Improving Railway Punctuality: A Comparative Multi-Criteria Analysis of Solutions Across Six Nations

Report in the course “**MMS200 - Project in Railway Technology**”

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1. Abstract

This project is a part of a master's program course named "Project in Railway Technology", with 7.5 ECTS credits. The report analyzes the issue of punctuality of railways in six nations – Sweden, Greece, Japan, Finland, Germany and France – and observes the massive variations between the quality of infrastructure, operating efficiency and investment. It evaluates three principal solutions to improve punctuality: enhancing from single to double tracks, running dedicated high-speed trains, and timetabling. In a Multi-Criteria Decision Analysis (MCDA), the report compares these approaches in terms of cost, safety, capacity and time to implement, taking into consideration the perspective of various stakeholders, such as rail operators and travelers. The findings of the MCDA suggest that while investments in infrastructure guarantee longer term benefits, timetabling is a cheap and simple measure to adopt in order to increase punctuality. It concludes that railway punctuality must not only be improved through technical aspect, but also through strategic planning and cooperation of stakeholders.

2. Introduction

2.1. Aim

Rail transportation is a significant part of modern transport networks, providing high-capacity, energy-efficient passenger and freight movement. Among key performance parameters, punctuality, which refers to the degree to which trains operate to timetabled arrival and departure times (International Union of Railways, UIC, 2020) is a key factor. Delay reduces user confidence, complicates logistics, and raises operating costs. In this report, punctuality is taken as a primary performance metric in railway operations, both in the performance of existing systems and in future potential. The aim of this report is to compare and assess rail punctuality in some countries, such as Sweden, Greece, Japan, Finland, Germany and France, which represent varying infrastructural difference and investment levels. Moreover, it aims to investigate technological and operational strategies that are used to improve punctuality in different networks.

2.2. Scope

This project focuses on investigating the status of railway punctuality over the past decade in six countries: Sweden, Greece, Japan, Finland, Germany, and France. The analysis is confined to examining punctuality trends and performance within this timeframe and geographic range. Furthermore, the scope of potential improvement strategies is limited to three key areas: upgrading single-track lines to double-track infrastructure, evaluating the impact of mixed traffic versus dedicated high-speed lines, and assessing the utilization of timetabling strategies, including dedicated to schedule time slots. A noteworthy example is the Shinkansen network in Japan, which achieves an average delay of less than one minute per train per year due to the use of dedicated tracks and advanced control systems (Japan Railways Group, 2023). In contrast, there are also networks such as the Greek, that face continuous problems related to aging infrastructure and low capacity, which result in frequent delays (Hellenic Train, 2024; European Commission, 2023).

2.3. Approach

The analysis starts with a comparative overview of the punctuality of railways according to recent performance data and operational experience from national rail operators. The procedure for finding information about the status in the countries was the first step, continuing with the investigation to get a sense of how the media in the country consider punctuality problems. Our approach is to identify and evaluate different punctuality improvement methods that exist via MCDA (Multi-Criteria Decision Analysis), describing the challenges that can be faced during the implementation process. During the writing, AI was utilized to enhance the language of this report.

3. Overview status in different countries

3.1 Sweden

In Sweden the most common definition of whether a train is on time is if it is 5 minutes and 59 seconds within scheduled time (Trafikverket, 2024). With that in mind, 91 percent of the passenger trains has been arriving on time since 2001. Lowest punctuality occurred in 2010 with 87.1 percent on time for 780 000 passenger train operations. The highest punctuality was in 2020 with 94.9 percent for 944 000 passenger trains which could be explained by the COVID-19 pandemic and travelling restrictions which decreased the capacity deficit (Krisinformation.se, 2020).

However, recent data from 2024 indicate a notable drop in punctuality to 87.2 percent which is the lowest in over a decade. While this decline is concerning, it must be kept in mind that it is based on a single year and should be interpreted cautiously until further data confirms a longer trend. The reduction in punctuality can though be explained by several factors such as aging infrastructure, adverse weather and a rise in incidents involving unauthorized people in the tracks (Sveriges Radio, 2025).

In response, Trafikverket has implemented targeted actions in recent years, including upgraded signaling systems, improved fencing around the tracks to prevent track intrusions and an overall increased infrastructure investment. These efforts, many of which were initiated before 2024, are a part of a broader national strategy to restore trust in the rail system and stop the negative trend.

Another major reason behind the delays is the lack of capacity on the tracks. Over the past years both freight traffic and passengers have increased significantly, especially during peak hours. Many sections of the rail network, particularly single-track lines, operate close to, or at full capacity, leaving little room to recover from disturbances or delays. Trafikverket has acknowledged that capacity shortages are a structural bottleneck for punctuality, and this situation often leads to chain reactions where minor delays escalate and affect other departures across the system (Tydal, 2025).

3.2 Greece

Greece's railways have faced chronic problems over the last couple of years, ranging from old infrastructure to poor safety and performance. A fatal collision outside Tempe in February 2023 resulted in the loss of 57 lives, due to issues like poor safety standards, low level of staffing and low-grade training (EODASAAM, 2025). With the term low-grade training, employees who work in the Hellenic railways might be trained to meet the basic requirements but not enough for facing serious circumstances. Another report published in December 2024 placed Greece's Hellenic Train among Europe's worst performing railway lines based on late performances and exaggeratingly in high ticket prices for their service (Kokkinidis, 2024). In response, the Greek government revealed in

January 2025 a €1.5 billion investment plan for railway development, which involves safety upgrades and infrastructure systems (GTP Headlines, 2025). However, the Greek government has originally been funded from Europe to maintain and renovate the railway system several years ago, but that never happened and it is unclear where all these investments went (Kostoulas, 2023). All these improvements emphasize the need to address the aging infrastructure as well as enhance the overall level of function and safety of the Greek railway network. Additional data for punctuality in Greek railways were not possible to obtain.

3.3 Japan

The Japanese railway system is generally known for being efficient, safe and punctual. This precision is obtained via a combination of dedicated high speed rail tracks, advanced automatic train control (ATC) technology, and cultural focus on punctuality and group discipline (Wu, 2024). Well-controlled boarding procedures are employed, where passengers queue through established lines and platforms, minimizing unnecessary times at stops. Moreover, the infrastructure is maintained to be in a good condition and operating staff are strictly trained to respond immediately in case of a failure, making the system reliable. All these components not only enhance punctuality but also passenger satisfaction and trust in the network, making the Japanese railway system a world standard in railway performance (Shinkansen, 2024; Shinkansen, 2024).

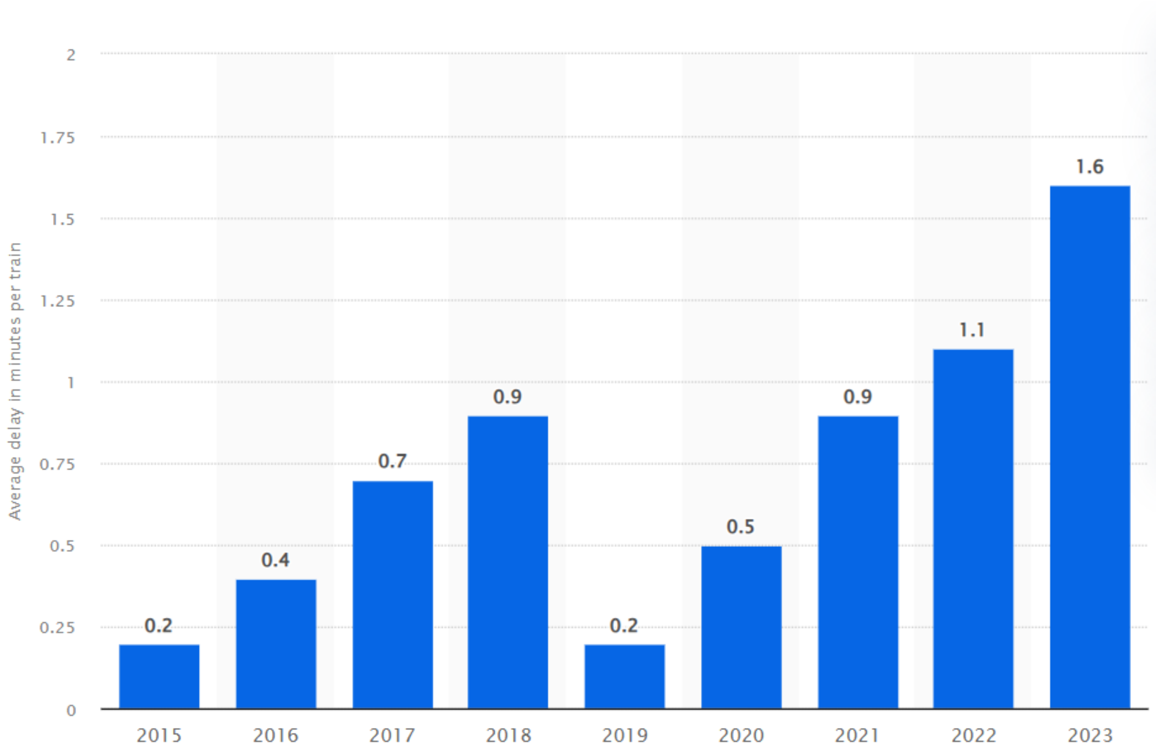

Figure 1. Average delay of Central Japan Railway Company's (JR Central) Tokaido Shinkansen trains in Japan from fiscal year 2015 to 2023(in minutes per train) (Arba, 2024)

3.4 Finland

In Finland, the definition of punctuality varies depending on the type of service. For long-distance trains, a train is considered on time if it arrives at its final destination within 5 minutes of the scheduled time, while for short-distance trains operating in the Helsinki region, the limit is 3 minutes (FTIA, 2024).

Punctuality for long-distance services has differed significantly throughout the past year, ranging between 56.9 percent and 87.5 percent, with an estimated annual average of around 80 percent. For short-distance commuter trains, performance has been more stable, with monthly punctuality figures ranging from 86.7 percent to 94 percent, averaging approximately 92 percent over the year.

A significant portion of delays, particularly in long-distance services, can be attributed to infrastructure-related issues. According to VR Group (the government-owned railway company in Finland), 50% of long-distance train delays were caused by track-related issues in July 2024, including speed restrictions and technical faults (VR Group, 2025). Additionally, 22% were caused by operator-related problems, and the remaining 28% stemmed from external factors such as vandalism.

To address these challenges, the Finnish Transport Infrastructure Agency (FTIA) has initiated several infrastructure projects aimed at enhancing capacity and reliability. Notably, the completion of the double track between Kupittaa and Turku in 2024 is expected to prevent congestion on the coastal line and improve overall punctuality (FTIA, 2024).

3.5 Germany

In Germany, a long-distance train is considered on time if it arrives within six minutes of its scheduled time. In 2024, the punctuality for long distance trains fell to 62.5%, marking the lowest level in over two decades (Deutsche Bahn, 2024). This decline continues a negative trend from previous years, with punctuality rates of 64.0% in 2023 and 65.2% in 2022.

On the other hand, regional trains have maintained better punctuality rates. In 2024, 90.3% of regional trains arrived on time, a slight decrease from 91.0% in 2023.

The main factors contributing to delays in long-distance services include failure-prone and aging infrastructure, adverse weather conditions, and high traffic density. Deutsche Bahn attributes approximately 80% of long-distance train delays to overloaded and outdated infrastructure. Additionally, selective overload in major transport hubs like Cologne, Hamburg and Frankfurt am Main have led to significant delays across the network.

In response to the challenges, Deutsche Bahn has implemented an infrastructure modernization program. A notable project is the renovation of the critical 70 km corridor between Mannheim and Frankfurt am Main called Riedbahn (Deutsche Bahn, 2025). It was finished in December 2024 and included replacement of signaling systems, switches and tracks and an implementation of the European Train Control System (ETCS). The project was a pilot for the broader initiative to modernize 40 high speed corridors across Germany by 2030.

Despite these efforts, the impact on punctuality has only been limited so far. In 2024, Deutsche Bahn paid approximately 197 million € in compensation for delays, which shows the ongoing challenges faced by the railway network.

3.6 France

In recent years, the French railway network has faced important punctuality problems, particularly evidenced in 2022, when some of the highest delays in the decade are noted (Thompson, 2023). The Paris region's commuter lines have also been affected by chronic delays, made worse by external conditions like storms in November 2023, which led to preventive stops and service interruptions on multiple lines. To address these issues, targeted plans like the 'Ramette' plan have been introduced on lines like the RER B to enhance punctuality via significant investment in new trains and advanced signaling systems. Additionally, opening to competition in regions like Provence-Alpes-Côte d'Azur is being discussed as a way of enhancing reliability and punctuality of service, ending the conventional monopoly.

3.7 Summary

Overall, the comparison shows clear differences in train punctuality between the countries, but also some common challenges. Japan stands out with exceptional punctuality due to dedicated tracks and well-developed routines, while Sweden, Germany, and France generally achieve high punctuality for commuter trains but face bigger problems with long-distance services. In these countries, as well as in Finland, the most common reasons for delays are lack of track capacity, aging infrastructure, and, in Finland’s and Sweden’s case, also tough weather conditions. Germany and Greece struggle the most, often due to old infrastructure and underinvestment.

Most countries are now working on different improvement projects and upgrades. However, the main issue that remains is limited capacity on the tracks. When the railway network is operating close to its maximum, even small disruptions can quickly lead to widespread delays. This means that solving capacity shortages is the most important step for achieving more reliable and punctual train services in the future.

Table 1. Comparison of the described countries with Definition of "On Time", Punctuality, Causes of Delays and Current Improvemnets

Country	Definition of “On Time”	Punctuality Statistics	Main Causes of Delays	Recent/Current Improvement Efforts
Sweden	Within 5:59 min of schedule	91% since 2001. Lowest: 87.1% (2010), Highest: 94.9% (2020), 2024: 87.2% (lowest in decade)	Aging infrastructure, adverse weather, increased unauthorized track intrusions, capacity shortages (especially on single-track lines)	Upgraded signaling, better fencing, infrastructure investments, national strategy to restore trust, capacity upgrades
Greece	Not clearly defined in sources	No recent reliable statistics. Recent reports list Hellenic Train among Europe’s worst for delays	Aging infrastructure, poor safety standards, lack of investment transparency, insufficient staff training	€1.5 billion railway investment plan (2025) for upgrades, but historical mismanagement of funds
Japan	Extremely strict; delays counted by seconds	Exceptionally punctual. Example: Tokaido Shinkansen avg. delay per train is consistently **under 1 minute**	Very rare, mostly due to natural disasters; strict systems prevent other delays	Continual maintenance, staff discipline, advanced ATC, passenger routines; system is global benchmark
Finland	Long distance: within 5 min. Commuter: within 3 min.	Long distance: ~80% (range 56.9–87.5%). Commuter: avg. ~92%	Infrastructure issues (track faults, speed restrictions), operator errors, weather, vandalism	Major upgrades (e.g., double track Kupittaa–Turku, 2024), focus on infrastructure and reliability

Germany	Within 6 min. of scheduled time	Long-distance: 62.5% (2024, lowest in decades), Regional: 90.3% (2024)	Overloaded & aging infrastructure, hub congestion, adverse weather	Major modernization (Riedbahn corridor, ETCS rollout), €197M in passenger delay compensation (2024), multi-year upgrade strategy
France	Not always stated, usually 5 min. for most services	Notable delays, especially in Paris region (2022 peak). Commuter lines chronically affected	Storms, old infrastructure, chronic capacity problems in commuter lines	'Ramette' plan (RER B line), new trains, improved signaling, regional competition to increase reliability

4. Possible strategies to increase punctuality

Figure 2 below illustrates the challenge of running mixed traffic on a single track, in this case a high-speed train approaching a slower freight train. Because there is only one track, the high-speed train must slow down and follow the freight train at the same speed until they reach a station with multiple tracks where overtaking is possible. This increases travel time for both trains and can cause congestion and inefficient use of the railway. The following sections will describe possible solutions to prevent this from happening.

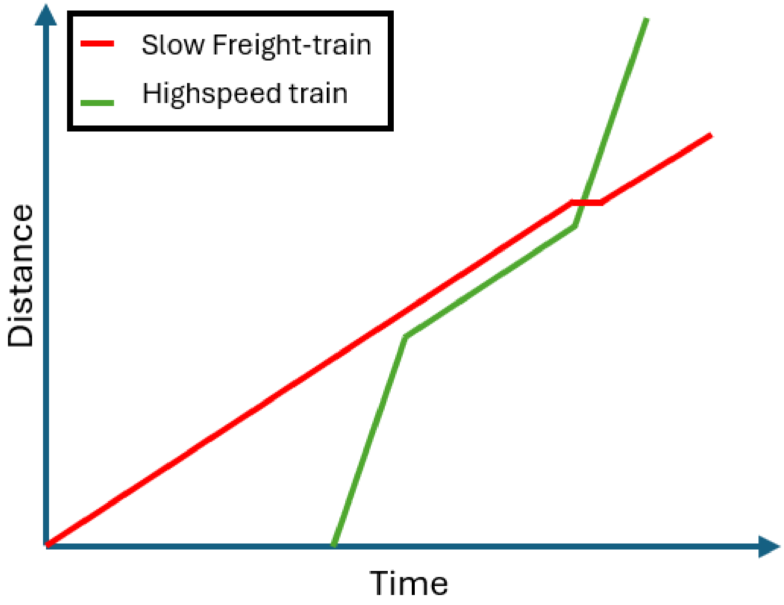

Figure 2. Diagram showing a high-speed train overtaking a slow freight train.

4.1 Expand Single to Double track

Expanding single track to double tracks is an obvious way to enhance a railway system in terms of increasing capacity, improving punctuality and operation flexibility. More specifically regarding punctuality, double tracks can reduce the delays significantly. This is because the congestion is reduced, giving the opportunity of more efficient train movements.

It is found that in single-track lines, delays are primarily caused by trains needing to decelerate, stop, and accelerate out of sidings to allow other trains to pass. This dynamic is largely eliminated in double-tracks, allowing for higher capacity and more efficient operations. However, in both configurations, the simultaneous operation of different train types (e.g., freight and passenger trains) consumes more capacity than homogeneous operations, leading to increased delays. Specifically, adding a passenger train to the system causes a larger increase in delay to freight trains compared to adding another freight train. This is due to the differing performance characteristics of passenger and freight trains, which complicate scheduling and dispatching decisions (Sogin S. L., Lai, Dick, & Barkan, 2013).

Double track configurations are also sensitive to speed differentials. A faster, high-priority train may need to use the second track in the opposing direction to overtake a slower train, thereby interfering with oncoming traffic on that track. Double-track configurations typically have delay distributions similar to exponential distributions, with many trains operating close to the minimum run time (Sogin S. L., Lai, Dick, & Barkan, 2013).

4.2 Dedicated high-speed lines

Building new high-speed lines are ideal solutions in terms of punctuality due to their dedicated infrastructure, minimal interference, and optimized operations for high-speed trains. It also opens up the previous lines for more freight and commuter trains. Dedicated high-speed rail lines are significantly more punctual than mixed-traffic lines because they are free from the obstructions caused by slower trains (Wu, 2024). They offer exceptional punctuality, as demonstrated by systems like Japan's Shinkansen, which consistently operate with minimal delays (Arba, 2024). Mixed-traffic rail lines, while more flexible and cost-effective, often suffer from delays because high-speed trains must share tracks with slower trains and freight. This sharing results in more congestion and conflicts, which directly impacts the punctuality of high-speed services. In this report and in the later MCDA section, we focus primarily on the concept of dedicated high-speed lines. In some cases, separation is relatively simple when multiple existing tracks are available. In others, where there is only a single line, new tracks need to be built.

4.3 Time tabling, dedicated time slots

Using structured timetabling and dedicated time slots during the night for freight trains are strategies for improving train punctuality. This is especially important when high-speed trains and freight trains share the same lines, as delays can cause a chain reaction and affect many other trains — particularly when high-speed trains need to pass slower freight trains. One solution could be to schedule freight trains during the night, since fewer people are traveling at that time. This approach helps reduce congestion during peak hours and makes it easier to maintain a stable and reliable schedule for passenger trains. By separating traffic types in time rather than space, the railway system can handle more trains without requiring costly infrastructure upgrades. In the long term, this kind of scheduling can improve overall efficiency, reduce delays, and provide better experience for both passengers and freight operators.

However, this approach also comes with some challenges. For people living near the tracks, running freight trains during night-time can lead to noise disturbances which affects sleep. There is also less flexibility which can delay deliveries and reduce the service quality of some types of goods. Additionally, railway maintenance is often carried out during the night, which can further reduce available capacity

(International Union of Railways, 2020) (Scheidt, 2019).

5. Analysis

The Multi Criteria Decision Analysis (MCDA) approach is helpful to evaluate the three strategies for improving railway punctuality. Each method was assessed against seven criteria across stakeholders: cost (short and long term), implementation time, safety, maintenance and regulation challenges, and capacity influence. Noteworthy is that although each stakeholder group can assign different weights (ratings) to these criteria based on their priorities (e.g. users prioritize safety and journey times, while operators focus on costs and capacity), the scores assigned to each strategy remained consistent.

The weights for the stakeholders and the ratings were assigned by the authors based on empirical judgment and reasonable assumptions. The scores of each strategy and the scores of each criterion depending on the stakeholders are explained below (lowest score 1 = e.g., most expensive, highest score 5 = e.g., less expensive). Below the results from the MCDA are presented in tables, one for each stakeholder and in an overall table as well.

The criteria were chosen to cover all the key aspects that stakeholders care about. Short-term cost refers to the cost of implementing the new improvement, while long-term cost includes things like maintenance and other future-related expenses. Implementation time is fairly self-explanatory, as is safety, which focuses on ensuring that no accidents occur.

Maintenance challenges are a different angle on long-term costs, but also include anything that prevents the train system from running smoothly and without interruptions. Regulation challenges refer to issues the government might face when trying to carry out the solution—such as dealing with rules, laws, or convincing others that the solution is worth investing in. Influence on capacity refers to how much additional capacity the implementation will provide.

Table 2. Multi Criteria Decision analysis for Rail operators.

Rail operators							
Rating	Criteria	Single track to double track		High speed		Time tabling	
		Score	Score*Rating	Score	Score*Rating	Score	Score*Rating
2	Short term cost	1	2	2	4	5	10
2	Long term cost	2	4	3	6	5	10
4	Implementation time	1	4	3	12	5	20
5	Safety	5	25	5	25	3	15
2	Maintenance challenges	1	2	4	8	4	8
1	Regulation challenges	1	1	2	2	5	5
4	Influence on capacity	5	20	3	12	2	8
	TOTALS		58		69		76

Table 3. Multi Criteria Decision analysis for Infrastructure Manager.

Infrastructure Manager		Single track to double track		High speed		Time tabling	
Rating	Criteria	Score	Score *Rating	Score	Score*Rating	Score	Score*Rating
4	Short term cost	1	4	2	8	5	20
5	Long term cost	2	10	3	15	5	25
2	Implementation time	1	2	3	6	5	10
5	Safety	5	25	5	25	3	15
4	Maintenance challenges	1	4	4	16	4	16
4	Regulation challenges	1	4	2	8	5	20
3	Influence on capacity	5	15	3	9	2	6
	TOTALS		64		87		112

Table 4. Multi Criteria Decision analysis for Users.

Users		Single track to double track		High speed		Time tabling	
Rating	Criteria	Score	Score*Rating	Score	Score*Rating	Score	Score*Rating
3	Short term cost	1	3	2	6	5	15
3	Long term cost	2	6	3	9	5	15
4	Implementation time	1	4	3	12	5	20
5	Safety	5	25	5	25	3	15
2	Maintenance challenges	1	2	4	8	4	8
1	Regulation challenges	1	1	2	2	5	5
3	Influence on capacity	5	15	3	9	2	6
	TOTALS		56		71		84

Table 5. Multi Criteria Decision analysis for all stakeholders combined.

Overall		Single track to double track		High speed		Time tabling	
Rating	Criteria	Score	Score*Rating	Score	Score*Rating	Score	Score*Rating
3	Short term cost	1	3	2	6	5	15
4	Long term cost	2	8	3	12	5	20
4	Implementation time	1	4	3	12	5	20
5	Safety	5	25	5	25	3	15
2	Maintenance challenges	1	2	4	8	4	8
3	Regulation challenges	1	3	2	6	5	15
4	Influence on capacity	5	20	3	12	2	8
	TOTALS		65		81		101

For the rail operators, the rankings below in Table 5 can be explained by the fact that short-term and long-term costs are not very important, since the implementation is mainly funded by the infrastructure managers and through taxes. Instead, implementation time is more critical, because if the process disrupts traffic, the company loses ticket revenue.

Safety is ranked very high, as passengers who feel unsafe are less likely to travel by train, which would reduce income and make it harder to attract employees. Maintenance challenges are less important, since the rail operators are not responsible, even though they are going to be affected. Regulatory challenges are even less relevant. However, the influence on capacity is ranked higher, because more capacity means potentially increased ticket revenue.

Table 6. Rating for Rail operators as a Stakeholder

Rail operators	
Rating	Criteria
2	Short term cost
2	Long term cost
4	Implementation time
5	Safety
2	Maintenance challenges
1	Regulation challenges
4	Influence on capacity

For the infrastructure manager, the rankings are a bit different. Costs are ranked higher, but on the other hand, implementation time is less important because the infrastructure manager does not lose money in the same way as, for example, the rail operators. Safety is also important, since it is one of the manager's core responsibilities. Maintenance challenges and regulation challenges are also important for the managers, since they cover the maintenance costs, and regulatory issues can be expensive and are likely something the infrastructure manager would want to avoid. The influence on capacity is only ranked moderately, with a score of three, because most of the other criteria seem too important to be ranked below or on the same level as the capacity.

Table 7. Rating for Infrastructure managers as a Stakeholder.

Infrastructure managers	
Rating	Criteria
4	Short term cost
5	Long term cost
2	Implementation time
5	Safety
4	Maintenance challenges
4	Regulation challenges
3	Influence on capacity

Overall, everything except safety and implementation time is ranked lower by the users. Implementation time is important because it directly affects their ability to use the trains. Costs are seen as moderately important, since they impact on ticket prices. Obviously, safety plays a vital role in people's decision to use trains, this is why it has the higher score. Maintenance and regulation challenges are clearly not the users' responsibility and would probably only matter if they affect other criteria like costs or implementation time. Influence on capacity is also rated as moderate, as that seems appropriate compared to the other criterions.

Table 8. Rating for Users as a Stakeholder

Users	
Rating	Criteria
3	Short term cost
3	Long term cost
4	Implementation time
5	Safety
2	Maintenance challenges
1	Regulation challenges
3	Influence on capacity

5.1 Explanation of ratings for each strategy

1) Single track to double track

This strategy involves the upgrade of single track railway lines to double track, increasing the capacity and decreasing delays caused by trains waiting for incoming traffic. The scores in the MCDA were:

- **Short-term cost:** Low score (1). It requires major infrastructure investment, track laying and land usage.
- **Long-term cost:** Low to moderate score (2). Higher initial cost but might be justified long-term.
- **Implementation time:** Low score (1). Long construction periods delay the benefits.
- **Safety:** High score (5). Significantly reduces train conflicts, increasing safety (scored high across all stakeholders).
- **Maintenance challenges:** Low score (1). Adding more track increases maintenance, although that more maintenance slots should be provided.
- **Regulation challenges:** Low score (1). Due needs to comply with infrastructure standards.
- **Influence on capacity:** High score (5). Dramatic improvement (scored high across all stakeholders.

In summary, there is a high impact of double track on punctuality through capacity enhancement but delayed return due to high cost and implementation time.

2) Dedicated high-speed lines

Implementing dedicated high-speed lines to reduce travel times. In some cases, existing tracks allow for easy separation, while in others, new tracks must be built.

- **Short-term cost:** Low to moderate score (2). Require track upgrades and in some cases new tracks, including significant investments.
- **Long-term cost:** Moderate score (3). Maintenance cost and energy cost increase over time.
- **Implementation time:** Moderate score (3). Quicker than double track, but still require upgrades.
- **Safety:** High score (5). Rated high, but not as impactful as capacity focused upgrades.
- **Maintenance challenges:** Moderate to high score (4). Faster trains equal to higher wear. On the other hand, a more homogenous type of wear.
- **Regulation challenges:** Low to moderate score (2). Potentially more regulatory oversight for high-speed operations.

- **Influence on capacity:** Moderate score (3). Faster trains might increase efficiency, and the capacity if new tracks is built.

In summary, high speed as a strategy for railway punctuality improves the journey times but does not necessarily decrease the delays or significantly improve the reliability without parallel system upgrades or low-speed traffic separation.

3) Time tabling

Optimizing train schedules for better reliability and coordination between trains.

- **Short-term cost:** High score (5). Software and planning are relatively cheaper than the other options.
- **Long-term cost:** High score (5). It is a sustainable solution with minimal cost over time.
- **Implementation time:** High score (5). Time tabling can be upgraded quickly comparing to the other strategies.
- **Safety:** Moderate score (3). Does not directly influence safety. However, it can reduce some incidents, like train congestion in a rush hour.
- **Maintenance challenges:** **Moderate to high score (4).** Low maintenance need, since there is no physical infrastructure changes.
- **Regulation challenges:** High score (5). Needs coordination across operators, more procedural challenges.
- **Influence on capacity:** Low to moderate score (2). Although it improves utilization, tracks are not added.

In summary, time tabling is a quick and beneficial strategy that enhances punctuality by optimizing current resources rather than expanding them.

6. Conclusion

6.1. Discussion

This report examined the topic of railway punctuality, by comparing different situations in six countries (Sweden, Greece, Japan, Finland, Germany and France) and assessing three improvement strategies, converting single to double track, implementing high speed lines and enhancing time tabling.

The analysis presented major differences in punctuality performance, from Japan's world class precision to Greece's systematic delays. This is happening since countries with great railway systems, such as Japan, rely on regular investments. Through MCDA, the three improvement strategies were evaluated across seven criteria and different stakeholder perspectives. The results of MCDA revealed that timetabling optimization is a low-cost, quick and most efficient strategy for budget-constrained networks, with immediate benefit in punctuality, without the need of additional infrastructure.

The MCDA showed that no single strategy is optimal. Each comes with distinct advantages and drawbacks. Double tracking has the highest impact on capacity and safety, however it is extremely costly and requires long implementation times. High speed services enhance travel time and efficiency, but they need significant infrastructure upgrades while offering moderate capacity improvements. Time tabling, the most economical option, is a low-cost and quick development that offer immediate results in punctuality problems.

Moreover, stakeholders view these strategies differently. Rail operators prioritize safety and capacity since these parameters affect the customer trust, which leads to revenue. On the other hand, infrastructure managers focus more on cost and regulatory concerns. Last, but not least, users care most about safety and fast implementation time, with the cost being a secondary concern. This diversity of priorities boosts the significance of integrated decision-making when planning railway strategies.

6.2. Conclusions

As a recap, punctuality is multi-dimensional and affected by infrastructure, operations and management culture. Infrastructure upgrades like double tracking offer the highest long-term benefit, however their feasibility depends on political will, funding availability and disruptions that are acceptable during implementation. Time tabling and operational optimization has high short-term returns and utilizes the capacity of the tracks during all hours. It takes advantage of existing assets, boosting coordination and minimizing conflicts without requiring new infrastructure. The limitation of timetabling is its dependence on current capacity and the need for close cooperation between stakeholders.

In conclusion you can optimize and improve the capacity of the tracks by timetabling, but when that limit is reached, some expanding of the infrastructure is needed.

6.3. Future work

In the future, a continuation of this work could involve discussing combinations of the improvement strategies and what overall scores those mixes would receive. It could also explore the compromises each implementation would require.

One improvement for future versions of the report could be to put more effort into comparing the maintenance challenges between implementations. This might lead to better results and recommendations for solutions like extended tracks and high-speed lines, as they do not wear out the infrastructure as quickly as the timetabling.

Another potential area for future analysis is evaluating different solutions to prevent unauthorized people from accessing the tracks—such as fencing and similar measures. According to Swedish statistics, between 500 and 1,300 delays per month in 2024 were caused by unauthorized individuals on the tracks. Even though this accounts for only 5–10 percent of total delays, it would still be interesting to investigate whether these incidents can be reduced or eliminated, and at what cost.

One final implementation that could be explored in the future is allowing faster freight trains. This would increase capacity in two ways: freight trains would spend less time on the tracks, and passenger trains would no longer need to slow down or pass slower freight trains.

The challenge, however, lies in financing this a freight trains currently run on much cheaper running gear that cannot handle the same speeds as passenger trains. It would be interesting to do an economic analysis to see if the increase in capacity could pay the cost of upgrading the running gear.

Another potential benefit of faster freight trains is that the wear on the tracks could become more uniform if all trains travel at similar speeds and carry approximately the same weight.

7. References

Arba, A. (2024, November 15). *Statista*. Retrieved from Statista : https://www.statista.com/statistics/1267031/jr-central-high-speed-train-tokaido-average-delay/

Deutsche Bahn. (2024). *Punctuality*. Retrieved from https://zbir.deutschebahn.com/2024/en/interim-group-management-report-unaudited/product-quality-and-digitalization/punctuality/

Deutsche Bahn. (2025, May 28). *General overhaul of the Riedbahn rail line*. Retrieved from https://db-engineering-consulting.com/en/projects/general-overhaul-of-the-riedbahn-rail-line/

EODASAAM. (2025). *Rail accident report: Head-on collision between a passenger train and a freight train in Tempi, 28 February 2023 (RL01-2025).* Hellenic Air & Rail Accident Investigation Board. Retrieved from https://www.harsia.gr

FTIA. (2024, Juni 10). *Punktlighet i fjärr- och närtrafik*. Retrieved from Finnish Transport Infrastructure Agency: https://vayla.fi/sv/trafikleder/material/statistik/jarnvagsstatistik/tagens-punktlighet

FTIA. (2024, December 12). *We achieved important milestones at numerous sites*. Retrieved from Finnish Transport Infrastructure Agency: https://vayla.fi/en/-/we-achieved-important-milestones-at-numerous-sites?utm_source=chatgpt.com

GTP Headlines. (2025, January 30). *Greece's Railway Network Set for Upgrades with €1.5 Billion Investment*. Retrieved from GTP Headlines: https://news.gtp.gr/2025/01/30/greeces-railway-network-set-for-upgrades-with-e1-5-billion-investment/

International Union of Railways. (2020). *Mixed-traffic lines—UIC handbook (Dec. 2020 ed.).* Retrieved from https://www.uic.org/IMG/pdf/mixed_uic_handbook_dec_2020-final_03.pdf

Kokkinidis, T. (2024, 12 12). *Greek Trains Follow Eurostar as the Worst in Europe*. Retrieved from Greek Reporter: https://greekreporter.com/2024/12/12/greek-trains-eurostar-worst-europe/

Kostoulas, V. (2023, 03 13). *H KATHIMERINI*. Retrieved from H KATHIMERINI : https://www.kathimerini.gr/politics/562317949/800-ekat-gia-toys-sidirodromoys-stin-ellada/

Krisinformation.se. (2020, March 17th). *A temporary ban on travel to Sweden due to covid-19*. Retrieved from https://www.krisinformation.se/en/news/2020/march/a-temporary-ban-on-travel-to-sweden-due-to-covid-19

Scheidt, M. (2019). *Train Slots: A Proposal for Open Access Railways.* Norrköping: RailNorrköping 2019. 8th International Conference on Railway Operations Modelling and Analysis (ICROMA).

Shinkansen. (2024, November 16). *How punctual are Japanese trains?* Retrieved from Shinkansen 2024: https://shinkansen2024.exblog.jp/36827820/

Sogin, S. L., Lai, Y.-C. R., Dick, C. T., & Barkan, C. P. (2013). *Comparison of Capacity of Single- and Double track rail lines (Transportation Research Record No. 2374, pp. 111–118).* Transportation Research Board. Retrieved from https://railtec.illinois.edu/wp/wp-content/uploads/2019/02/Sogin-2013-TRB.pdf

Sogin, S. L., Lai, Y.-C., Dick, C., & Barkan, C. P. (2013). *Analyzing the incremental transition from single to double track railway lines (Paper presented at the International Association of Railway Operations Research conference).* University of Illinois at Urbana-Champaign. Retrieved from https://railtec.illinois.edu/wp/wp-content/uploads/2019/01/Sogin%20et%20al%202013b%20IAROR.pdf

Sveriges Radio. (2025, Januri 16). *Swedish trains still delayed: 2024 worst year for over a decade*. Retrieved from https://www.sverigesradio.se/artikel/swedish-trains-still-delayed-2024-worst-year-for-over-a-decade?utm_source=chatgpt.com

SVT. (2024, February 9). *I Finland rullar tågen trots svåra vinterförhållanden*. Retrieved from Uutiset: https://www.svt.se/nyheter/uutiset/svenska/i-finland-rullar-tagen-aven-i-de-svara-vinterforhallandena

Thompson, H. (2023, July 26). *French train delays last year 'among the worst seen in a decade'*. Retrieved from The Connexion: https://www.connexionfrance.com/news/french-train-delays-last-year-among-the-worst-seen-in-a-decade/100746

Trafikverket. (2024, Februari 23). *Järnkoll på persontågens punktlighet*. Retrieved from https://www.trafikverket.se/resa-och-trafik/jarnvag/jarnkoll--fakta-om-svensk-jarnvag/jarnkoll-pa-persontagens-punktlighet/

Tydal. (2025, Maj 21). *Punktlighet per tågoperatör*. Retrieved from Tågstatistik: http://www.statistik.tågexperterna.nu

VR Group. (2025). *Our company*. Retrieved Maj 21, 2025, from https://www.vrgroup.fi/en/vrgroup/our-company/

Wu, J. (2024, July 11). *The Secrets to the Punctuality of Japan's Trains*. Retrieved from Japan Manifest: https://www.japanmanifest.com/punctuality-of-japanese-trains/