritization and phasing, as the private consortium required sufficient revenue certainty to justify their investment, leading to an initial focus on the international connection to the Channel Tunnel before extending domestic services. The success of this model has influenced rail prioritization in other countries, with Australia's Inland Rail project and various high-speed rail proposals in the United States considering PPP structures to accelerate development.

The cost structure of rail investments significantly affects prioritization decisions, with projects often categorized by their capital intensity and operational cost profiles. Electrification projects, for instance, typically require substantial upfront capital investment but deliver long-term operational savings through reduced energy costs and maintenance requirements. The Swiss Federal Railways' systematic prioritization of electrification since the 1950s reflects this economic calculus, with the country's decision to complete its network electrification by 1960 based on comprehensive lifecycle cost analysis that demonstrated significant long-term savings despite the initial capital outlay. Similarly, double-tracking projects that eliminate bottlenecks often show favorable economic returns through increased capacity and reliability, as demonstrated by the prioritization of double-tracking on the Union Pacific's Sunset Route in the United States, which reduced freight transit times between Los Angeles and New Orleans by over 24 hours and substantially improved network reliability.

Economic spillover effects have become increasingly recognized in rail prioritization frameworks, acknowledging that rail investments create value beyond direct users and operators. Agglomeration economies—the productivity gains that occur when businesses and workers cluster together—represent a significant spillover effect that has influenced the prioritization of urban rail systems worldwide. The construction of Copenhagen’s Metro Circle Line was prioritized partly based on projections that it would strengthen economic agglomeration in the metropolitan area by improving connectivity between business districts and residential areas, thereby increasing labor market efficiency and business collaboration. Similarly, the prioritization of Paris’s Grand Paris Express project was heavily influenced by economic modeling that predicted the new metro lines would generate substantial agglomeration benefits by better connecting suburban business centers with each other and with central Paris, potentially increasing the region’s GDP by 1-2% upon completion.

The interaction between economic efficiency and other prioritization criteria creates complex trade-offs that transportation planners must navigate. While economic factors