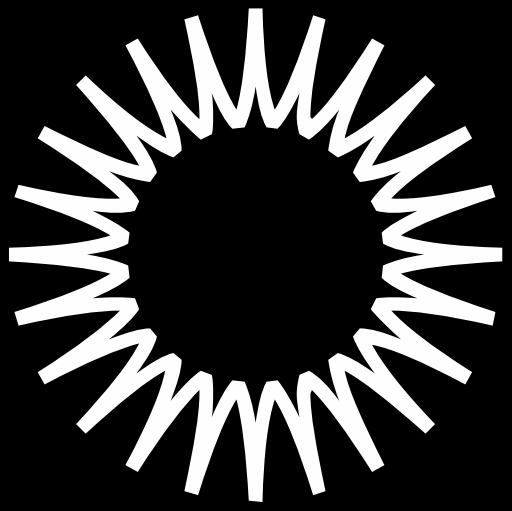

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#CostOfTranspo

Cost Overruns in Transportation Projects

What can be done?

Adam Finkin

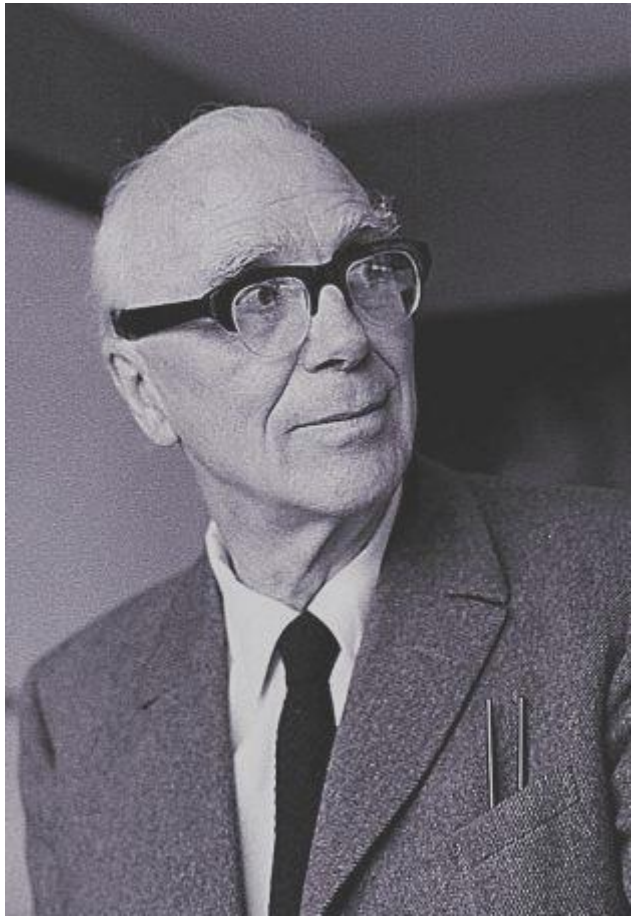
ARUP

Introduction to Arup



Sir Ove Arup founded his practice in London in 1946 based on a belief in 'total design' — the integration of the design process and the interdependence of all the professions involved, the creative nature of engineering, the value of innovation and the social purpose of design.

- 11,000+ engineers, designers, planners, management consultants and economists
- 90 networked offices
- 37 countries worldwide



Who We Are

- A global, integrated, multidisciplinary firm of professionals working together to tackle complex planning, infrastructure and building design challenges
- **~12,000** engineers, designers, planners, management consultants and economists
- +**90** networked offices in +**37** countries
- **Total Design** Full service from concept through completion
- Dedicated to delivering **value** through expertise, global resources and **local** delivery



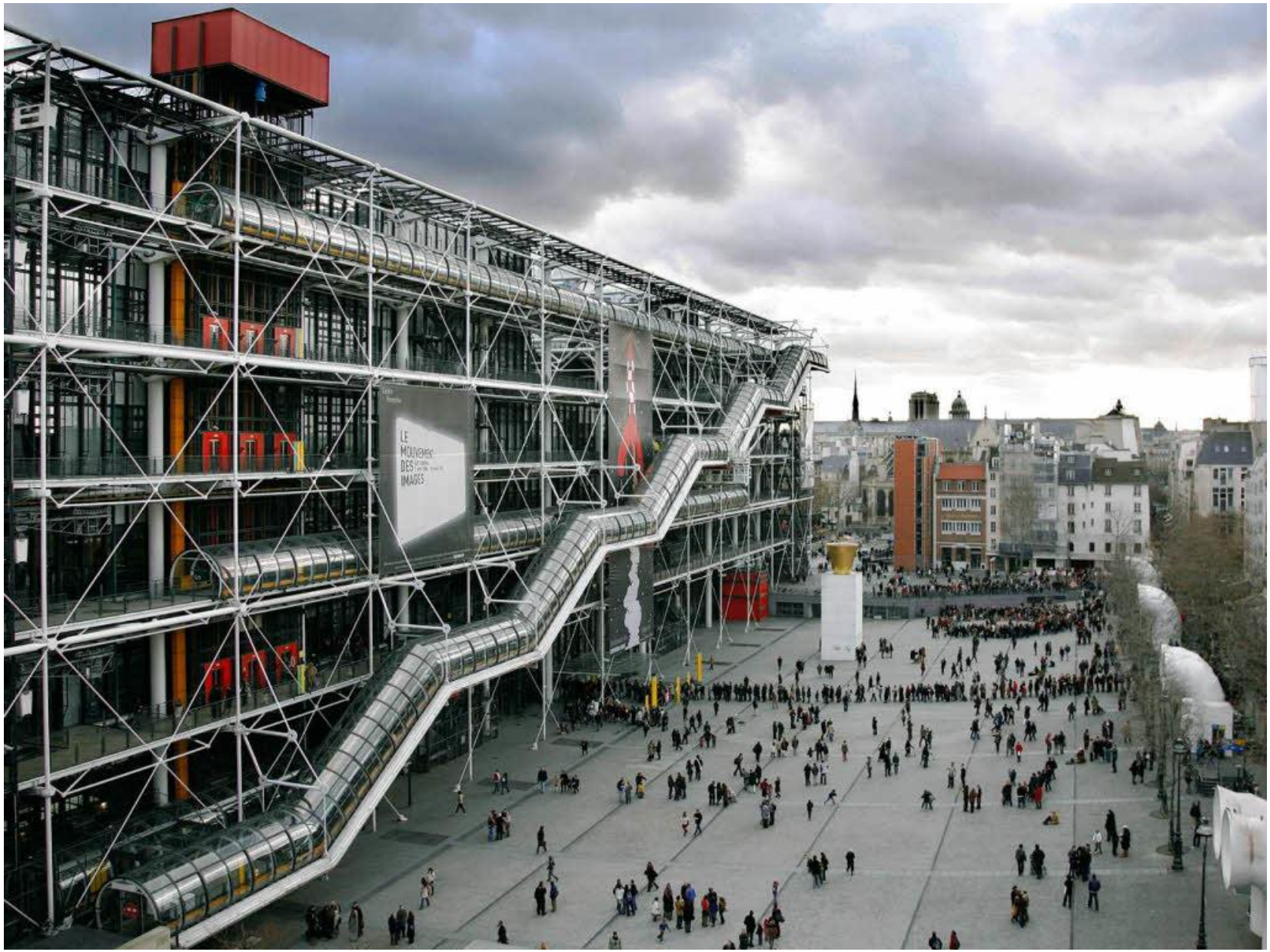


We are a global provider of total design, engineering and business solutions.

Arup in the Americas

Sydney Opera House, Australia

ARUP



Pompidou Centre, Paris, France

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30 St Mary Axe (Gherkin), London, UK

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Aquatic Center (Water Cube), Beijing China

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Beijing National Stadium (Birds Nest), China

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CCTV Tower, Beijing, China

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Apple Campus 2, California

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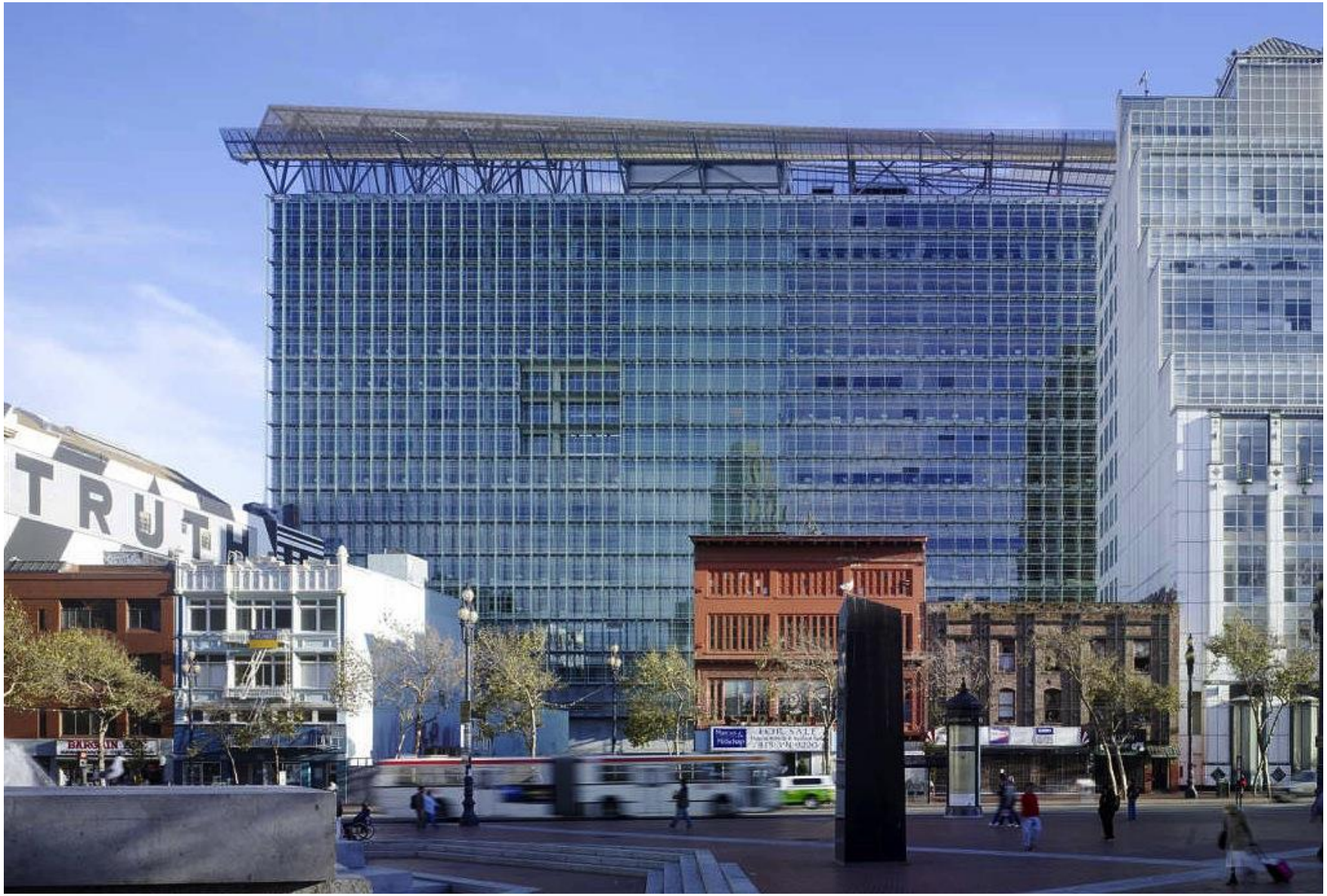

Federal Building, San Francisco, CA

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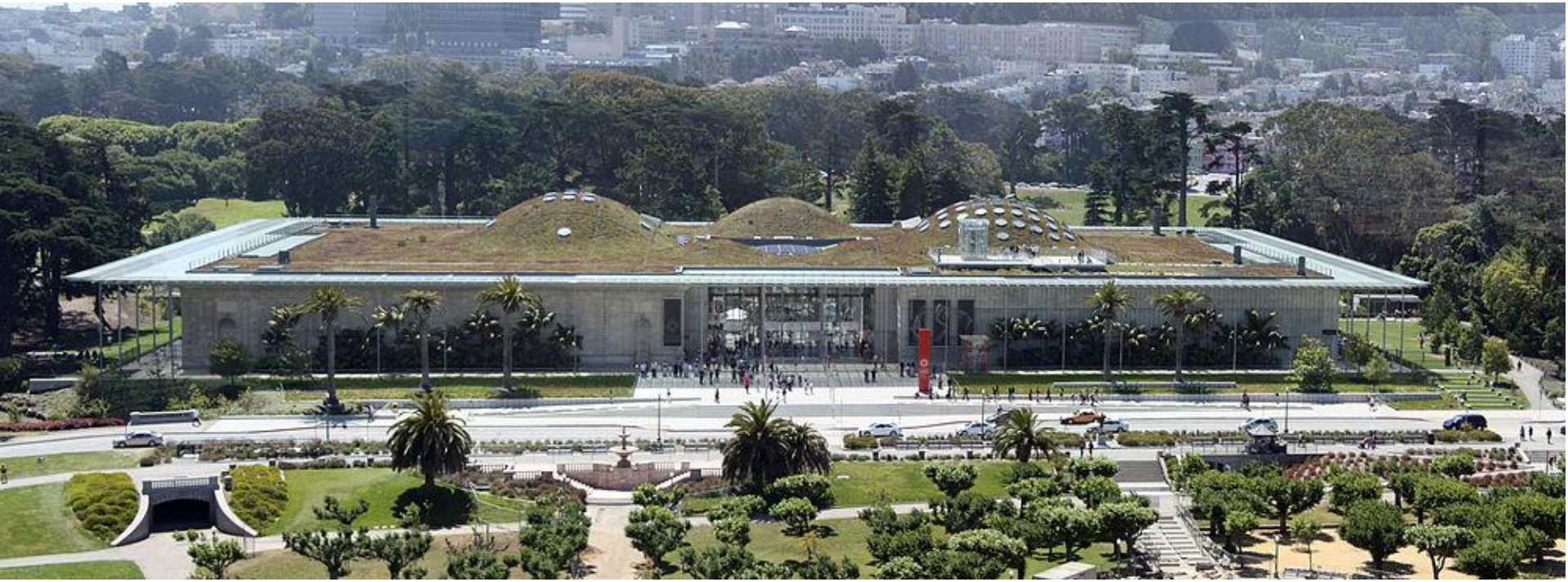

California Academy of Sciences, San Francisco, CA

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Øresund Bridge, Denmark, Copenhagen

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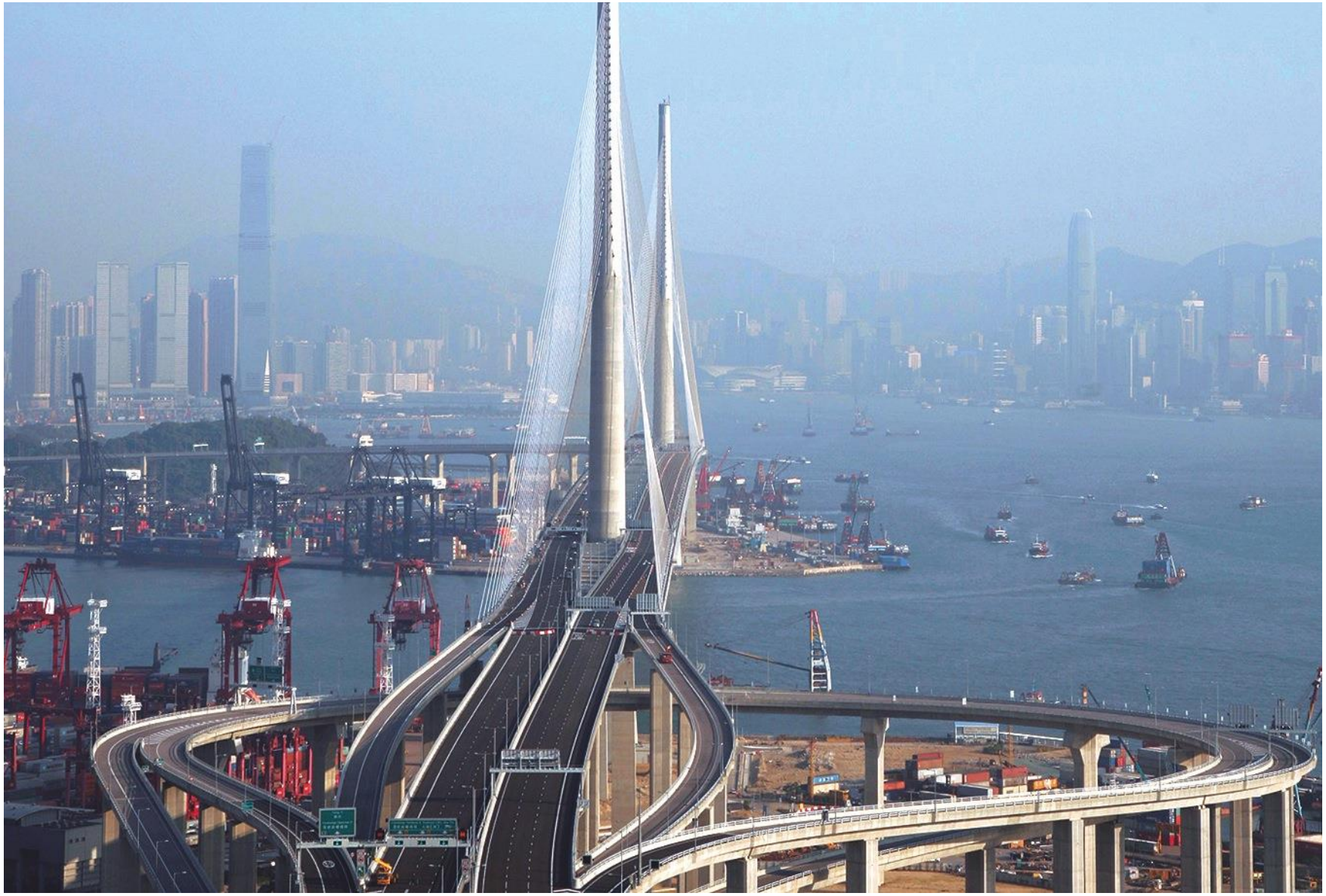


Stonecutters, Hong Kong

ARUP

A30, Montreal, Canada

ARUP

Gerald Desmond, Los Angeles, CA

ARUP

Millenium Bridge, London

ARUP

Fulton Street Transit Center, NYC

ARUP

Second Ave Subway, NYC

ARUP

Presidio Parkway, San Francisco, CA

ARUP

Transbay Terminal, San Francisco, CA

ARUP

California High Speed Rail, CA

ARUP

Currently, **90%** of **Transport** Infrastructure Projects experience $ and Time **Overruns**

Flyvbjerg et al
Transport Reviews, Vol. 24, No. 1, 3–18, January 2004

Historical Data:

Project	Cost Overrun (%)
Suez Canal, Egypt	1,900
Scottish Parliament Building, Scotland	1,600
Sydney Opera House, Australia	1,400
Montreal Summer Olympics, Canada	1,300
Concorde Supersonic Aeroplane, UK, France	1,100
Troy and Greenfield Railroad, USA	900
Excalibur Smart Projectile, USA, Sweden	650
Canadian Firearms Registry, Canada	590
Lake Placid Winter Olympics, USA	560
Medicare transaction system, USA	560
Bank of Norway headquarters, Norway	440
Furka Base Tunnel, Switzerland	300
Verrazano Narrow Bridge, USA	280
Boston's Big Dig Artery/Tunnel project, USA	220
Denver International Airport, USA	200
Panama Canal, Panama	200
Minneapolis Hiawatha light rail line, USA	190
Humber Bridge, UK	180
Dublin Port Tunnel, Ireland	160
Montreal Metro Laval extension, Canada	160
Copenhagen Metro, Denmark	150
Boston–New York–Washington Railway, USA	130
Great Belt Rail Tunnel, Denmark	120
London Limehouse Road Tunnel, UK	110
Brooklyn Bridge, USA	100

Flyvbjerg et al 2014
Project Management Journal, Vol. 45

Historical Data:

Project	Original	Final
Boston Big Dig	$2.6b (1985)	$14.6b (2005)
NYC East Side Access	$4.3b (1999)	$10.8b (2014)
San Francisco Bay Bridge	$1.4b (1996)	$6.3b (2013)
Denver International Airport	$2.1b (1990)	$4.8b (1995)
NYC WTC Rail Station	$2.0b (2004)	$4.0b (2015)
Denver West Light Rail	$250m (1997)	$707m (2013)
VA-Springfield Interchange	$241m (1994)	$676m (2003)

Edwards and Kaeding
Cato Institute, Tax & Budget Bulletin, No. 72, Sept 2015

Average % Over **Initial** Cost Estimates

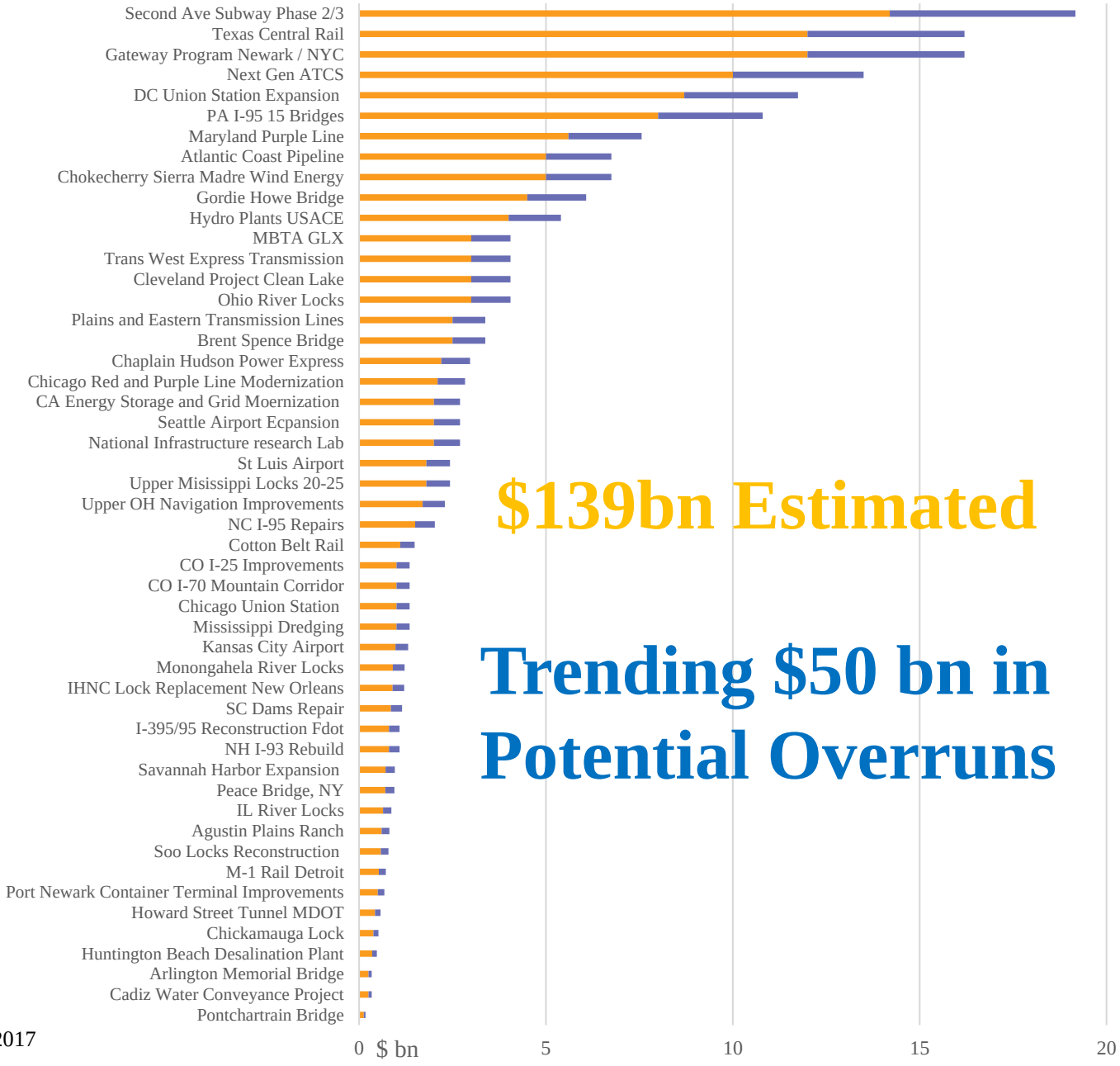
+45% = Rail

+34% = Bridge and Tunnel

+20% = Highways

Flyvbjerg et al
Transport Reviews, Vol. 24, No. 1, 3–18, January 2004

Top 50 US Projects:



$139bn Estimated

Trending $50 bn in Potential Overruns

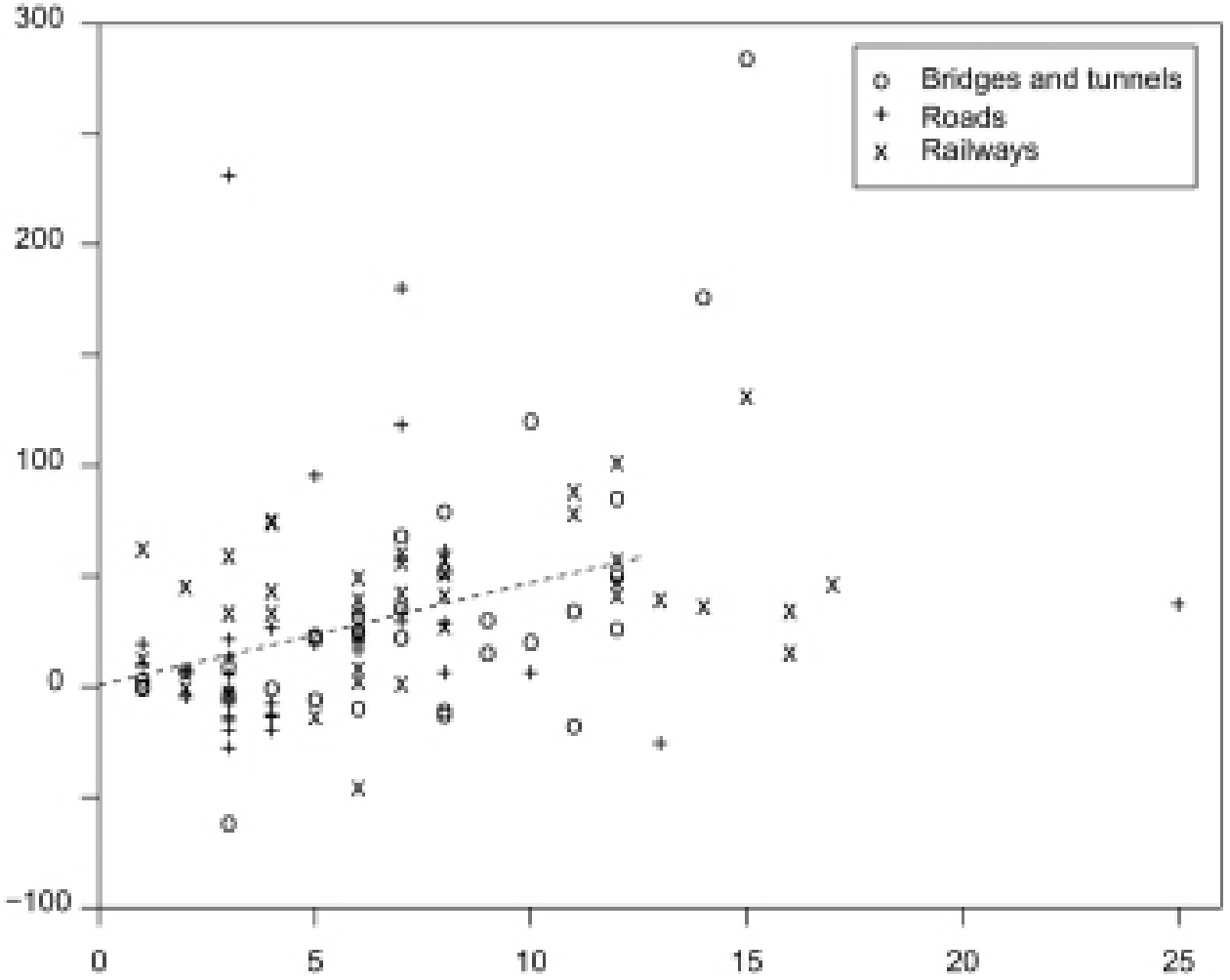
President Donald Trump – Priority List
Emergency & National Security Projects, Jan 2017

ARUP

Escalation % between **Inception** and O**peration**

*Avg.= **4.6%** yearly*

*"For every **$1 bn** in project cost*
*A yearly delay = **$46m**"*



Flyvbjerg et al
Transport Reviews, Vol. 24, No. 1, 3–18, January 2004

a) **why** is this happening?

b) **what** is being done?

c) **are** we seeing **results**?

*"No construction project is **risk free**.*

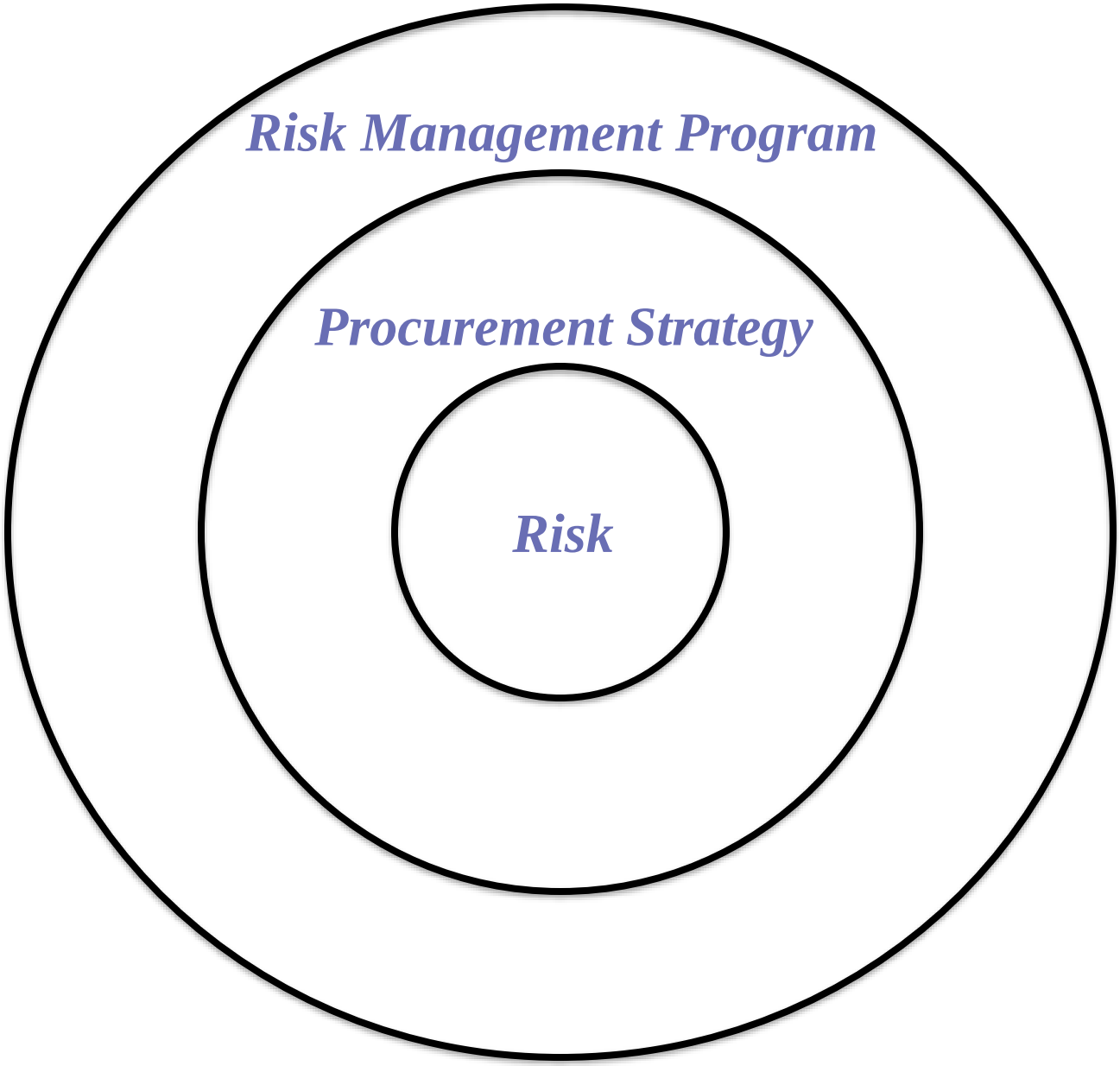
*Risk can be managed, minimised, **shared**, transferred, or accepted.*

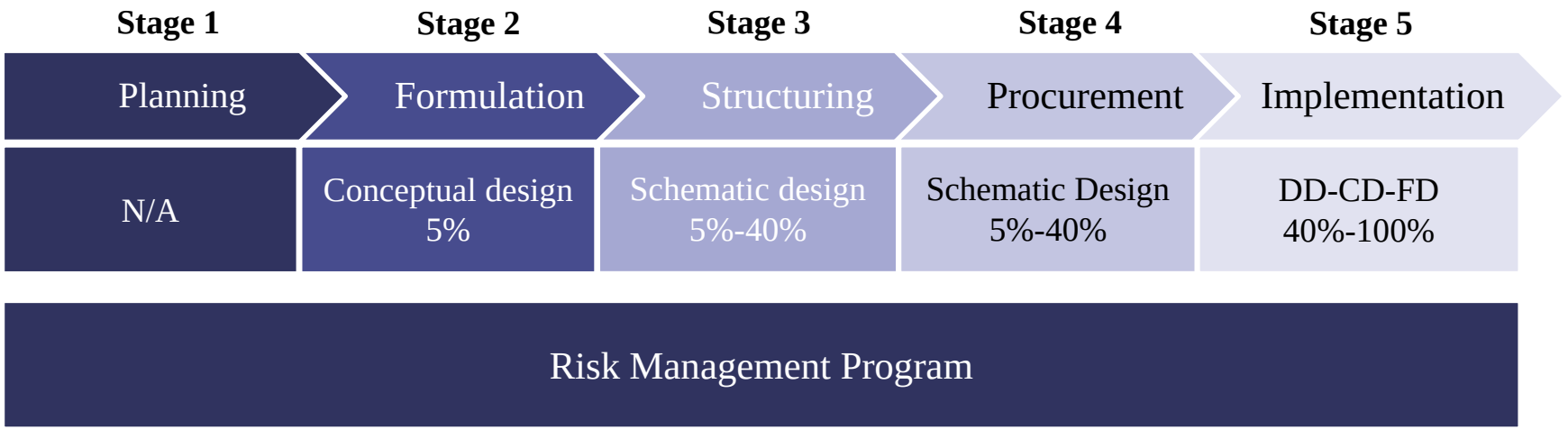
*It can not be **ignored**"*

- Sir Michael Latham

Construction the Team, 1994

Final Report of the Government / Industry Review of Procurement And Contractual Arrangements in the UK Construction Industry


Risk Management Program
Procurement Strategy
Risk


Stage 1
Stage 2
Stage 3
Stage 4
Stage 5
Planning
Formulation
Structuring
Procurement
Implementation
N/A
Conceptual design
5%
Schematic design
5%-40%
Schematic Design
5%-40%
DD-CD-FD
40%-100%
Risk Management Program

a) **why** is this happening?

b) **what** is being done?

c) **are** we seeing **results**?

Why?

Rank	Reason
1	Owner Design/Scope Changes
2	Design Development / Growth from Original
3	Lack of Information - Missing Info
4	Poor, Incomplete, Unclear Design Brief
5	Poor Estimates, Risk Assessment, or Contingency
6	Design Team Performance
7	Project Management
8	Unrealistic Time Expectation
9	Differing Site conditions
10	Project Team Organization
11	Claims and Change Orders
12	Commercial pressures
13	Inexperienced Project Teams or Owner
14	Wrong Procurement Vehicle
15	External Market Factors

Simon Jackson
PROJECT COST OVERRUNS AND RISK MANAGEMENT
School of Construction Management and Engineering, The University of Reading, 2002

Why?

Rank	Reason	
1	Owner Design/Scope Changes	**Known-Unknowns**
2	Design Development / Growth	
3	Lack of Information - Missing Info	
4	Poor, Incomplete, Unclear Design Brief	
9	Differing Site conditions	**Unknown-Unknowns**
11	Claims and Change Orders	
6	Design team performance	**Experience / Human Factor**
7	Project management	
10	Project Team Organization	
13	Inexperienced Project Teams or Owner	
14	Wrong Procurement Vehicle	**Procurement**
12	Commercial pressures	**Market Factors**
15	External Market Factors	
5	Poor Estimates, Risk/Contingency	**Estimate + Risk Analysis**
8	Unrealistic Time Expectation	

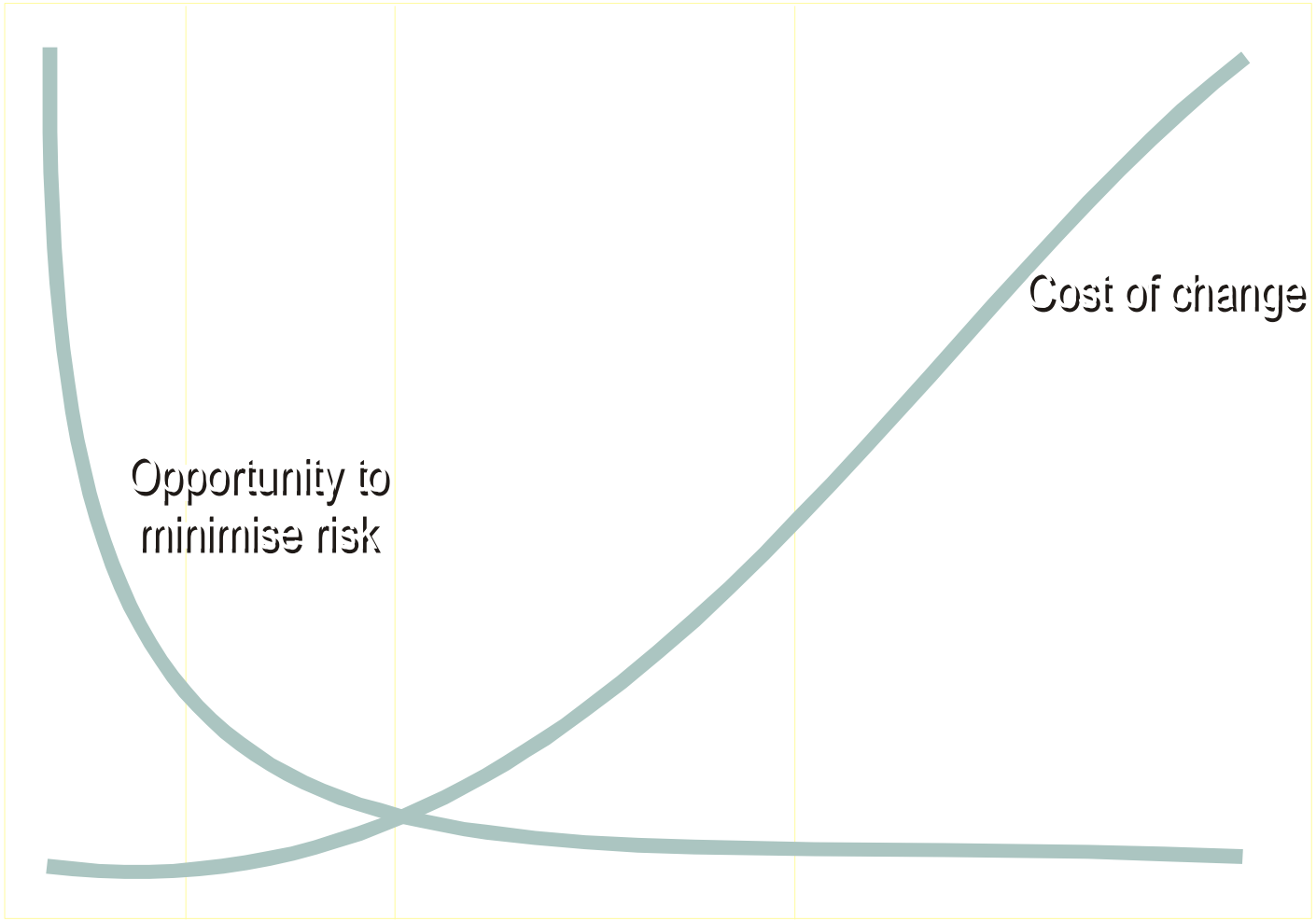
Simon Jackson
PROJECT COST OVERRUNS AND RISK MANAGEMENT
School of Construction Management and Engineering, The University of Reading, 2002

a) **why** is this happening?

b) **what** is being done?

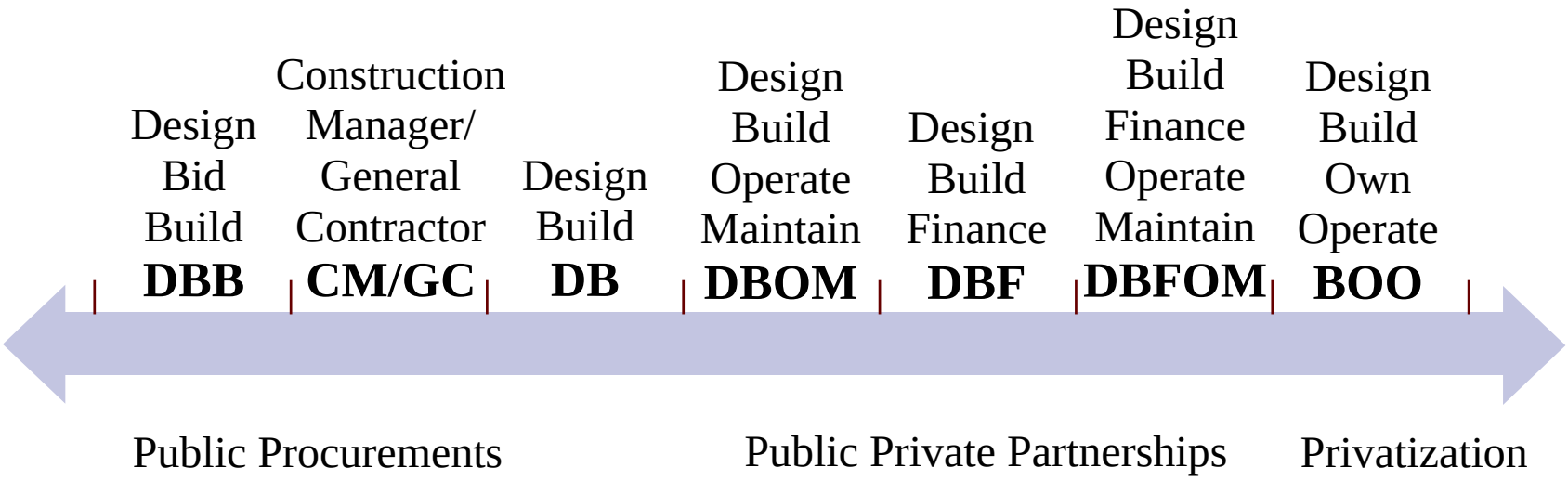
c) **are** we seeing **results**?

Known-Unknowns



Planning | Formulation | Structuring | Procurement | Implementation

Procurement



“I know my costs…

…and I know yours too.”

- Andrew Carnegie

American Experience
http://www.pbs.org/wgbh/amex/carnegie/filmmore/transcript/

Estimating, Scheduling, and Risk

Estimating, Scheduling, and Risk

Estimate Entry - Tree View

View of Estimate

- Tappan Zee Bridge-Opt 5-Initial Build
  - 1000000 : Site Access, Plant, Staging Areas, Laydown
  - 2000000 : Dredge
  - 3000000 : Temp Access Trestle
  - 4000000 : Approach - Substructure - Piles
  - 4100000 : Approach - Substructure- Pile Cap and Pier
    - 4110000 : Zone 1 - P1 to P2
    - 4120000 : Zone 1 - P3 to P4
    - 4130000 : Zone 2 - P5 to P8
      - 4130100 : Cofferdams
      - 4130200 : Pile Cap
        - 10100 - Furnish Materials
        - 10200 - Form
        - 10300 - Place Rebar
        - 10400 - Place Concrete
        - 10500 - Finish / Cure Concrete
        - 10600 - Transport Materials for Activity
      - 4130300 : Pier
      - 4130400 : Pier Table - Concrete
    - 4140000 : Zone 3 -P9 to P17
    - 4150000 : Zone 4 -P18 to P23
    - 4160000 : Zone 6- P26 to P27
    - 4170000 : Zone 7 - P28 to P29
    - 4180000 : Zone 7- P30 to P32
    - 4190000 : Zone 8 - P33 to P35
  - 4200000 : Approach - Superstructure - Steel Truss
  - 5000000 : Main Span - Substructure - Piles
  - 5100000 : Main Span - Substructure - Cap & Pylon
  - 5200000 : Main Span - Superstructure - Steel Box Girder
  - 5500000 : Final Build - Transit Implementation
  - 6000000 : Abutments
  - 7000000 : Deck & Appurtenances
  - 8000000 : Existing Bridge Demolition
  - 9900000 : PROJECT INDIRECTS

Estimating, Scheduling, and Risk

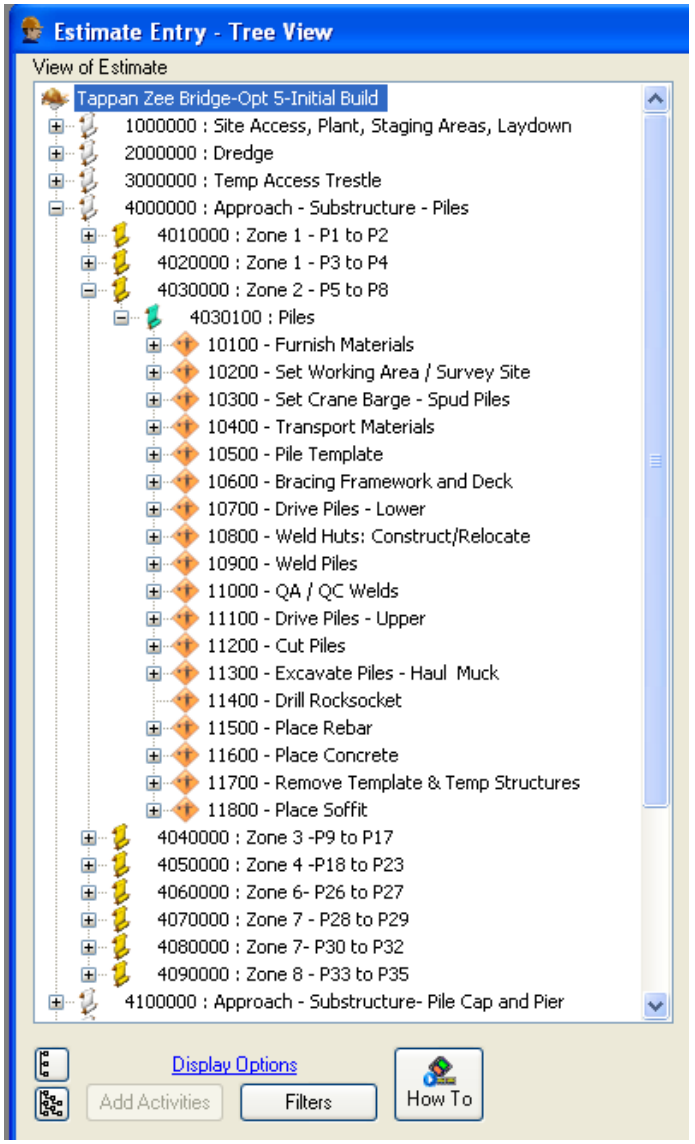
A – Construct coffer dam

B

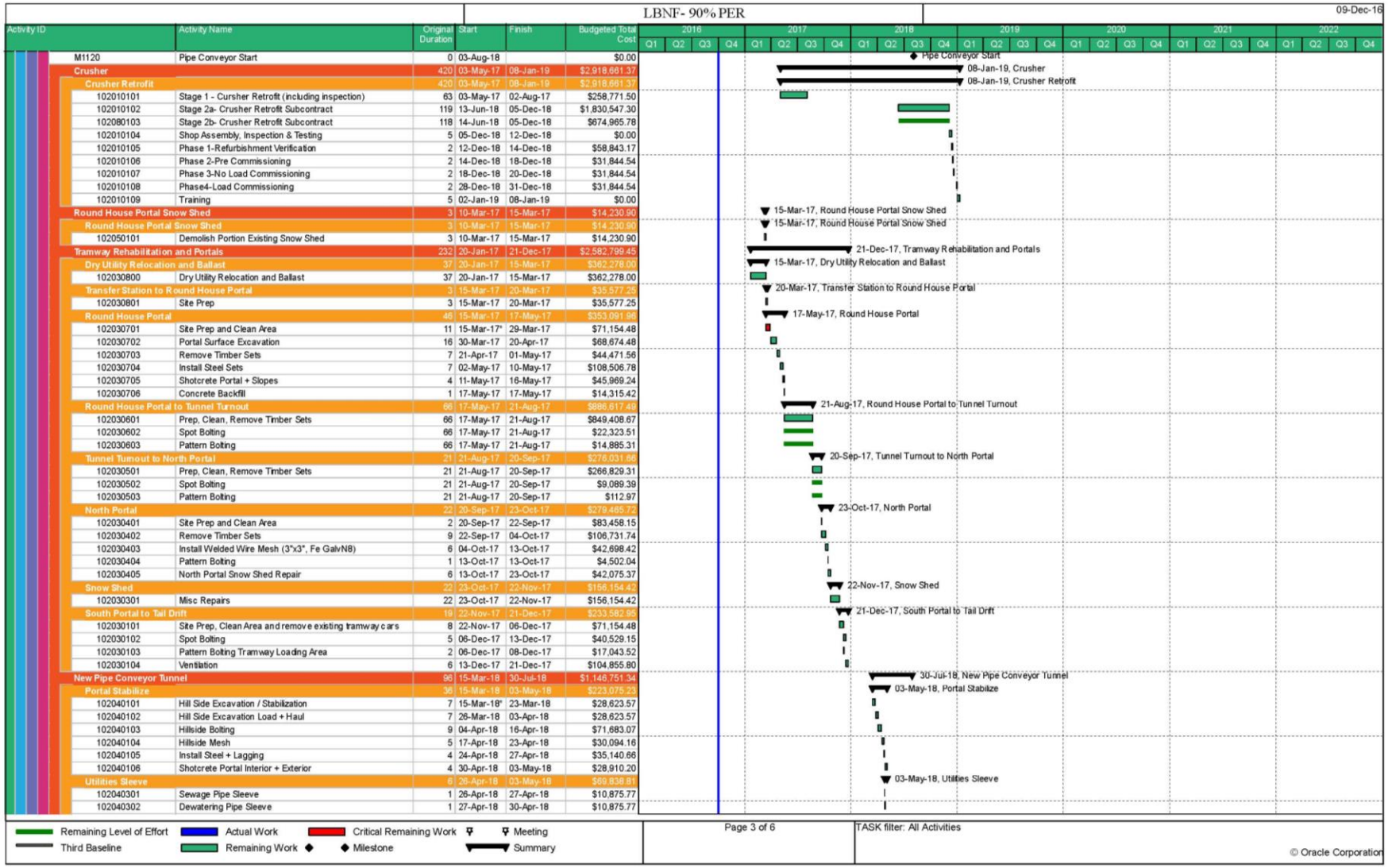
Install Pile template on sheet piles and drive piles

C

Pour concrete seal slab, dewater coffer dam, install reinforcing and pour footing concrete



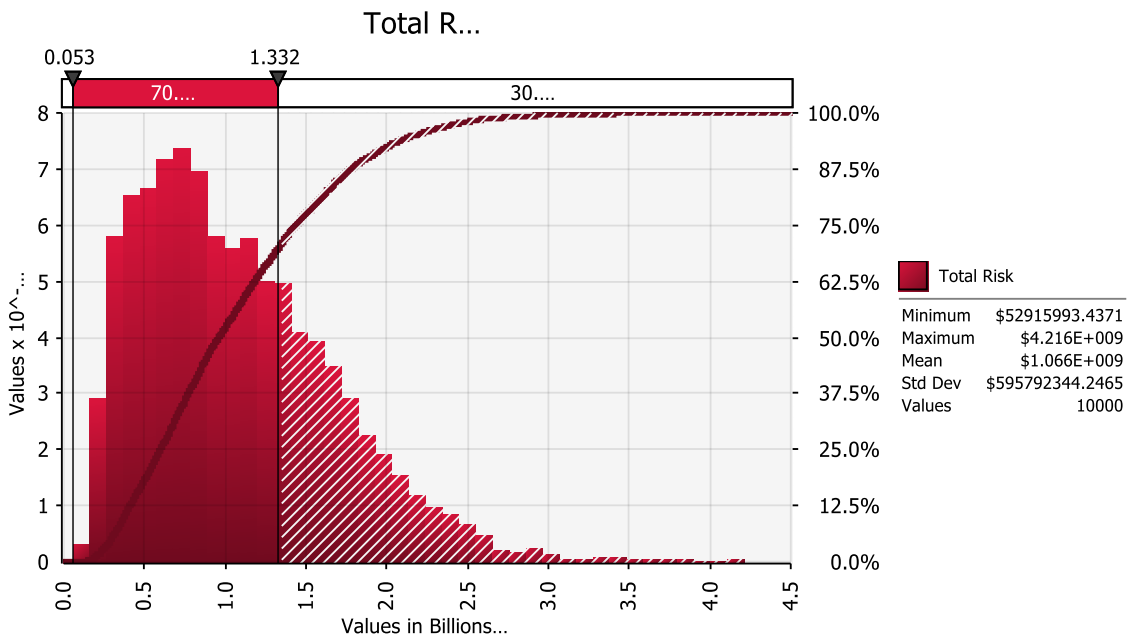
Estimating, Scheduling, and Risk



Activity ID	Activity Name	Original Duration	Start	Finish	Budgeted Total Cost
M1120	Pipe Conveyor Start	0	03-Aug-18		$0.00
Crusher		420	03-May-17	08-Jan-19	$2,918,661.37
Crusher Retrofit		420	03-May-17	08-Jan-19	$2,918,661.37
102010101	Stage 1 - Cursher Retrofit (including inspection)	63	03-May-17	02-Aug-17	$258,771.50
102010102	Stage 2a- Crusher Retrofit Subcontract	119	13-Jun-18	05-Dec-18	$1,830,547.30
102080103	Stage 2b- Crusher Retrofit Subcontract	118	14-Jun-18	05-Dec-18	$674,965.78
102010104	Shop Assembly, Inspection & Testing	5	05-Dec-18	12-Dec-18	$0.00
102010105	Phase 1-Refurbishment Verification	2	12-Dec-18	14-Dec-18	$58,843.17
102010106	Phase 2-Pre Commissioning	2	14-Dec-18	18-Dec-18	$31,844.54
102010107	Phase 3-No Load Commissioning	2	18-Dec-18	20-Dec-18	$31,844.54
102010108	Phase4-Load Commissioning	2	28-Dec-18	31-Dec-18	$31,844.54
102010109	Training	5	02-Jan-19	08-Jan-19	$0.00
Round House Portal Snow Shed		3	10-Mar-17	15-Mar-17	$14,230.90
Round House Portal Snow Shed		3	10-Mar-17	15-Mar-17	$14,230.90
102050101	Demolish Portion Existing Snow Shed	3	10-Mar-17	15-Mar-17	$14,230.90
Tramway Rehabilitation and Portals		232	20-Jan-17	21-Dec-17	$2,582,799.45
Dry Utility Relocation and Ballast		37	20-Jan-17	15-Mar-17	$362,278.00
102030800	Dry Utility Relocation and Ballast	37	20-Jan-17	15-Mar-17	$362,278.00
Transfer Station to Round House Portal		3	15-Mar-17	20-Mar-17	$35,577.25
102030801	Site Prep	3	15-Mar-17	20-Mar-17	$35,577.25
Round House Portal		46	15-Mar-17	17-May-17	$353,091.96
102030701	Site Prep and Clean Area	11	15-Mar-17*	29-Mar-17	$71,154.48
102030702	Portal Surface Excavation	16	30-Mar-17	20-Apr-17	$68,674.48
102030703	Remove Timber Sets	7	21-Apr-17	01-May-17	$44,471.56
102030704	Install Steel Sets	7	02-May-17	10-May-17	$108,506.78
102030705	Shotcrete Portal + Slopes	4	11-May-17	16-May-17	$45,969.24
102030706	Concrete Backfill	1	17-May-17	17-May-17	$14,315.42
Round House Portal to Tunnel Turnout		66	17-May-17	21-Aug-17	$886,617.49
102030601	Prep, Clean, Remove Timber Sets	66	17-May-17	21-Aug-17	$849,408.67
102030602	Spot Bolting	66	17-May-17	21-Aug-17	$22,323.51
102030603	Pattern Bolting	66	17-May-17	21-Aug-17	$14,885.31
Tunnel Turnout to North Portal		21	21-Aug-17	20-Sep-17	$276,031.66
102030501	Prep, Clean, Remove Timber Sets	21	21-Aug-17	20-Sep-17	$266,829.31
102030502	Spot Bolting	21	21-Aug-17	20-Sep-17	$9,089.39
102030503	Pattern Bolting	21	21-Aug-17	20-Sep-17	$112.97
North Portal		22	20-Sep-17	23-Oct-17	$279,465.72
102030401	Site Prep and Clean Area	2	20-Sep-17	22-Sep-17	$83,458.15
102030402	Remove Timber Sets	9	22-Sep-17	04-Oct-17	$106,731.74
102030403	Install Welded Wire Mesh (3"x3", Fe GalvN8)	6	04-Oct-17	13-Oct-17	$42,698.42
102030404	Pattern Bolting	1	13-Oct-17	13-Oct-17	$4,502.04
102030405	North Portal Snow Shed Repair	6	13-Oct-17	23-Oct-17	$42,075.37
Snow Shed		22	23-Oct-17	22-Nov-17	$156,154.42
102030301	Misc Repairs	22	23-Oct-17	22-Nov-17	$156,154.42
South Portal to Tail Drift		19	22-Nov-17	21-Dec-17	$233,582.95
102030101	Site Prep, Clean Area and remove existing tramway cars	8	22-Nov-17	06-Dec-17	$71,154.48
102030102	Spot Bolting	5	06-Dec-17	13-Dec-17	$40,529.15
102030103	Pattern Bolting Tramway Loading Area	2	06-Dec-17	08-Dec-17	$17,043.52
102030104	Ventilation	6	13-Dec-17	21-Dec-17	$104,855.80
New Pipe Conveyor Tunnel		96	15-Mar-18	30-Jul-18	$1,146,751.34
Portal Stabilize		36	15-Mar-18	03-May-18	$223,075.23
102040101	Hill Side Excavation / Stabilization	7	15-Mar-18*	23-Mar-18	$28,623.57
102040102	Hill Side Excavation Load + Haul	7	26-Mar-18	03-Apr-18	$28,623.57
102040103	Hillside Bolting	9	04-Apr-18	16-Apr-18	$71,683.07
102040104	Hillside Mesh	5	17-Apr-18	23-Apr-18	$30,094.16
102040105	Install Steel + Lagging	4	24-Apr-18	27-Apr-18	$35,140.66
102040106	Shotcrete Portal Interior + Exterior	4	30-Apr-18	03-May-18	$28,910.20
Utilities Sleeve		6	26-Apr-18	03-May-18	$69,838.81
102040301	Sewage Pipe Sleeve	1	26-Apr-18	27-Apr-18	$10,875.77
102040302	Dewatering Pipe Sleeve	1	27-Apr-18	30-Apr-18	$10,875.77

ARUP

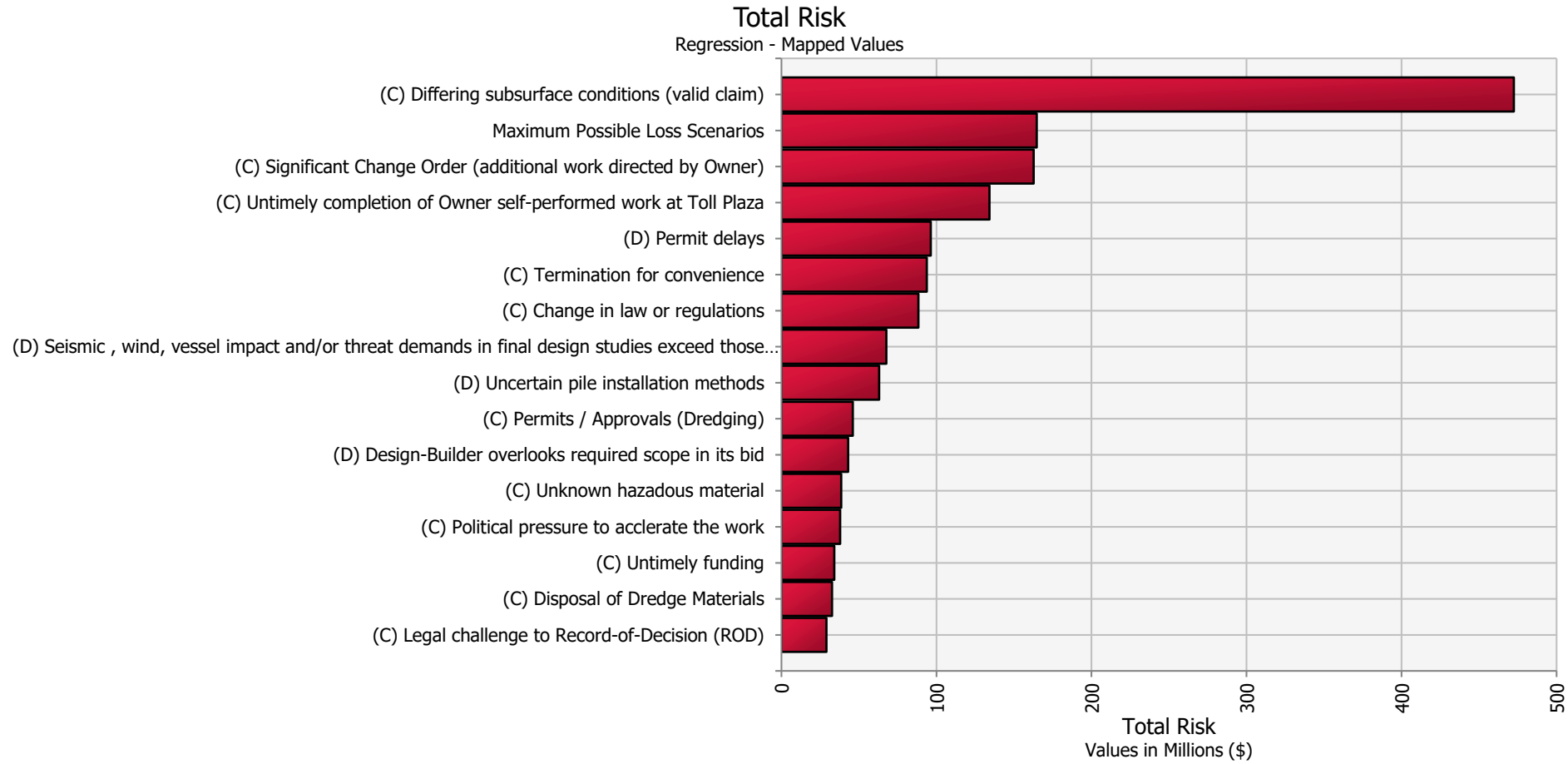
Estimating, Scheduling, and Risk



SUMMARY RISK RESULTS	
Mean	$ 1,044,351,102
90th Percentile	$ 1,305,438,877
70th Percentile	$ 1,201,003,767
5th Percentile	$ 1,096,568,657

Required Contingency (Short Span DEIS)	
Mean	40.0%
90th Percentile	35.0%
70th Percentile	30.0%
5th Percentile	24.3%

Estimating, Scheduling, and Risk



Market Factors

- Local markets **overheat**
- Delayed projects **escalate** quickly
- Over-demand **slows** productivity
- Mega-projects affect the **world** market
  - Joint Ventures
  - Commodities / Hedging
  - Price futures

Experience / Human Factor

- **Experienced** Project Teams
- **Qualified** Professionals
- **Collaboration**
- Stakeholder **Engagement**

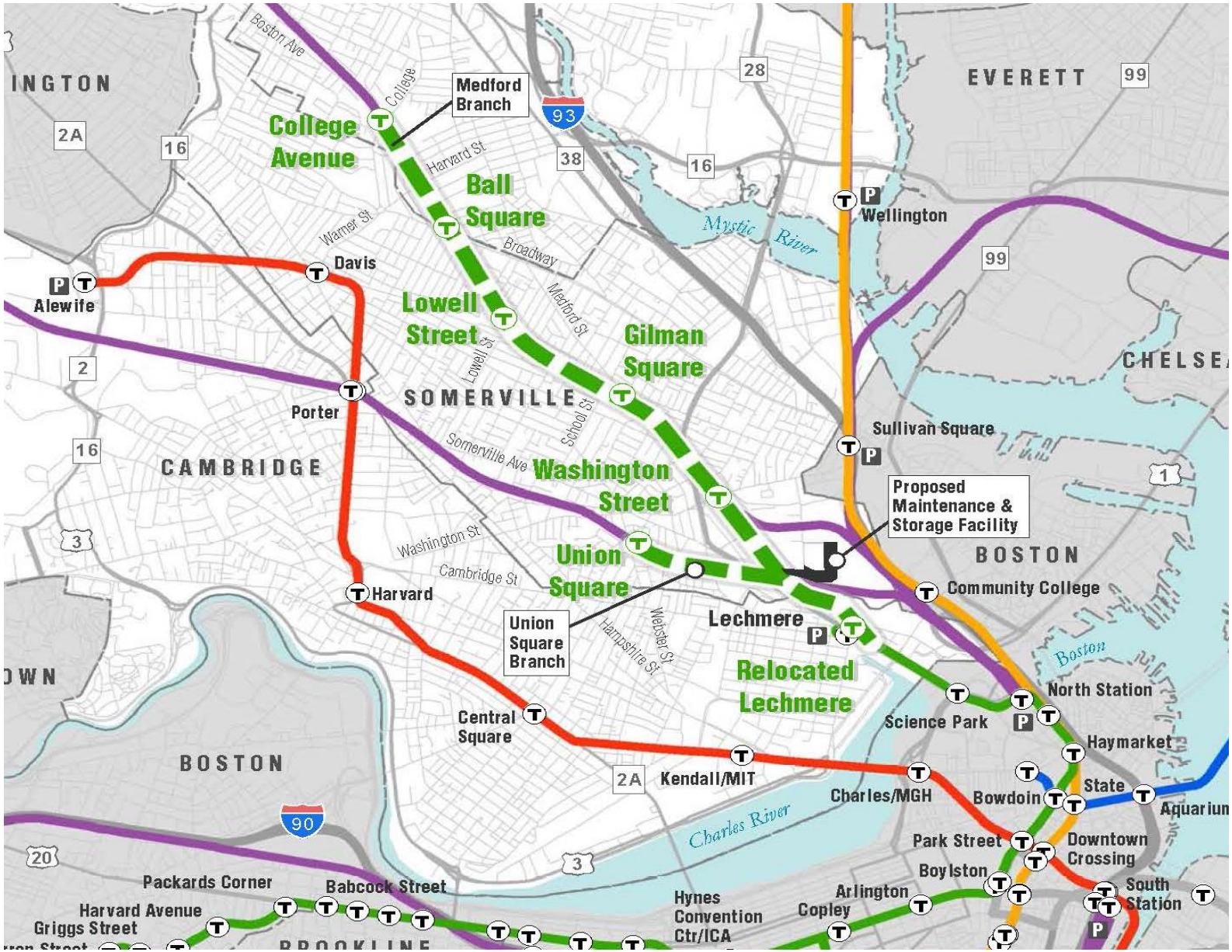
a) **why** is this happening?

b) **what** is being done?

c) **are** we seeing **results**?

Tappan Zee Bridge / New New York Bridge, NYC

ARUP

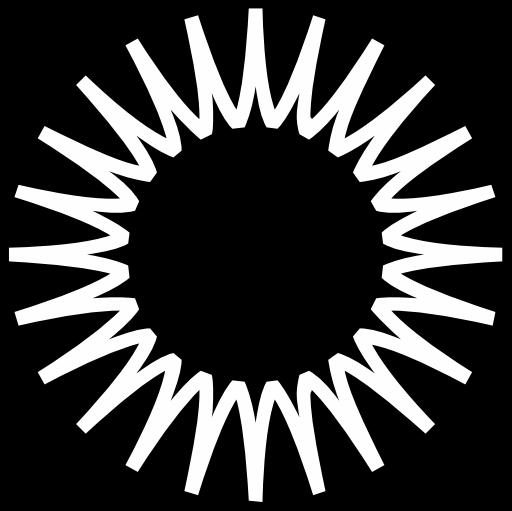

College Avenue
Medford Branch
Ball Square
Lowell Street
Gilman Square
Washington Street
Union Square
Union Square Branch
Relocated Lechmere
Proposed Maintenance & Storage Facility
Lechmere
Community College
Sullivan Square
Wellington
Alewife
Davis
Porter
Harvard
Central Square
Kendall/MIT
Charles/MGH
Science Park
North Station
Haymarket
State
Bowdoin
Aquarium
Park Street
Downtown Crossing
Boylston
Arlington
Copley
Hynes Convention Ctr/ICA
South Station
Babcock Street
Packards Corner
Harvard Avenue
Griggs Street
SOMERVILLE
CAMBRIDGE
BOSTON
EVERETT
CHELSEA
Mystic River
Charles River
Boston
Harvard St
Broadway
Medford St
Lowell St
School St
Somerville Ave
Washington St
Cambridge St
Hampshire St
Webster St
Warner St
Boston Ave
College

"When a person with money meets a person with experience, the one with experience ends up with the money, and the one with money leaves with experience"

- Warren Buffett

Berkshire Hathaway Annual Letter

Andrew Ross Sorkin - New York Times
Buffett Asks Big Money: Why Pay High Fees, Dealbook, Feb 27th, 2017



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