**DEMANDES D’ACCÈS À L’INFORMATION COMPLÉTÉES**

**BANQUE DE L’INFRASTRUCTURE DU CANADA**

| Numéro de la demande | Résumé de la demande | Traitement de la demande | Nombre de pages divulguées |
|---|---|---|---|
| A-2022-005 | Obtenir copie complète de toute les études/analyses/recherches, évaluations/ ou autres rapports faisant référence ou ayant un lien avec le du dossier d’un train à grande fréquences ou train à grande vitesse du gouvernement fédérale et ce depuis 2 ans à ce jour. | Communication partielle | 293 |

**COMPLETED ACCESS TO INFORMATION REQUESTS**

**CANADA INFRASTRUCTURE BANK**

| Request Number | Summary of Request | Disposition | Pages Disclosed |
|---|---|---|---|
| A-2022-005 | Obtain a complete copy of all studies/analyses/research, evaluations/ or other reports referring to or related to the federal government's high frequency or high speed rail file for the past 2 years to date. | Disclosed in part | 293 |

# Indicative Economic Assessment VIA HFR versus HSR

Ministerial Briefing to

The Honorable Catherine McKenna, Minister of Infrastructure and Communities

and The Honorable Marc Garneau, Minister of Transport

October X, 2020

Note to Reader: This presentation is based on indicative, high-level, general information that was available to the QMOT team within the allotted timeframe as directed by JPO.



DRAFT

# Purpose of the Presentation

- The purpose of this presentation is to:
  - Provide information on High Speed Rail systems and their use around the world; and,
  - To provide comparisons between HSR and HFR along key metrics
- It is organized in four parts to cover the following themes:
  1. Definitions
  2. HSR Key Considerations and Metrics
  3. HSR Operations in Winter
  4. HSR and HFR Comparison
- Appendices A, B, and C provide additional information on HSR systems around the world, HSR and HFR technical requirements, and summary references

# Table of Contents

# 1.1. Definitions: High Frequency Rail (HFR) and High Speed Rail (HSR)

## High Speed Rail (HSR)

- Various definitions exist for HSR. *(https://uic.org/com/enews/596-high-speed/article/the-definition-of-high-speed-rail?page=thickbox_enews)*
  - UK East Coast Main Line (ECML) and West Coast Main Line (WCML) (200 km/h (125 mph))
  - Acela service on Northeast Corridor (NEC) (241 km/h (150 mph))
  - HS2 (300 km/h (186mph))
- For the purposes of this presentation, HSR is defined as:
  - Rail service that combines technologies to operate at increased maximum allowable speed of 300 km/h or greater

## High Frequency Rail (HFR)

- Conventional intercity rail service that includes dedicated and shared right of way (ROW) with priority assigned to passenger service and tracks to increase the number of trips, reduce trip times, and improve the reliability of service between the major cities of Toronto, Ottawa, Montreal and Quebec operating at up to 177 km/h (110 mph) with design speed of 200 km/h (125 mph). *Source: VIA HFR Technical note,* https://corpo.viarail.ca/en/projects-infrastructure/

# 2.1. HSR Strengthens Economic Benefits

| Benefits | Description |
|---|---|
| Accessibility | HSR time savings enables workers to move about the mega-region faster and more freely. |
| Reliability | Greater frequencies, fewer delays, better on-time performance than cars and airplanes. |
| Connectivity | Increased labour mobility and expanded commuter should give employers access to larger pools of skilled workers and employees access to more job options. |
| Spatial Agglomeration | Firms benefit from locating in closer proximity to other complementary firms and make use of the accessibility to activities and skilled labor resulting in regional productivity growth. |
| Reduced Road and Airport Congestion | Reduced long-distance auto trips, further alleviating highway congestion.<br>Competitive alternative to air, reduces congestion at capacity constrained airports, possibility to defer investment in secondary airports in Montreal and Toronto. |
| Reduced Greenhouse Gas Emissions and Improved Air Quality | Electrified HSR service reduces GHG emissions from trains compared to diesel-powered HFR.<br>Reduced auto and air trips further reduce transportation sector carbon footprint. |
| Energy Sovereignty | Clean electricity sources available along the corridor to reduce dependency on imported fossil fuels. |

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

# 2.2. HSR Benchmark – CAPEX

CAPEX costs vary based on:

- ✓ Labour market
- ✓ Construction materials
- ✓ Engineering Complexities
- ✓ System design
- ✓ Geography
- ✓ Civil works
- ✓ Structures requirements

HSR Benchmark Cost (2020 CAD $/km)

Average Cost per km (2020 CAD, Millions)

[redacted]

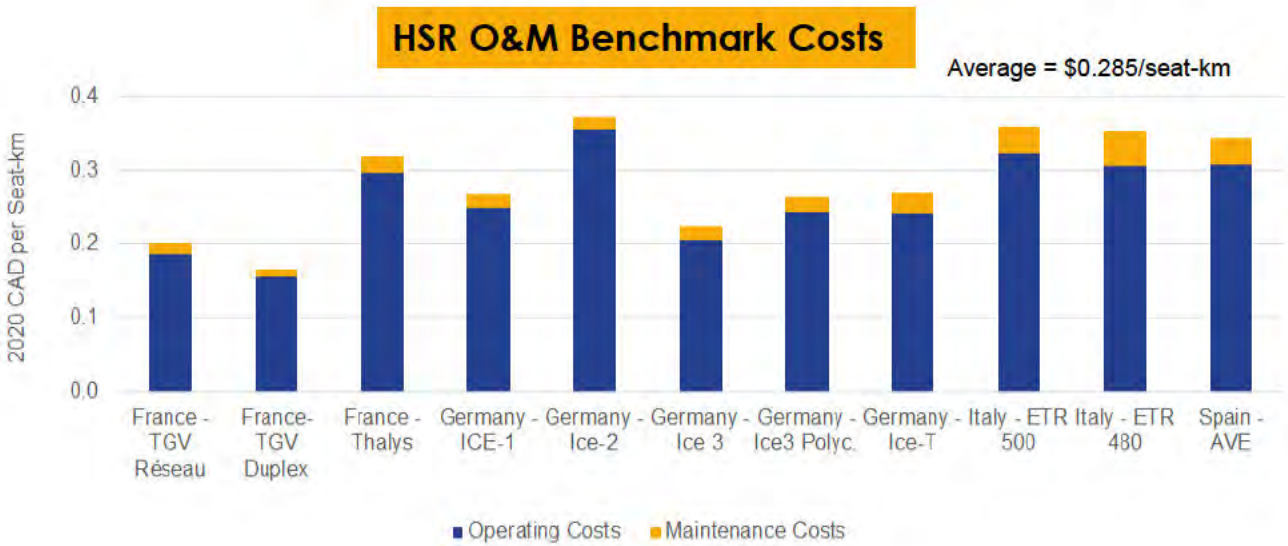
High Speed Rail Project

**Note: not all systems within the table are in operation (e.g. systems in North America)**

# 2.3. HSR Benchmark – Indicative OPEX

O&M costs vary based on:

- ✓ Rolling stock technology
- ✓ Corridor length
- ✓ Seat capacity
- ✓ Ridership levels
- ✓ Service frequency
- ✓ Energy prices
- ✓ Labour costs




*Sources: QMOT Analysis based on Economic Analysis of High Speed Rail in Europe (Fundación Banco Bilbao Vizcaya Argentaria (Fundación BBVA), 2009). Based on actual operating costs.*

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

# 2.4. City Access Factors to Consider for HSR

- **Key Elements include:**

[redacted]

# 2.5. Success Factors: Where HSR Works Best

- ✓ Strong transit connections (LRT, subway, commuter rail, etc.)
- ✓ Optimal HSR corridor length (i.e. distance between economic centers)
- ✓ City pairs:
  - ✓ Large metropolitan area and city populations
  - ✓ Large metropolitan area GDP
  - ✓ Megaregion (considers population density and urban form)
  - ✓ Collaborating economic sectors

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

# 2.6. Selected HSR Systems: Key Metrics

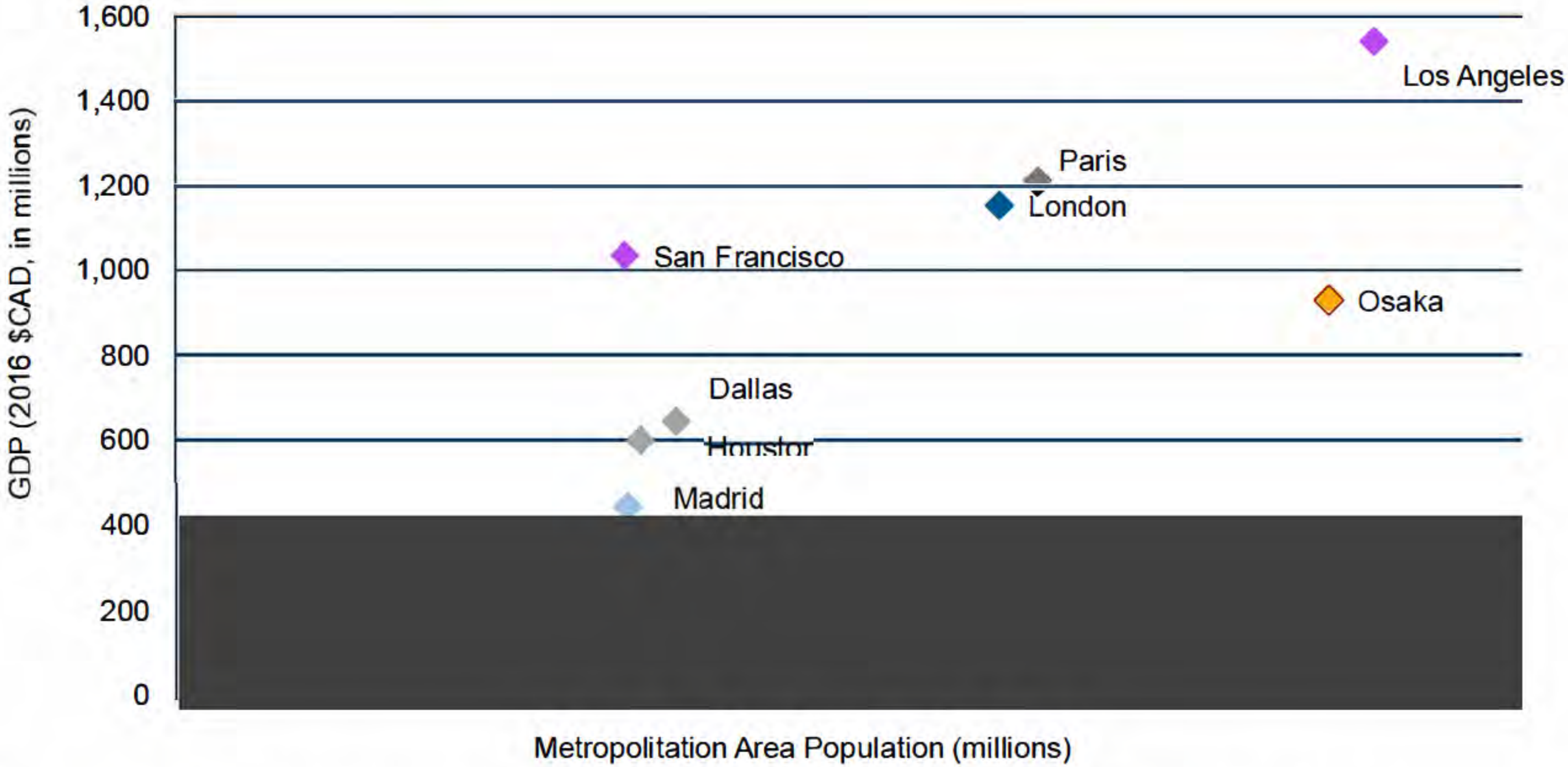
| Project / Location | Capital cost (2020 CAD) | Cost per track km (2020 CAD) | Population of cities served - combined (2016)[1] | GDP of cities served – combined (2016 CAD)[1] | Total length (km) of project |
|---|---|---|---|---|---|
| **Existing HSR Systems in Operation** | | | | | |
| **France-LGV Sud-Est (Paris/Lyon)** | $9.3 billon | $22 Million | 15 million | $1.4 billion | 425 |
| **Spain-AVE (Madrid-Barcelona)** | $32.9 billion | $53 million | 12 million | $740 million | 621 |
| **UK-High Speed 1 (HS1) (London - Channel Tunnel)** | $26.1 billion | $237 million | 12 million (London only) | $1.2 billion (London only) | 109 |
| **Japan-Sanyo Shinkansen (Osaka-Fukuoka)** | $6.8 billion | $11 million | 20 million | - | 626 |
| **Taiwan-High Speed Rail (Taipei-Kaohsiung)** | $90.1 billion | $257 million | - | - | 350 |
| **Proposed HSR Systems (Not in Operation)** | | | | | |
| **USA-California HSR Phase 1 (San Francisco-Los Angeles)** | $107 billion | $128 million | 24 million | $2.6 billion | 836 |
| **USA-Texas High-Speed Train (Dallas-Houston)** | $24.3 billion | $64 million | 14 million | $1.2 billion | 380 |
| [redacted] | | | | | |

- [1] Combined population of cities served and combined GDP of cities served based only on cities identified under "Project/Location", unless otherwise noted.
- [2] Note: Planning for this proposed HSR system has not moved ahead.

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

# 2.7. GDP to Population Ratio

*Sample HSR Cities and Potential Canadian Markets(1)*




(1)The cities identified in the scatter plot are a small sample of cities that are served by HSR and excludes the Asian market (aside from Osaka).

- HSR system is in operation (Paris, Lyon, Barcelona, Madrid, London, and Osaka);
- HSR system is not in operation (San Francisco, Los Angeles, Dallas, and Houston) and;
- Potential Canadian Markets (Quebec City, Ottawa, Montreal, and Toronto).

Source: https://stats.oecd.org/

## 2.8. HSR Profitability

- HSR line developments generally consider a fuller analysis of direct and wider economic benefits than purely operating profitability.
- HSR capital infrastructure has been provided by Governments to operators at a written down value (e.g. HS1 UK, Japan).
- Many HSR lines operate within wider rail systems (ownership) making underlying operating profitability difficult to analyze.
- The examples of HSR systems covering operating costs through farebox and other income was identified below.
- QMOT selected three of the JR companies as examples: JR West, Central, and East.
- The following table outlines the year-end profits as of March 31, 2019.

| JR Company | Approximate Profit [(1)] | | |
|---|---|---|---|
| | 2019 Yen | 2019 CAD (Converted)[(2)] | 2020 CAD (Escalated)[(3)] |
| **JR West** | ¥107.8 billion | $1.2 billion | $1.3 billion |
| **JR Central** | ¥445,037 billion<br>(Referred to as "Net Income") | $5.3 billion | $5.4 billion |
| **JR East** | ¥297.3 billion | $3.5 billion | $3.6 billion |

- (1) Note that this reflects profits company-wide and not only for Shinkansen revenue service.
- (2) Conversion rate of 1 Japanese Yen= 0.01199 CAD assumed.
- (3) Escalation rate of 3% per year assumed.

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

[redacted]

# 3.1. HSR Operations in Winter: Key Considerations

- QMOT was unable to identify an HSR system that operates at 300km/h (186 mph) in -30 degrees Celsius conditions.

- However, information was found on rail systems operating between 200-250km/h (125-155 mph) in extreme cold conditions. It is worth noting that rail systems tend to reduce operating speeds at certain temperatures such as -30 degrees Celsius.

- In general, some of the risks and important implications of operating HSR and conventional rail systems in low temperatures and snow include, but may not be limited to:
  - Broken rail, broken rail detection, and train detection;
  - Malfunctioning and freezing of switches;
  - Malfunctioning of brakes on rolling stock;
  - Freezing and short-circuiting of signals and other controls and communications systems and;
  - Freezing of overhead catenary system (OCS) power lines.

- Kloow (2011) examined rail operations between 200-250 km/h (125-155 mph) in winter climates with a focus on Sweden. They noted that above 250 km/h (155 mph), winter-related issues involving components such as disc brakes, pantographs, snow clearing, and ballast pick-up become more severe the higher the operating speed.

- Specific consideration to providing special facilities such as for snow removal and special spare train sets storage at strategic locations are also incorporated into the design of the rail system to allow the operator to respond to such cold weather conditions.

Sources: https://www.hsrail.org/cold-weather-passenger-trains; http://gronataget.se/upload/TR10_2011.pdf; and https://uic.org/IMG/pdf/railadapt_final_report.pdf

# 3.2. Example Systems

The following are examples of HSR/higher-speed rail operating in climates at -30 degrees Celsius or lower:

- China: The only HSR line that was identified to operate in a climate colder than -30 degrees Celsius was the Harbin-Dalian high-speed train, which began operations in 2012. It is located in northeastern China where temperatures range between 40 to -40 degrees Celsius. While the service has a maximum operating speed of 350 km/h (217 mph) in the summer, the maximum operating speed reduces to 250 km/h (155 mph) in the winter.
  - Some key considerations of this line include having facilities for snow and ice removal and train sets specially designed for the corridor.
  - As well, to operate HSR in extremely cold regions of the country, the China Railway Design Corporation (CRDC) developed technologies related to civil works (such as anti-freeze tunnel technology), electrical and mechanical systems (such as for OCS ice-melting), and operation and safety facilities (such as various monitoring systems).

- Russia: The Moscow-St. Petersburg "Sapsan" train was designed to operate in -50 degree Celsius conditions. The service mostly operates at 200 km/h (125 mph) but does reach 250km/h (155 mph) along the route.

Source: https://www.hsrail.org/cold-weather-passenger-trains; https://en.wikipedia.org/wiki/Harbin%E2%80%93Dalian_high-speed_railway; https://rusmania.com/transport/sapsan-high-speed-train; and https://uic.org/IMG/pdf/railadapt_final_report.pdf

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

[redacted]

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

[redacted]

[redacted]

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

[redacted]

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

# List of Appendices

- Appendix A: Selected HSR Systems
- Appendix B: HSR and HFR Technical Considerations
- Appendix C: Summary References

# Appendix A: Selected HSR Systems

# Rail Networks with High Speed Rail Across the Globe

**European Railway Networks**
**Source: Bernese Media**


**Railway Network in China**
**Source: Wikipedia**


**Railway Network in Japan**
**Source: Hisagi**


**Taiwan High Speed Rail**
**Source: World of Maps**

**Railway Network in South Korea**
**Source: KTX**

**Note: The maps reflect multiple systems operating at various speeds**

# Selected HSR Systems: Notes

- The following slides present selected HSR systems in Europe, Asia, and North America.
    - The European and Asian systems are in operation.
    - Systems were selected based on maximum operating speed to the current study.
    - The HSR systems for North America are in planning and/or construction phases.
    - The Quebec City-Windsor Corridor system was added per JPO request.

- The following assumptions were made for the selected HSR systems:
    - Escalation 3% per year
    - Escalation 1.5% for Japan
    - End year 2020
    - Currency exchange 1 USD = 1.4 CAD
    - Currency exchange 1 Pound = 1.71 CAD
    - Currency exchange 1 NTD = 0.045 CAD
    - Currency exchange 1 Euro = 1.56 CAD
    - Location factors vary for each country

- Unavailable information is noted on its respective slide.

- Where information was not available but comparable values were identified, the applicable parameters were included.

- Some selected HSR systems included several references, refer to "Summary References" in Appendix C for full list.

# TGV-France

TGV: France HSR Network
LGV Sud-Est: Paris-Lyon HSR Line

| Owner(s) / Operator(s) | Path to HSR: Project background | Path to HSR: Nature of project (greenfield, upgrade, etc.) | Regulatory Approvals | Business Case Characteristics - Financing |
|---|---|---|---|---|
| **Owner and operator:** SNCF (French National Railways)<br>• State-owned | Sud-Est was first HSR line in Europe. Alleviated rail congestion.<br><br>Country-wide HSR network expanded from there, focusing on:<br>• City size/demand<br>• Congestion<br>• Profitability | Country-wide TGV network uses mixed infrastructure:<br>**Separate HSR Lines**<br>• Used for longer distances<br>• 37% of network are HSR-dedicated lines<br>**Conventional Lines**<br>• Used for approach to large cities<br>• High-speed trains can operate on conventional lines | Subject to "Napoleonic tradition" under Roman law, not common law<br>• Legislative and executive authorities had the power<br>• **"Declaration of public utility":** expropriated land to build LGV<br>• Allowed for quicker implementation of TGV network | Overall, the TGV network started with the most viable lines and were financed based on profitability.<br><br>Sud-Est was financed 100% by SNCF. The line had the following rates of return:<br>• 15% financial<br>• 30% social |

Source: https://en.wikipedia.org/wiki/LGV_Sud-Est ;
https://www.itf-oecd.org/sites/default/files/docs/dp201326.pdf ;
https://reader.elsevier.com/reader/sd/pii/S2352146517307214?token=7E2FF14E4A75E95245DA89A6DD47CE3F8867B50F507005537AC7DBD92533223F9642455B0571732085318C59E848D928 ;
High-Speed Rail: Lessons for Policy Makers from Experiences Abroad (Barcelona Report); and
High-Speed Rail: International Lessons for U.S. Policy Makers

# France – LGV Sud-Est (Paris-Lyon)

| Construction | | | Operations | | Ridership | | |
|---|---|---|---|---|---|---|---|
| Capital cost (CAD) | Timeline | Cost per track km (2020 CAD) | First operational year | Annual operating costs (CAD) | Example ticket price (2020 CAD) | Annual ridership | Revenue (CAD) |
| $4.0 billion (1983)<br>$9.3 billon (2020) | 1975 (approved), 1975-1983 (construction) | $22 million | 1981 (part), 1983 (full) | $18,700,000 (2002)<br>$31,790,000 (2020) of single track HSR maintenance cost (country-wide) | $82.97 (one-way) | 44.4 million in 2017 | $13 billion in 2019 (SNCF high speed and conventional long distance) |

| Network/Service | | | | | | Geography/Terrain |
|---|---|---|---|---|---|---|
| Average operating speed (km/h) | Max. operating speed (km/h) | Total length (km) of project | Headways / trip time (express) | Number of stations | Distances between stations (km) | |
| 220 | 300 (260 during first operational year) | 425 | Headway not available; approximately 2 hours | 4 | 142 (calculated average) | Flat; some mountains and hills surrounding Lyon |

## Assumptions (Based on Arup Report):

Escalation factor = 111% (base year = 1983)
Location factor = 1.10
Operating cost (excludes compounded escalation value) = $44,000 X [1+(18 years X 0.03)] X 1.1

## Major Communities Served:

Paris: Metropolitan Area Population (2016): 13 million; City Density: 20,000/km$^2$
Lyon: Metropolitan Area Population (2016): 2 million; City Density: 11,000/km$^2$

Source: Several, including High-Speed Rail: Lessons for Policy Makers from Experiences Abroad (Barcelona Report); Economic Analysis of High Speed Rail in Europe (BBVA, 2009); For additional references refer to summary references items 9, 14, 50, 54, 55, 59, 62, 64, 65, 69, 72, 75, 97, 99 and 119 (see Appendix C for details).

# Spain – AVE (Madrid-Barcelona)

AVE: Spain's HSR Service

| Owner(s) / Operator(s) | Path to HSR: Project background | Path to HSR: Nature of project (greenfield, upgrade, etc.) | Regulatory Approvals | Business Case Characteristics - Financing |
|---|---|---|---|---|
| **Infrastructure owner:** ADIF AV<br>• State-owned<br><br>**Operator:** Renfe Operadora<br>• State-owned | Planning commenced in the 1980's.<br><br>First HSR line (Madrid-Seville) opened in 1992<br>• Implemented to improve economic development in Southern Spain<br><br>HSR country-wide development stemmed years later. | Separate, country-wide HSR network.<br><br>The Madrid-Barcelona HSR extends to France. The line sections include:<br>• Madrid-Lleida (2003)<br>• Lleida-Tarragona (2006)<br>• Tarragona-Barcelona (2008)<br>• Figueres (Spain)-Perpignan (France) (2010)<br>• Barcelona-Figueres (2013) | The following are the regulatory considerations for the full line:<br><br>Regulatory Agencies:<br>Ministry of Development<br>• Ministry of Environment<br><br>Legal and regulatory environment:<br>• The European System of Accounts SEC-95<br>• Spanish public contracts law 24/2011<br>• *Real Decreto* 12/2011 (public contract legislation)<br><br>Events impacting the project:<br>• The Infrastructure and Transport Plan of the Spanish Government<br>• Law of Railway Sector 39/2003 (17 November) | Madrid-Barcelona-France financed by:<br>• Spanish Government<br>• EU Cohesion Fund<br>• TEN-T (Trans-European Transport Network)<br>• European Investment Bank (EIB) loans |

Source: http://www.mega-project.eu/assets/exp/resources/High_Speed_Rail-Madrid-Barcelona-French-frontier.pdf ; High-Speed Rail: Lessons for Policy Makers from Experiences Abroad (Barcelona Report) ; https://www.sciencedirect.com/science/article/pii/S2352146517307214 ; and https://en.wikipedia.org/wiki/Madrid%E2%80%93Barcelona_high-speed_rail_line

# Spain – AVE (Madrid-Barcelona)

| Construction | | | Operations | | | Ridership | |
|---|---|---|---|---|---|---|---|
| Capital cost (CAD) | Timeline | Cost per track km (2020 CAD) | First operational year | Annual operating costs (2020 CAD) | Example ticket price (2020 CAD) | Annual ridership | Revenue (CAD) |
| $14.9 billion (2007)<br>$32.9 billion (2020) | 1993 (tender)<br>1995 (construction began)<br>Base year 2007 | $53 million | 2003 and 2006 (part), 2008 (full) | $32,292,000 (2002)<br>$78,867,000 (2020)<br>Single track maintenance cost | $133.78 (one-way) | 8.7 million in 2017 (Madrid-Barcelona-France) | $6 billion in 2018 (Renfe's entire network rev.) |

| Network/Service | | | | | | Geography/Terrain |
|---|---|---|---|---|---|---|
| Average operating speed (km/h) | Max. operating speed (km/h) | Total length (km) of project | Headways / trip time (express) | Number of stations | Distances between stations (km) | |
| 236 | 300 | 621 | Headway not available; approximately 2:30 hours | 7 | 104 (calculated average) | Varied; hilly regions and lowland. Madrid-Barcelona-France: 255 viaducts and bridges (58km) and 83 tunnels (86 km). |

## Assumptions (Based on Arup Report):

Escalation factor = 39% (base year = 2007)
Location factor = 1.59
Operating cost (excludes compounded escalation value) = $52,000 X [1+(18 years X 0.03)] X 1.59

## Major Communities Served:

Madrid: Metropolitan Area Population (2016): 7 million; City Density: 5,300/km$^2$
Barcelona: Metropolitan Area Population (2016): 5 million; City Density: 16,000 people/km$^2$

Source: Several, including: High-Speed Rail: Lessons for Policy Makers from Experiences Abroad (Barcelona Report) ; http://www.mega-project.eu/assets/exp/resources/High_Speed_Rail-Madrid-Barcelona-French-frontier.pdf ; for additional references refer to summary references items 2, 9, 14, 54, 60, 63, 66, 67, 73, 97, 116, and 119 (see Appendix C for details).

# UK – High Speed 1 (London-Channel Tunnel)

| Owner(s) / Operator(s) | Path to HSR: Project background | Path to HSR: Nature of project (greenfield, upgrade, etc.) | Regulatory Approvals | Business Case Characteristics - Financing |
|---|---|---|---|---|
| **Owner/Operator:** HS1 Ltd<br>• Until 2040<br>• Private sector<br>• **O&M Contractor:** Network Rail (High Speed)<br><br>**Mainline Operators:**<br>**Domestic service:** London South Eastern Railway (LSER)<br>**International service:** Eurostar<br><br>HS1 Ltd. also services East Midlands Railway, Thameslink, and freight operator. | • Connect the UK with the rest of Europe quicker and more reliably<br>• Develop new commuter service<br>• Improve rail capacity<br>• Economic development | **Section 1:** open countryside with bridge crossings, etc.<br>**Section 2:** urban setting, mostly tunnels<br><br>Double track and mixed traffic:<br>• High speed passenger and commuter trains; freight trains<br><br>60% of project is in existing transportation corridors<br>25% of the route is tunnelled | **Channel Tunnel Rail Link Act 1996:** provided for the project to be implemented. Also outlined a private sector entity would build, maintain, and operate it.<br><br>**Channel Tunnel Rail Link (Supplementary Provisions) Act 2008:** Updated the Act to support the 2009 restructuring and sale.<br><br>Additional applicable legislation to HS1:<br>• Parts of Railways Acts of 1993 and 2005, Railways and Transport Safety Act 2003, and secondary legislation<br><br>HS1 Ltd. Is the Infrastructure Manager under Rail Regulation 2016. | **Initially:** Private Finance Initiative (PFI)<br>**After restructuring:** Public Private Partnership (P3)<br><br>Financed through government grants and government guaranteed private finance.<br><br>The private company "London Continental Railways" (LCR) was to finance, build, and operate the project.<br>• Restructured in 1998 and 2002 due to financial difficulties from low Eurostar UK revenue forecasts<br>• Was purchased by the government in 2009<br><br>Overall, the public sector became more involved in the project than anticipated. |

Source: Several, including: https://highspeed1.co.uk/about-us;
https://www.systra.com/en-project/high-speed-1-hsr-link-between-london-and-the-channel-tunnel;
for additional references refer to summary references items 9, 52, 58, and 109-111 (see Appendix C for details).

# UK – High Speed 1 (HS1) (London-Channel Tunnel)

| Construction | | | Operations | | Ridership | | |
|---|---|---|---|---|---|---|---|
| Capital cost (CAD) | Timeline | Cost per track km (2020 CAD) | First operational year | Annual operating costs (CAD) | Example ticket price (2020 CAD) | Annual ridership | Revenue (2020 CAD) |
| \$18.9 billion (2007) \$26.1 billion (2020) | 1996 (contract award), 1998-2003 (section 1 construction), 2000-2007 (section 2 construction) | \$237 million | International: 2003 (part), 2007 (full) Domestic: 2009 | \$407 million (2013) \$493 million (2020) | \$59.14 | 20 million (2016) | \$1 billion (calculated) |

| Network/Service | | | | | | |
|---|---|---|---|---|---|---|
| Average operating speed (km/h) | Max. operating speed (km/h) | Total length (km) of project | Headways / trip time (express) | Number of stations | Distances between stations (km) | Geography/Terrain |
| Not available | International: 300 Domestic: 230 | 109 | Domestic: 80+ daily trips per direction; 37 minutes | 4 | 36 (calculated average) | Rolling terrain and farmland; 117 bridges, 26.5km of tunnels, and 6km of viaducts |

## Assumptions (Based on Arup Report):

Escalation factor = 39% (base year = 2007)
Location factor = 1.00
Operating cost (excludes compounded escalation value) = \$407 million X [1+(7 years X 0.03)] X 1.0

## Major Communities Served:

London: Metropolitan Area Population (2016): 12 million; City Density: 5,666/km$^2$

Source: Several, including: https://www.ice.org.uk/what-is-civil-engineering/what-do-civil-engineers-do/high-speed-one-and-st-pancras-station ; http://researchbriefings.files.parliament.uk/documents/SN00267/SN00267.pdf ; for additional references refer to summary references items 52, 56, 57, 61, 68, 71, 74, 76, 97, 108 and 119 (see Appendix C for details).

# Japan – Sanyo Shinkansen (Osaka-Fukuoka)

| Owner(s) / Operator(s) | Path to HSR: Project background | Path to HSR: Nature of project (greenfield, upgrade, etc.) | Regulatory Approvals | Business Case Characteristics - Financing |
|---|---|---|---|---|
| In 1987, Japanese National Railways (JNR) separated and became private.<br><br>Sanyo Shinkansen is owned and operated by West Japan Railway Company (JR West). | Country-wide HSR network developed to support all regions, as a result of:<br>• Rapidly growing economy<br>• Loss of population to certain areas<br><br>First global HSR was the Tokaido Shinkansen (Tokyo-Osaka), opened in 1964. | New Shinkansen Line called Sanyo Shinkansen<br>• Extension of country-wide network<br>• Connected to Tokaido Shinkansen (Tokyo-Osaka)<br><br>Two Sanyo Shinkansen phases:<br>• Shin-Osaka-Okayama, opened in 1972<br>• Okayama-Hakata (Fukuoka), opened in 1975 | **National Shinkansen Railway Construction Law**<br>• Approved May 1970<br>• Outlines definitions, objectives of the network, and procedures | Project built by the Japan Railway Construction Public Corporation (JRCPC), which was created by the government.<br><br>Construction cost funding:<br>• JNR (public at the time)<br>• Government's treasury investment and loan fund<br>• Borrowed funds from the private sector |

Source: http://www.omegacentre.bartlett.ucl.ac.uk/wp-content/uploads/2014/12/JAPAN_SHINKANSEN_PROFILE.pdf ;
https://en.wikipedia.org/wiki/San%27y%C5%8D_Shinkansen ;
https://www.westjr.co.jp/global/en/about-us/history/ ; and
https://www.jrailpass.com/blog/tokaido-shinkansen-jr-pass

# Japan – Sanyo Shinkansen (Osaka-Fukuoka)

| Construction | | | Operations | | Ridership | | |
|---|---|---|---|---|---|---|---|
| Capital cost (CAD) | Timeline | Cost per track km (2020 CAD) | First operational year | Annual operating costs (2020 CAD) | Example ticket price (2020 CAD) | Annual ridership | Revenue (CAD) |
| \$4.1 billion (1975) \$6.8 billion (2020) | 1965 (authorized), 1967 (construction began) -1975 | \$11 million (nominal) (calculated) | 1972 (part), 1975 (full) | Not available | \$191.79 | 85 million in 2018 (JR West Shinkansen) | \$19 billion in 2019 (JR West Operating Revenue) (converted) |

| Network/Service | | | | | | |
|---|---|---|---|---|---|---|
| Average operating speed (km/h) | Max. operating speed (km/h) | Total length (km) of project | Headways / trip time (express) | Number of stations | Distances between stations (km) | Geography/Terrain |
| 210* | 300 | 626 | Varies; 2.5 hours | 19 | 35 (calculated average) | Mountainous; joins two islands |

*Average operating speed Tokaido Shinkansen (Tokyo-Osaka)

## Assumptions:

Escalation factor = 68% (base year = 1975)
Location factor = 0.99

## Major Communities Served:

Osaka: Metropolitan Area Population (2016): 17 million
Fukuoka: Metropolitan Area Population (2016): 3 million; City Density: 4,600/km$^2$

Source: Several, including: High-Speed Rail: Lessons for Policy Makers from Experiences Abroad (Barcelona Report) ; http://www.omegacentre.bartlett.ucl.ac.uk/wp-content/uploads/2014/12/JAPAN_SHINKANSEN_PROFILE.pdf ; for additional references refer to summary references items 14, 54, 78, 81-86, 88, 89, 97 and 119 (see Appendix C for details).

# Taiwan – High Speed Rail (Taipei-Kaohsiung)

| Owner(s) / Operator(s) | Path to HSR | | Regulatory Approvals | Business Case Characteristics - Financing |
|---|---|---|---|---|
| | Project background | Nature of project (greenfield, upgrade, etc.) | | |
| **Owner/Operator:** Taiwan High Speed Rail Corporation (THSRC) | Project allows for business travel between Taipei and Kaohsiung with a distance of 350 km in 90 minutes and builds on economic development along the route.<br><br>Project was initially planned to be public sector. Due to increased public fiscal burdens, the Legislative Yuan withdrew the budget allocated to the HSR Project and decided on a Design-Built-Operate-Maintain-Transfer (DBOMT) procurement. | Greenfield | Taiwan Ministry of Transportation and Communications (MOTC) | Privately financed by Taiwan High Speed Rail Corporation (THSRC) with some government subsidy (P3)<br><br>DBOMT<br><br>THSRC has a concession to finance, construct, and operate the HSR for a period of 35 years and a concession for HSR station area development for a period of 50 years. |

Source: https://en.thsrc.com.tw/ArticleContent/50fa391b-09a7-4728-98e7-8b7901a795d8

# Taiwan – High Speed Rail (Taipei-Kaohsiung)

| Construction | | | Operations | | Ridership | | |
|---|---|---|---|---|---|---|---|
| Capital cost (CAD) | Timeline | Cost per track km (2020 CAD) | First operational year | Annual operating costs (2020 CAD) | Example ticket price (2020 CAD) | Annual ridership | Revenue (2020 CAD) |
| $23.1 billion (2005)<br>$90.1 billion (2020) | 1998 - Contract award<br>2005 - Construction complete<br>2007 – Full operation | $257 million | 2007 | $1.16 billion (2019)<br>$3.1 billion (2020) | $68.64 | 67.4 million in 2019 | $2.1 billion |

| Network/Service | | | | | | Geography/Terrain |
|---|---|---|---|---|---|---|
| Average operating speed (km/h) | Max. operating speed (km/h) | Total length (km) of project | Headways / trip time (express) | Number of stations | Distances between stations (km) | |
| Not available | 300 | 350 | 6 trains/hr (NB)<br>7 trains/hr (SB)/ 1:30 | 12 | 32 | Varied terrain<br>Approximately 73% of line runs on viaducts and 18% is in tunnels. |

## Assumptions:

Escalation factor = 45% (base year = 2005)
Location factor = 2.69
Operating cost (excludes compounded escalation value) = $1.16 billion X [1+(1 years X 0.03)] X 2.69

## Major Communities Served:

Taipei City: Population: 2.65 million; Density: 9,700/km$^2$
Taichung: Population: 2.82 million; Urban Density: 5,400/km$^2$
Kaohsiung: Population: 2.77 million; Urban Density: 7,100/km$^2$

Source: Several, including: https://inta-aivn.org/images/assets/inta33/chiu_inta33_the_bot_experience_of_taiwans_high_speed_rail_construction_project.pdf ; https://www.thsrc.com.tw/event/InvestorRelations/ShareholdersMeeting/2019_anual_report_EN.pdf ; for additional references refer to summary references items 91, 92, 94, 95, 96, 98 and 119 (see Appendix C for details).

# USA – California HSR Phase 1 (San Francisco-Los Angeles)

| Owner(s) / Operator(s) | Path to HSR: Project background | Path to HSR: Nature of project (greenfield, upgrade, etc.) | Regulatory Approvals | Business Case Characteristics - Financing |
|---|---|---|---|---|
| **Contracting authority:** California High-Speed Rail (CHSR) | **Key points:**<br>• **1981:** HSR first considered at the state-level<br>• **Mid-1990's:** increased transportation congestion (air, rail, and road) motivates planning<br>• **1996:** report by the state's Intercity High-Speed Rail Commission determined HSR would be feasible. | Majority of project anticipated to be built along existing transportation corridors (rail and road)<br>• E.g. San Francisco to San Jose "blended system" between the HSR and Caltrain<br><br>Project separated into ten sections: geographic, environmental, and economics | **California's High-Speed Rail Act (1996):** created the high-speed rail authority that would begin planning for the project.<br><br>**Environmental planning:**<br>**Tier 1:** broad program<br>• 2 of 2 documents completed (2005 and 2008/2012)<br>**Tier 2:** individual projects<br>• 3 of 10 Phase 1 documents are completed<br>• For reference, environmental review and permitting took 4 and 5 years, for Merced to Fresno and Fresno to Bakersfield, respectively. | **Funding Sources**<br>**Federal:**<br>• American Recovery and Reinvestment Act (ARRA) and Fiscal Year 2010 (FY10) Transportation, Housing and Urban Development funds<br>• Total: $5 billion (2020 CAD)<br>**State:**<br>• Cap-and-Trade (received and future) and Proposition 1A bond funds<br>• Total: $24-28 billion (2020 CAD)<br><br>Total available funds: **$29-32 billion (2020 CAD)** (as of December 31, 2019)<br><br>Civil construction procured under multiple design build contracts; not integrated. |

Sources: Several, including https://hsr.ca.gov/docs/about/business_plans/2020_Business_Plan.pdf;
HSR-CIB Case Studies;
for additional references refer to summary references items 33, 34, 39, 104, 105, 106, 107 (see Appendix C for details).

# USA – California HSR Phase 1 (San Francisco-Los Angeles)

| Construction | | | Operations | | Ridership | | |
|---|---|---|---|---|---|---|---|
| Capital cost (CAD) | Timeline | Cost per track km (2020 CAD) | First operational year | Annual operating costs (CAD) | Example ticket price (2020 CAD) | Annual ridership | Revenue (CAD) |
| $107 billion (2020) | 2009-2013/2014/in progress (environmental review), 2015 (construction began) - in progress | $128 million | 2031 (part) 2033 (full) | $1.4 billion (2034) (converted)* | Varies | 27.8 million (2034)* | $2.2 billion (2034, converted)* |

| Network/Service | | | | | | |
|---|---|---|---|---|---|---|
| Planned operating speed (km/h) | Max. operating speed (km/h) | Total length (km) of project | Headways / trip time (express) | Number of stations | Distances between stations (km) | **Geography/Terrain** |
| Not available | 354 | 836 | Headways not available; 2:40 | 15 | 60 (calculated average) | Various; mountains and valleys |

*Based on 2034 medium forecasts

## Assumptions:

Escalation factor = 15% (base year = 2015)
Location factor = 0.87

## Major Communities Served:

San Francisco: Metropolitan Area Population (2016): 7 million; City Density: 7,255/km$^2$
Los Angeles: Metropolitan Area Population (2016): 18 million; City Density: 3,276/km$^2$

Source: Several, including https://hsr.ca.gov/docs/about/business_plans/2020_Business_Plan.pdf ; https://www.permits.performance.gov/permitting-projects/california-high-speed-rail-progam-fresno-bakersfield-project-section ; for additional references refer to summary references items 34, 38, 39, 40, 41, 46, 47, 48 and 119 (see Appendix C for details).

# USA – Texas High-Speed Train (Dallas-Houston)

| Owner(s) / Operator(s) | Path to HSR | | Regulatory Approvals | Business Case Characteristics - Financing |
|---|---|---|---|---|
| | Project background | Nature of project (greenfield, upgrade, etc.) | | |
| Project being developed by Texas Central | **HSR in Texas, pre-project:**<br>• **1987:** HSR planning at the state-level began<br>• **1989:** report by the Texas Turnpike Authority determined HSR would be feasible (under certain conditions)<br>• **1989-1995:** Texas High-Speed Rail Authority created and then abolished, respectively<br><br>Motivation for this project:<br>• Road congestion increasing on I-45<br>• Additional time required for air travel | Utility corridor as the feasible alternative.<br><br>Project would require:<br>• Double tracks<br>• **Closed system:** dedicated ROW | Regulatory approval process led by the Federal Railroad Administration (FRA)<br>• Includes 12+ federal and state agencies<br><br>**Key step:** Final Environmental Impact Statement published in 2020<br>• Took 6 years to produce<br>• Allows for: permits to be finalized, the Record of Decision, and for construction to begin | The project is private and for-profit.<br><br>Market-led approach<br>• Funded by investors and entrepreneurs<br>• No grants from the US Government or State of Texas<br>• Would have no operational subsidy once in service |

Sources: Several, including https://legacy.lib.utexas.edu/taro/tslac/20071/tsl-20071.html ; https://railroads.dot.gov/elibrary/dallas-houston-high-speed-rail-project-corridor-alternatives-analysis-technical-report ; for additional references refer to summary references items 36, 102, and 103 (see Appendix C for details).

# USA – Texas High-Speed Train (Dallas-Houston)

| Construction | | | Operations | | Ridership | | |
|---|---|---|---|---|---|---|---|
| Capital cost (CAD) | Timeline | Cost per track km (2020 CAD) | First operational year | Annual operating costs (2020 CAD) | Example ticket price (2020 CAD) | Annual ridership | Revenue (2020 CAD) |
| $24.3 billion (2020) | 2014 (environmental review and permitting started) – ongoing | $64 million (calculated) | Not available | Not available | Varies | 6 million in 2029 | Not available |

| Network/Service | | | | | | Geography/Terrain |
|---|---|---|---|---|---|---|
| Planned operating speed (km/h) | Max. operating speed (km/h) | Total length (km) of project | Headways / trip time (express) | Number of stations | Distances between stations (km) | |
| 300 (planned) | 330 | 380 | 30 minutes peak, 1 hour off-peak; 90 minutes | 3 | 190 (calculated average) | Rolling terrain |

**Assumptions:**
Escalation factor = 0% (base year = 2020)
Location factor = 0.87

**Major Communities Served:**
Dallas: Metropolitan Area Population (2016): 7 million; City Density: 1,527/km$^2$
Houston: Metropolitan Area Population (2016): 7 million; City Density: 1,398/km$^2$

Source: Several, including https://www.texascentral.com/facts/ ; https://www.permits.performance.gov/permitting-projects/dallas-houston-high-speed-rail ; for additional references refer to summary references items 35, 37, 42, 43, 49 and 119 (see Appendix C for details).

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

[redacted]

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

[redacted]

# Appendix B: HSR and HFR Technical Considerations

# Comparison of Technical Requirements
# Track Cross Section

s. 18(a)
s. 18(b)
s. 18(d)

[redacted]

# Comparison of Technical Requirements
# Track Design

s. 18(a)
s. 18(b)
s. 18(d)

[redacted]

s. 18(a)
s. 18(b)
s. 18(d)

# Alignment - Curves & Track Geometry

[redacted]

# Appendix C: Summary References

# Summary References


1. [redacted]
2. Economic Analysis of High Speed Rail in Europe (Fundación Banco Bilbao Vizcaya Argentaria (Fundación BBVA), 2009);
3. [redacted]
4. California High-Speed Rail Program – Technical Memo on Typical Cross Sections for 15% Design;
5. [redacted]
6. Developments in High-Speed Track Design;
7. High-Speed Rail Aerodynamic Assessment and Mitigation Report DOT/FRA/ORD-15/40;
8. 49 CFR 213.307 Classes of track: operating speed limits;
9. Updated Feasibility Study of a High Speed Rail Service in the Quebec City-Windsor Corridor (EcoTrain, 2011);

[redacted]

11. TN 02: HSR scenarios and fare sensitivities (Steer, 2020);
12. Option 3 HSR Demand & Revenue Summary. Slide. (N.D.);

[redacted]

14. Preliminary Business Case for High Speed Rail on the Toronto to Windsor Corridor (2016);
15. High-Speed Rail: Lessons for Policy Makers from Experiences Abroad (Research Institute of Applied Economics, Universitat de Barcelona, 2010);
16. High-Speed Rail International Lessons for U.S. Policy Makers (America 2050, 2011);
17. Toronto - Kitchener – London Ontario High Speed Rail (fcp, 2014);
18. The Maglev Train (2015);
19. High Speed Rail in Ontario: Transforming mobility, connecting communities, integrating centres of innovation and fostering regional economic growth and development (2016);
20. [redacted]
21. Three notable High Speed Rail Corridors (N.D);
22. Where High-Speed Rail Works Best - America 2050 (America 2020, N.D.);
23. Rail Network Maps: Bernese Media, Wikipedia, Hisagi, World of Maps, KTX;
24. High-Speed Rail: Lessons for Policy Makers from Experiences Abroad (Research Institute of Applied Economics, 2010) ("Barcelona Report");
25. Email communication containing information regarding conservative and optimistic schedule for construction (Sent August 20, 2020);


s. 18(a)
s. 18(b)
s. 18(d)
s. 18.1(1)(d)
s. 21(1)(a)
s. 21(1)(b)

# Summary References


26. https://corpo.viarail.ca/en/projects-infrastructure/ ;
27. https://uic.org/IMG/pdf/uic_noise_flyer_2019.pdf ;
28. https://uic.org/passenger/highspeed/article/high-speed-database-maps ;
29. https://www.travelchinaguide.com/cityguides/shanghai/getting-around.htm ;
30. https://hsr.ca.gov/programs/environmental/guidelines_reports.aspx ;
31. https://hsr.ca.gov/docs/about/business_plans/2020_Business_Plan.pdf ;
32. https://www.permits.performance.gov/permitting-projects/dallas-houston-high-speed-rail;
33. https://www.permits.performance.gov/permitting-projects/california-high-speed-rail-progam-fresno-bakersfield-project-section;
34. https://www.permits.performance.gov/permitting-projects/california-high-speed-rail-program-merced-fresno-project-section;
35. https://www.texascentral.com/ridership/ ;
36. https://www.texascentral.com/facts/ ;
37. https://www.texascentral.com/infrastructure/;
38. https://hsr.ca.gov/docs/communication/info_center/factsheets/gtf_construction.pdf ;
39. https://hsr.ca.gov/high_speed_rail/project_sections/ ;
40. https://en.wikipedia.org/wiki/San_Francisco ;
41. https://en.wikipedia.org/wiki/Los_Angeles ;
42. https://en.wikipedia.org/wiki/Dallas ;
43. https://en.wikipedia.org/wiki/Houston;
44. https://en.wikipedia.org/wiki/Montreal ;
45. https://en.wikipedia.org/wiki/Toronto;
46. https://hsr.ca.gov/about/business_plans/2020/chapter_1/ ;
47. https://www.worldatlas.com/webimage/countrys/namerica/usstates/caland.htm ;
48. https://www.texascentral.com/posts/the-difference-in-the-texas-and-california-hsr-projects/ ;
49. https://texasalmanac.com/topics/environment/physical-regions-texas ;
50. https://en.wikipedia.org/wiki/LGV_Sud-Est ;
51. https://www.ice.org.uk/what-is-civil-engineering/what-do-civil-engineers-do/high-speed-one-and-st-pancras-station;

# Summary References


52. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/466084/first_interim_evaluation_hs1_main-report.pdf;
53. https://en.wikipedia.org/wiki/TGV#:~:text=The%20TGV%20(French%3A%20Train%20%C3%A0,state%2Downed%20national%20rail%20operator.&text=The%20TGV%20network%20in%20France%20carries%20about%20110%20million%20passengers%20a%20year. ;
54. https://uic.org/IMG/pdf/20200227_high_speed_lines_in_the_world.pdf ;
55. http://www.ejrcf.or.jp/jrtr/jrtr40/pdf/f22_ard.pdf ;
56. https://www.railway-technology.com/projects/highspeedone/ ;
57. https://highspeed1.co.uk/about-us ;
58. https://www.ingenia.org.uk/Ingenia/Articles/a13b3724-cfe8-488e-af86-e5c4c688d519 ;
59. https://www.railwaygazette.com/high-speed/eu-funding-supports-etcs-on-lgv-sud-est/46359.article ;
60. https://en.wikipedia.org/wiki/Madrid%E2%80%93Barcelona_high-speed_rail_line ;
61. http://www.railtechnologymagazine.com/rail-news/looking-back-over-hs1-10-years-on ;
62. https://medias.sncf.com/sncfcom/finances/Publications_Groupe/SNCF_Your_Global_Transport_Partner_2020.pdf ;
63. https://www.railjournal.com/financial/ridership-growth-lifts-renfe-revenue-and-profit/ ;
64. https://en.wikipedia.org/wiki/Paris ;
65. https://en.wikipedia.org/wiki/Lyon ;
66. https://en.wikipedia.org/wiki/Madrid ;
67. https://en.wikipedia.org/wiki/Barcelona ;
68. https://en.wikipedia.org/wiki/London ;
69. https://en.oui.sncf/en/train/timetables/paris/lyon ;
70. https://www.railway-technology.com/projects/highspeedone/ ;
71. https://www.southeasternrailway.co.uk/timetables ;
72. https://en.oui.sncf/en/tgv/route/paris/lyon ;
73. https://www.renfe.com/es/es/viajar/prepara-tu-viaje/horarios ;
74. https://ticket.southeasternrailway.co.uk/journeys-grid/STP/AFK/2020-08-17T19:30//1/0/ ;
75. https://www.worldatlas.com/webimage/countrys/europe/france/frland.htm ;

# Summary References


76. https://www.worldatlas.com/webimage/countrys/europe/england/ukeland.htm ;
77. https://en.wikipedia.org/wiki/Shinkansen#:~:text=The%20cost%20of%20constructing%20the,million%20from%20the%20World%20Bank. ;
78. https://www.railway-technology.com/features/feature1216/ ;
79. http://www.omegacentre.bartlett.ucl.ac.uk/wp-content/uploads/2014/12/JAPAN_SHINKANSEN_PROFILE.pdf ;
80. https://en.wikipedia.org/wiki/San%27y%C5%8D_Shinkansen ;
81. https://www.westjr.co.jp/global/en/ir/library/annual-report/2019/pdf/jr_west_integrated_report_2019.pdf ;
82. https://www.westjr.co.jp/global/en/ir/library/annual-report/2018/pdf/jr_west_annual_report_2018.pdf ;
83. https://www.jrailpass.com/blog/sanyo-shinkansen-jr-pass ;
84. https://en.wikipedia.org/wiki/Osaka ;
85. https://en.wikipedia.org/wiki/Fukuoka ;
86. https://www.westjr.co.jp/global/en/timetable/ ;
87. https://www.westjr.co.jp/global/en/about-us/history/ ;
88. https://spice.fsi.stanford.edu/docs/geography_of_japan ;
89. https://www.worldatlas.com/webimage/countrys/asia/japan/jpland.htm ;
90. https://www.thsrc.com.tw/event/InvestorRelations/ShareholdersMeeting/2019_anual_report_EN.pdf ;
91. https://en.wikipedia.org/wiki/Taiwan_High_Speed_Rail ;
92. https://en.thsrc.com.tw/ArticleContent/a3b630bb-1066-4352-a1ef-58c7b4e8ef7c ;
93. https://inta-aivn.org/images/assets/inta33/chiu_inta33_the_bot_experience_of_taiwans_high_speed_rail_construction_project.pdf ;
94. https://en.wikipedia.org/wiki/Taipei#Demographics ;
95. https://en.wikipedia.org/wiki/Kaohsiung ;
96. https://en.wikipedia.org/wiki/Taichung ;
97. https://stats.oecd.org/ ;
98. https://en.wikipedia.org/wiki/Taiwan_High_Speed_Rail#cite_note-MOTC_THSR_stat-77 ;
99. https://www.itf-oecd.org/sites/default/files/docs/dp201326.pdf ;
100. https://legacy.lib.utexas.edu/taro/tslac/20071/tsl-20071.html ;
101. https://railroads.dot.gov/elibrary/dallas-houston-high-speed-rail-project-corridor-alternatives-analysis-technical-report ;
102. https://railroads.dot.gov/environmental-reviews/dallas-houston-high-speed-rail/dallas-houston-high-speed-rail-passenger ;
103. https://www.texascentral.com/posts/environmental-impact-statement-advances-texas-high-speed-train-project/#:~:text=On%20May%2029%2C%202020%2C%20the,environment%20along%20the%20240%2Dmile ;


DRAFT

# Summary References


104. https://www.railway-technology.com/projects/california/ ;
105. https://www.caltrain.com/projectsplans/CaltrainModernization/BlendedSystem.html ;
106. https://hsr.ca.gov/programs/environmental/ ;
107. https://hsr.ca.gov/programs/environmental/tier1.aspx ;
108. https://www.systra.com/en-project/high-speed-1-hsr-link-between-london-and-the-channel-tunnel ;
109. https://highspeed1.co.uk/media/x31jse0d/hs1-network-statement-2021-final-26-may-2020.pdf ;
110. http://researchbriefings.files.parliament.uk/documents/SN00267/SN00267.pdf ;
111. https://commonslibrary.parliament.uk/research-briefings/sn00070/ ;
112. https://www.southeasternrailway.co.uk/timetables ;
113. https://www.sciencedirect.com/science/article/pii/S2352146517307214 ;
114. https://reader.elsevier.com/reader/sd/pii/S2352146517307214?token=7E2FF14E4A75E95245DA89A6DD47CE3F8867B50F507005537AC7DBD92533223F9642455B0571732085318C59E848D928 ;
115. https://en.thsrc.com.tw/ArticleContent/50fa391b-09a7-4728-98e7-8b7901a795d8 ;
116. https://www.worldatlas.com/webimage/countrys/europe/spain/esland.htm;
117. http://www.mega-project.eu/assets/exp/resources/High_Speed_Rail-Madrid-Barcelona-French-frontier.pdf ;
118. FRA 49 CFR Part 213 - Track Safety Standards ;
119. High Speed Benchmarks – Sep 2020.xlsx Report by Arup ;
120. https://www.lek.com/sites/default/files/insights/pdf-attachments/2109-High-Speed-Rail-Profitability.pdf ;
121. https://global.jr-central.co.jp/en/company/ir/annualreport/_pdf/annualreport2019.pdf ;
122. https://www.jreast.co.jp/e/investor/ar/2019/pdf/ar_2019-all.pdf ;
123. https://www.hsrail.org/cold-weather-passenger-trains ;
124. http://gronataget.se/upload/TR10_2011.pdf ;
125. https://uic.org/IMG/pdf/railadapt_final_report.pdf ;
126. https://en.wikipedia.org/wiki/Harbin%E2%80%93Dalian_high-speed_railway ;
127. https://rusmania.com/transport/sapsan-high-speed-train

***End of the Ministerial Briefing Deck ***

The following slides are supporting documents and appendices.

Note: some slides located in the first half of the deck (for the Ministerial Briefing) are also located in the second half of the deck (supporting documents and appendices) to keep applicable information grouped together.

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

# 1.1. Executive Summary

- HFR is being designed to accommodate operating speeds of 110 mph and build criteria of 125 mph where feasible
- Velocity of 186 mph (300 km/h) is typical of what are generally considered to be true high speed trains (HSTs) operating on European and Asian HSR systems
- High Speed Rail requires electrification.
- Modern high speed railways are built to have very long sections of straight or only slightly curved track – horizontal curves
- Modern high speed railways are built to have inflections in gradient that are sufficiently mild that passengers do not notice the changes and it has low impact on infrastructure – vertical curves

[redacted]

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

# 1.1. Executive Summary Continued

[redacted]

- Key items that would be impacted are:
  - Curves and Track Geometry
  - Track Cross-Section Design
  - Track Design
  - Structures
  - Traction Power Supply
  - Train Control and Communications
  - Grade Separated and Dedicated Right of Way
  - Maintenance
  - Cost to Build

[redacted]

# 4. HSR Profitability and Factors for Success

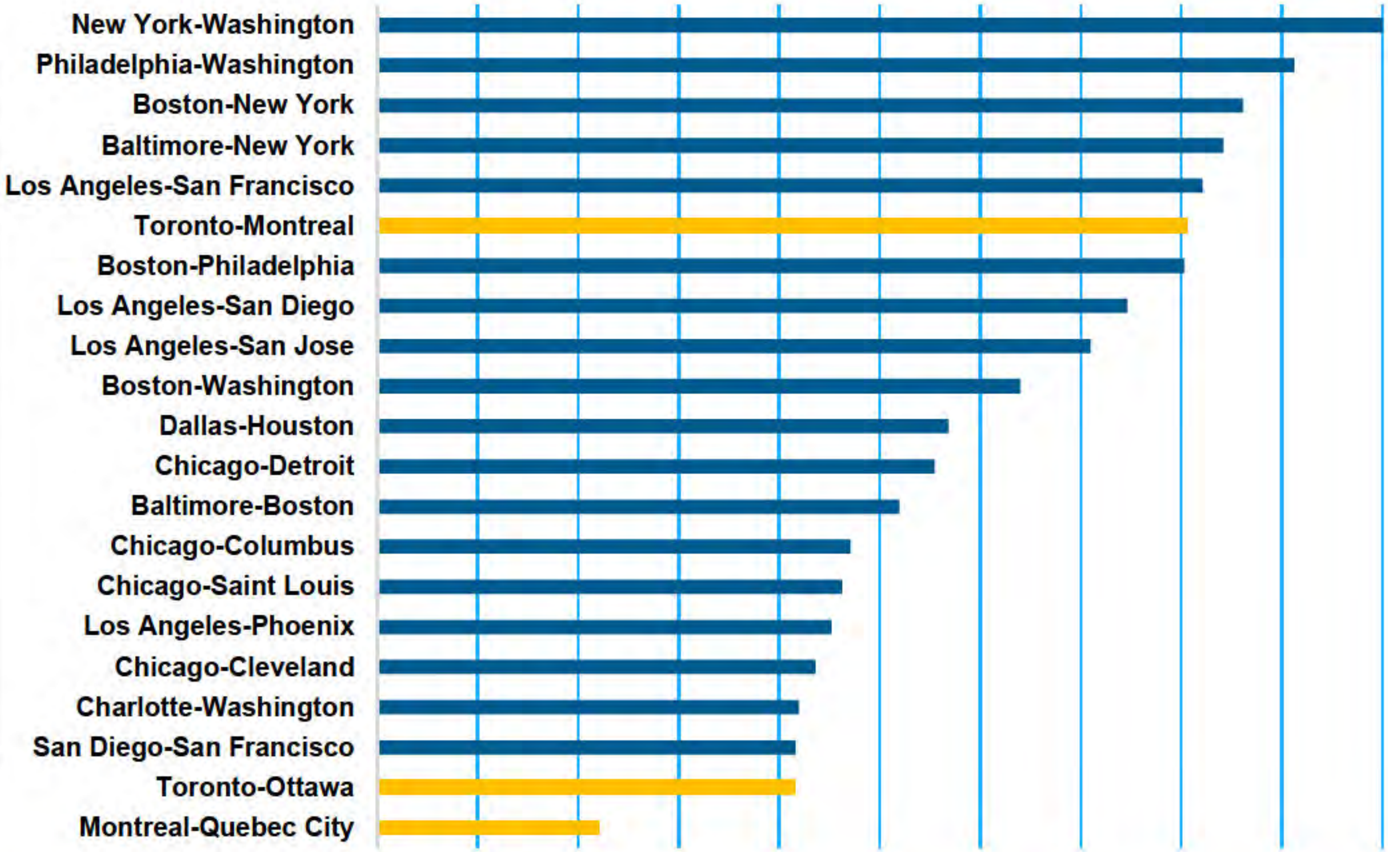
# 4.1. Success Factors: Where HSR Works Best

- ✓ Strong transit connections (LRT, subway, commuter rail, etc.)
- ✓ Optimal HSR corridor length (i.e. distance between economic centers)
- ✓ City pairs:
  - ✓ Large metropolitan area and city populations
  - ✓ Large metropolitan area GDP
  - ✓ Megaregion (considers population density and urban form)
  - ✓ Collaborating economic sectors

# 4.2. Success Factors: Where HSR Works Best

- America 2050 developed a tool for assessing which potential HSR corridors would have the greatest demand and evaluated 27,000 US city pairs
- Sample calculation suggests Toronto-Montreal would rank 6th in North America

- **Need to consider:**
  - ✓ Strong transit connections (LRT, subway, commuter rail, etc.)
  - ✓ Length of HSR corridor (i.e. distance between economic centers)
  - ✓ City pairs:
    - ✓ Metropolitan area and city populations
    - ✓ Metropolitan area GDP
    - ✓ Megaregion (considers population density and urban form)
    - ✓ Collaborating economic sectors



[redacted]

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

[redacted]

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

[redacted]

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

[redacted]

[redacted]

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

[redacted]

[redacted]

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

[redacted]

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

[redacted]

[redacted]

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

[redacted]

[redacted]

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

[redacted]

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

[redacted]

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

[redacted]

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

[redacted]

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

[redacted]

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

[redacted]

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

[redacted]

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

[redacted]

[redacted]

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

[redacted]

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

[redacted]

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

[redacted]

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

[redacted]

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

[redacted]

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

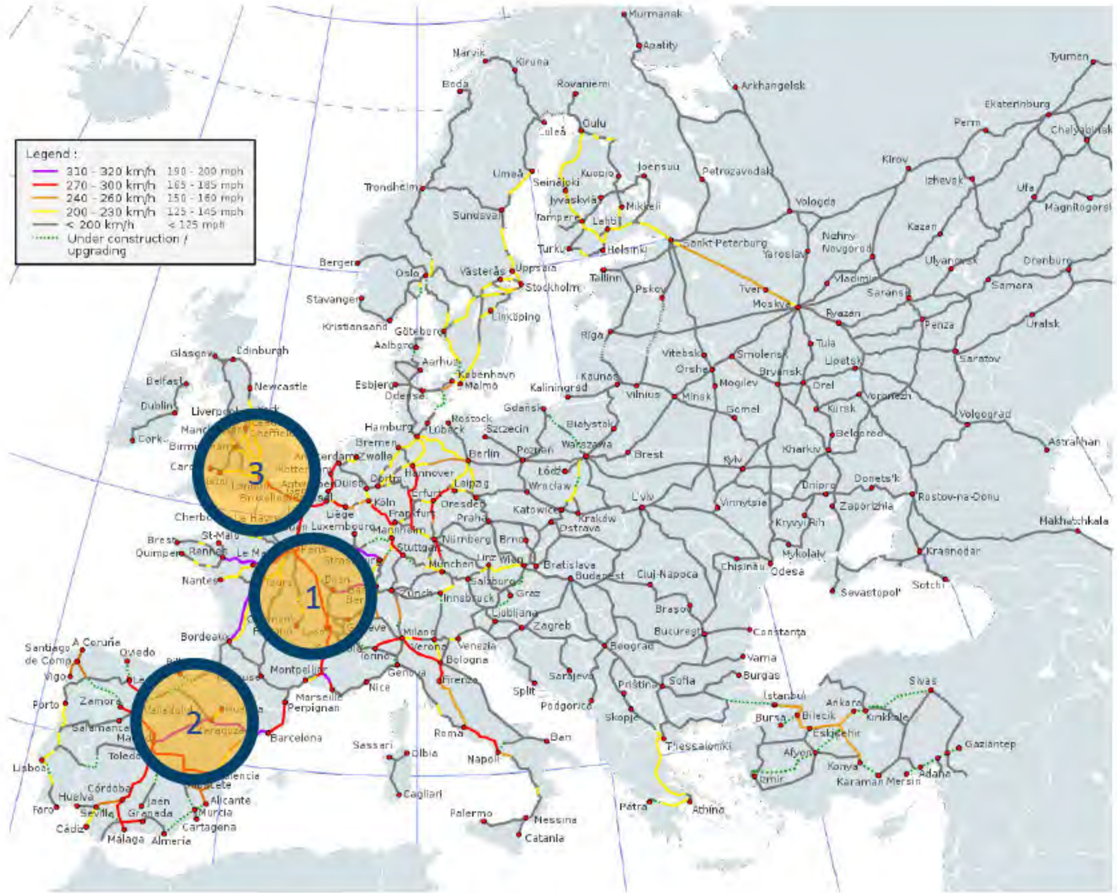
# Selected HSR Systems – Summary

| Project / Location | Capital cost (2020 CAD) | Cost per track km (2020 CAD) | First Operational Year | Total length (km) of project |
|---|---|---|---|---|
| **Existing HSR Systems in Operation** | | | | |
| France-LGV Sud-Est (Paris/Lyon) | $9.3 billon | $22 Million | 1981 (part), 1983 (full) | 425 |
| Spain-AVE (Madrid-Barcelona) | $32.9 billion | $53 million | 2003 and 2006 (part), 2008 (full) | 621 |
| UK-High Speed 1 (HS1) (London - Channel Tunnel) | $26.1 billion | $237 million | International: 2003 (part), 2007 (full) Domestic: 2009 | 109 |
| Japan-Sanyo Shinkansen (Osaka-Fukuoka) | $6.8 billion | $11 million | 1972 (part), 1975 (full) | 626 |
| Taiwan-High Speed Rail (Taipei-Kaohsiung) | $90.1 billion | $257 million | 2007 | 350 |
| **Proposed HSR Systems (Not in Operation)** | | | | |
| USA-California HSR Phase 1 (San Francisco-Los Angeles) | $107 billion | $128 million | Planned 2031 (part) 2033 (full) | 836 |
| USA-Texas High-Speed Train (Dallas-Houston) | $24.3 billion | $64 million | Not available | 380 |
| [redacted] | | | | |

(1)Note: Planning for this proposed HSR system has not moved ahead.

# Europe

1. **France** – LGV Sud-Est (Paris-Lyon)
2. **Spain** – AVE (Madrid-Barcelona)
3. **United Kingdom** – High Speed 1 (London-Channel Tunnel)




*Note: Selected projects are in operation and have a maximum operating speed of 300 km/h*

Map Source: https://en.wikipedia.org/wiki/High-speed_rail

# TGV-France

TGV: France HSR Network
LGV Sud-Est: Paris-Lyon HSR Line

| Owner(s) / Operator(s) | Path to HSR: Project background | Path to HSR: Nature of project (greenfield, upgrade, etc.) | Regulatory Approvals | Business Case Characteristics - Financing |
|---|---|---|---|---|
| **Owner and operator:** SNCF (French National Railways)<br>• State-owned | Sud-Est was first HSR line in Europe. Alleviated rail congestion.<br><br>Country-wide HSR network expanded from there, focusing on:<br>• City size/demand<br>• Congestion<br>• Profitability | Country-wide TGV network uses mixed infrastructure:<br>**Separate HSR Lines**<br>• Used for longer distances<br>• 37% of network are HSR-dedicated lines<br>**Conventional Lines**<br>• Used for approach to large cities<br>• High-speed trains can operate on conventional lines | Subject to "Napoleonic tradition" under Roman law, not common law<br>• Legislative and executive authorities had the power<br>• **"Declaration of public utility":** expropriated land to build LGV<br>• Allowed for quicker implementation of TGV network | Overall, the TGV network started with the most viable lines and were financed based on profitability.<br><br>Sud-Est was financed 100% by SNCF. The line had the following rates of return:<br>• 15% financial<br>• 30% social |

Source: https://en.wikipedia.org/wiki/LGV_Sud-Est ;
https://www.itf-oecd.org/sites/default/files/docs/dp201326.pdf ;
https://reader.elsevier.com/reader/sd/pii/S2352146517307214?token=7E2FF14E4A75E95245DA89A6DD47CE3F8867B50F507005537AC7DBD92533223F9642455B0571732085318C59E848D928 ;
High-Speed Rail: Lessons for Policy Makers from Experiences Abroad (Barcelona Report); and
High-Speed Rail: International Lessons for U.S. Policy Makers

# France – LGV Sud-Est (Paris-Lyon)

| Construction | | | Operations | | Ridership | | |
|---|---|---|---|---|---|---|---|
| Capital cost (CAD) | Timeline | Cost per track km (2020 CAD) | First operational year | Annual operating costs (CAD) | Example ticket price (2020 CAD) | Annual ridership | Revenue (CAD) |
| $4.0 billion (1983)<br>$9.3 billon (2020) | 1975 (approved),<br>1975-1983 (construction) | $22 million | 1981 (part),<br>1983 (full) | $18,700,000 (2002)<br>$31,790,000 (2020) of single track HSR maintenance cost (country-wide) | $82.97 (one-way) | 44.4 million in 2017 | $13 billion in 2019 (SNCF high speed and conventional long distance) |

| Network/Service | | | | | | Geography/Terrain |
|---|---|---|---|---|---|---|
| Average operating speed (km/h) | Max. operating speed (km/h) | Total length (km) of project | Headways / trip time (express) | Number of stations | Distances between stations (km) | |
| 220 | 300<br>(260 during first operational year) | 425 | Headway not available; approximately 2 hours | 4 | 142 (calculated average) | Flat; some mountains and hills surrounding Lyon |

## Assumptions (Based on Arup Report):

Escalation factor = 111% (base year = 1983)
Location factor = 1.10
Operating cost (excludes compounded escalation value) = $44,000 X [1+(18 years X 0.03)] X 1.1

## Major Communities Served:

Paris: Metropolitan Area Population (2016): 13 million; City Density: 20,000/km$^2$
Lyon: Metropolitan Area Population (2016): 2 million; City Density: 11,000/km$^2$

Source: Several, including High-Speed Rail: Lessons for Policy Makers from Experiences Abroad (Barcelona Report); Economic Analysis of High Speed Rail in Europe (BBVA, 2009); For additional references refer to summary references items 9, 14, 50, 54, 55, 59, 62, 64, 65, 69, 72, 75, 97, 99 and 119 (see Appendix G for details).

# Spain – AVE (Madrid-Barcelona)

AVE: Spain's HSR Service

| Owner(s) / Operator(s) | Path to HSR: Project background | Path to HSR: Nature of project (greenfield, upgrade, etc.) | Regulatory Approvals | Business Case Characteristics - Financing |
|---|---|---|---|---|
| **Infrastructure owner:** ADIF AV<br>• State-owned<br><br>**Operator:** Renfe Operadora<br>• State-owned | Planning commenced in the 1980's.<br><br>First HSR line (Madrid-Seville) opened in 1992<br>• Implemented to improve economic development in Southern Spain<br><br>HSR country-wide development stemmed years later. | Separate, country-wide HSR network.<br><br>The Madrid-Barcelona HSR extends to France. The line sections include:<br>• Madrid-Lleida (2003)<br>• Lleida-Tarragona (2006)<br>• Tarragona-Barcelona (2008)<br>• Figueres (Spain)-Perpignan (France) (2010)<br>• Barcelona-Figueres (2013) | The following are the regulatory considerations for the full line:<br><br>Regulatory Agencies:<br>Ministry of Development<br>• Ministry of Environment<br><br>Legal and regulatory environment:<br>• The European System of Accounts SEC-95<br>• Spanish public contracts law 24/2011<br>• *Real Decreto* 12/2011 (public contract legislation)<br><br>Events impacting the project:<br>• The Infrastructure and Transport Plan of the Spanish Government<br>• Law of Railway Sector 39/2003 (17 November) | Madrid-Barcelona-France financed by:<br>• Spanish Government<br>• EU Cohesion Fund<br>• TEN-T (Trans-European Transport Network)<br>• European Investment Bank (EIB) loans |

Source: http://www.mega-project.eu/assets/exp/resources/High_Speed_Rail-Madrid-Barcelona-French-frontier.pdf ; High-Speed Rail: Lessons for Policy Makers from Experiences Abroad (Barcelona Report) ; https://www.sciencedirect.com/science/article/pii/S2352146517307214 ; and https://en.wikipedia.org/wiki/Madrid%E2%80%93Barcelona_high-speed_rail_line

# Spain – AVE (Madrid-Barcelona)

| Construction | | | Operations | | Ridership | | |
|---|---|---|---|---|---|---|---|
| Capital cost (CAD) | Timeline | Cost per track km (2020 CAD) | First operational year | Annual operating costs (2020 CAD) | Example ticket price (2020 CAD) | Annual ridership | Revenue (CAD) |
| $14.9 billion (2007)<br>$32.9 billion (2020) | 1993 (tender)<br>1995 (construction began)<br>Base year 2007 | $53 million | 2003 and 2006 (part), 2008 (full) | $32,292,000 (2002)<br>$78,867,000 (2020)<br>Single track maintenance cost | $133.78 (one-way) | 8.7 million in 2017 (Madrid-Barcelona-France) | $6 billion in 2018 (Renfe's entire network rev.) |

| Network/Service | | | | | | Geography/Terrain |
|---|---|---|---|---|---|---|
| Average operating speed (km/h) | Max. operating speed (km/h) | Total length (km) of project | Headways / trip time (express) | Number of stations | Distances between stations (km) | |
| 236 | 300 | 621 | Headway not available; approximately 2:30 hours | 7 | 104 (calculated average) | Varied; hilly regions and lowland. Madrid-Barcelona-France: 255 viaducts and bridges (58km) and 83 tunnels (86 km). |

## Assumptions (Based on Arup Report):

Escalation factor = 39% (base year = 2007)
Location factor = 1.59
Operating cost (excludes compounded escalation value) = $52,000 X [1+(18 years X 0.03)] X 1.59

## Major Communities Served:

Madrid: Metropolitan Area Population (2016): 7 million; City Density: 5,300/km$^2$
Barcelona: Metropolitan Area Population (2016): 5 million; City Density: 16,000 people/km$^2$

Source: Several, including: High-Speed Rail: Lessons for Policy Makers from Experiences Abroad (Barcelona Report) ; http://www.mega-project.eu/assets/exp/resources/High_Speed_Rail-Madrid-Barcelona-French-frontier.pdf ; for additional references refer to summary references items 2, 9, 14, 54, 60, 63, 66, 67, 73, 97, 116, and 119 (see Appendix G for details).

# UK – High Speed 1 (London-Channel Tunnel)

| Owner(s) / Operator(s) | Path to HSR: Project background | Path to HSR: Nature of project (greenfield, upgrade, etc.) | Regulatory Approvals | Business Case Characteristics - Financing |
|---|---|---|---|---|
| **Owner/Operator:** HS1 Ltd<br>• Until 2040<br>• Private sector<br>• **O&M Contractor:** Network Rail (High Speed)<br><br>**Mainline Operators:**<br>**Domestic service:** London South Eastern Railway (LSER)<br>**International service:** Eurostar<br><br>HS1 Ltd. also services East Midlands Railway, Thameslink, and freight operator. | • Connect the UK with the rest of Europe quicker and more reliably<br>• Develop new commuter service<br>• Improve rail capacity<br>• Economic development | **Section 1:** open countryside with bridge crossings, etc.<br>**Section 2:** urban setting, mostly tunnels<br><br>Double track and mixed traffic:<br>• High speed passenger and commuter trains; freight trains<br><br>60% of project is in existing transportation corridors<br>25% of the route is tunnelled | **Channel Tunnel Rail Link Act 1996:** provided for the project to be implemented. Also outlined a private sector entity would build, maintain, and operate it.<br><br>**Channel Tunnel Rail Link (Supplementary Provisions) Act 2008:** Updated the Act to support the 2009 restructuring and sale.<br><br>Additional applicable legislation to HS1:<br>• Parts of Railways Acts of 1993 and 2005, Railways and Transport Safety Act 2003, and secondary legislation<br><br>HS1 Ltd. Is the Infrastructure Manager under Rail Regulation 2016. | **Initially:** Private Finance Initiative (PFI)<br>**After restructuring:** Public Private Partnership (P3)<br><br>Financed through government grants and government guaranteed private finance.<br><br>The private company "London Continental Railways" (LCR) was to finance, build, and operate the project.<br>• Restructured in 1998 and 2002 due to financial difficulties from low Eurostar UK revenue forecasts<br>• Was purchased by the government in 2009<br><br>Overall, the public sector became more involved in the project than anticipated. |

Source: Several, including: https://highspeed1.co.uk/about-us;
https://www.systra.com/en-project/high-speed-1-hsr-link-between-london-and-the-channel-tunnel;
for additional references refer to summary references items 9, 52, 58, and 109-111 (see Appendix G for details).

# UK – High Speed 1 (HS1) (London-Channel Tunnel)

| Construction | | | Operations | | Ridership | | |
|---|---|---|---|---|---|---|---|
| Capital cost (CAD) | Timeline | Cost per track km (2020 CAD) | First operational year | Annual operating costs (CAD) | Example ticket price (2020 CAD) | Annual ridership | Revenue (2020 CAD) |
| \$18.9 billion (2007)<br>\$26.1 billion (2020) | 1996 (contract award),<br>1998-2003 (section 1 construction),<br>2000-2007 (section 2 construction) | \$237 million | International: 2003 (part), 2007 (full)<br>Domestic: 2009 | \$407 million (2013)<br>\$493 million (2020) | \$59.14 | 20 million (2016) | \$1 billion (calculated) |

| Network/Service | | | | | | Geography/Terrain |
|---|---|---|---|---|---|---|
| Average operating speed (km/h) | Max. operating speed (km/h) | Total length (km) of project | Headways / trip time (express) | Number of stations | Distances between stations (km) | |
| Not available | International: 300<br>Domestic: 230 | 109 | Domestic: 80+ daily trips per direction; 37 minutes | 4 | 36 (calculated average) | Rolling terrain and farmland; 117 bridges, 26.5km of tunnels, and 6km of viaducts |

## Assumptions (Based on Arup Report):

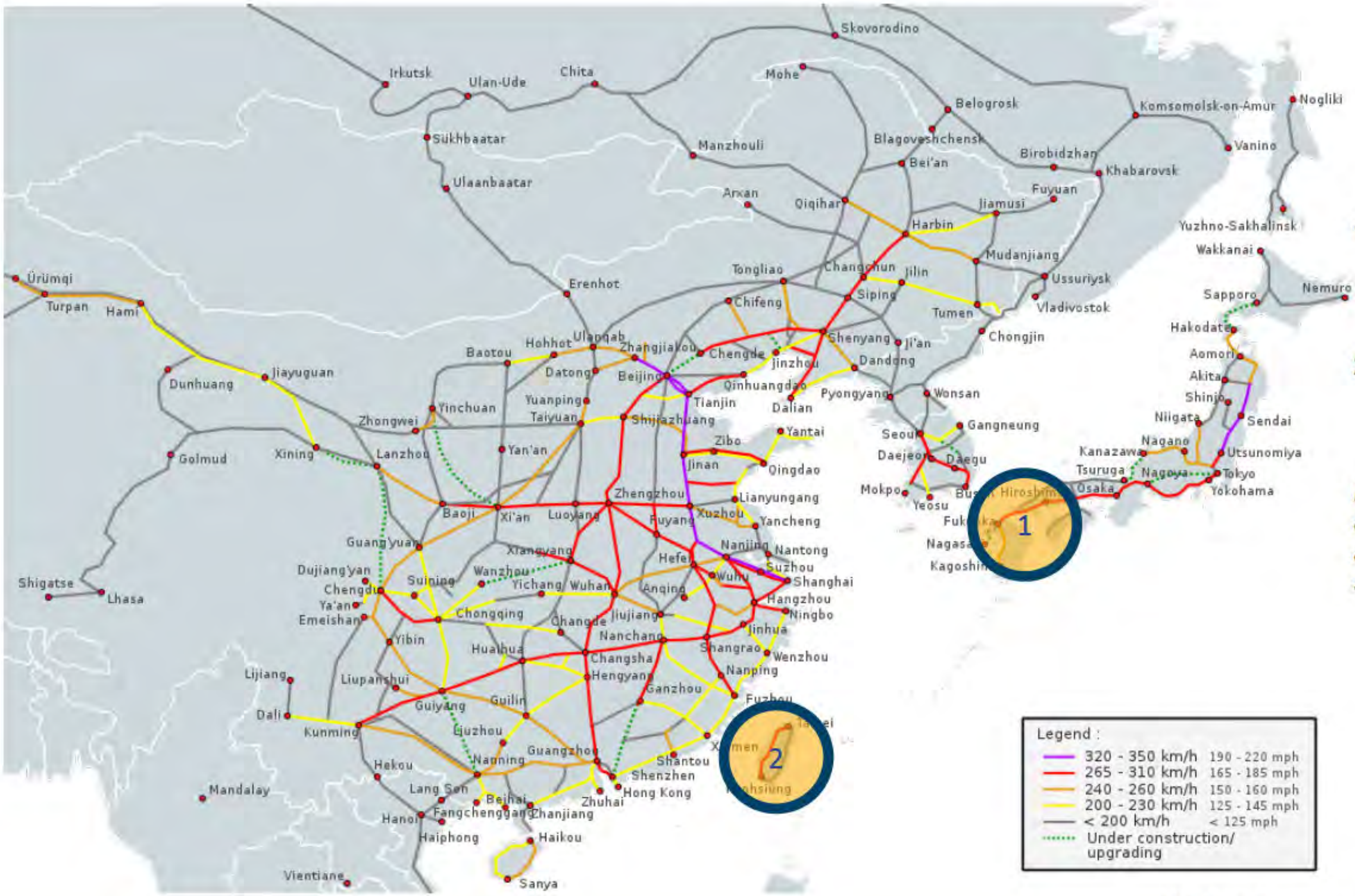
Escalation factor = 39% (base year = 2007)
Location factor = 1.00
Operating cost (excludes compounded escalation value) = \$407 million X [1+(7 years X 0.03)] X 1.0

## Major Communities Served:

London: Metropolitan Area Population (2016): 12 million; City Density: 5,666/km$^2$

Source: Several, including: https://www.ice.org.uk/what-is-civil-engineering/what-do-civil-engineers-do/high-speed-one-and-st-pancras-station ; http://researchbriefings.files.parliament.uk/documents/SN00267/SN00267.pdf ; for additional references refer to summary references items 52, 56, 57, 61, 68, 71, 74, 76, 97, 108 and 119 (see Appendix G for details).

# Asia




1. **Japan** – Sanyo Shinkansen (Osaka-Fukuoka)
2. **Taiwan** – High Speed Rail (Taipei-Kaohsiung)

*Note: Selected projects are in operation and have a maximum operating speed of 300 km/h*

Map Source:
https://en.wikipedia.org/wiki/High-speed_rail

# Japan – Sanyo Shinkansen (Osaka-Fukuoka)

| Owner(s) / Operator(s) | Path to HSR: Project background | Path to HSR: Nature of project (greenfield, upgrade, etc.) | Regulatory Approvals | Business Case Characteristics - Financing |
|---|---|---|---|---|
| In 1987, Japanese National Railways (JNR) separated and became private.<br><br>Sanyo Shinkansen is owned and operated by West Japan Railway Company (JR West). | Country-wide HSR network developed to support all regions, as a result of:<br>• Rapidly growing economy<br>• Loss of population to certain areas<br><br>First global HSR was the Tokaido Shinkansen (Tokyo-Osaka), opened in 1964. | New Shinkansen Line called Sanyo Shinkansen<br>• Extension of country-wide network<br>• Connected to Tokaido Shinkansen (Tokyo-Osaka)<br><br>Two Sanyo Shinkansen phases:<br>• Shin-Osaka-Okayama, opened in 1972<br>• Okayama-Hakata (Fukuoka), opened in 1975 | **National Shinkansen Railway Construction Law**<br>• Approved May 1970<br>• Outlines definitions, objectives of the network, and procedures | Project built by the Japan Railway Construction Public Corporation (JRCPC), which was created by the government.<br><br>Construction cost funding:<br>• JNR (public at the time)<br>• Government's treasury investment and loan fund<br>• Borrowed funds from the private sector |

Source: http://www.omegacentre.bartlett.ucl.ac.uk/wp-content/uploads/2014/12/JAPAN_SHINKANSEN_PROFILE.pdf ; https://en.wikipedia.org/wiki/San%27y%C5%8D_Shinkansen ; https://www.westjr.co.jp/global/en/about-us/history/ ; and https://www.jrailpass.com/blog/tokaido-shinkansen-jr-pass

# Japan – Sanyo Shinkansen (Osaka-Fukuoka)

| Construction | | | Operations | | Ridership | | |
|---|---|---|---|---|---|---|---|
| Capital cost (CAD) | Timeline | Cost per track km (2020 CAD) | First operational year | Annual operating costs (2020 CAD) | Example ticket price (2020 CAD) | Annual ridership | Revenue (CAD) |
| \$4.1 billion (1975) \$6.8 billion (2020) | 1965 (authorized), 1967 (construction began) -1975 | \$11 million (nominal) (calculated) | 1972 (part), 1975 (full) | Not available | \$191.79 | 85 million in 2018 (JR West Shinkansen) | \$19 billion in 2019 (JR West Operating Revenue) (converted) |

| Network/Service | | | | | | Geography/Terrain |
|---|---|---|---|---|---|---|
| Average operating speed (km/h) | Max. operating speed (km/h) | Total length (km) of project | Headways / trip time (express) | Number of stations | Distances between stations (km) | |
| 210* | 300 | 626 | Varies; 2.5 hours | 19 | 35 (calculated average) | Mountainous; joins two islands |

*Average operating speed Tokaido Shinkansen (Tokyo-Osaka)

## Assumptions:

Escalation factor = 68% (base year = 1975)
Location factor = 0.99

## Major Communities Served:

Osaka: Metropolitan Area Population (2016): 17 million
Fukuoka: Metropolitan Area Population (2016): 3 million; City Density: 4,600/km$^2$

Source: Several, including: High-Speed Rail: Lessons for Policy Makers from Experiences Abroad (Barcelona Report) ; http://www.omegacentre.bartlett.ucl.ac.uk/wp-content/uploads/2014/12/JAPAN_SHINKANSEN_PROFILE.pdf ; for additional references refer to summary references items 14, 54, 78, 81-86, 88, 89, 97 and 119 (see Appendix G for details).

# Taiwan – High Speed Rail (Taipei-Kaohsiung)

| Owner(s) / Operator(s) | Path to HSR | | Regulatory Approvals | Business Case Characteristics - Financing |
|---|---|---|---|---|
| | Project background | Nature of project (greenfield, upgrade, etc.) | | |
| **Owner/Operator:** Taiwan High Speed Rail Corporation (THSRC) | Project allows for business travel between Taipei and Kaohsiung with a distance of 350 km in 90 minutes and builds on economic development along the route.<br><br>Project was initially planned to be public sector. Due to increased public fiscal burdens, the Legislative Yuan withdrew the budget allocated to the HSR Project and decided on a Design-Built-Operate-Maintain-Transfer (DBOMT) procurement. | Greenfield | Taiwan Ministry of Transportation and Communications (MOTC) | Privately financed by Taiwan High Speed Rail Corporation (THSRC) with some government subsidy (P3)<br><br>DBOMT<br><br>THSRC has a concession to finance, construct, and operate the HSR for a period of 35 years and a concession for HSR station area development for a period of 50 years. |

Source: https://en.thsrc.com.tw/ArticleContent/50fa391b-09a7-4728-98e7-8b7901a795d8

# Taiwan – High Speed Rail (Taipei-Kaohsiung)

| Construction | | | Operations | | Ridership | | |
|---|---|---|---|---|---|---|---|
| Capital cost (CAD) | Timeline | Cost per track km (2020 CAD) | First operational year | Annual operating costs (2020 CAD) | Example ticket price (2020 CAD) | Annual ridership | Revenue (2020 CAD) |
| \$23.1 billion (2005)<br>\$90.1 billion (2020) | 1998 - Contract award<br>2005 - Construction complete<br>2007 – Full operation | \$257 million | 2007 | \$1.16 billion (2019)<br>\$3.1 billion (2020) | \$68.64 | 67.4 million in 2019 | \$2.1 billion |

| Network/Service | | | | | | Geography/Terrain |
|---|---|---|---|---|---|---|
| Average operating speed (km/h) | Max. operating speed (km/h) | Total length (km) of project | Headways / trip time (express) | Number of stations | Distances between stations (km) | |
| Not available | 300 | 350 | 6 trains/hr (NB)<br>7 trains/hr (SB)/ 1:30 | 12 | 32 | Varied terrain<br>Approximately 73% of line runs on viaducts and 18% is in tunnels. |

## Assumptions:

Escalation factor = 45% (base year = 2005)
Location factor = 2.69
Operating cost (excludes compounded escalation value) = \$1.16 billion X [1+(1 years X 0.03)] X 2.69

## Major Communities Served:

Taipei City: Population: 2.65 million; Density: 9,700/km$^2$
Taichung: Population: 2.82 million; Urban Density: 5,400/km$^2$
Kaohsiung: Population: 2.77 million; Urban Density: 7,100/km$^2$

Source: Several, including: https://inta-aivn.org/images/assets/inta33/chiu_inta33_the_bot_experience_of_taiwans_high_speed_rail_construction_project.pdf ; https://www.thsrc.com.tw/event/InvestorRelations/ShareholdersMeeting/2019_anual_report_EN.pdf ; for additional references refer to summary references items 91, 92, 94, 95, 96, 98 and 119 (see Appendix G for details).

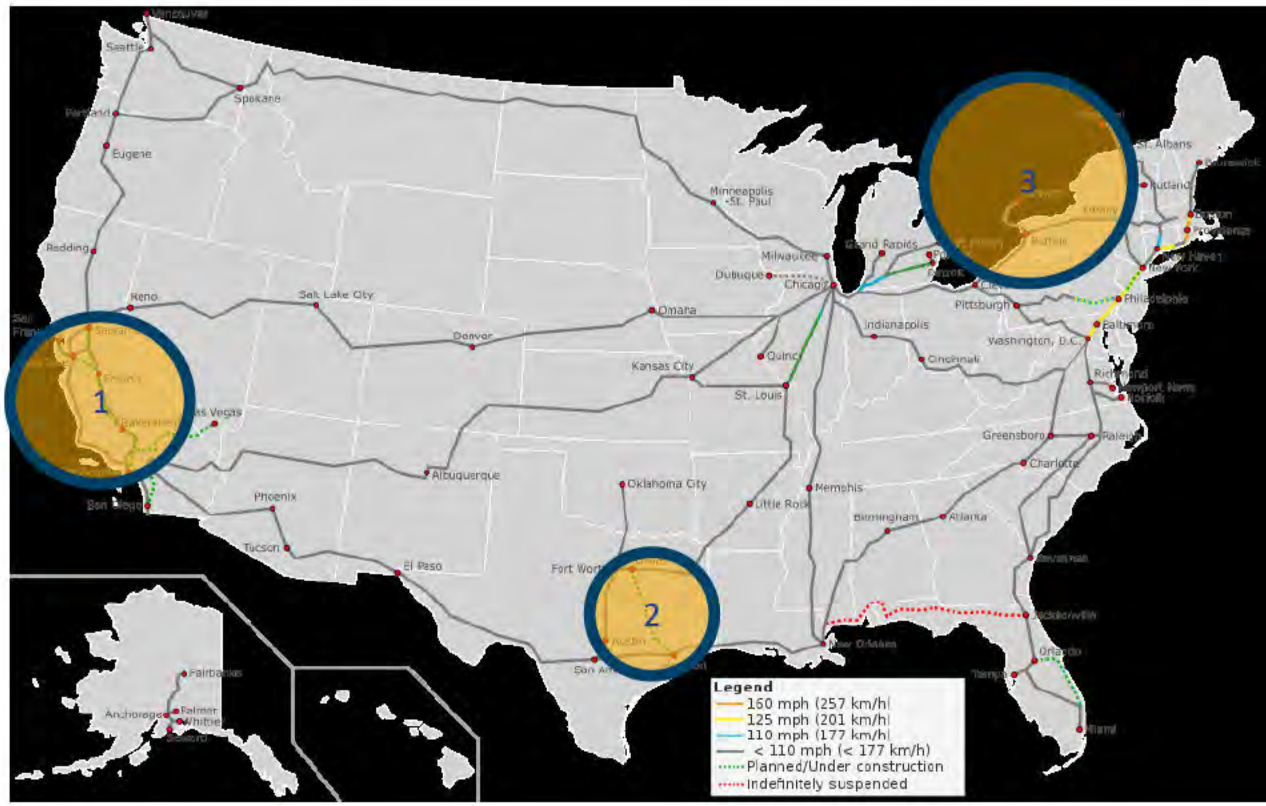
PRIVILEGED AND CONFIDENTIAL- DO NOT SHARE AND/OR COPY

# North America

1. **USA** –
   California HSR Phase 1 (San Francisco - Los Angeles)

2. **USA** – Texas High-Speed Train (Dallas - Houston)

3. **Canada** – Quebec City - Windsor Corridor




*Note:*
*Selected projects are either currently being constructed or in planning phases*

# USA – California HSR Phase 1 (San Francisco-Los Angeles)

| Owner(s) / Operator(s) | Path to HSR: Project background | Path to HSR: Nature of project (greenfield, upgrade, etc.) | Regulatory Approvals | Business Case Characteristics - Financing |
|---|---|---|---|---|
| **Contracting authority:** California High-Speed Rail (CHSR) | **Key points:**<br>• **1981:** HSR first considered at the state-level<br>• **Mid-1990's:** increased transportation congestion (air, rail, and road) motivates planning<br>• **1996:** report by the state's Intercity High-Speed Rail Commission determined HSR would be feasible. | Majority of project anticipated to be built along existing transportation corridors (rail and road)<br>• E.g. San Francisco to San Jose "blended system" between the HSR and Caltrain<br><br>Project separated into ten sections: geographic, environmental, and economics | **California's High-Speed Rail Act (1996):** created the high-speed rail authority that would begin planning for the project.<br><br>**Environmental planning:**<br>**Tier 1:** broad program<br>• 2 of 2 documents completed (2005 and 2008/2012)<br>**Tier 2:** individual projects<br>• 3 of 10 Phase 1 documents are completed<br>• For reference, environmental review and permitting took 4 and 5 years, for Merced to Fresno and Fresno to Bakersfield, respectively. | **Funding Sources**<br>**Federal:**<br>• American Recovery and Reinvestment Act (ARRA) and Fiscal Year 2010 (FY10) Transportation, Housing and Urban Development funds<br>• Total: $5 billion (2020 CAD)<br>**State:**<br>• Cap-and-Trade (received and future) and Proposition 1A bond funds<br>• Total: $24-28 billion (2020 CAD)<br><br>Total available funds: **$29-32 billion (2020 CAD)** (as of December 31, 2019)<br><br>Civil construction procured under multiple design build contracts; not integrated. |

Sources: Several, including https://hsr.ca.gov/docs/about/business_plans/2020_Business_Plan.pdf;
HSR-CIB Case Studies;
for additional references refer to summary references items 33, 34, 39, 104, 105, 106, 107 (see Appendix G for details).

# USA – California HSR Phase 1 (San Francisco-Los Angeles)

| Construction | | | Operations | | Ridership | | |
|---|---|---|---|---|---|---|---|
| Capital cost (CAD) | Timeline | Cost per track km (2020 CAD) | First operational year | Annual operating costs (CAD) | Example ticket price (2020 CAD) | Annual ridership | Revenue (CAD) |
| $107 billion (2020) | 2009-2013/2014/in progress (environmental review), 2015 (construction began) - in progress | $128 million | 2031 (part) 2033 (full) | $1.4 billion (2034) (converted)* | Varies | 27.8 million (2034)* | $2.2 billion (2034, converted)* |

| Network/Service | | | | | | |
|---|---|---|---|---|---|---|
| Planned operating speed (km/h) | Max. operating speed (km/h) | Total length (km) of project | Headways / trip time (express) | Number of stations | Distances between stations (km) | **Geography/Terrain** |
| Not available | 354 | 836 | Headways not available; 2:40 | 15 | 60 (calculated average) | Various; mountains and valleys |

*Based on 2034 medium forecasts

## Assumptions:

Escalation factor = 15% (base year = 2015)
Location factor = 0.87

## Major Communities Served:

San Francisco: Metropolitan Area Population (2016): 7 million; City Density: 7,255/km²
Los Angeles: Metropolitan Area Population (2016): 18 million; City Density: 3,276/km²

Source: Several, including https://hsr.ca.gov/docs/about/business_plans/2020_Business_Plan.pdf ; https://www.permits.performance.gov/permitting-projects/california-high-speed-rail-progam-fresno-bakersfield-project-section ; for additional references refer to summary references items 34, 38, 39, 40, 41, 46, 47, 48 and 119 (see Appendix G for details).

# USA – Texas High-Speed Train (Dallas-Houston)

| Owner(s) / Operator(s) | Path to HSR | | Regulatory Approvals | Business Case Characteristics - Financing |
|---|---|---|---|---|
| | Project background | Nature of project (greenfield, upgrade, etc.) | | |
| Project being developed by Texas Central | **HSR in Texas, pre-project:**<br>• **1987:** HSR planning at the state-level began<br>• **1989:** report by the Texas Turnpike Authority determined HSR would be feasible (under certain conditions)<br>• **1989-1995:** Texas High-Speed Rail Authority created and then abolished, respectively<br><br>Motivation for this project:<br>• Road congestion increasing on I-45<br>• Additional time required for air travel | Utility corridor as the feasible alternative.<br><br>Project would require:<br>• Double tracks<br>• **Closed system:** dedicated ROW | Regulatory approval process led by the Federal Railroad Administration (FRA)<br>• Includes 12+ federal and state agencies<br><br>**Key step:** Final Environmental Impact Statement published in 2020<br>• Took 6 years to produce<br>• Allows for: permits to be finalized, the Record of Decision, and for construction to begin | The project is private and for-profit.<br><br>Market-led approach<br>• Funded by investors and entrepreneurs<br>• No grants from the US Government or State of Texas<br>• Would have no operational subsidy once in service |

Sources: Several, including https://legacy.lib.utexas.edu/taro/tslac/20071/tsl-20071.html ; https://railroads.dot.gov/elibrary/dallas-houston-high-speed-rail-project-corridor-alternatives-analysis-technical-report ; for additional references refer to summary references items 36, 102, and 103 (see Appendix G for details).

# USA – Texas High-Speed Train (Dallas-Houston)

| Construction | | | Operations | | Ridership | | |
|---|---|---|---|---|---|---|---|
| Capital cost (CAD) | Timeline | Cost per track km (2020 CAD) | First operational year | Annual operating costs (2020 CAD) | Example ticket price (2020 CAD) | Annual ridership | Revenue (2020 CAD) |
| $24.3 billion (2020) | 2014 (environmental review and permitting started) – ongoing | $64 million (calculated) | Not available | Not available | Varies | 6 million in 2029 | Not available |

| Network/Service | | | | | | |
|---|---|---|---|---|---|---|
| Planned operating speed (km/h) | Max. operating speed (km/h) | Total length (km) of project | Headways / trip time (express) | Number of stations | Distances between stations (km) | Geography/Terrain |
| 300 (planned) | 330 | 380 | 30 minutes peak, 1 hour off-peak; 90 minutes | 3 | 190 (calculated average) | Rolling terrain |

**Assumptions:**
Escalation factor = 0% (base year = 2020)
Location factor = 0.87

**Major Communities Served:**
Dallas: Metropolitan Area Population (2016): 7 million; City Density: 1,527/km$^2$
Houston: Metropolitan Area Population (2016): 7 million; City Density: 1,398/km$^2$

Source: Several, including https://www.texascentral.com/facts/ ; https://www.permits.performance.gov/permitting-projects/dallas-houston-high-speed-rail ; for additional references refer to summary references items 35, 37, 42, 43, 49 and 119 (see Appendix G for details).

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

[redacted]

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

[redacted]

[redacted]

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

[redacted]

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

[redacted]

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

[redacted]

[redacted]

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

[redacted]

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

[redacted]

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

[redacted]

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

[redacted]

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

[redacted]

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

[redacted]

[redacted]

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

[redacted]

[redacted]

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

[redacted]

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

[redacted]

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)

[redacted]

s. 18(a)
s. 18(b)
s. 21(1)(a)
s. 21(1)(b)