# 30th Spencer J. Buchanan Lecture

Friday, October 14, 2022 at 2 PM
College Station Hilton
https://briaud.engr.tamu.edu/buchananlecture/

## Risk Mitigation in the Changing Relationship between Contractors and Engineers

The 2022 Spencer J. Buchanan Lecture

By Dr. Mark W. Buchanan

## Geotechnical Systems, Uncertainty and Risk

The 2021 Terzaghi Lecture

By Dr. Gregory B. Baecher

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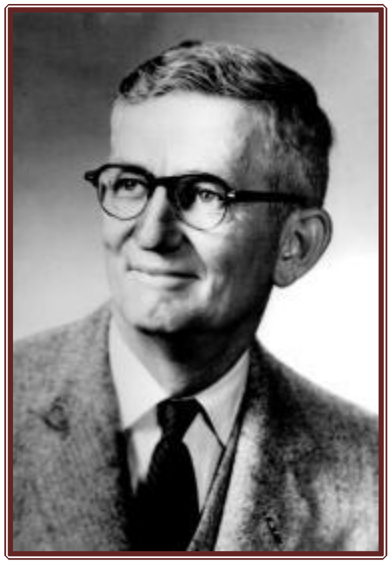
# SPENCER J. BUCHANAN



Spencer J. Buchanan, Sr. was born in 1904 in Yoakum, Texas. He graduated from Texas A&M University with a degree in Civil Engineering in 1926, and earned graduate and professional degrees from the Massachusetts Institute of Technology and Texas A&M University.

He held the rank of Brigadier General in the U.S. Army Reserve, (Ret.), and organized the 420th Engineer Brigade in Bryan-College Station, which was the only such unit in the Southwest when it was created. During World War II, he served the U.S. Army Corps of Engineers as an airfield engineer in both the U.S. and throughout the islands of the Pacific Combat Theater. Later, he served as a pavement consultant to the U.S. Air Force and during the Korean War he served in this capacity at numerous forward airfields in the combat zone. He held numerous military decorations including the Silver Star. He was founder and Chief of the Soil Mechanics Division of the U.S. Army Waterways Experiment Station in 1932, and also served as Chief of the Soil Mechanics Branch of the Mississippi River Commission, both being Vicksburg, Mississippi.

Professor Buchanan also founded the Soil Mechanics Division of the Department of Civil Engineering at Texas A&M University in 1946. He held the title of Distinguished Professor of Soil Mechanics and Foundation Engineering in that department. He retired from that position in 1969 and was named professor Emeritus. In 1982, he received the College of Engineering Alumni Honor Award from Texas A&M University.

He was the founder and president of Spencer J. Buchanan & Associates, Inc., Consulting Engineers, and Soil Mechanics Incorporated in Bryan, Texas. These firms were involved in numerous major international projects, including twenty-five RAF-USAF airfields in England. They also conducted Air Force funded evaluation of all U.S. Air Training Command airfields in this country. His firm also did foundation investigations for downtown expressway systems in Milwaukee, Wisconsin, St. Paul, Minnesota; Lake Charles, Louisiana; Dayton, Ohio, and on Interstate Highways across Louisiana. Mr. Buchanan did consulting work for the Exxon Corporation, Dow Chemical Company, Conoco, Monsanto, and others.

Professor Buchanan was active in the Bryan Rotary Club, Sigma Alpha Epsilon Fraternity, Tau Beta Pi, Phi Kappa Phi, Chi Epsilon, served as faculty advisor to the Student Chapter of the American Society of Civil Engineers, and was a Fellow of the Society of American Military Engineers. In 1979 he received the award for Outstanding Service from the American Society of Civil Engineers.

Professor Buchanan was a participant in every International Conference on Soil Mechanics and Foundation Engineering since 1936. He served as a general chairman of the International Research and Engineering Conferences on Expansive Clay Soils at Texas A&M University, which were held in 1965 and 1969.

Spencer J. Buchanan, Sr., was considered a world leader in geotechnical engineering, a Distinguished Texas A&M Professor, and one of the founders of the Bryan Boy's Club. He died on February 4, 1982, at the age of 78, in a Houston hospital after an illness, which lasted several months.

# The Spencer J. Buchanan '26 Chair in Civil Engineering

The College of Engineering and the Department of Civil Engineering gratefully recognize the generosity of the following individuals, corporations, foundations, and organizations for their part in helping to establish the Spencer J. Buchanan '26 Professorship in Civil Engineering. Created in 1992 to honor a world leader in soil mechanics and foundation engineering, as well as a distinguished Texas A&M University professor, the Buchanan Professorship supports a wide range of enriched educational activities in civil and geotechnical engineering. In 2002, this professorship became the Spencer J. Buchanan '26 Chair in Civil Engineering.

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Every effort was made to ensure the accuracy of this list. If you feel there is an error, please contact the Engineering Development Office at 979-845-5113. A pledge card is enclosed on the last page for potential contributions.

# Spencer J. Buchanan Lecture Series

| | | |
|---|---|---|
| 1993 | Ralph B. Peck | "The Coming of Age of Soil Mechanics: 1920 - 1970" |
| 1994 | G. Geoffrey Meyerhof | "Evolution of Safety Factors and Geotechnical Limit State Design" |
| 1995 | James K. Mitchell | "The Role of Soil Mechanics in Environmental Geotechnics" |
| 1996 | Delwyn G. Fredlund | "The Emergence of Unsaturated Soil Mechanics" |
| 1997 | T. William Lambe | "The Selection of Soil Strength for a Stability Analysis" |
| 1998 | John B. Burland | "The Enigma of the Leaning Tower of Pisa" |
| 1999 | J. Michael Duncan | "Factors of Safety and Reliability in Geotechnical Engineering" |
| 2000 | Harry G. Poulos | "Foundation Settlement Analysis – Practice Versus Research" |
| 2001 | Robert D. Holtz | "Geosynthetics for Soil Reinforcement" |
| 2002 | Arnold Aronowitz | "World Trade Center: Construction, Destruction, and Reconstruction" |
| 2003 | Eduardo Alonso | "Exploring the Limits of Unsaturated Soil Mechanics: the Behavior of Coarse Granular Soils and Rockfill" |
| 2004 | Raymond J. Krizek | "Slurries in Geotechnical Engineering" |
| 2005 | Tom D. O'Rourke | "Soil-Structure Interaction Under Extreme Loading Conditions" |
| 2006 | Cylde N. Baker | "In Situ Testing, Soil-Structure Interaction, and Cost Effective Foundation Design" |
| 2007 | Ricardo Dobry | "Pile response to Liquefaction and Lateral Spreading: Field Observations and Current Research" |
| 2008 | Kenneth Stokoe | "The Increasing Role of Seismic Measurements in Geotechnical Engineering" |
| 2009 | Jose M. Roesset | "Some Applications of Soil Dynamics" |
| 2010 | Kenji Ishihara | "Forensic Diagnosis for Site-Specific Ground Conditions in Deep Excavations of Subway Constructions" |
| 2011 | Rudolph Bonaparte | "Cold War Legacy – Design, Construction, and Performance of a Land-Based Radioactive Waste Disposal Facility" |
| 2012 | W. Allen Marr | "Active Risk Management in Geotechnical Engineering" |
| 2013 | Andrew J. Whittle | " Importance of Undrained Behavior in the Analysis of Soil-Structure Interaction" |
| 2014 | Craig H. Benson | "Landfill Covers: Water Balance, Unsaturated Soils, and a Pathway from Theory to Practice" |
| 2015 | William F. Marcuson III | "Katrina in Your Rearview Mirror" |
| 2016 | Edward Kavazanjian | "Bio-Geo-Alchemy: Biogeotechnical Carbonate Precipitation for Hazard Mitigation and Ground Improvement." |
| 2017 | Jonathan D. Bray | "Turning Disaster into Knowledge" |
| 2018 | Paul W. Mayne | "Versatility of Cone Penetration Tests in GeoCharacterization" |
| 2019 | Gregory B. Baecher | "Putting Numbers on Geotechnical Judgement" |
| 2020 | Lidija Zdravkovic | "Soil Characterisation for Advanced Geotechnical Design: Parameter Derivation" |

The texts of the lectures and a DVD's of the presentations are available by contacting:

Dr. Jean-Louis Briaud
Spencer J. Buchanan '26 Chair Distinguished Professor
Zachry Department of Civil Engineering
Texas A&M University
College Station, TX 77843-3136, USA
Tel: 979-845-3795
E-mail: **briaud@tamu.edu**

| | | |
|---|---|---|
| 2021 | Philippe Jeanjean | "Offshore Geotechnics: From Oil and Gas to Renewable Energy" |
| 2022 | Mark W. Buchanan | "Risk Mitigation in the Changing Relationship between Contractors and Engineers" |

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# AGENDA

The Thirtieth Spencer J. Buchanan Lecture
Friday, October 12, 2022
Hilton Hotel and Conference Center
College Station, TX

| | |
|---|---|
| 2:00 p.m. | Introduction by Dr. Jean-Louis Briaud |
| 2:10 p.m. | A few words by Dr. Zachary Grasley, Head of Zachry Department of Civil and Environmental Engineering |
| 2:15 p.m. | Introduction of Dr. Gregory B. Baecher by Jean-Louis Briaud |
| 2:20 p.m. | "Geotechnical Systems, Uncertainty and Risk" 2021 Terzaghi Lecture by Dr. Gregory B. Baecher |
| 3:20 p.m. | Introduction of Dr. Mark W. Buchanan by Jean-Louis Briaud |
| 3:25 p.m. | "Risk Mitigation in the Changing Relationship between Contractors and Engineers" 2022 Buchanan Lecture by Dr. Mark W. Buchanan |
| 4:30 p.m. | Closure with Jean-Louis Briaud |
| 5:30 p.m. | Reception at the Briaud Residence |

# Biographies


## DǌŜƎƻǌè .ͦ .ŀŜǑKŜǌΣ tK5Σ b!9

Glenn L. Martin Institute Professor of Engineering
Department of Civil and Environmental Engineering
University of Maryland, College Park, Maryland 20742
**9Ƴŀƛƭ** gbaecher@mac.com


Dr. Baecher is Glenn L Martin Institute Professor of Engineering at the University of Maryland. He holds a BSCE from UC Berkeley and a PhD in geotechnical engineering from MIT. He is the author of six books on risk, safety, and the protection of civil infrastructure; and 200+ technical publications. He is recipient of the USACE Commander's Award for Public Service, the Panamanian National Award for Science and Technology Innovation, GEOSnet Distinguished Achievement Award for contributions to geotechnical reliability, and is a member of the US National Academy of Engineering and of the UC Berkeley Academy of Distinguished Alumni.

# [illegible]

[illegible] in [illegible] TX
**Email:** [illegible]

[illegible]

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# *"Geotechnical Systems, Uncertainty and Risk"*

The 2021 Terzaghi Lecture
By Dr. Gregory B. Baecher

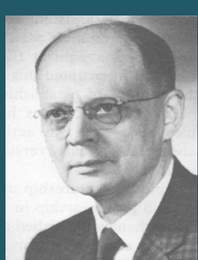
# Geotechnical systems, uncertainty, & risk

## 2021 Terzaghi Lecture

Gregory B. Baecher

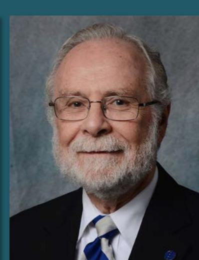
University of Maryland

# Geotechnical systems, uncertainty, & risk



1965

1981



2004

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## Geotechnical systems, uncertainty, & risk

MIT in the 1970-80s

John T. Christian †
C. Allin Cornell †
Herbert H. Einstein
Ronald C. Hirschfeld †
Charles C. Ladd †
W. Allen Marr
Erik Vanmarcke
Daniele Veneziano
Robert V. Whitman †

Later collaborators

Luis Alfaro
Tony Bennett
Karl Dise
Charles Dowding
Jerry Foster
Gerald E. Galloway
Robert B. Gilbert
Fernando Guerra
Desmond Hartford
Robert L. Johnson
Lewis (Ed) Link
Martin W. McCann
Ross McGillivray
Samuel G. Paikowski
Robert C. Patev
KK Phoon
Timo Schwekendiek
Nate Snorteland
Romanas Wolfsborg
TH Wu †
Li Min Zhang
P. Andy Zielinski

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## Geotechnical systems, uncertainty, & risk

Two themes …

1. What have we learned about assessing risk on complex projects?
2. How should we think about uncertainty.

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## Geotechnical systems, uncertainty, & risk

I. Tonen revisited (RVW's 1981 Terzaghi Lecture)

II. Interagency Performance Evaluation Taskforce

III. Tampa Bay site characterization

IV. Panama Canal engineering risk study

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## Part I. TONEN REVISITED

Bob Whitman

W. Allen Marr

Mishac Yegian

Bill Lambe

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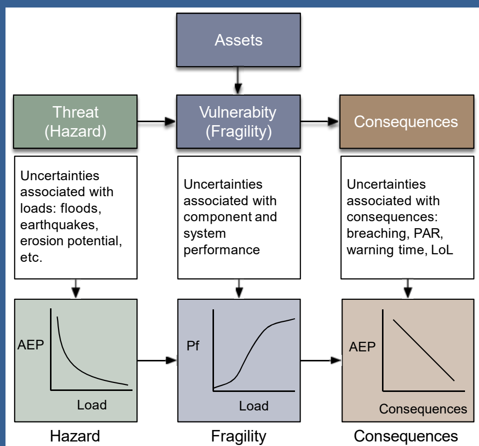
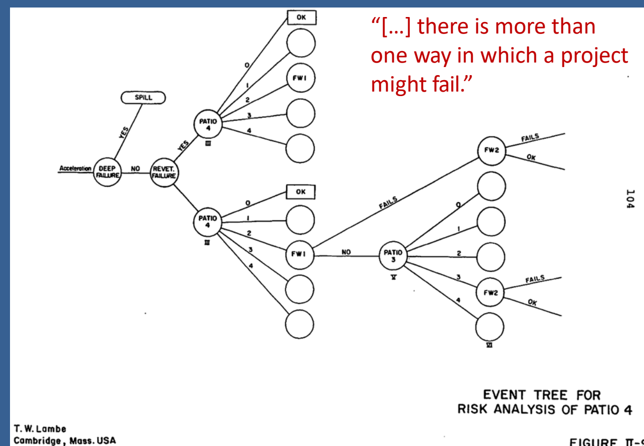
# Part I.  TONEN REVISITED

## Threat-vulnerability-consequence (TVC)

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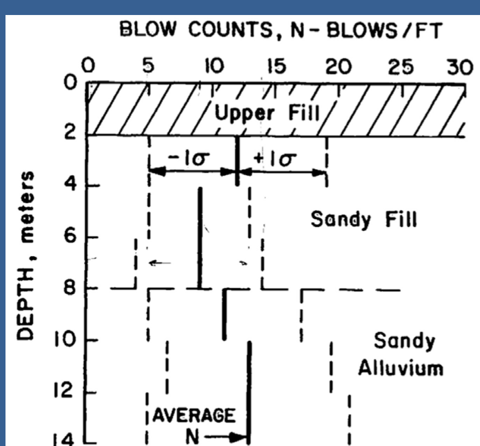
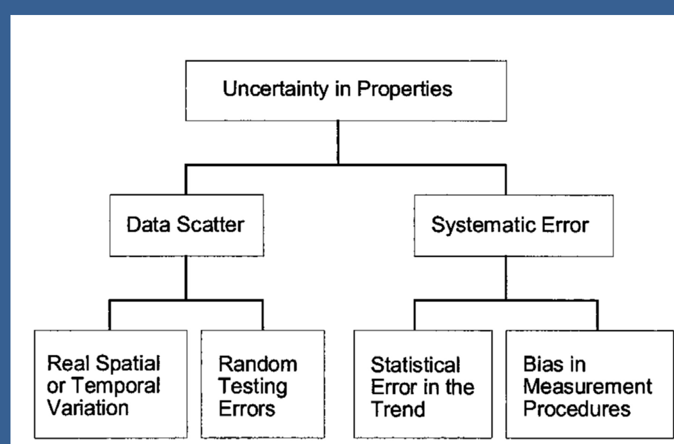
# Part I.  TONEN REVISITED

## Variability and bias in soil property measurements

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# Part I. TONEN REVISITED

## Spatial averaging and correlation

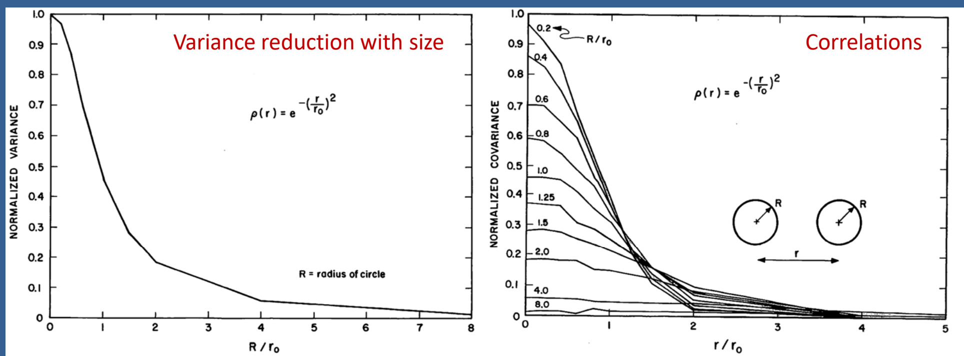


Figure 7. Spatial averaging and correlation of soil properties beneath tanks of various sizes and distances (TWL Associates 1982a). The LHS (a) shows variance reduction as a function of tank radius. The RSH (b) shows the covariance between the averages of soil properties under adjacent tanks as a function of their radius and separation.

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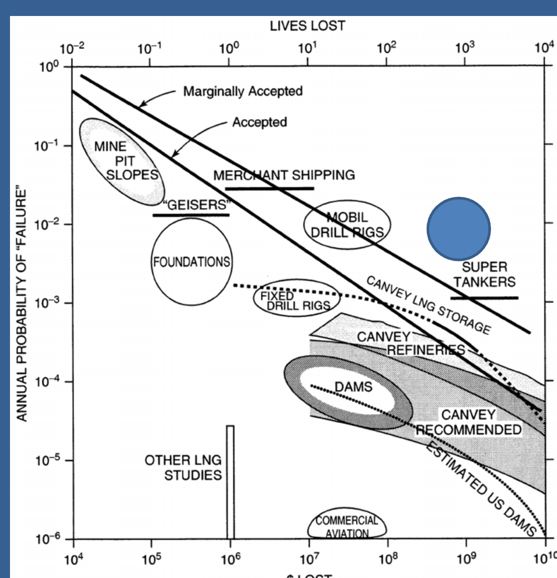
# Part I. TONEN REVISITED

## Risk communication

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## Part I. TONEN REVISITED

**Practical lessons**

Need to organize uncertainties Need to explain geotechnical data

Need to account for spatial variation

Need to communicate risk to stakeholders.

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## Lessons learned

Probability is in the model, not the ground *

* Matheron, G. *The Theory of Regionalized Variables and Its Application - Spatial Variabilities of Soil and Landforms*. Fontainebleau: Les Cahiers du Centre de Morphologie Mathematique 8, 1971.

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## Lessons learned

Uncertainty is epistemic, it’s in the mind

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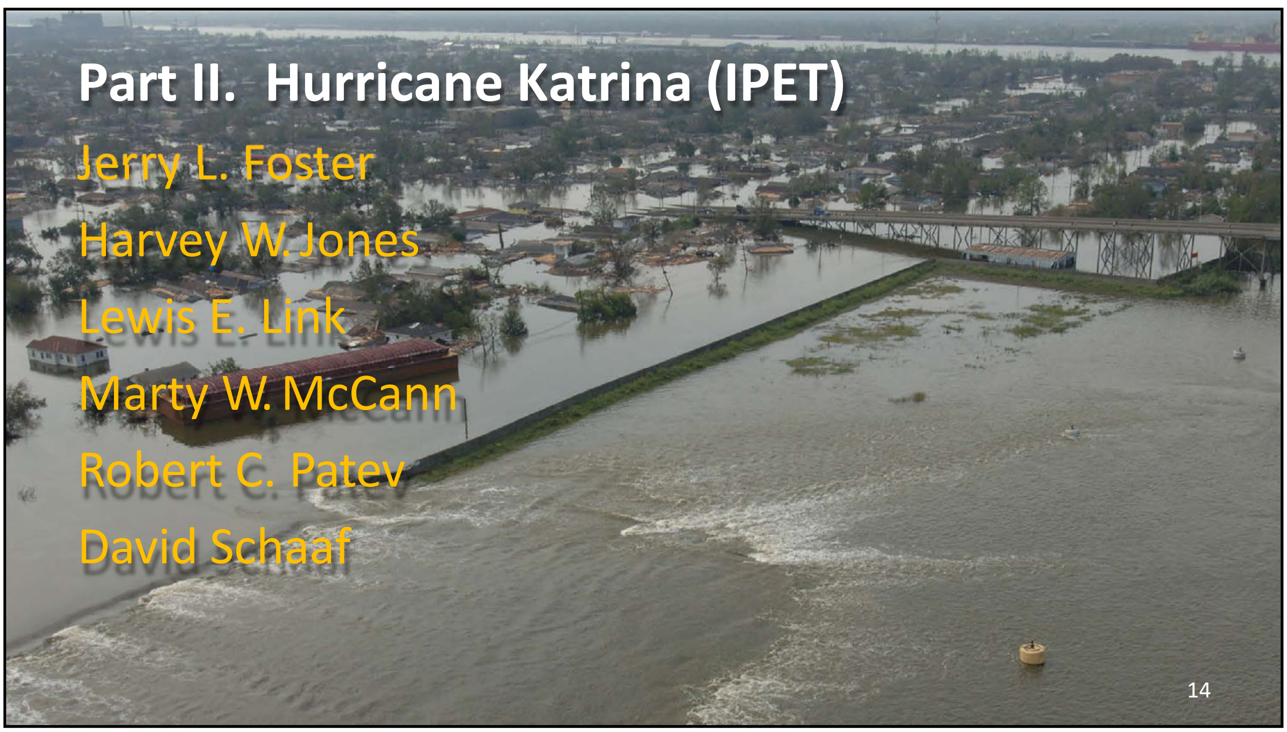
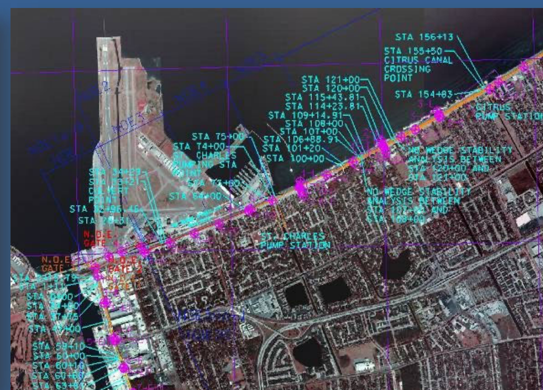


# Part II. Hurricane Katrina (IPET)

## “Did it work as a system?”

The system



The model

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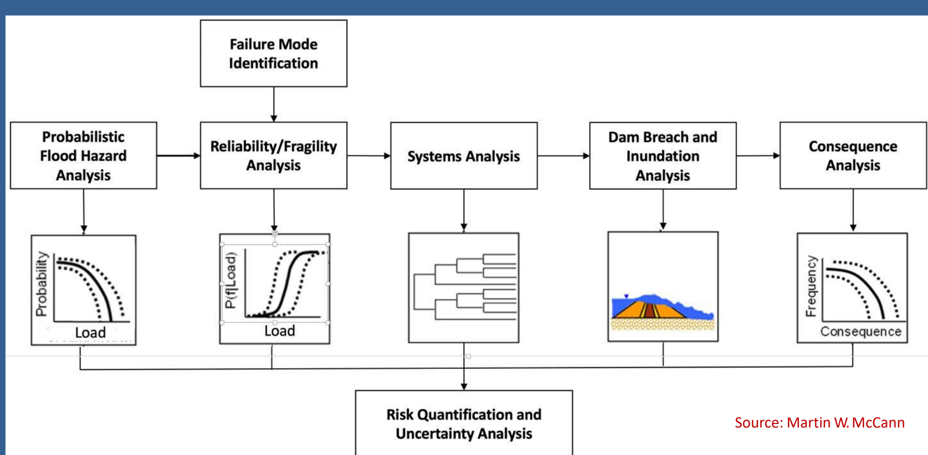
# Part II. Hurricane Katrina (IPET)

## Threat-vulnerability-consequence (TVC) revisited




Source: Martin W. McCann

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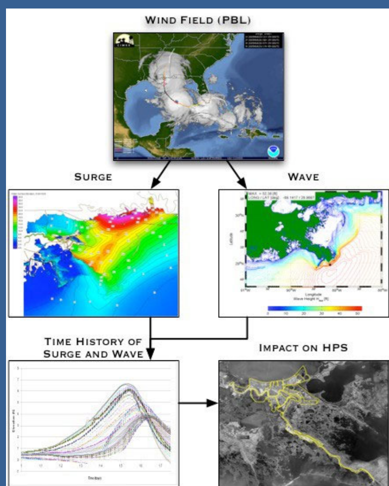
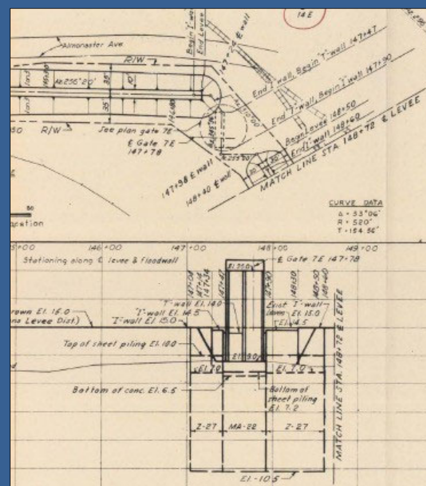
# Part II.  Hurricane Katrina (IPET)

## Working with legacy analyses



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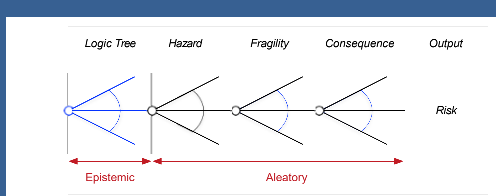
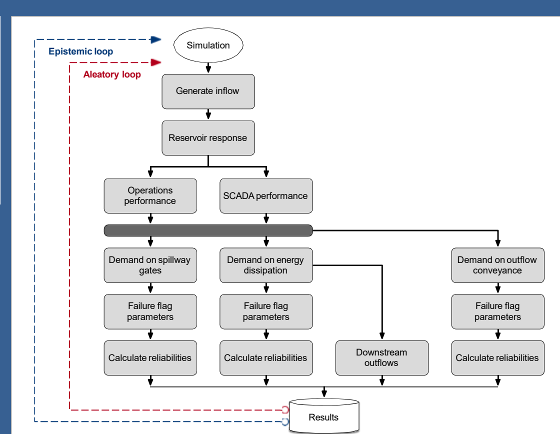
# Part II.  Hurricane Katrina (IPET)

## Philosophical lessons about risk analysis

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## Geotechnical systems, uncertainty, & risk

Practical lessons

Need for formalism in organizing data and analyses,

Event trees don't scale,

Putting numbers on engineering judgment,

Need to communicate risk to the public.

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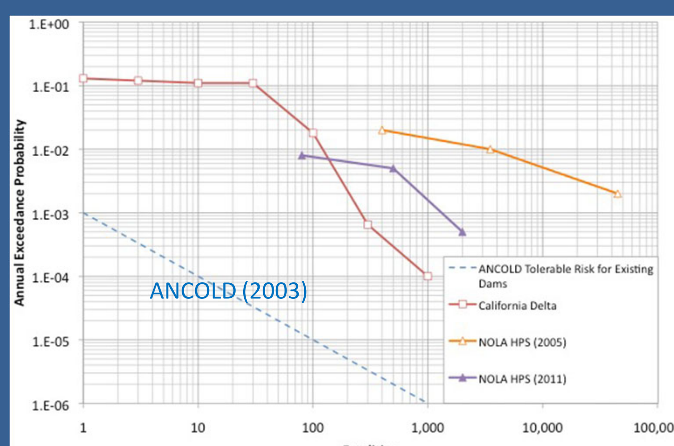
## Part II. Hurricane Katrina (IPET)

Risk communication

*Safe* is not an engineering term *




*Paraphrased from, Petroski, H. (2011). "How Safe Is Safe Enough?" *NPR.org*, March 29

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## Bayesian digression

The statistics we all learned in college is useless

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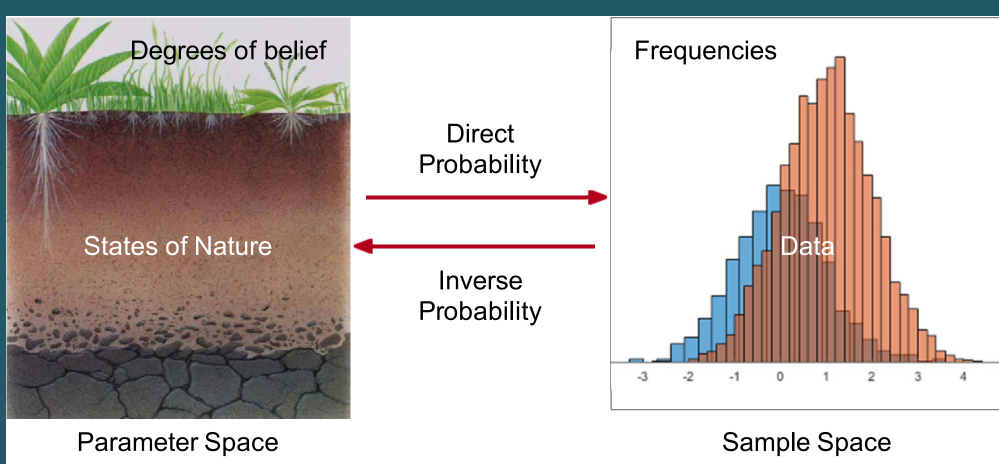
## Bayesian digression

Uncertainty is about states of nature

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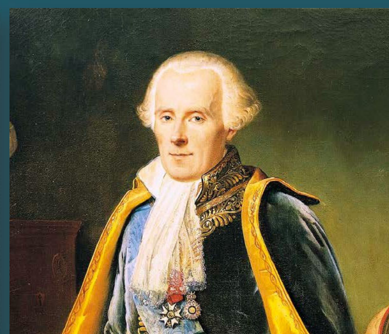
## Bayesian digression

### There at the beginning …

Not actually Thos. Bayes (1701?-61)



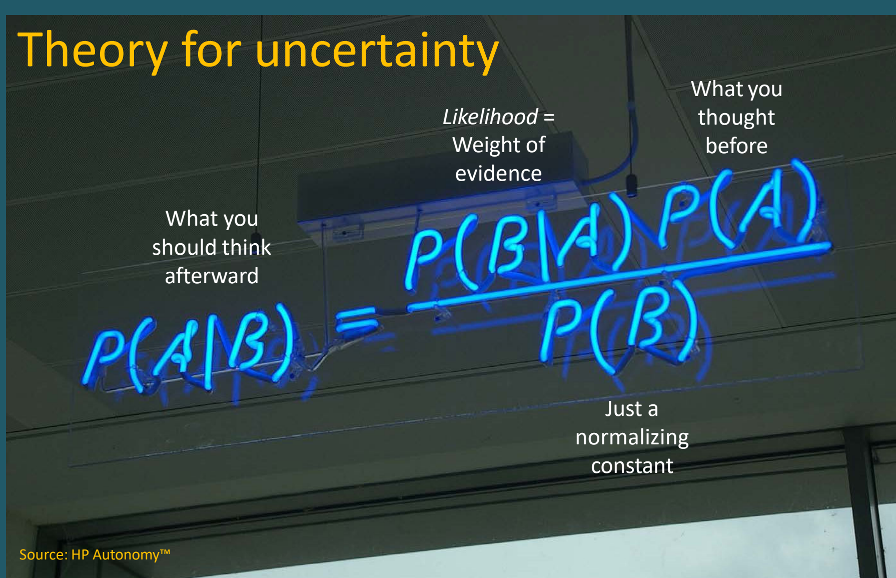
Actually Laplace (1749-1827)

Sir Harold Jeffreys (1891-1989)



## Bayesian digression

### Theory for uncertainty




"One sees, from this Essay, that **the theory of probabilities is basically just common sense reduced to calculus**; it makes one appreciate with exactness that which accurate minds feel with a sort of instinct, often without being able to account for it." — Laplace

## Bayesian digression

### Geotechnical engineers are all Bayesians*(ACM)

H&H people are frequentists

Geotechs are Bayesians

Structural people care mostly about meeting code

*ACM = According to me

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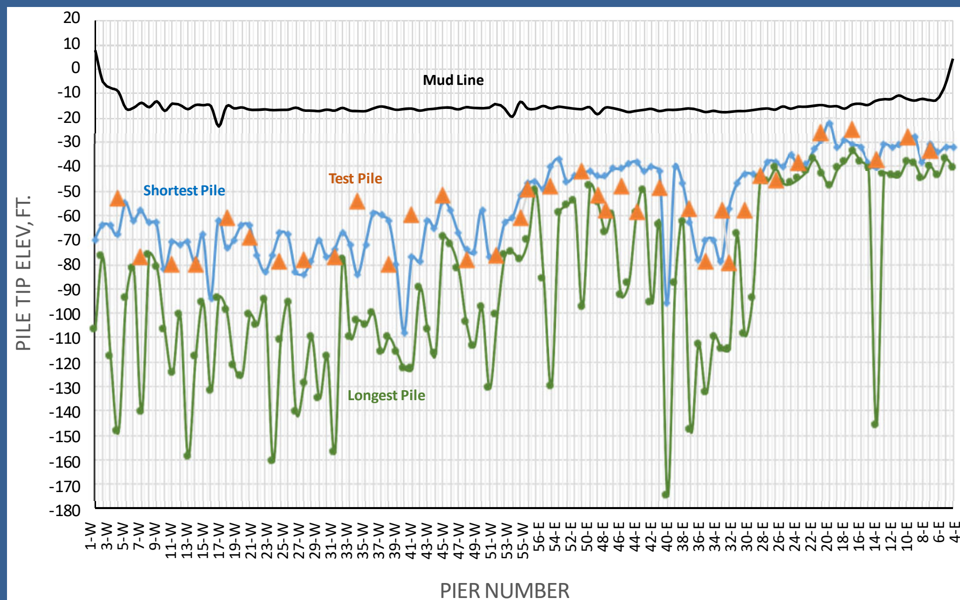
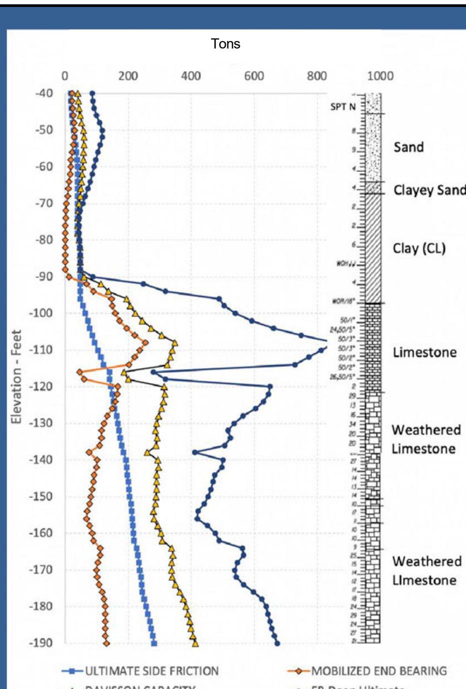
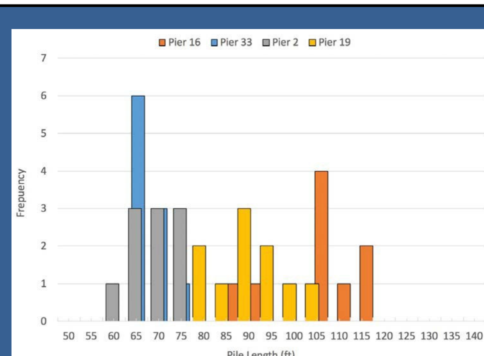
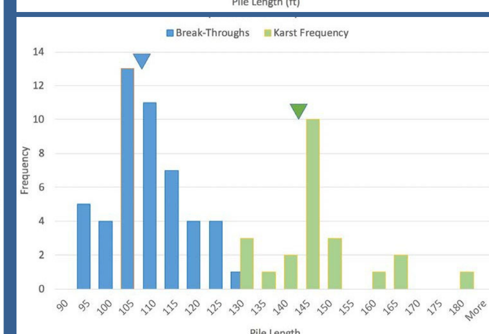

Mud Line
Shortest Pile
Test Pile
Longest Pile
PILE TIP ELEV, FT.
PIER NUMBER
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
1-W
3-W
5-W
7-W
9-W
11-W
13-W
15-W
17-W
19-W
21-W
23-W
25-W
27-W
29-W
31-W
33-W
35-W
37-W
39-W
41-W
43-W
45-W
47-W
49-W
51-W
53-W
55-W
56-E
54-E
52-E
50-E
48-E
46-E
44-E
42-E
40-E
38-E
36-E
34-E
32-E
30-E
28-E
26-E
24-E
22-E
20-E
18-E
16-E
14-E
12-E
10-E
8-E
6-E
4-E
2-E

27


Tons
0
200
400
600
800
1000
SPT N
Sand
Clayey Sand
Clay (CL)
Limestone
Weathered Limestone
Weathered LImestone
Elevation - Feet
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
ULTIMATE SIDE FRICTION
MOBILIZED END BEARING
DAVISSON CAPACITY
FB-Deep Ultimate


Pier 16
Pier 33
Pier 2
Pier 19
Frequency
Pile Length (ft)
0
1
2
3
4
5
6
7
50
55
60
65
70
75
80
85
90
95
100
105
110
115
120
125
130
135
140


Break-Throughs
Karst Frequency
Frequency
Pile Length
0
2
4
6
8
10
12
14
90
95
100
105
110
115
120
125
130
135
140
145
150
155
160
165
170
175
180
More

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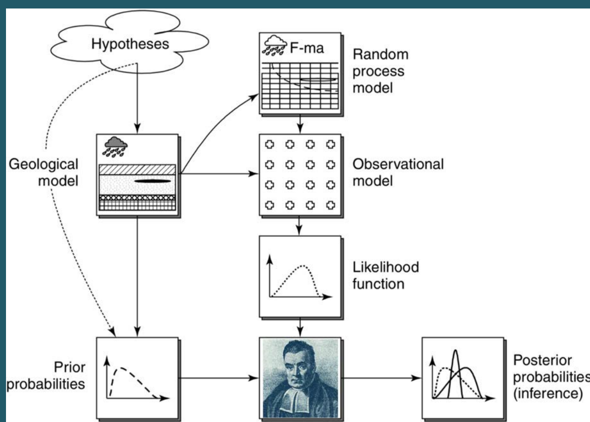
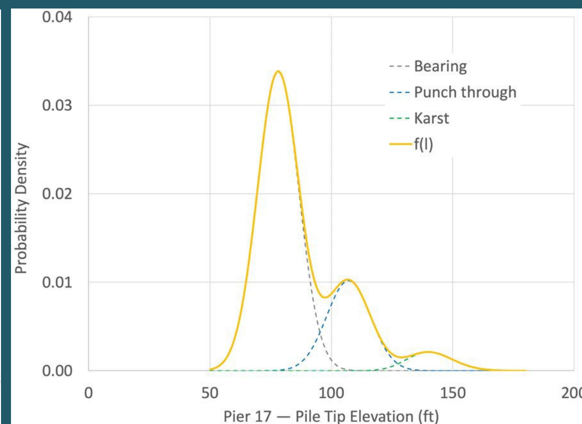
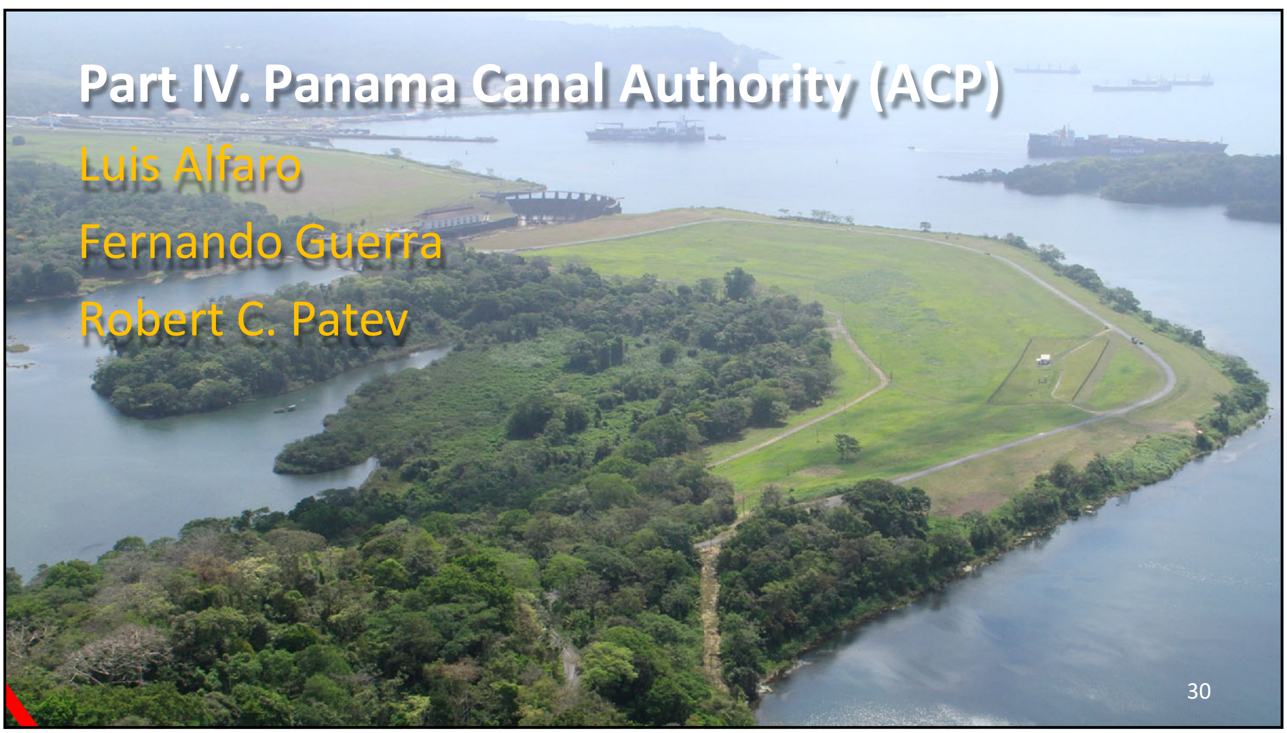
# Geotechnical systems, uncertainty, & risk

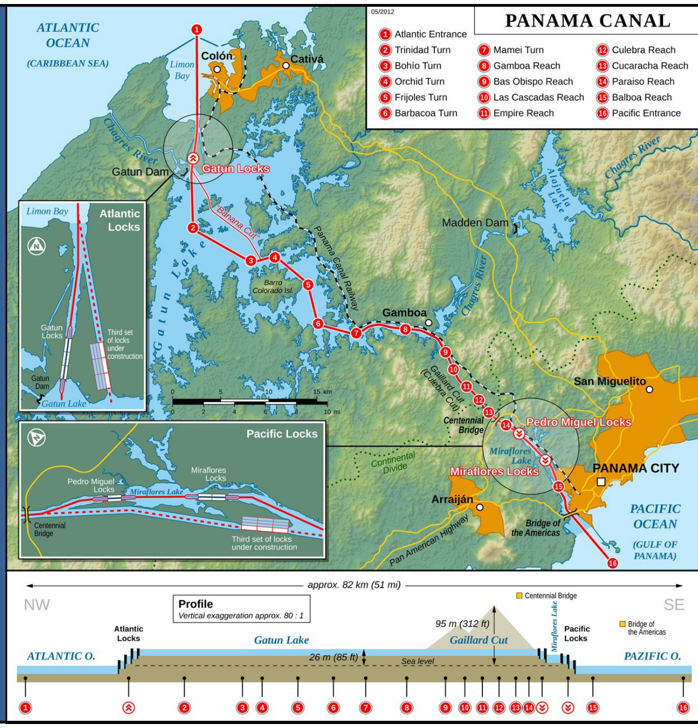
## Thinking rationally about uncertainty

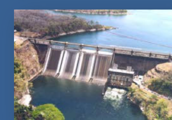



29





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# Part IV. Panama Canal Authority (ACP)

## Risk register

| | # | Category | Structure | Event | Description | Component | Description | Failure Mode | Failure Cause | Remark | Liklihood (Y) | Consquences (X) | Risk Index | Risk Matrix Box Number | Natural (N) or Aging (A) | Low Probability | Low Consequences | Med Probability | Med Consequences |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | | | | | | | | | | Consequences | | | | | | | | EVENTS | |
| 110 | | | | | | Abutments | | Structural failure | Overload and concrete overstressed | | 2 | 1 | 0 | 15 | N | 0.9 | 500000 | 0.09 | 100000000 |
| 111 | | | | | | Roadway Bridge | | Structural failure | Concrete overstressed | | 3 | 1 | 0 | 14 | N | 0.9 | 500000 | 0.09 | 100000000 |
| 112 | | | | Corrosion | Metal deterioration | Drum gates | Structural steel | Yielding | Loss of member thickness | | 3 | 1 | 0 | 14 | A | 0.9 | 500000 | 0.09 | 100000000 |
| 113 | | | | | | | | Gate out of commission | Water infiltration due to holes in the structure | Asumiendo que la compuerta se traba a nivel 232' y el lago empieza a subir por arriba de este nivel C | 3 | 2 | 1 | 10 | A | 0.9 | 500000 | 0.09 | 100000000 |
| 114 | | | | | | Gate machinery | | Yielding | Loss of member thickness | | 3 | 1 | 0 | 14 | A | 0.9 | 500000 | 0.09 | 100000000 |
| 115 | | | | | | Roadway Bridge | | Structural damage | Reinforced steel corrosion | | 4 | 1 | 0 | 13 | A | 0.9 | 500000 | 0.09 | 100000000 |
| 116 | | | | | | Sluice gates | | Yielding | Loss of member thickness | | 3 | 1 | 0 | 14 | A | 0.9 | 500000 | 0.09 | 100000000 |
| 117 | | | | Aging | Metal fatigue and concrete deterioration | Drum gates | Steel structure, and all castings in concrete | Fatigue | Excess vibration due to water flow | | 1 | 1 | 0 | 16 | A | 0.9 | 500000 | 0.09 | 100000000 |
| 118 | | | | | | Concrete piers | | | | | -1 | -1 | -1 | -1 | A | 0.9 | 500000 | 0.09 | 100000000 |
| 119 | | | | | | Concrete main section | | | | | -1 | -1 | -1 | -1 | A | 0.9 | 500000 | 0.09 | 100000000 |
| 120 | | | | | | Gate machinery | Mechanical, electrical, and control systems | | | | -1 | -1 | -1 | -1 | A | 0.9 | 500000 | 0.09 | 100000000 |
| 121 | | | | | | Sluice gates | | | | | -1 | -1 | -1 | -1 | A | 0.9 | 500000 | 0.09 | 100000000 |
| 122 | | | | | | Abutments | | | | | -1 | -1 | -1 | -1 | A | 0.9 | 500000 | 0.09 | 100000000 |
| 123 | | | | | | Roadway bridge | | | | | -1 | -1 | -1 | -1 | A | 0.9 | 500000 | 0.09 | 100000000 |

Team Members | Matrix Colors - Numbering | Matrix Summary by Structures | Earth Dams | Spillways | Existing Locks | New Locks | Power System | Navigation Channel | Bridges | Buildings | Water Plants | Events | R

## Part IV. Panama Canal Authority (ACP)

East Cucaracha Slide of February 2, 1913 (Courtesy, ACP)

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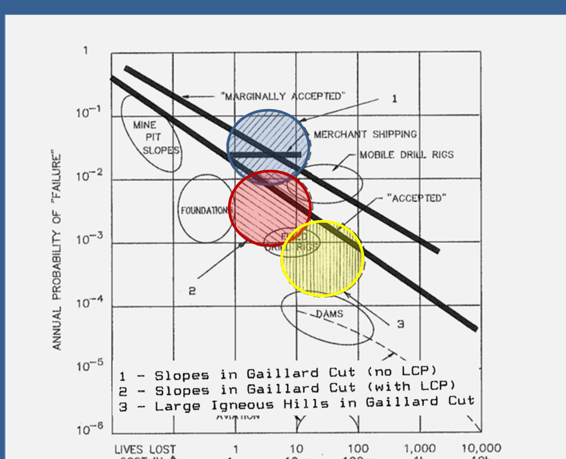
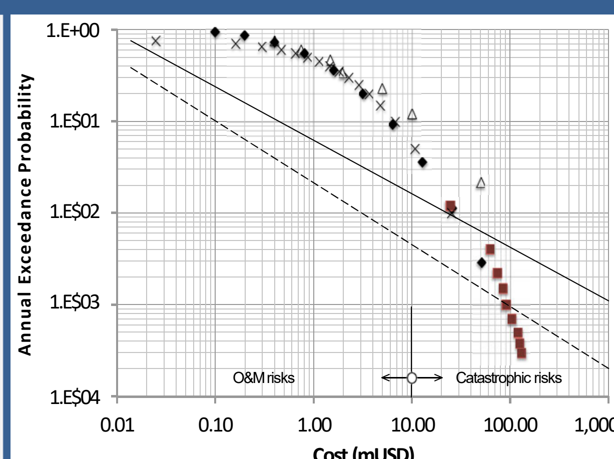
## Part IV. Panama Canal Authority (ACP)

Landslide control program




(Alfaro 1988)

# Part IV. Panama Canal Authority (ACP)

Practical lessons about risk analysis

The organizing power of qualitative risk assessment.

Need to communicate risk to management.

Sometimes need to accommodate legacy analyses.

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# So what ?

- Rationally dealing with risk in large geotechnically-engineered systems …
  - Risk analysis approach is still evolving but mature
  - Successful on large geotechnical projects
- The statistics we learned in college is unhelpful [ACM] …
  - Probability is in the model, not the ground
  - Uncertainty is epistemic and subjective
- Bayesian thinking is the natural way to think about uncertainties …
  - The way geotechnical engineers actually think
  - Allows strong conclusions from sparse data
  - Foundation of the observational method

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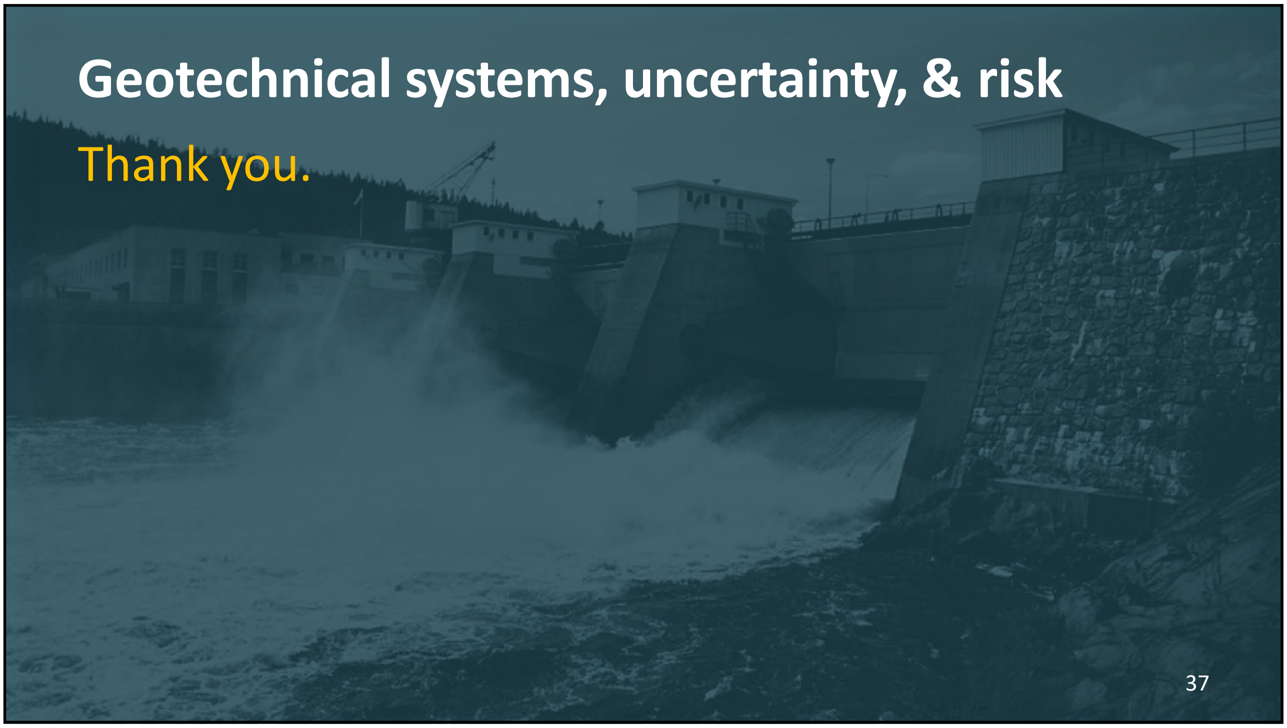
Geotechnical systems, uncertainty, & risk
Thank you.
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# *"Risk Mitigation in the Changing Relationship between Contractor and Engineers"*

The 2022 Spencer J. Buchanan Lecture

By Dr. Mark W. Buchanan

# 2022 Buchanan Lecture

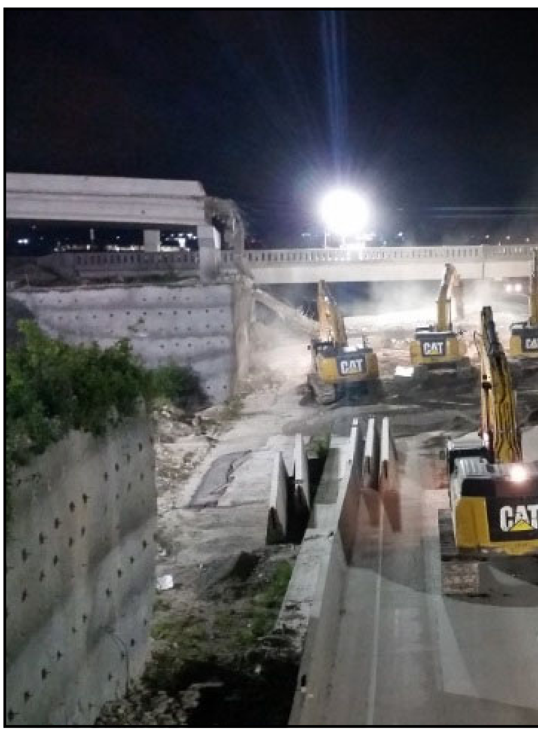
The Dynamic Relationship Between Contractors and Engineers, Risk Mitigation, and Best Practice

## Introduction

- Dr. Jean-Louis Briaud
  - University Distinguished Professor
  - Distinguished Member ASCE
  - Past President ASCE (2021)
  - Buchanan Chair Holder
  - Scholar and Gentleman

## Introduction

- General Spencer J. Buchanan, USACE
  - Texas A&M Class of 1926
  - Professor Emeritus, TAMU
  - True Gentleman

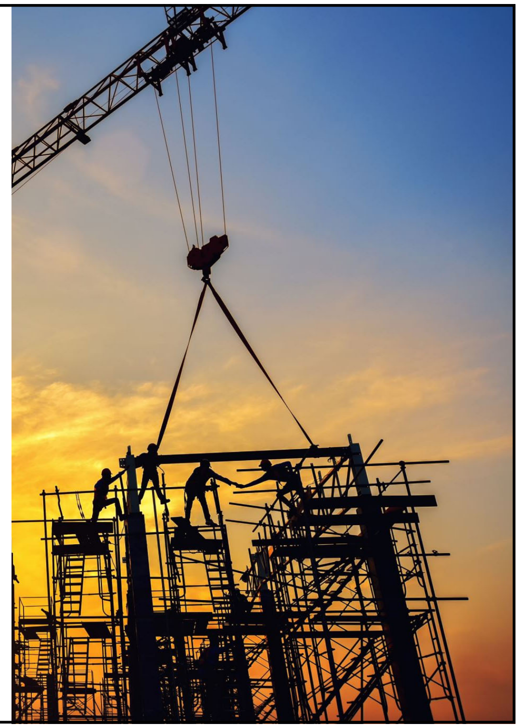



## Changing Professional Dynamic

- Historic Preconceptions
- Generational Dynamics and New Technology
- Commonality of Emerging Construction Contract Platforms
  - Design/Build
  - CMAR
  - Public Private Partnership
  - Conclusion: Owner Risk Mitigation, Innovation, Acceleration

# Heavy Civil Design/Build

- D/B Prequalification
- Teaming Agreement through Pre-Award Design; 0.5% vs. Stipend
- Teaming Agreement K Platforms
- Design Agreement; 6% of estimate cost to construct
- Know the Parties
- Know the Scope
- Know the Schedule (inc. Design Schedule)
- Know the 'Plan'
- Participate in the Bid



# Risk Mitigation

- Cost/Benefit Comparison: Engineering and Contracting
- Difference in Business Models
- Reconciling to Success

## Fort Lauderdale Airfield Expansion

- Performance Specification
- Success Fee
- Cohabitate
- Daily Over-the-Shoulder
- Daily Schedule
- Foresight

## Fort Lauderdale Airfield Expansion $240 Million

- Design/Build
- Performance Specification (747-800 vs Airbus 380)
- Success Fee
- Notice runway threshold and ‘tunnels’

# Fort Lauderdale Airfield Expansion

- Notice common point of aircraft landing location (‘touchdown’) over tunnel.
- MD 747-800 vs. Airbus A380

# Fort Lauderdale Airfield Expansion

- Consider length of tunnel for US 1
- Consider the number of tunnels
- Consider skew
- Consider National Fire Protection Code
- Is it an overpass or tunnel?
- 3,600 driven piles increased, post bid, from 18” to 24”

## Fort Lauderdale Airfield Expansion

- Consider the skew of the runway boundaries to the 'tunnel'…length determination made at centerline

## Fort Lauderdale Airfield Expansion Lessons Learned

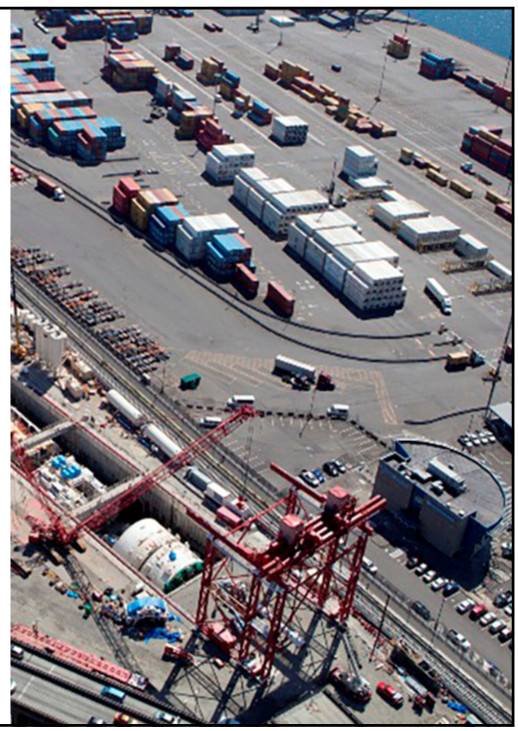
- Take Performance Specifications very seriously
- Always stay cognizant of the 'big picture'

# Alaskan Viaduct Tunnel Bore

- Nature of Joint Venture Platform
- Engineer: Secant Wall
- Contractor: Criticality of Glacial Till Interaction
- Accountability

# Alaskan Viaduct
# $1.4 Billion

- Secant DS Entrance Pit complete
- TBM modules in the pit, assembly ongoing
- 360’ x 60’…largest TBM in the world at the time
- Single use; $82 M



# Alaskan Viaduct

- Portions of the TBM hoisted off ships and preparing for assembly

# Alaskan Viaduct:

- Twin Conveyors
- Precast Panel ring panels


# Alaskan Viaduct

- At the time, the world's largest TBM
- One use, then dismantled
- Cutter teeth replacement at 1,000 LF
- Piezometer strike at 1,500 LF

# Alaskan Viaduct

- Secant shaft retaining wall
- Notice hydrostatic pressure relief
- FRP TBM 'valley'

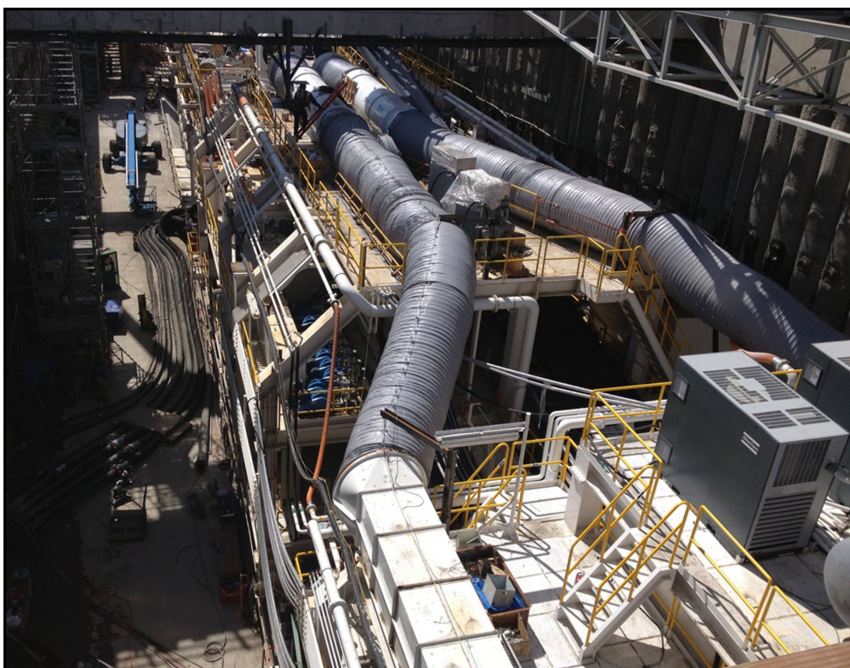
# Alaskan Viaduct

- Entrance pit ready for TBM assembly


# Alaskan Viaduct

# Alaskan Viaduct

- Entrance pit ready for TBM assembly
- TBM staged beside pit
- Gantry crane and Manitowoc 999 ready to assemble

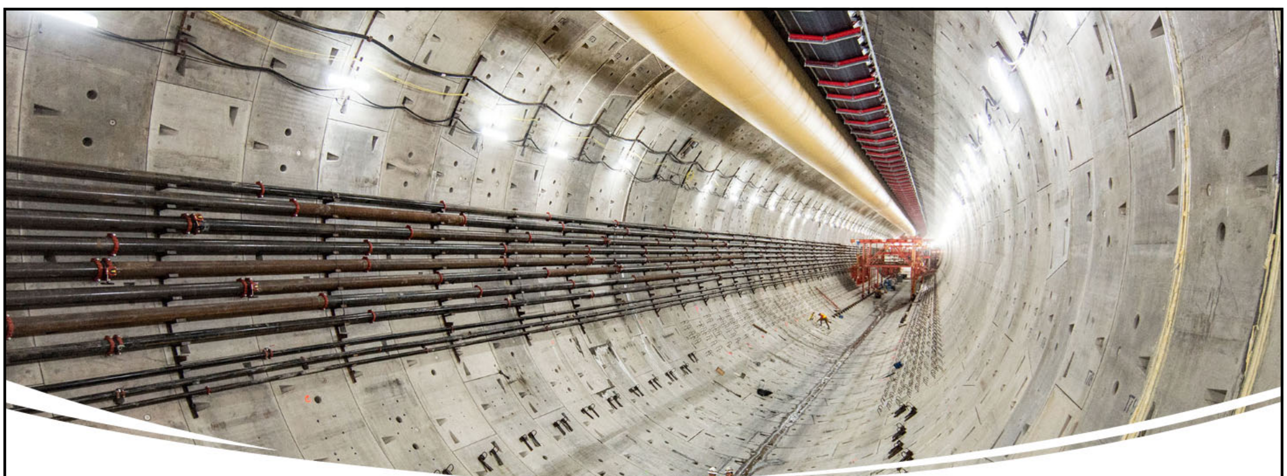


# Alaskan Viaduct

- 360’ TBM assemble and ready for excavation

# Alaskan Viaduct

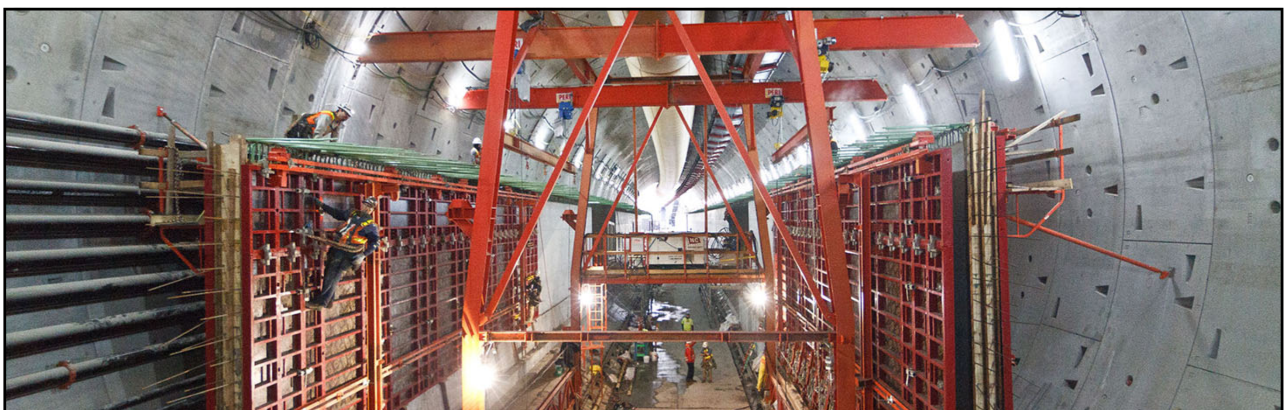
- Notice precast panels (issue)
- Conveyor
- Ventilation



# Alaskan Viaduct

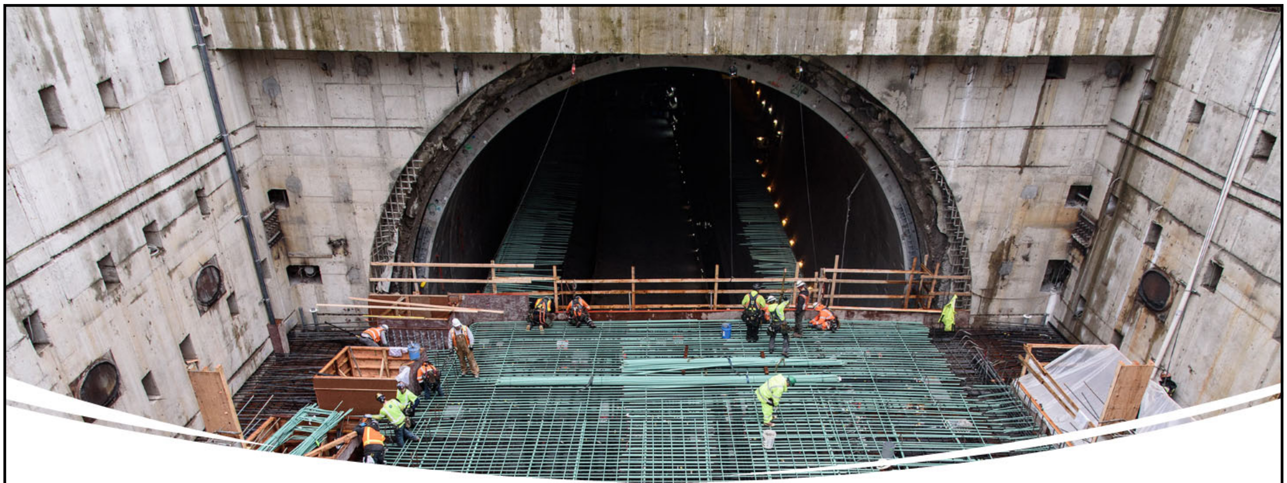
- Rolling Gangform for interior walls and decks for split (over/under) highway

# Alaskan Viaduct



## Alaskan Viaduct

- Rolling form system for interior wall build out.  Note rebar projections for highway decks



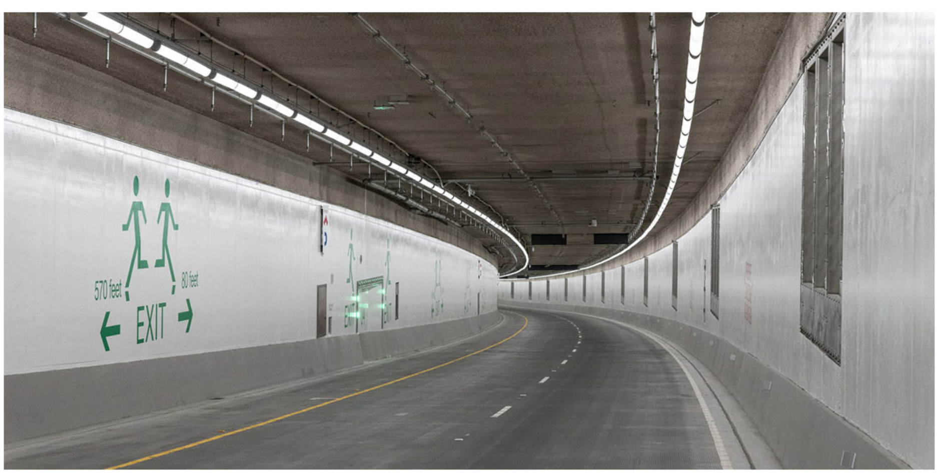
# Alaskan Viaduct

- Interior walls poured with rebar projections for the ldeck
- Upper Deck formed at the extraction pit

## Alaskan Viaduct

# Alaskan Viaduct

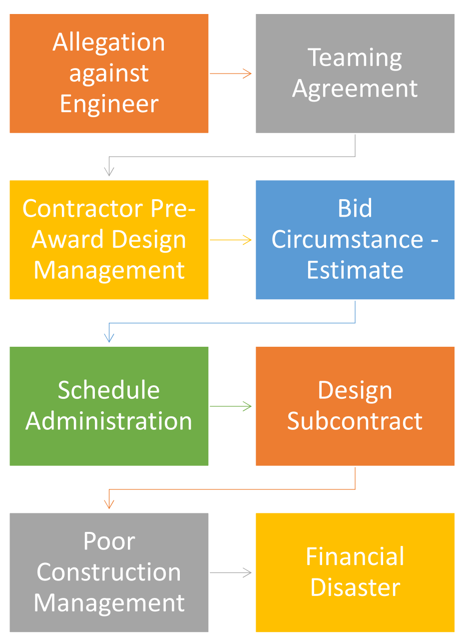
# Alaskan Viaduct



# Alaskan Viaduct Lessons Learned

- Engineer to stay very cognizant of Design Schedule
- Contractor should know JV partner well and carefully consider Managing vs. Minority Partner configuration.
- Considerations for Division of Scope

## Undisclosed Project (litigation= $270m)



# Undisclosed Project Lessons Learned

- Conceptual Nature of Pre-Award Design
- Contractor Design Manager
- Pre-Award Design Contract and Liabilities
- Estimating Process (Contingency and Quantities)
- Scheduling Process
- Design Subcontract
- The ‘Plan’…Plan to Build; Build to Plan

# Conclusions:

- Hard Infrastructure is a significant market
- Horizontal in nature, large market for civil/geotechnical
- The evolving relationship between Contractors and Engineers matters
- D/B provides innovation, speed, enhanced margins…and risk
- Focus on the nuances enhances success

# Lessons Learned - Globally

- Understand stakeholder cultures and motivations (history, backlog, repeat partnerships, etc.) and Design Coordinator expertise.
- Examine Subk platform and Limit of Liability in Teaming Agreement and its relationship with the Design Subcontract.
- Active Participation in Project Baseline Schedule (Inc. Engineering Deliverables) and Schedule Updates – know the Critical Path!!
- Active Participation in Project Estimate/Bid (Read 1 and 2, quantities, risk, 11th hour changes, etc.)
- Understand the Conceptual Nature of D/B and integrate with Risk Register and Contingency Fees
- Success Fee Pitfalls – Promote Innovation, but not at the risk of productivity or scope creep
- Performance Specification Pitfalls – especially late performance specification adjustments.
- Cohabitation during design function – delivery schedule, over-the-shoulder reviews, costs, etc.
- Develop a Project-Level Culture of cooperation, collaboration, accountability and trust

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| | | Year 2 | $ | Year 5 | $ |
| Total Commitment: | $ | Year 3 | $ | | |

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