Why do many mega projects suffer from time and cost overruns?

Analysis of typical failure patterns
2019

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Mega Projects – Definition and Key Observations

Definition

1. Large scale and complex projects of transformational nature
2. ⩾ $1bn and Multi-year
3. Competing Financial and Social/ Economic/Strategic objectives

"Megaprojects are not magnified versions of smaller projects…..They are a completely different breed in terms of level of aspirations, lead times, complexity and stakeholder involvement"

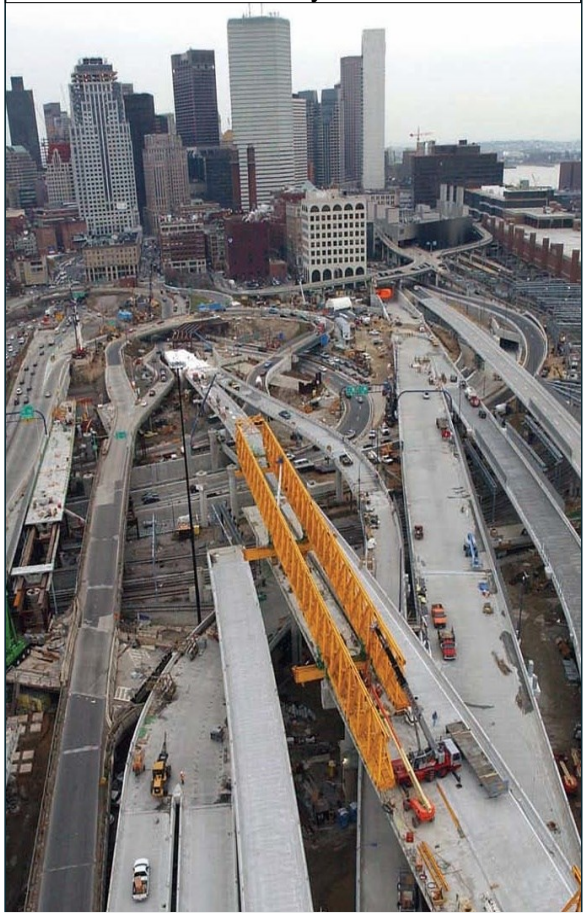
Key Observations

1. 9 out of 10 go over budget
   - Overruns of 50% are common; and >50% are not uncommon
   - Rail Projects 44.7% over budget; Bridges and Tunnels 35% over budget
2. Time over run
   - 1 year delay estimated to increase costs by ~4.5-5%
   - Dams delayed 45% on average

Source:
1) McKinsey Article "Megaprojects: The good, the bad, and the better"
2) Article by Bent Flyvjerg, Oxford University "What You Should Know About Megaprojects, and Why: An Overview"

Central Artery/Tunnel Project Boston - The “Big Dig”

Central Artery/Tunnel Project Boston, (the “Big Dig”)	
Location	Boston, USA
Time	1991 - 2007
Owner	Massachusetts Turnpike Authority



Description

- Known as the most expensive highway job in the US
- Re-routing the central artery of interstate 93 through the center of the city into the 1.5 mile Thomas P. O’Neill Jr. Tunnel
- Several related subprojects: Construction of the Ted Williams Tunnel (3.5 mile tunnel extending Interstate 90 to Logan International Airport), the Leonard P. Zakim Bunker Hill Memorial Bridge over the Charles River, and the Rose Kennedy Greenway in the space vacated by the previous I-93 elevated roadway
- It included excavating 16mn cubic yards of dirt; used 3mn cubic yards of concrete

Budget and time span

	Planned	Effective	Overrun
Cost[1)]	USD 6.0bn	USD 14.6bn USD 22bn with interest	243% 367%
Time[2)]	1991 - 1998	1991 - 2007	229%

Challenges

- Unanticipated geological problems due to the area being a landfill (unstable ground)
- Barriers such as buried houses and sunken ships
- Tunneling was undertaken with railway and metro traffic uninterrupted
- Use of advanced techniques (e.g. ground freezing, stabilizing existing metro tunnels from beneath)
- Big design flaws and persisting problems with quality of work and materials
  - “Thousands of leaks” because contractors did not pour concrete correctly
  - Use of sub-standard materials by sub contractors e.g. leading to a roof collapse of the tunnel)
  - 25,000 light fixtures for the tunnel had to be replaced due to galvanic corrosion

1) 2007 dollars, inflation adjusted to make 1991 and 2007 figures comparable, the initially planned volume in 1982 was USD 2.8bn at 1982 dollar value; the figure including interest was estimated by the Boston Globe 2) Start of construction, the planning began already in 1982

Source: 1) Massachusetts Department of Transportation - “Project Background - The Big Dig”; 2) The Boston Globe, 29 Dec 2015 - “10 years later, did the Big Dig deliver?”; 3) Construction Equipment Guide, 04 Jun 2007 - “Triumph, Tragedy Mark Boston’s Big Dig Project”

Channel Tunnel

> "It's a wonderful thing from which we've all benefited, apart from the people who paid for it to be built who lost substantially all their money,"
> *said Douglas McNeill, investment director and analyst at Charles Stanley*

Channel Tunnel

Location	France/UK
Time	1988 - 1994
Owner	Getlink SE (former Euro-tunnel) in BOOT agreement

Description

- 50.45 km long rail tunnel linking Folkestone-Kent, UK, with Coquelles, in Northern France, beneath the English Channel at the Strait of Dover
- Construction not considered to be exceptionally difficult, with mostly favorable geological conditions
- Up to 400 trains pass through the tunnel each day, carrying an average of 50,000 passengers, 6,000 cars, 180 coaches and 54,000 tons of freight
- Built as a build-own-operate-transfer (BOOT) project with a concession till 2058
- Initial financing cushion of 25% proved to be insufficient, with several additional fund raising rounds required a major debt restructuring in 1997
- Recognized as first mainline rail to use special cooling equipment (chilled water)

Budget and time span

	Planned	Effective	Overrun
Construction Cost	GBP 2.8bn	GBP 4.65bn	166%
Full Cost	GBP 4.8bn[1)]	GBP 10.5bn	219%
Time	1988 - 1993	1988 - 1994	120%

Challenges

- Changed specifications for the tunnel (need for air conditioning systems to improve safety that were not included the initial design)
- Issues with the communication between the British and French teams who were essentially tunneling from the two different sides and meeting in the middle
- The contract was bid on by competing firms, this framework necessarily encourages the 'winner's curse' of the successful bidders having the lowest and most optimistic price estimates

1) Construction 2.8bn, Financing costs 1.0bn, Inflation 489mn, Other 565bn

Source: 1) Project Management Institute; 2) FT, 05.05.2014 - "Channel tunnel's 20th birthday holds lesson on big projects"; Eurotunnel/Getlink Group Homepage - "How the Channel Tunnel was Built", 3) Telegraph, 01 Dec 2015 – "The Channel Tunnel: 20 fascinating facts"; 4) Japan Railway and Transport Review Nr. 11 - "Financing Eurotunnel"

Burj Khalifa

Burj Khalifa	
Location	Dubai, UAE
Time	2004 - 2009
Owner	Emaar Properties

Description

- The Burj Khalifa has been the tallest structure in the world since 2008 with a total height of 828 m. It is the centerpiece of large-scale, mixed-use development
- 22 million man-hours, 55,000-ton steel rebar and 110,000-ton concrete were used to complete the construction of the tower in 6 years
- There are 163 floors located above the ground served by 58 elevators running at a top speed of 10 meters per second. Burj Khalifa has 2957 parking spaces, 304 hotel rooms and 900 apartments

Budget and time span

	Planned	Effective	Overrun
Cost	USD 876mn	USD 1.5bn	171%
Time	Jan 2004 - Sep 2008	Jan 2004 - Dec 2009	127%

Challenges

- Cost increases due to design changes: The height of the structure was out of esthetical reasons changed from 808 m to 828 m (with previous height changes of up to 100m assumed, but not proven, as the initially planned height was never disclosed), the Armani Hotel was included in the building, and during the construction work the design of apartments was changed towards more luxurious finishes
- Delays caused by labor problems (strikes for higher wages and safer working conditions)
- With the longer duration, material price inflation in 2008 for steel (+75%), cement, and other commodities hit the costs

Source: 1) Council on Tall Buildings and Urbat Habitat – “Brief on the construction planning of the burj dubai project dubai uae”; 2) Civil & Structural Engineer – “Design and construction of the world's highest building”; 3) Skidmore, Owings and Merril - “Burj Khalifa Structural Engineering”; 4) Gahendra Chand – “Burj Khalifa Management analysis”

Sydney Opera House

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Sydney Opera House

Location	Sydney, Australia
Time	1959 - 1973
Owner	New South Wales Government

Description

- Multi-venue performing arts center in Sydney, New South Wales, Australia. Considered to be one of the 20th century's most famous and distinctive buildings
- The House hosts 3,000 events every year
- Its performances have an annual audience of two million
- The building was listed as a UNESCO World Heritage site in 2007
- One of the first structural designs to use Araldite (synthetic resign adhesive to bond metals)
- The opera house was funded to a great extent by a lottery running from November 1957 till September 1986, and raising a total of AUD 102mn

Budget and time span

	Planned	Effective	Overrun
Cost	AUD 7mn	AUD 102mn	1,457%
Time	Mar 1959 - Jan 1963	1959 - 1973	365%

Challenges

- “No plan, only aspiration” – During the bidding process, the most elegant design was selected, although it did not meet the competition rules
- Construction started before design finalized, e.g. no clear concept of how the roof might be constructed, consequently the roof was built iteratively (trial and error)
- The architect Joern Utzon led the project with Ove Arup, the person in charge for structure and engineering, but without a real project manager
- 1966 Utzon was forced to resign, left Australia (with the design plans), never returned
- The building was then finished by Australian engineers, developing the design from scratch

Source: 1) Sourcecable, 8 October 2014 – “Opera House Named to Over-Budget Hall of Shame”; 2) Architecture Blog, 19 Feb 2018 – “The Sidney Opera House construction: A case of project management failure”; 3) News Corp Australia, 22 Oct 2013 – “Why Sydney's Opera House was the world‘s biggest planning disaster”

Scottish Parliament Building

Scottish Parliament Building

Location	Edinburgh, Scotland
Time	1999 - 2004
Owner	Scottish Parliamentary Corporate Body

Description

- A campus of several buildings, reflecting different architectural styles, with a total floor area of 31,000 square meters (312,000 sq. ft.), providing accommodation for Members of the Scottish Parliament, their researchers and parliamentary staff
- The parliament building won numerous awards and has been described as "a tour de force of arts and crafts and quality without parallel in the last 100 years of British architecture“

Budget and time span

	Planned	Effective	Overrun
Cost	GBP 40mn	GBP 241mn GBP 414mn (Fully loaded cost)[1)]	602% 1,035%
Time	1999 – 2001	1999 - 2004	250%

Challenges

- The primary cause is scope creep. Namely changes to size, scale and specifications during the construction
- Cost estimates were increased all the time, with information fed to the public piece-meal (first estimates did not include the price for the land, professional fees and VAT)
- The project was complicated by the deaths of the architect in July 2000 and the responsible First Minister the following October; and the existence of a multi-headed client consisting of the SPCB, the Presiding Officer and an architectural advisor
- The client was “obsessed with early completion” and failed to understand the impact on cost and completion date, if high-quality work and a complex building were required

1) During the planning of the project the construction cost for the corpus of the buildings exclusively was used as the estimate for the full cost in order for the project to appear financially attractive. E.g. the cost for the land, consulting fees, demolition and archeology work, risk & provisions, and the VAT were not included in the first estimate of GBP 40mn

Source: 1) Scotsman, 28 Aug 2003 – “Holyrood's world-class price overrun”; 2) Strategic Project and Portfolio Management, 8 Feb 2011 - “Project Failure – Scottish Parliament”

The British Library building at St. Pancras

The British Library building

Location	UK, London
Time	Beginning 1970's-1997
Owner	The British Library

Description

- The building at St. Pancras is the largest public building constructed in the UK in the 20th century ("The British Library" is actually not a building but an institution disposing of several facilities. It was established in 1973 by the Parliament)
- The basements extend to a depth of 24.5 meters
- A total floor area of over 112,000 sq meters spread over 14 floors - 9 above ground, 5 below
- 10 million bricks and 180,000 tones of concrete were used

Budget and time span

	Planned	Effective	Overrun
Cost	GBP 164mn	GBP 511mn	311%
Time	1982-1989	1982-1997	214%

Challenges

- The project, initially planned to be placed in Bloomsbury, faced resistance from the residents and neighborhood conservation initiatives. Thus, several years were spent to agree on a new location with the necessity to redesign the building when finally the location was changed from Bloomsbury to St. Pancras
- Successive governments slashed the budget, most heavily under the Thatcher administration, when the building was "cut in half". Accordingly the project had to be constantly redesigned
- Due to the long project duration key people were changing permanently, with chains of responsibility broken, and project knowledge lost
- The project faced persistent quality issues with the materials used, and the mechanical, electrical and plumbing installations

Source: 1) The NYT, 17 Sep 1995 – "Britain's Ugly Duckling Library Ready to Fly"; 2) The British Library – "History of the British Library"; 3) The Independent, 10 Jul 1994 – "What took them so long?"

F-22 Raptor fighter aircraft development

F-22 Raptor	
Location	USA
Time	1981 – 2014 (production terminated)
Owner	United States Airforce

Description

- Fifth-generation, single-seat, twin-engine, all-weather stealth tactical fighter aircraft
- With increasing costs for the program, the number of aircraft to be procured was successively reduced from 750 to a final procurement tally of 187, thus dampening the cost increase of the program, but resulting in tripling the cost per unit
- The high cost of the aircraft, a lack of clear air-to-air mission due to delays in Russian and Chinese fighter programs, a ban on exports, and development of the more versatile F-35 led to the end of F-22 production

Budget and time span

	Planned	Effective	Overrun
Cost (per aircraft)	USD 139mn	USD 412mn	296%
Time (development)[1)]	1981-1990	1981-2000	211%

Challenges

- The aircraft combined several new technologies: It is the first operational aircraft to combine super cruise, super maneuverability, stealth, and sensor fusion in a single weapons platform. As many of the underlying technologies and the mode of their integration into one system were not fully developed yet, unforeseen setbacks and delays occurred, more then doubling the development time
- The final price per aircraft depends to a high extent on scale effects in production. With the volume of the program being reduced to control the total cost, and the development costs steadily increasing, the price per unit tripled
- As the export of the related technology is forbidden by federal law, economies of scale through accessing markets abroad cannot be achieved

1) Time from the official Air Force requirement, Lockheed and Northrop had started development before
Source: 1) LA Times, 16 Jun 2013 – “F-22 program produces few planes, soaring costs”; 2) Wired, 22 Dec 2012 – “Buyer’s Remorse: How Much Has The F-22 Really Cost?”

Berlin Brandenburg Airport

Berlin Brandenburg Airport	
Location	Germany
Time	2006 – 2020 (current plan, initially to open in 2011)
Owner	Berlin Brandenburg Flughafen Holding (state owned)

Description

- International airport currently under construction, with a projected annual passenger volume of 34 mn, expected to be the third busiest airport in Germany
- Part of the business model of the airport was the assumption that Berlin might become an international hub, accordingly the airport was planned with a substantial recreational and shopping infrastructure. It turned out that no airline would make Berlin their hub

Budget and time span

	Planned	Effective	Overrun
Cost	EUR 2.83bn	EUR 10.3bn (est.)[2)]	364%
Time[1)]	2006-2011	2006-2020 (est.)	280%

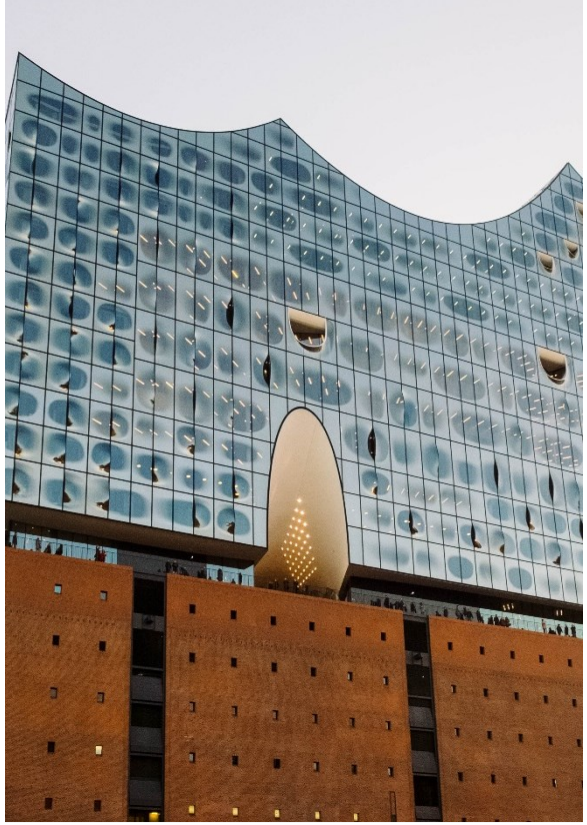
Challenges

- The airport was heavily opposed by the people living in the vicinity, delaying the planning process process with a multitude of law suits
- During construction, due to underestimating the actual costs, construction flaws and increased collateral expenses for soundproofing nearby homes (soundproofing alone is estimated to be at EUR 50mn) costs increased steadily. New severe construction flaws keep popping up on a regular base
- 26 days before moving flight operations to the new airport, the opening was postponed due to severe construction flaws (e.g. non-operational fire safety systems)
- Financial control by the local/federal governments was found by the Brandenburg state comptroller as "insufficient and inefficient", with several cases of corruption

1) Time for actual construction. The planning process started in 1991 and took 15 years due to law suits about the ownership (initially the airport was intended to be a private company, but then the project was taken over by the state) and environmental and residents protection issues 2) Estimated full costs including necessary works after the official opening
Source: 1) Bloomberg, 30 Mar 2017 – "Berlin's Airport Debacle: Five Years Late and Counting"; Financial Times, 15 Dec 2017 – "Berlin's new airport to open almost a decade later than planned"

Elbe Philharmonic Hall

Elbe Philharmonic Hall	
Location	Germany
Time	2007 – 2016
Owner	Municipality of Hamburg



Description

- One of the largest and most acoustically advanced concert halls in the world
- The building has three concert venues. The Great Concert Hall can accommodate 2,100 visitors whereby the performers are in the center of the hall surrounded by the audience in a vineyard style arrangement
- The acoustics were designed by Yasuhisa Toyota who installed about 10,000 individually micro-shaped drywall plates to disperse sound waves
- The building also includes also a hotel and residential space

Budget and time span

	Planned	Effective	Overrun
Cost	EUR 77m	EUR 789m	1,025%
Time	2007-2010	2007-2016	300%

Challenges

- The initial price of EUR 77m, deceptively set very low by the responsible politicians was even by the architect considered as being “absurdly low”, given that the interior showed an “unparalleled scale of ambition”, e.g. featuring 1,000 hand-blown glass lamps and 10,000 uniquely carved acoustic panels
- Materials were sourced at very high prices (planners had spent almost €300 on each toilet brush and paper towel dispensers cost €957 each)
- Building work ceased for a year amid a legal battle between the city, the Swiss architects Herzog & de Meuron and the builders Hochtief
- The architects were paid EUR 94mn on the base of a one-sided agreement in which also the owner waived all claims towards them, especially cost responsibility

Source: 1) The Guardian, 04 Nov 2017 – “We thought it was going to destroy us”; 2) Der Spiegel, 10 Jan 2013 – “A History of Political Deception in Germany”

Krestovsky Stadium in Saint Petersburg

Krestovsky Stadium

Location	Russia, Saint Petersburg
Time	2007 – 2017
Owner	City of Saint Petersburg

Description

- Retractable roof stadium in the western portion of Krestovsky Island in Saint Petersburg
- The design of the stadium is a modified and enlarged version of the Toyota Stadium in Toyota City, Japan
- Until now, many problems have not been solved (the roof is leaking, the lawn is not properly insulated and tends to rot, lots of quality issues which were only provisionally fixed)

Budget and time span

	Planned	Effective	Overrun
Cost	USD 249m	USD 1.1bn	440%
Time	2007-2009	2007-2017	500%

Challenges

- The stadium was envisioned as a facility with around 40,000 seats. When Russia was selected to host the 2017 FIFA Confederations Cup and the 2018 FIFA World Cup, the stadium had to be expanded to around 70,000 seats. With many parts already ordered, and the foundation of the stadium already in place, plans had to be redrawn, and the stadium had to be redesigned
- Architect Kisho Kurokawa, who had drawn up the plans, died in 2007
- In 2010 new federal laws for fire safety were introduced, requiring the replacement of materials and design changes. Other materials, used in the building, were emitting toxic substances and had to be replaced
- Widespread corruption (billing of fictitious works, covered by corrupt officials)

Source: 1) Futbolgrad, 24 Apr 2017 – “Krestovsky Stadium – The World’s Most Expensive Football Stadium Finally Opens”; 2) The Duran, 09 Oct 2017 – “The story behind FC Zenit’s twelve year construction saga of Krestovsky Stadium in St. Petersburg”; 3) Crime Russia, 12 Jan 2017 – “Construction cost of the most expensive stadium of Russia”