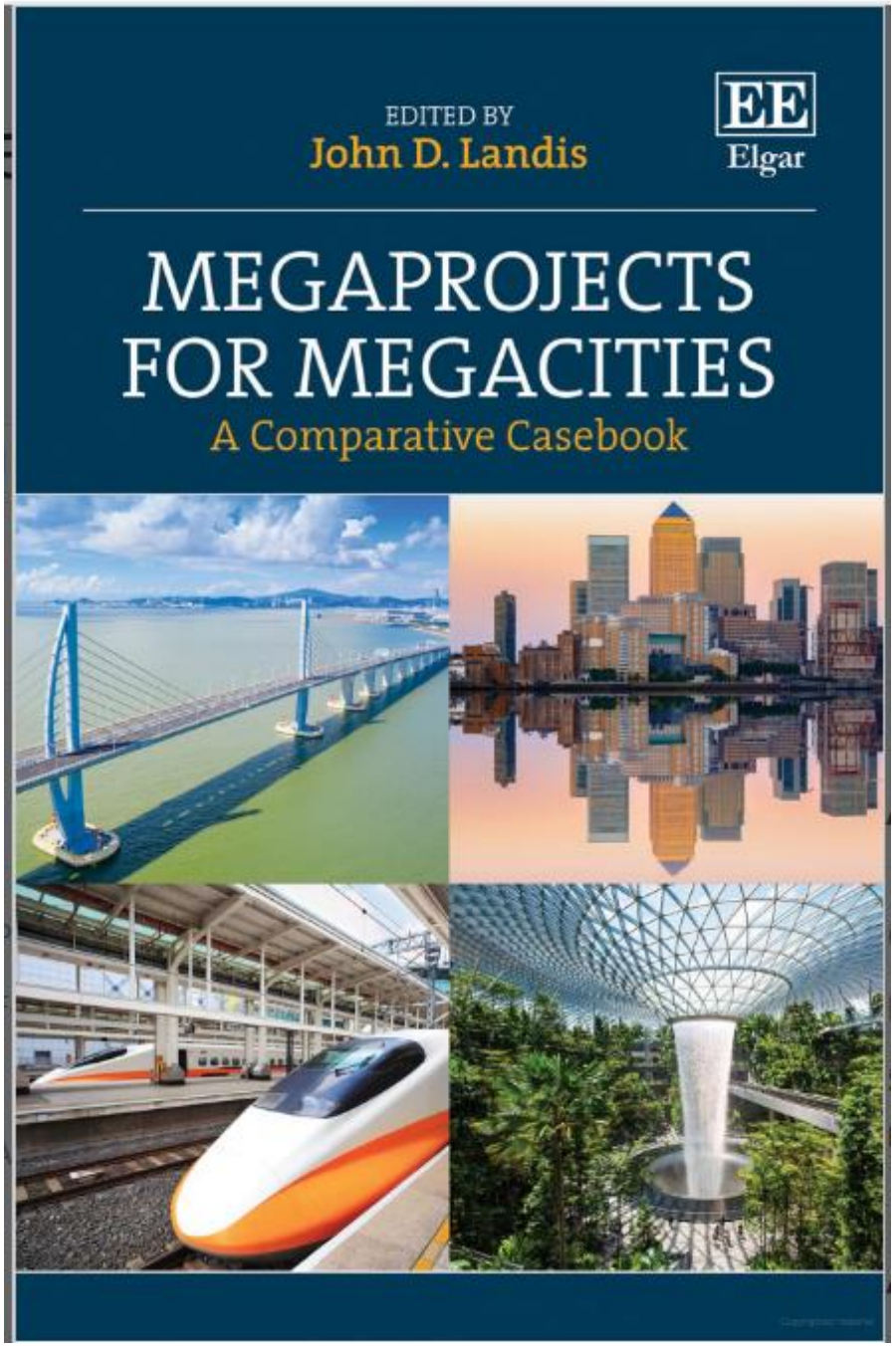



Edward Elgar Publishing, December 2022

with chapter contributions from David L. Gordon, Ziming Liu, Zhong-Ren Peng, Molly Riddle, Oscar Serpell, Erik Vergel-Tovar, Patricia Warren, Jan Whittington and Anthony G.O. Yeh

# Agenda

1. Megaprojects Pro & Con
2. Book Approach & Organization
3. A Brief History in Four Eras
4. Four Transportation Megaprojects Up Close
5. The Seven Secrets of Megaproject Success

# *Megaprojects Pro & Con*

# Conventional Wisdoms

"A plausible argument can be made that the age of urban megaprojects has passed" (Alan Altshuler and David Luberoff writing about Boston's "Big Dig" project in *Megaprojects: The Changing Politics of Urban Public Investments*, 2004)

Megaprojects are always "over budget, over time, under benefits, and over and over again." (Bent Flyvbjerg's "Iron Law of Megaprojects", 2014)

# Megaproject Definition

Oxford Handbook of Megaproject Management (2017):

*"Megaprojects are large-scale, complex ventures that typically cost **$1 billion or more**, take many years to develop and build, involve multiple public and private stakeholders, generate potentially transformation impacts, and affect large numbers of people"*

# Megaproject Pros & Cons

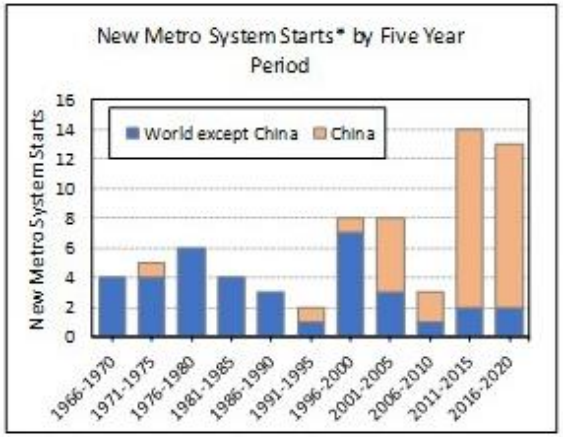
**Pros: The Lure of Megaprojects**

- Improved planning efficiencies (physical & service area coverage economies of scale)
- Improved design, engineering & construction efficiencies
- Financing efficiencies through economies of scale & better risk-pooling
- Expanded benefit capture and equity opportunities
- Opportunities to promote greater sustainability, resilience and equity
- Network & operations benefits

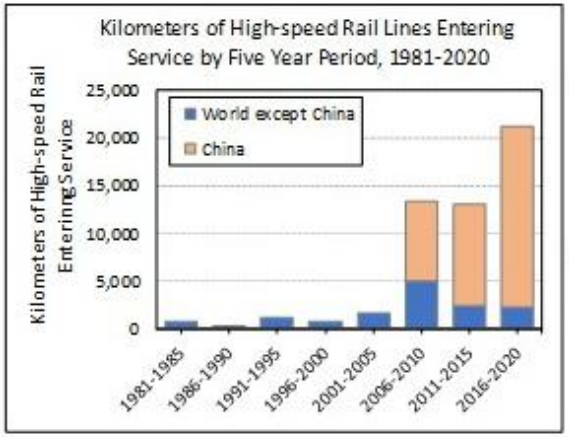
**Cons: Flyvbjerg's Potential Pitfall List**

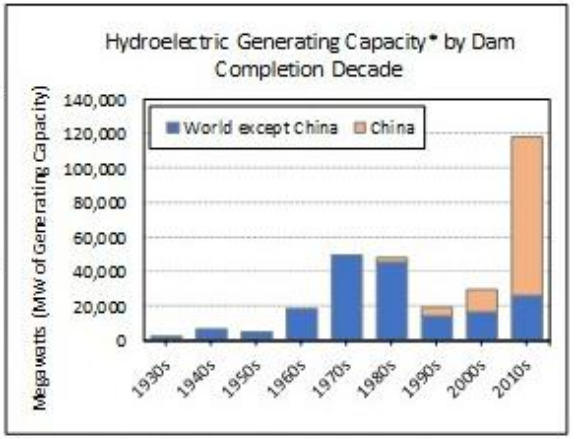
- Excessive planning time horizons/incorrect discount rate
- Lack of relevant project management experience
- Embedded stakeholder conflicts of interest
- Lack of learning opportunities
- Poor quality market and financial analysis
- Principal-agent problems and rent-seeking behavior
- Vulnerability to "Black Swan" events
- Positive information & feedback biases

# Megaprojects on the Upswing:
## Global Megaproject Deliveries by Project Type & Period

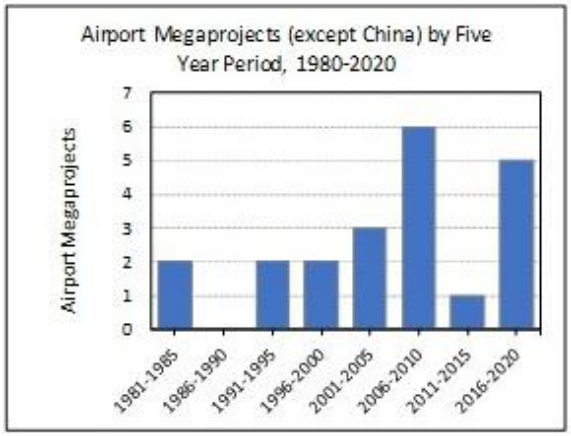


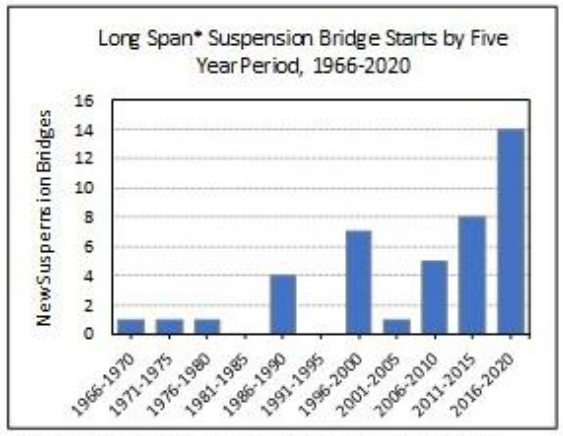

* includes metro systems longer than 50 km



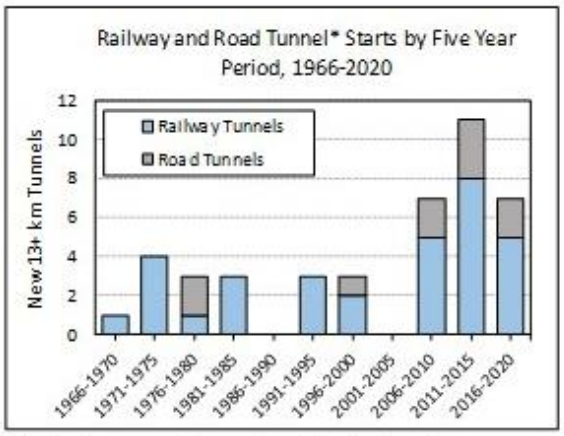




* limited to dams generating 2,000 MW or more



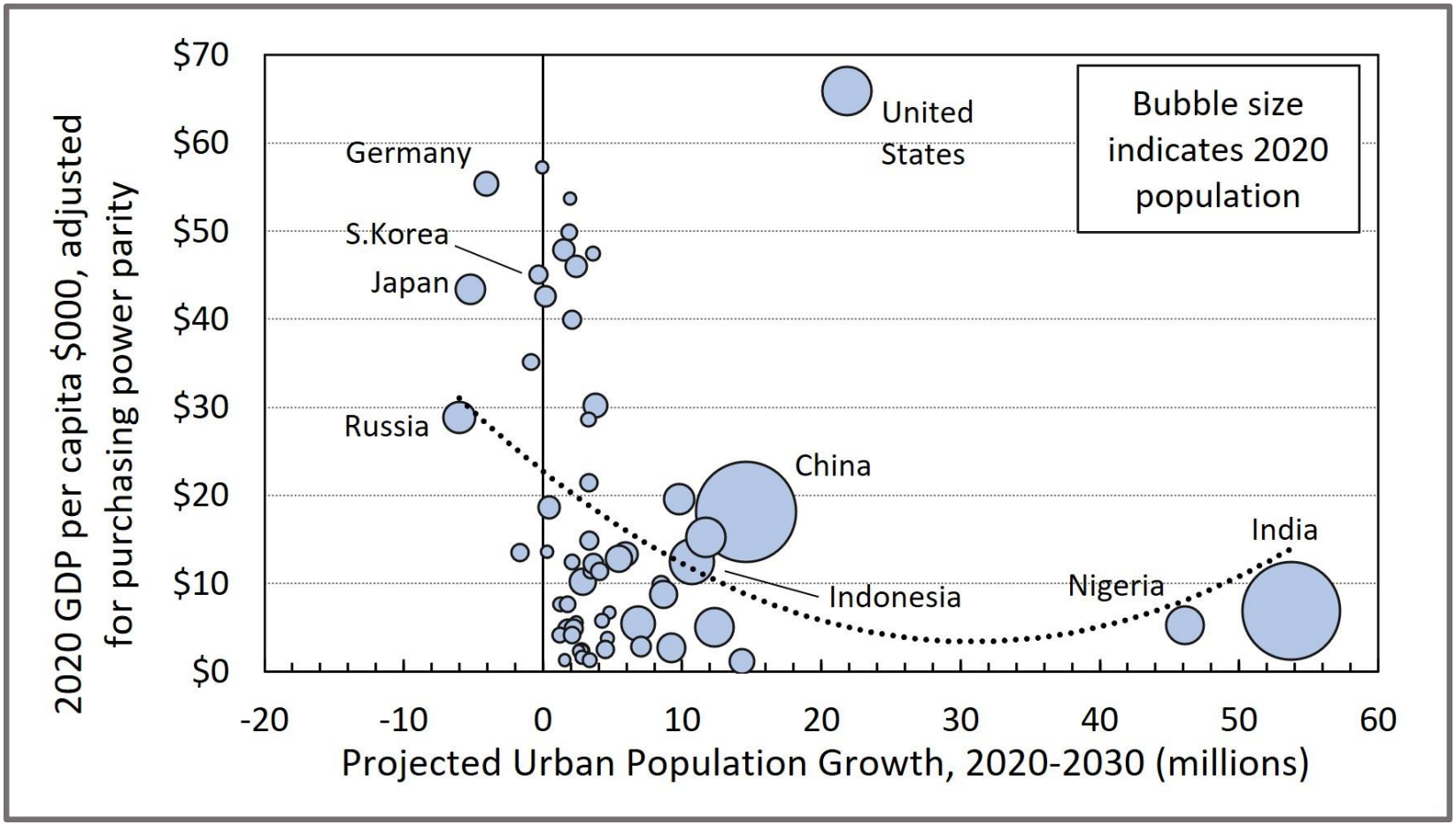

* limited to bridges with main spans longer than 900 m




* limited to tunnels longer than 13 Km inn length

# How Big is the Megaproject Market?

## The population growth & financing "sweet spot"



# *Book Approach & Organization*

# Book Approach

- Organized around a series of carefully selected *common-format comparative case studies* that connect contemporary megaproject **practice** with **performance.**
- **Practice** includes planning, design and engineering, financing, construction and project management, delivery and operation.
- **Performance measures** include: (i) achieves its goals in a timely and cost-efficient manner; (ii) generates expected benefits and revenues; (iii) promotes synergies and positive externalities/minimizes negative externalities and social costs; (iv) promotes sustainability, resilience and equity; and (v) offers positive and transferable lessons and models for practice.
- Each chapter concludes with a series of project-specific and global practice **lessons and takeaways**.

# Case Selection Criteria

- Embody bold ambitions
- Recent: Started or completed after 2010
- Relevant to contemporary practice
- Urban-oriented
- Diversity of project types
- Geographically representative
- Notable design or engineering features
- Diverse financing forms
- Available documentation
- Diversity of outcomes (good, bad and everything in between)
- Clear cause-effect narratives
- Diversity of takeaways

# List of the Cases

**Urban Transportation Projects**

1. *London Crossrail*
2. *China High-speed Rail*
3. Four metro projects in Beijing, Shanghai, Guangzhou and Shenzhen
4. Six Bus Rapid Transit in South America & Asia

**Bridge & Tunnel Projects**

5. *Seattle Alaska Way Viaduct Replacement Project*
6. Hong Kong-Zhuhai-Macau Bridge

**Airport Projects**

7. Singapore Jewel Changi Airport
8. *Berlin Brandenburg Airport & LaGuardia Terminal B Reconstruction*

**Urban Development Projects**

9. Canary Wharf – London
10. HafenCity Hamburg
11. Songdo IBD - S. Korea

**Park & Energy Projects**

12. Brooklyn Bridge Park – NYC
13. Five Renewable Energy Projects in the UK, Morocco, India, China and the U.S.

# Case Study Locations

# *A Brief History in Four Eras*

I. 1825 - 1915: Promoting Commerce & Trade
II. 1935 - 1995: Megaprojects Across America
III. 1964 - 2016: Megaprojects Go Global
IV. 1994 – Present: China Takes the Lead

# I. 1825 - 1915: Promoting Commerce & Trade

a) **The Erie Canal (1817-1825)** – The first modern megaproject [Engineered; used new technologies (gunpowder), publicly-financed, intended to expand commercial market & serve broader populace]

b) The Suez Canal (1859-1869) – Making the world smaller

c) The U.S. Transcontinental Railroad (1862-1869) – Opening up a continent

d) The Gotthard Tunnel under the Swiss Alps (1871, Switzerland) & the Trans-Siberian Railroad (1904, Russia)

e) The Panama Canal (1903-1914) – America Ascendant


363 miles long,
40 feet wide,
4 feet deep,
173m elevation change, 36 locks.
Cost: $200 million (in 2020 dollars)

# II. 1935 - 1995: Megaprojects Across America

- The Bessemer steel revolution: Suspension bridges & skyscrapers

a) **The Hoover Dam (1928–1936) – Redefining the possible**

b) TVA (1933 – 1950) – Hydro power & flood control on an industrial scale

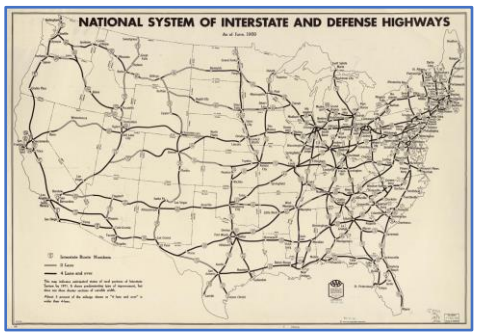
c) **The U.S. Interstate Highway System (1956-1991): The biggest megaproject in history**

d) BART/MARTA/Metro (1966-1984): Reinventing commuter rail for the automobile era

e) Battery Park City (1969-2005): A new town in town, and the largest downtown master-planned community in the United States

f) The Big Dig (1991-2007) – The end of an era

(a)




(c)

(d)

(e)

# III. 1964 - 2016: Megaprojects Go Global

a) The Delta Works (The Netherlands, 1958)

**b) The Shinkansen Bullet Train (Japan, 1964)**

**c) Mexico City Metro (Mexico, 1969)**

d) TGV-Tres a Grande Vitesse (France, 1981)

e) Canary Wharf (United Kingdom, 1991)

f) The Chunnel (United Kingdom/France, 1994)

g) 3 Asian Super Airports - Kansai, Hong Kong, Incheon (Japan, HK, S. Korea)

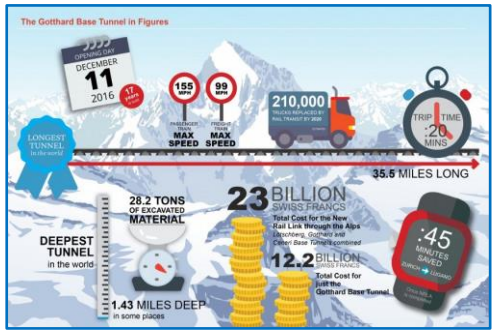
h) Akashi Kaikyo Bridge (Japan, 1998)

i) The Gotthard Base Tunnel (Switzerland, 2016)


(a)

(b)


(c)




(i)

# IV. 1994 – Present: China Takes the Lead

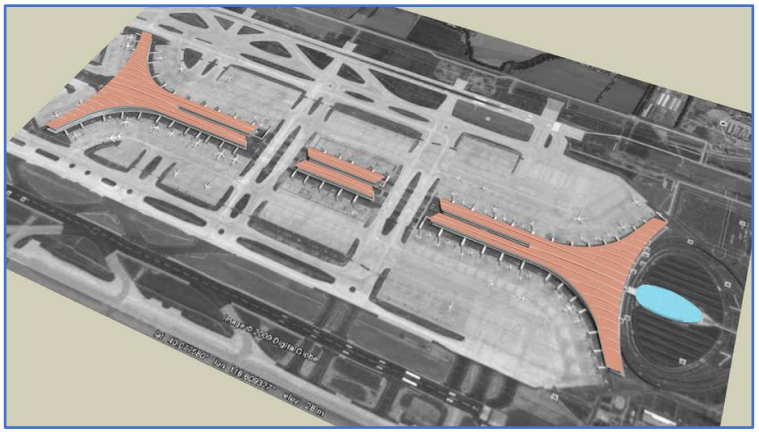
a) **The Three Gorges Dam (1992-2012): Powering a nation**

b) Beijing Capital International Airport (1999-2008): Beijing builds its showpiece

c) Shanghai Metro System (1993-present): From global laggard to global leader in 20 years

d) **China High-speed Rail Network (2004-2018): Ambition meets standardization**

(a)



(b)

(c)

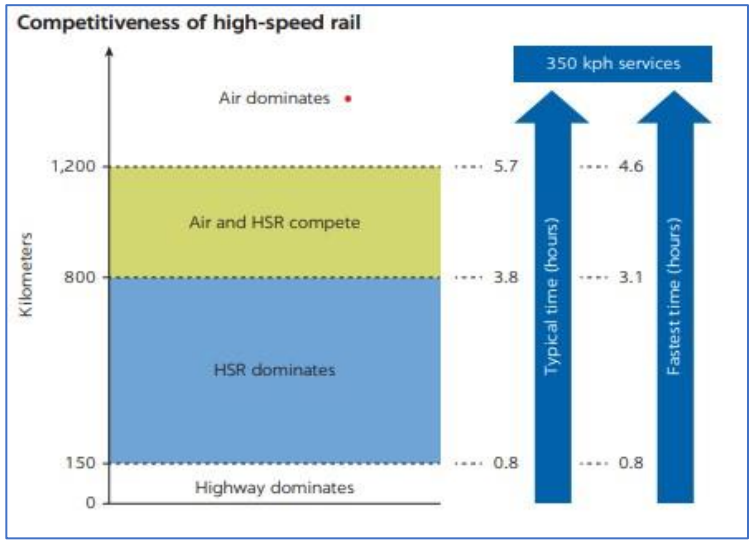
# *Four Transportation Megaprojects Up Close*

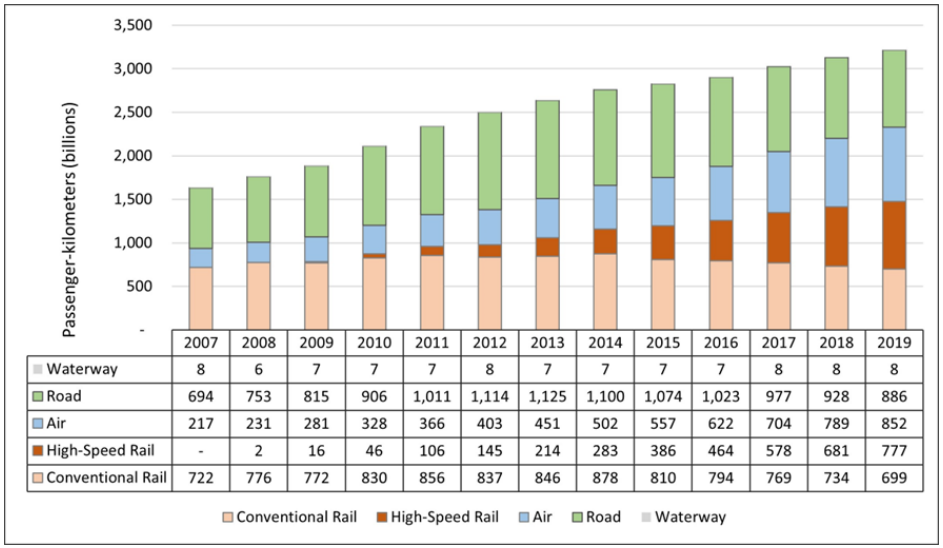
# 1. China's (Amazing) 40,000 km National High-speed Rail Network


Chapter Authors: Ziming Liu & John Landis

# China's National HSR Network by the Numbers

- 37,000-km, national ("8 by 8") HSR network connecting ALL large Chinese cities with 2X – 30X daily service.
- Two speed classes of trains (300-350 kph and 200-250 kph).
- 2 billion passengers in 2019, 3x the number traveling by air; and 13x the number of passenger-kms of second-place Japan.
- Cut rail travel times by two-thirds. (e.g., Beijing-Shanghai: 10 hrs. to 4 hrs.)
- Estimated capital cost: US$ 630 billion.
- 4 years from funding authorization to opening of first line; 16 years to 37,000 km!!!




| | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Waterway | 8 | 6 | 7 | 7 | 7 | 8 | 7 | 7 | 7 | 7 | 8 | 8 | 8 |
| Road | 694 | 753 | 815 | 906 | 1,011 | 1,114 | 1,125 | 1,100 | 1,074 | 1,023 | 977 | 928 | 886 |
| Air | 217 | 231 | 281 | 328 | 366 | 403 | 451 | 502 | 557 | 622 | 704 | 789 | 852 |
| High-Speed Rail | - | 2 | 16 | 46 | 106 | 145 | 214 | 283 | 386 | 464 | 578 | 681 | 777 |
| Conventional Rail | 722 | 776 | 772 | 830 | 856 | 837 | 846 | 878 | 810 | 794 | 769 | 734 | 699 |

# China's National HSR Network: Rights & Wrongs

**What went right?**

**MOST EVERYTHING:** (i) National network designed to take advantage of 200 – 1200 km HSR "sweet spot"; (ii) Technology transfer model: turnkey acquisition → domestic engineering & manufacturing expertise; (iii) Government doubled down on HSR construction during the GFC; (iv) Planning, engineering, construction and financing procedures all standardized; (v) Capable & driven project management team.

**What went wrong?**

**NOT MUCH.** Some lines opened before they were thoroughly tested, leading to a 2011 train collision in which 40 passengers were killed and 192 were injured. Initial fare structure was not sensitive to line-by-line demand. No effect on China's economic geography.


# China National HSR Network: Summary Scores

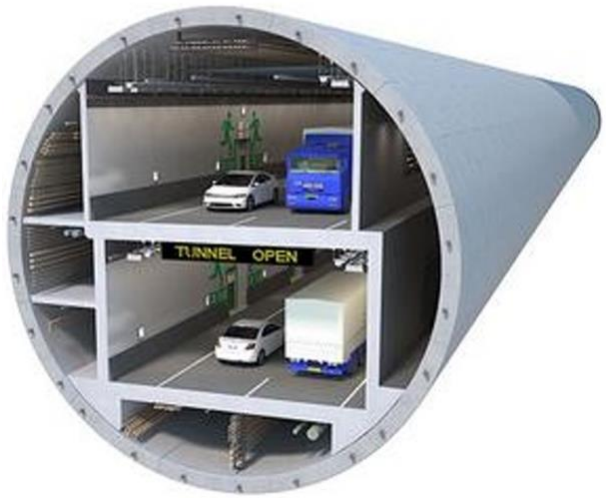
| | **Performance Criteria and Ratings:** 4=yes, 3=mostly yes, 2=somewhat, 1=mostly no, 0=no, U=unknown | China HSR | Seattle Hwy 99 Tunnel | London Crossrail | Berlin Brandenburg Airport | New LaGuardia Terminal B |
|---|---|---|---|---|---|---|
| 1 | Achieves project goals and objectives in a timely manner | **4** | 4 | 2 | 2 | 4 |
| 2 | Uses appropriate and cost-efficient technologies | **4** | 4 | 3 | 3 | 4 |
| 3 | Avoids significant planning, engineering, construction and delivery delays. | **4** | 2 | 1 | 0 | 4 |
| 4 | Avoids significant design, engineering, construction and delivery cost overruns. | U | 3 | 1 | 0 | 4 |
| 5 | Operating revenues meet projections | 2 | 3 | 4 | 3 | 3 |
| 7 | Utilizes a robust revenue projection and financing model. | U | 2 | 4 | 2 | 3 |
| 6 | Manages major sources of development and financial risk. | U | 2 | 2 | 2 | 3 |
| 8 | Provides for ongoing operations and management activities. | **3** | 3 | 3 | 2 | 3 |
| 9 | Promotes synergies, and positive externalities. | **3** | 4 | 4 | 1 | 2 |
| 10 | Minimizes environmental and social costs. | **3** | 3 | 3 | 1 | 1 |
| 11 | Incorporates sustainability, resilience, and/or equity concerns. | **3** | 2 | 2 | 1 | 1 |
| 12 | Generates positive and transferable lessons & experience | **3** | 3 | 3 | 1 | 3 |
| **Total Success Score** | | **29** | **35** | **32** | **18** | **35** |
| **Percentage Success Score** | | **73%** | **73%** | **67%** | **38%** | **73%** |

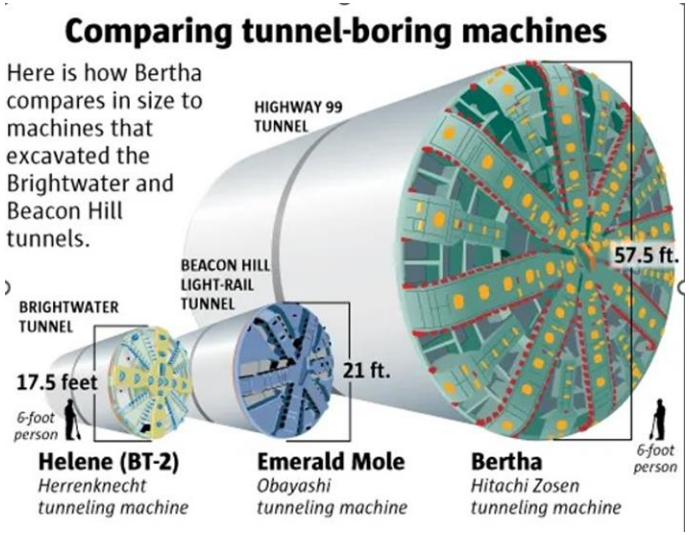
# 2. *Seattle SR99 Tunnel/ Alaska Way Viaduct Replacement Project*


Chapter Authors: Prof. Jan Whittington & Molly Riddle

# Seattle SR99 Tunnel Project by the Numbers

- 2.3-mile 58-foot single-bore tunnel beneath downtown Seattle replacing the elevated Alaska Way Viaduct completed in 1959 and damaged in the 2001 Nisqually Earthquake
- Planning started: 2003
- Voter approval of the single-bore design: August 2011
- Boring operations begin: June 2013
- ***Time-out to repair broken Bertha: Two years (12/2013 – 12/2015)***
- Tunnel opens to traffic: February 2019, three years behind schedule
- Budgeted cost:  $3.1 billion / Final cost $3.35 billion (7% cost overrun)
- Average daily tunnel traffic (December 2019, after tolling began): 57,000 vehicles – 23,000 less than the elevated viaduct.



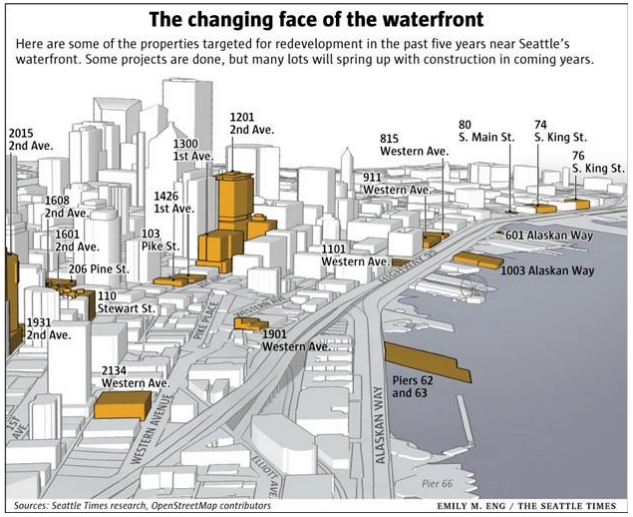
# The SR99 Tunnel Project: Rights & Wrongs

## What Went Right?

- WSDOT's project management and budgeting process.
- The collaborative "Partnership Process" that guided the planning process after Seattle voters rejected WSDOT's preferred replacement concepts in 2007.
- Planning and implementation of the Waterfront Seattle Concept Design by the Central Waterfront Committee, James Corner Field Operations, the Seattle Planning Department, and later, the Friends of the Seattle Waterfront.

## What Went Wrong?

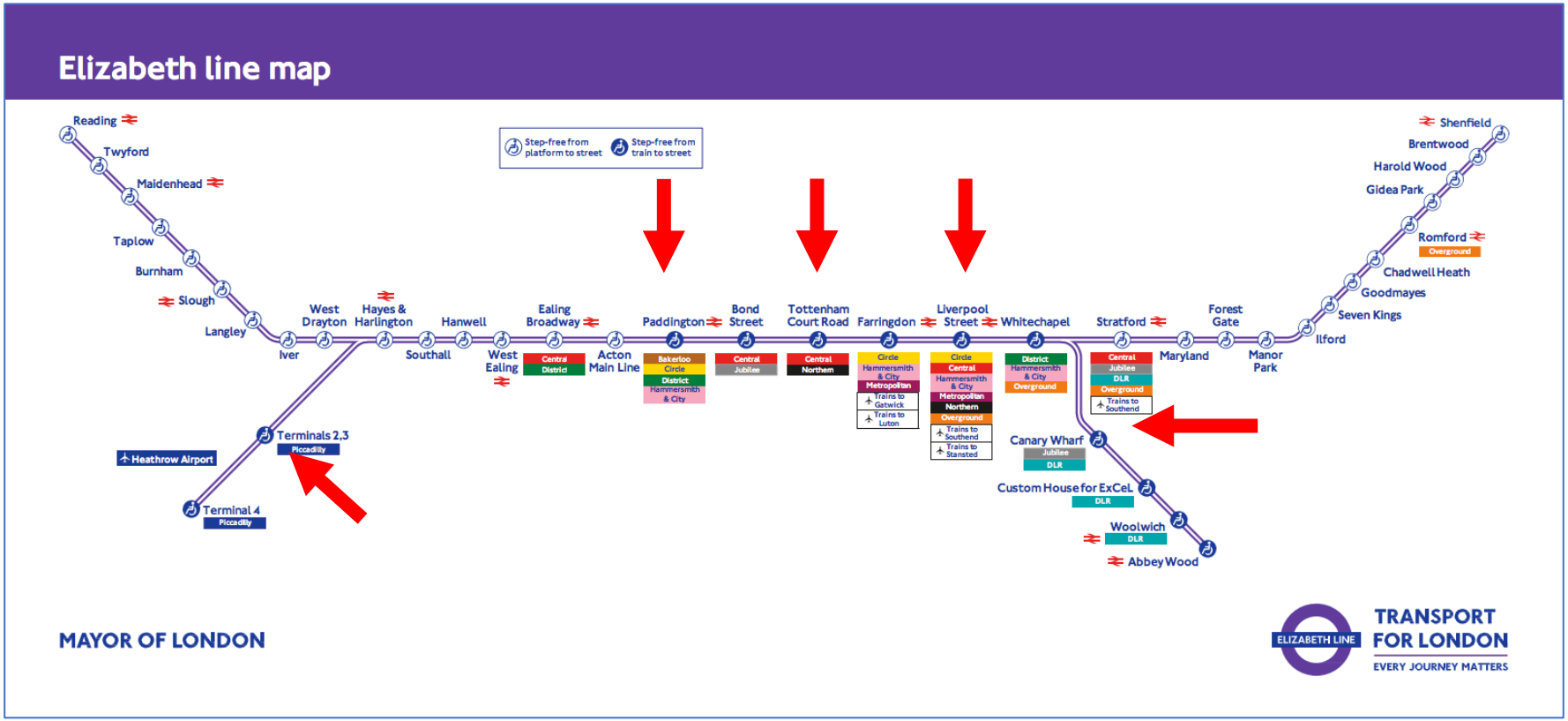
- Planning Round 1 (2003-2007): AWVRP planning process was too technocratic and insufficiently collaborative, resulting in voter rejection of both of WSDOT's preferred alternatives.
- Seattle Mayor Mike McGinn's unwillingness to sign the completed EIS.
- WSDOT 's lack of contingency planning and budgeting for a project using a new boring technology (Bertha) with no backup TBM, and an international tunneling consortium whose partners each had different incentives (and spoke different languages).

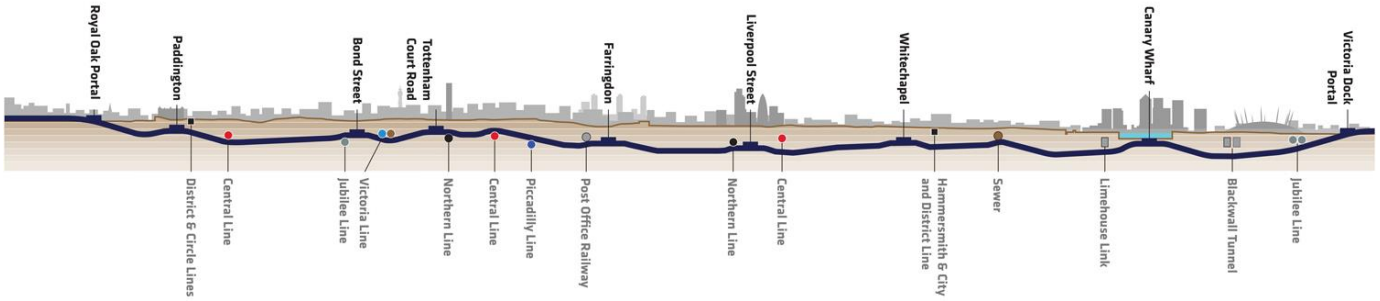


# Seattle SR 99 Tunnel Project: Summary Scores

| | **Performance Criteria and Ratings:** 4=yes, 3=mostly yes, 2=somewhat, 1=mostly no, 0=no, U=unknown | China HSR | Seattle SR99 Tunnel | London Crossrail | Berlin Brandenburg Airport | New LaGuardia Terminal B |
|---|---|---|---|---|---|---|
| 1 | Achieves project goals and objectives in a timely manner | 4 | **4** | 2 | 2 | 4 |
| 2 | Uses appropriate and cost-efficient technologies | 4 | **4** | 3 | 3 | 4 |
| 3 | Avoids significant planning, engineering, construction and delivery delays. | 4 | 2 | 1 | 0 | 4 |
| 4 | Avoids significant design, engineering, construction and delivery cost overruns. | U | **3** | 1 | 0 | 4 |
| 5 | Operating revenues meet projections | 2 | **3** | 4 | 3 | 3 |
| 7 | Utilizes a robust revenue projection and financing model. | U | 2 | 4 | 2 | 3 |
| 6 | Manages major sources of development and financial risk. | U | 2 | 2 | 2 | 3 |
| 8 | Provides for ongoing operations and management activities. | 3 | **3** | 3 | 2 | 3 |
| 9 | Promotes synergies, and positive externalities. | 3 | **4** | 4 | 1 | 2 |
| 10 | Minimizes environmental and social costs. | 3 | **3** | 3 | 1 | 1 |
| 11 | Incorporates sustainability, resilience, and/or equity concerns. | 3 | 2 | 2 | 1 | 1 |
| 12 | Generates positive and transferable lessons & experience | 3 | **3** | 3 | 1 | 3 |
| **Total Success Score** | | **29** | **35** | **32** | **18** | **35** |
| **Percentage Success Score** | | **73%** | **73%** | **67%** | **38%** | **73%** |

# 3. London Crossrail (Elizabeth Line)



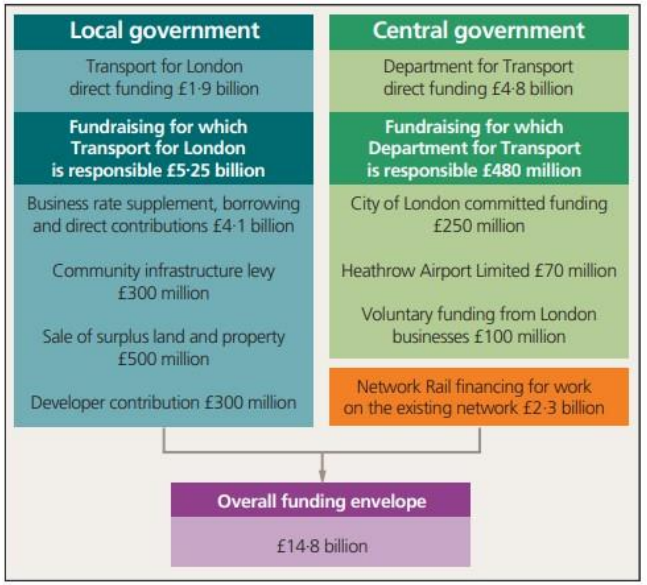



# Crossrail by the Numbers

- **117 km** high-speed metro line connecting Heathrow Airport (and parts west) to central London, Canary Wharf, and London's East End residential communities. Its 21 km central section runs in deep bore tunnels.
- First proposed in the 1940s. After several false starts, construction was **approved by Parliament in 2008 at a projected cost of £15.9B** (later reduced to £14.8B) Scheduled for completion in 2018.
- Finally opened in 2022 at a cost 30% above the original projection.
- 10 new stations built by different contractors. Entirely new digital signaling and train control technology linked to passenger information system

Selected before and after travel times:

- Paddington to Tottenham Court Road: 20 minutes → 4 minutes
- Bond Street to Whitechapel: 24 minutes → 10 minutes
- Paddington to Canary Wharf: 34 minutes → 17 minutes
- Canary Wharf to Heathrow: 55 minutes → 39 minutes



# Crossrail Rights and Wrongs

**What went right?**

- The UK Government's project approval process requiring project sponsors to fully document and stress test their funding model before approval is granted.
- The overall project concept which centered on shortening travel times between London's business centers as a means of promoting further agglomeration economies and value generation.
- The tunnel boring program.

**What went wrong?**

- An unproven project management approach that substituted a matrix model (in which contractors coordinate with each other) for a traditional hierarchical control model.
- An overemphasis on trying innovative management approaches.
- Senior executives and project managers in denial about the root causes of project delays and cost overruns.
- Relying on different contractors to build different stations.
- Unresolved management and funding conflicts between the two principal clients: The Department for Transport (DfT) and Transport for London (TfL)

# London Crossrail: Summary Scores

| | **Performance Criteria and Ratings:** 4=yes, 3=mostly yes, 2=somewhat, 1=mostly no, 0=no, U=unknown | China HSR | Seattle Hwy 99 Tunnel | London Crossrail | Berlin Brandenburg Airport | New LaGuardia Terminal B |
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| 7 | Utilizes a robust revenue projection and financing model. | U | 2 | **4** | 2 | 3 |
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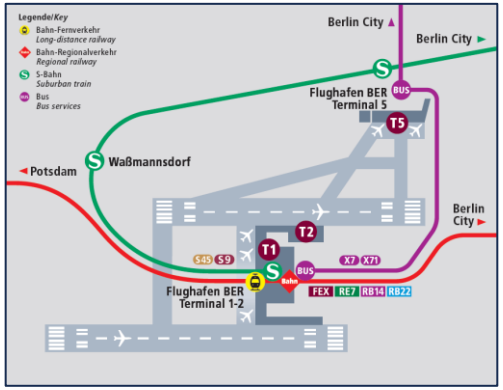
| **Total Success Score** | | **29** | **35** | **32** | **18** | **35** |
| **Percentage Success Score** | | **73%** | **73%** | **67%** | **38%** | **73%** |

# 4. Two 21st Century Airports: Berlin Brandenburg & LaGuardia Terminal B

Berlin Brandenburg Airport Locator Map and Area Plan


LaGuardia Airport Locator Map and Terminal B Reconstruction Plan


# Berlin & LaGuardia by the Numbers

| | Berlin Brandenburg Int'l. Airport | LaGuardia Airport Central Terminal B Reconstruction |
|---|---|---|
| Overall Market Size (2015) | **3.5M** metro area population; **29.5M** airport passengers(2 airports); 6% per year passenger growth rate | **18.4M** metro area population; **124M** passengers (3 airports); 2% per year passenger growth rate |
| Capacities | **360,000** sqM terminal**, 41** gates, serving **45** million passengers (max)- replacing Tegel & Schoenfeld Airports | **78,000** sqM terminal, **38** gates, serving **17.5** M passengers (max) – |
| Lead Sponsors/ Funders | Flughafen Berlin Brandenburg GmbH (FBB), a joint venture of the Berlin and Brandenburg state governments | PPP involving Port Authority of NY & NJ with LaGuardia Gateway Partnership (LGP) |
| Approval Given/ Construction Begins/ Promised Opening | 1999 / Sept. 2006 / October 2010 | 2016 / 2016 / 2021 (terminal remained in operation during construction) |
| Construction Completed | October 2020 (+10 years) | 2021 |
| Approved Budget | €2.2 billion | $4 billion |
| Estimated Final Cost | €8.2 billion (270% overrun) | $4 billion |

# Berlin & LaGuardia– Rights & Wrongs

| New Berlin Brandenburg Airport | LGA Terminal B Reconstruction |
|---|---|
| **What Went Right?**<br>• Absolutely nothing.<br>**What Went Wrong?**<br>• Losing PPP bidder initiated a lengthy & costly lawsuit.<br>• FBB senior managers had no experience managing an airport project, and repeatedly misled sponsors and the public about the project's status.<br>• Contractors hired without a final work program in place.<br>• Subcontractors couldn't effectively coordinate with each other, resulting in normal change orders creating unnecessary bottlenecks.<br>• Ventilation and fire suppression system didn't work as designed, requiring a costly redesign.<br>• Terminal design was too inflexible for needs of rapidly changing airline industry. | **What Went Right?**<br>• Despite last-minute interference by NY Governor Cuomo, the PA's initial (and excellent) terminal redesign remained in place.<br>• Governor Cuomo was a strong project champion.<br>• The design, engineering and construction contractors had worked together on airport projects in the past.<br>• Experienced PA project managers kept the project on schedule and budget.<br>• The PPP negotiations went off without a hitch.<br>• All the project partners were committed to keeping the existing terminal open during construction.<br>**What Went Wrong?**<br>• Ongoing uncertainties about the people mover feasibility and use (Funding eventually canceled in 2022). |

# Berlin & LaGuardia: Summary Scores

| | **Performance Criteria and Ratings:** 4=yes, 3=mostly yes, 2=somewhat, 1=mostly no, 0=no, U=unknown | China HSR | Seattle Hwy 99 Tunnel | London Crossrail | Berlin Brandenburg Airport | New LaGuardia Terminal B |
|---|---|---|---|---|---|---|
| 1 | Achieves project goals and objectives in a timely manner | 4 | 4 | 2 | 2 | **4** |
| 2 | Uses appropriate and cost-efficient technologies | 4 | 4 | 3 | **3** | **4** |
| 3 | Avoids significant planning, engineering, construction and delivery delays. | 4 | 2 | 1 | 0 | **4** |
| 4 | Avoids significant design, engineering, construction and delivery cost overruns. | U | 3 | 1 | 0 | **4** |
| 5 | Operating revenues meet projections | 2 | 3 | 4 | **3** | **3** |
| 7 | Utilizes a robust revenue projection and financing model. | U | 2 | 4 | 2 | **3** |
| 6 | Manages major sources of development and financial risk. | U | 2 | 2 | 2 | **3** |
| 8 | Provides for ongoing operations and management activities. | 3 | 3 | 4 | 2 | **3** |
| 9 | Promotes synergies, and positive externalities. | 3 | 4 | 3 | 1 | 2 |
| 10 | Minimizes environmental and social costs. | 3 | 3 | 3 | 1 | 1 |
| 11 | Incorporates sustainability, resilience, and/or equity concerns. | 3 | 2 | 3 | 1 | 1 |
| 12 | Generates positive and transferable lessons & experience | 3 | 3 | 2 | 1 | **3** |
| **Total Success Score** | | **29** | **35** | **32** | **18** | **35** |
| **Percentage Success Score** | | **73%** | **73%** | **67%** | **38%** | **73%** |

# *The Seven Secrets of Megaproject Success*

# The Seven Secrets of Megaproject Success

1. Project manager competence and experience matter above all else!!!! (👍 Singapore Jewel Changi & LaGuardia Airports/👎 Berlin-Brandenburg Airport)
2. Project planners and managers should carefully study past projects to learn from experience. (👍 Singapore Changi & BRT/ 👎 Brooklyn Bridge Park)
3. For multi-site projects, standardization can a source of cost-efficiency and timely delivery. (👍 China HSR & City Metros/ 👎 Crossrail)
4. Senior project management should be knowledgeable, capable, and accountable. (👍 HafenCity/ 👎 London Crossrail)
5. Key market assumptions and budgets/schedules should be stress tested. (👍 London Crossrail/ 👎 HKZM Bridge)
6. Develop contingency scheduling and financing plans for worst-case scenarios. (👍 LaGuardia Airport/ 👎 Seattle AWVR Tunnel)
7. Look to make the transportation-land use connection. (👍 Seattle AWVR Tunnel & London Crossrail & Curitiba BRT/ 👎 Jakarta BRT)