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Megaprojects Don’t Have to Fail

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My Viewpoint on the subject

- My firm studies industrial projects for capital-intensive firms around the world: oil and gas production, refining and petrochemicals, metals and minerals and pharmaceuticals
- We also work for the power sector, but largely for firms or projects not subject to rate-based regulation; those familiar with the Averch-Johnson effect will not wonder why
- Companies pay us to help them develop and execute their capital projects with lower costs, better schedules, better operability and less risk
- In the 34 years since I left doing similar work at the Rand Corporation, we have amassed the largest and most detailed databases of capital projects in the world
- Many of these are megaprojects—large, complex, engineering-intensive projects ranging up to $100 billion

My Point of View on the Subject

I do not see how we can successfully decarbonize our energy production without a very large baseload contribution from nuclear power

I increasingly despair of our ability to make that large contribution a reality, at least in the Western World

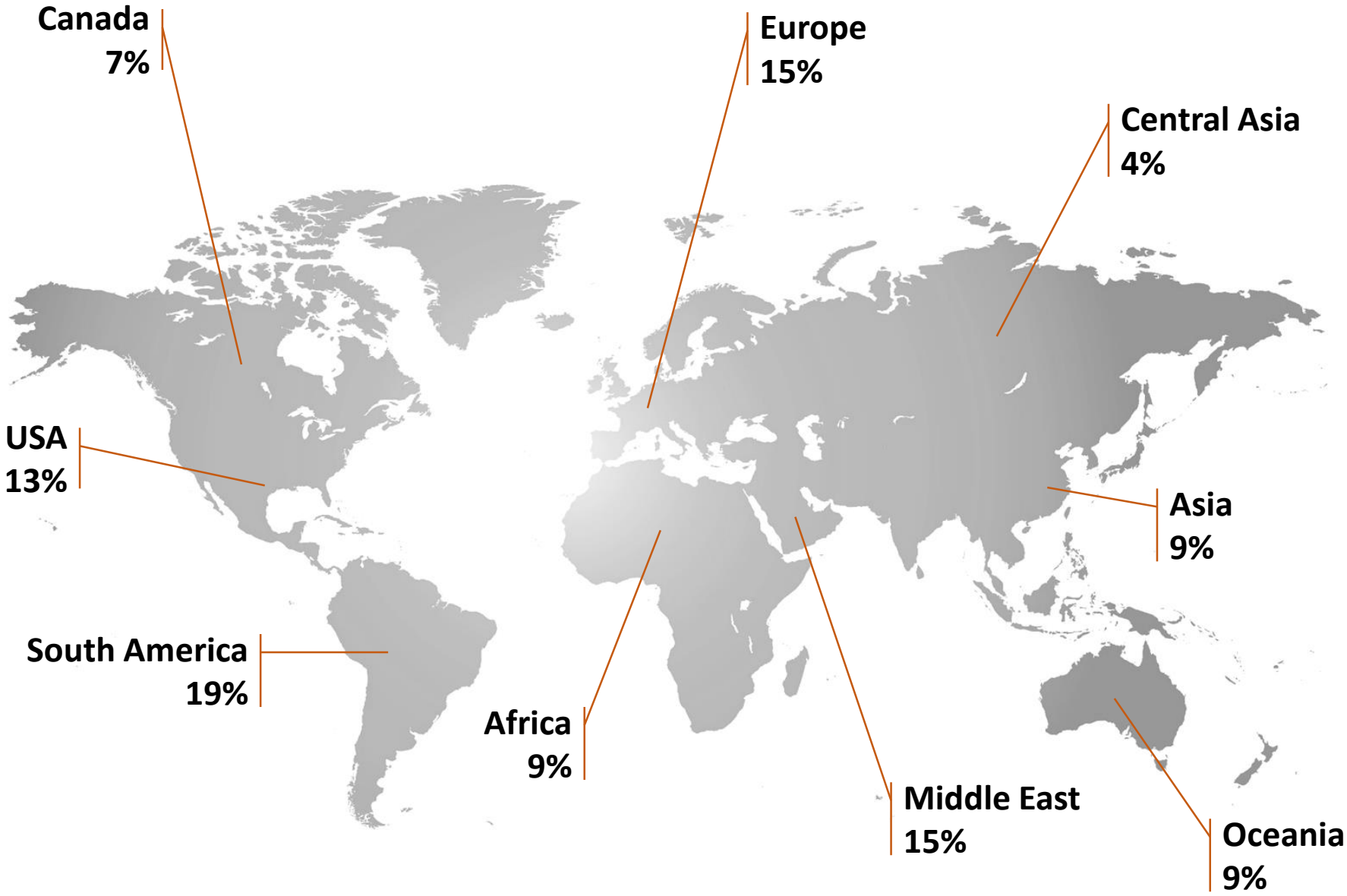
In my view the problem is not opposition or regulation, it is the abominably poor quality of nuclear power projects

It is really quite unnecessary

Megaproject Database

Megaproject Characteristics	
Number of Megaprojects	514
Median Megaproject Cost (2011 USD) Range of Megaproject Costs (2011 USD)	$3.6 billion $1 billion to $116 billion
Median Execution Duration Average Cycle Time Duration	44 months 66 months
Number of Owners Represented	~80
Average Authorization Year	2009
Projects With Any New Technology	27%

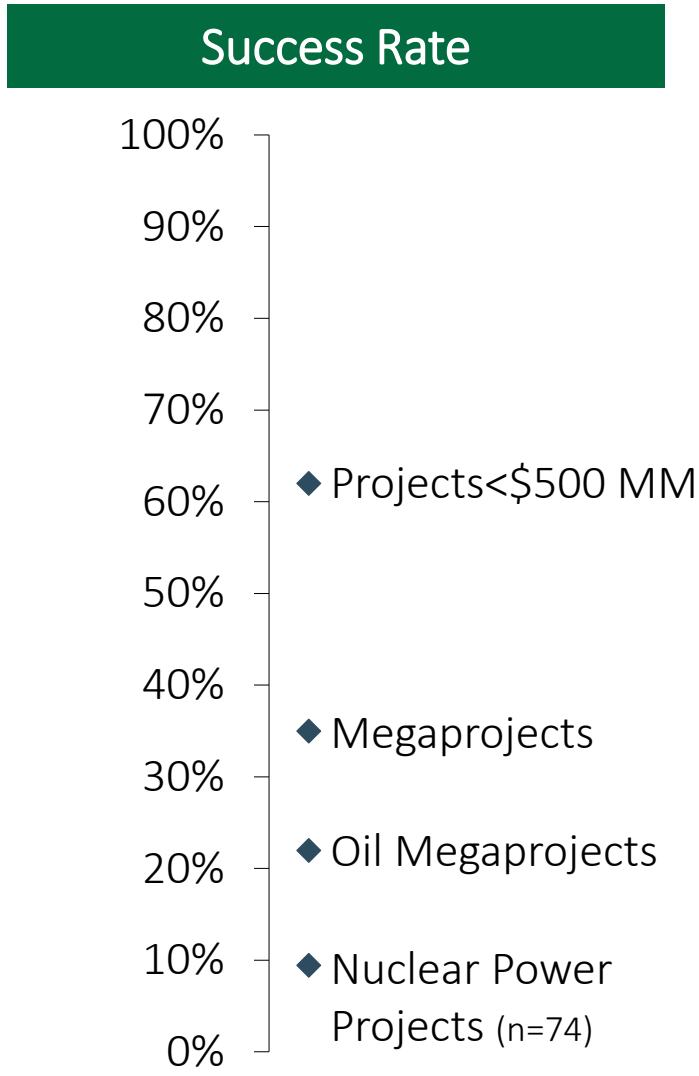
Megaproject Geographical Distribution



Defining Success and Failure

We deem a project to be a *Success* if all occurred:

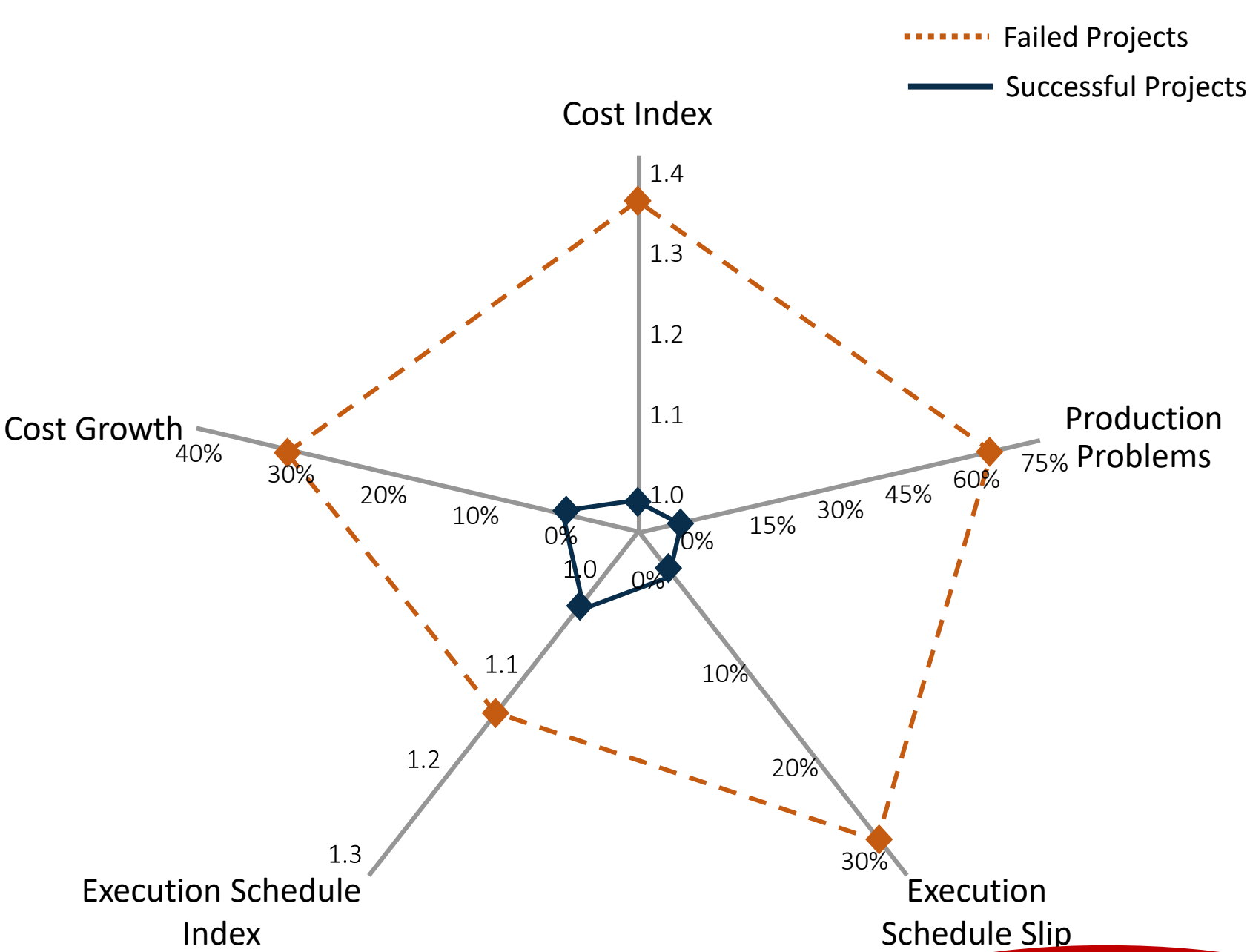
Costs Growth from full-funds authorization (real)	Less than 25%
Cost Competitiveness	Less than 1.25
Execution Schedule Slipped	Less than 25%
Severe and Continuing Production Problems (First two years)	No



Median nuke overrun is 110%

The Excellent and the Ugly

Megaprojects Are Either Very Good or Very Bad



Median nuke schedule slip is 65%

Why Do Megaprojects Have This Unusual Bimodal Distribution of Outcomes?

- Bimodal pattern of outcomes is the result of the most critical megaproject characteristic:

Megaprojects are fragile!

- Megaprojects do not tend to go somewhat wrong when things become problematic, they fall apart
- Understanding megaproject fragility is key to successfully managing these ventures
- These projects must be tightly integrated to achieve economic success
- But that makes them very vulnerable to cascade failures
- Which means the planning for the projects must be extraordinarily robust

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Outcomes are Disappointing—but Not All are Disappointing!

- Megaprojects often fail, but they don't *all* fail—174 megaprojects in our sample were *brilliant* successes
- They were no easier than the failures
  - Hostile physical and social environments
  - Highly complex technically
  - No different in terms of size
- 174 is far too many to have been generated by good luck
- More importantly, the successes are not in any sense a random draw in terms of how their sponsors approached the projects and the work they did to prepare them

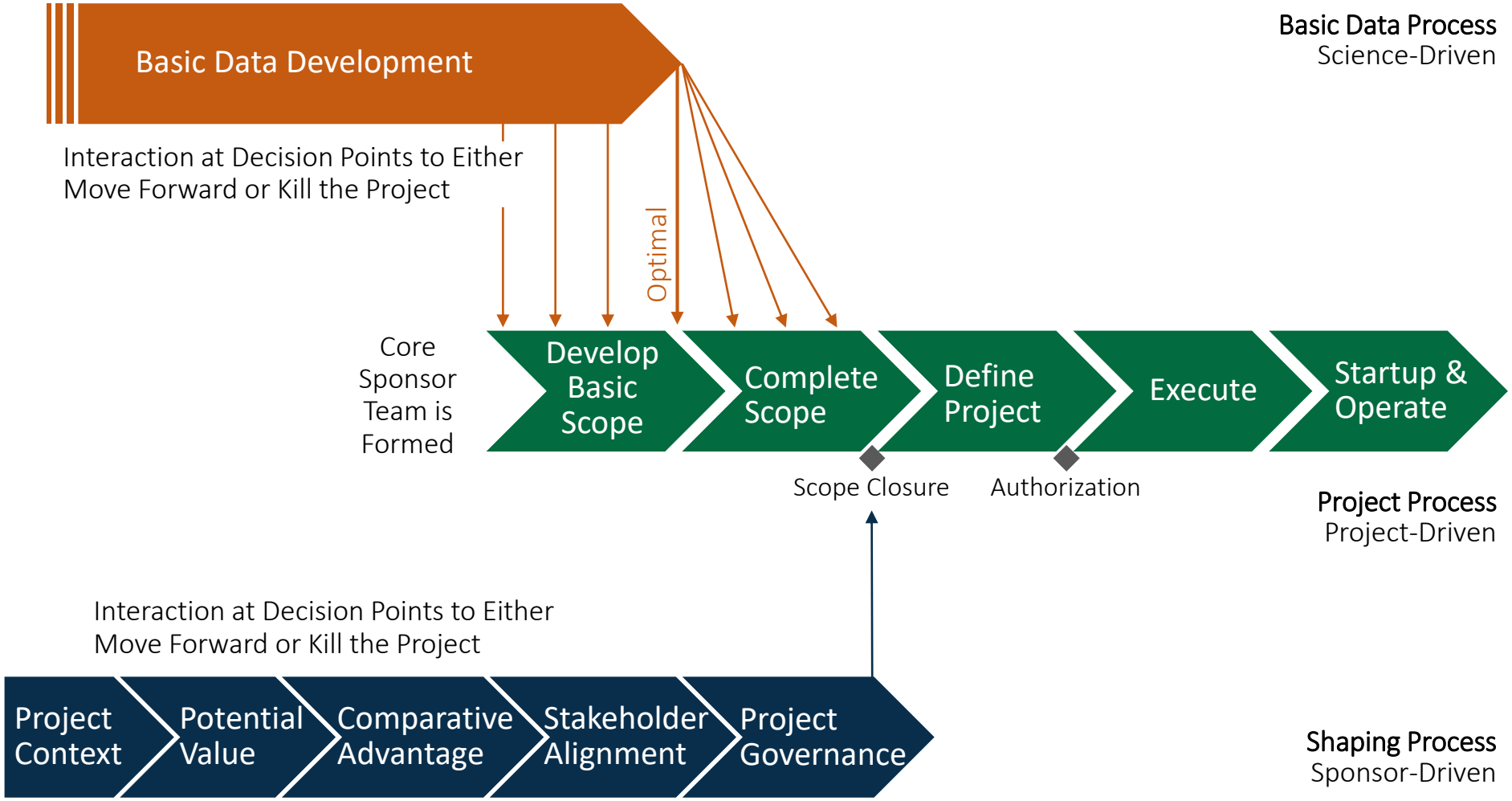
Three Necessary Conditions to Succeed

1. The **Basic Data must be complete and stable** well before the project is authorized

2. The lead sponsor must **shape** the project context by allocating the project's value such that stakeholders are in fundamental agreement and turbulence that would disrupt the project is minimized

3. The lead sponsor team must **fully and carefully define** the project prior to the start of execution such that the plan developed can be followed and owner controls implemented

Megaproject Front-end Development Process is more Complex



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What Are the Basic Data?

- A comprehensive set of parameters that govern the design
  - Express the science underlying engineering design of facilities that will be built
  - Reflect choices made to meet the business need, e.g. location
  - Reflect information developed during constructability reviews, such as logistics, infrastructure requirements, and construction constraints
- Guide engineers on:
  - Materials to use
  - Heat and mass balances that determine sizing
  - Set points
  - Hazards

Basic Data Are the Foundation of the Scope Development Team's Effort

- Basic Data need to be available and complete by middle of Scope Development phase
  - Ideally, most Basic Data would be available prior to start of scope development
  - Basic Data must be early enough in scope development to ensure that the design fully reflects them
- Timing of the Basic Data affects business decisions and shaping process
  - When Basic Data are incomplete, items are usually missing from the essential scope – leading to unduly optimistic cost and schedule estimates
  - Costs then grow during FEED and degrade front-end planning quality
  - Changes to the Basic Data can fundamentally change the value of a project and thereby crash the Shaping

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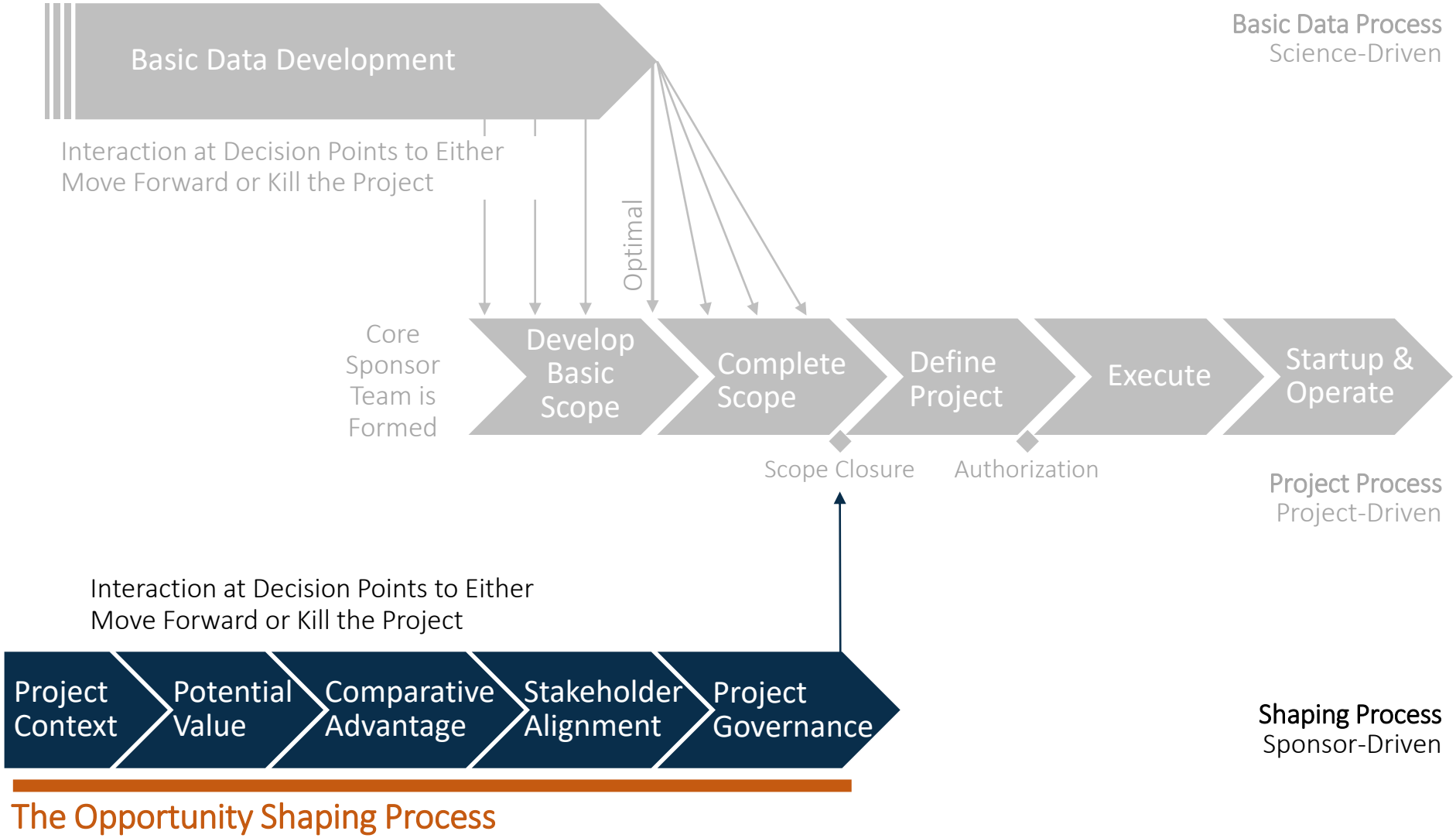
Basic Data and Nukes

- The history of nuclear power is replete with Basic Data changes
- The light water reactor was never a very desirable choice as a power reactor:
  - Not fail-safe
  - Not hot enough
  - Fuel cycle poses weapons proliferation problems
  - Hard to close fuel cycle
- Basic data changes continued as the first 80 or so reactors were built in the US and Europe; thus the basis of design was ever-evolving
- Every new design creates a host of changes to Basic Data and makes another first-of-a-kind
  - OL3, the Finnish EPR, is now loading fuel after a mere 15.5 years of execution
  - Flamanville, the first EPR design, is now forecast to be complete 187 months after authorization
  - Vogtle 3/4 AP 1000 design has also suffered numerous design changes
  - Basic Data errors have already shown up at Hinckley Point C
- Even when “standard designs” were used, almost everything was re-engineered

Megaproject Development Process

Stream Two



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Disruptions During Execution Cause Failure

- Megaprojects fail when they encounter severe turbulence during execution (late planning to startup)
- Unless Basic Data errors are found, turbulence is most often caused by unhappy stakeholders of one sort or another
- Most common forms of turbulence include:
  - Delays
  - Major changes in scope
  - Forced changes in project strategy
- There may be other sources of turbulence, e.g., unstable markets for factor inputs, but they rarely cause failure by themselves
- The turbulence occurs because the projects were not properly shaped

Primary Goals of the Shaping Process

Stabilize the environment in which the project will be executed

Configure the project so that it is profitable for the stakeholder-investors

Shaping reduces turbulence in the project environment that leads to changes and disruptions and ultimately project failure

Megaprojects Require Shaping

Shaping | **A complex process of fashioning a real project out of a business opportunity**

- Should be led and substantially staffed by the lead sponsor business
  - Other functions will support the effort but cannot lead it successfully
- Most companies and government organizations lack a coherent documented process for project shaping, creating an environment in which mistakes are easy
- Attempts to push forward without shaping the project almost always result in abandonment before sanction, or in failure

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What Does "Aligning the Stakeholders" Really Mean?

- Alignment isn't schmoozing, seducing, or misleading
- Stakeholders are people who want something of value from the project and have the means to get it (or make life miserable)
- 'Aligning the stakeholders' means allocating the value in such a way as to make the stakeholders satisfied enough with the result
- The alignment process starts as soon as the basic contours of the project are known

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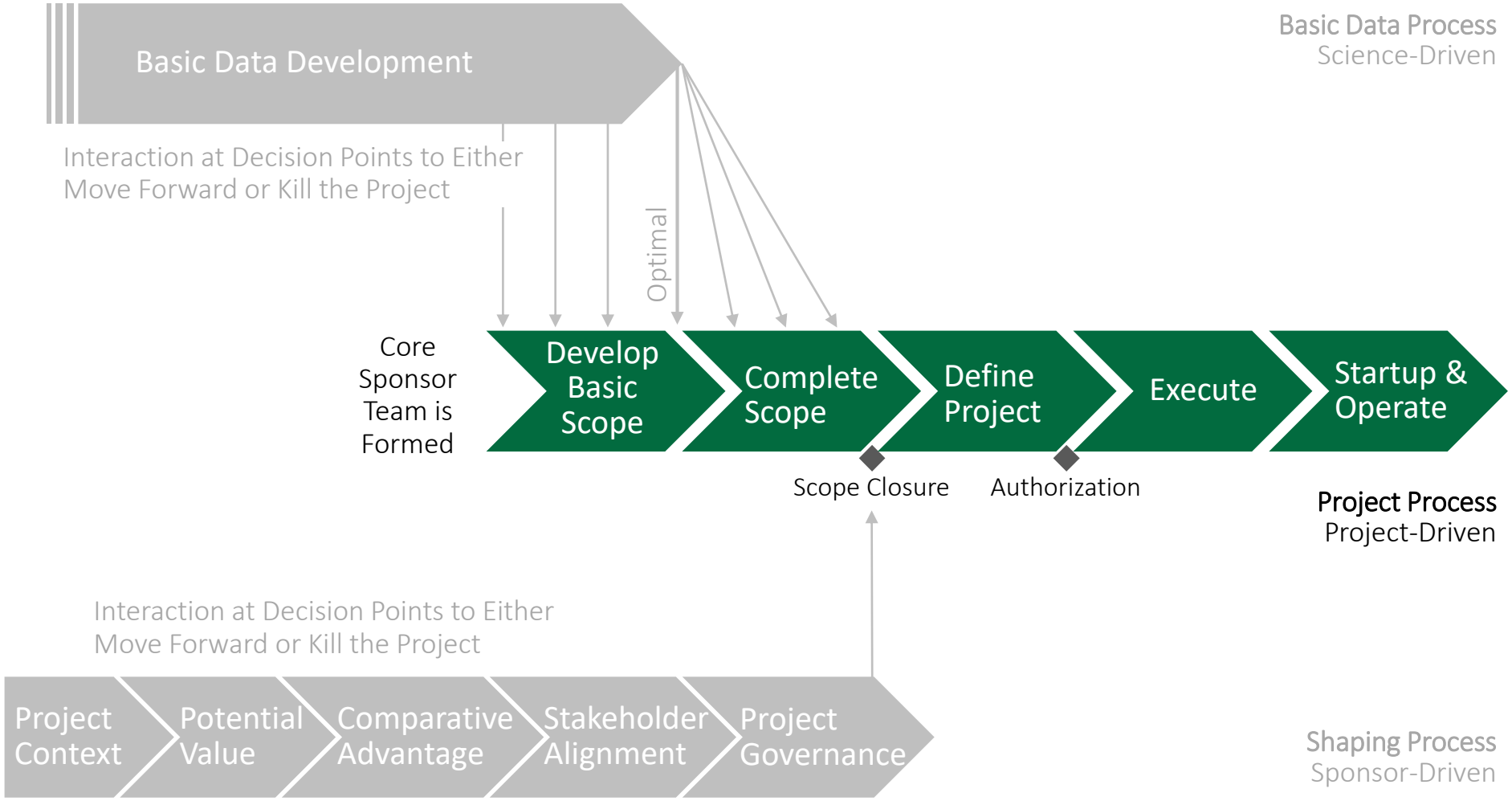
Shaping and Nukes

- Opposition to nuclear power is a fact of life
- Opposition slows the front-end of nuclear power projects, but has not often actually disrupted the construction process
- Addressing the opposition would undoubtedly be easier if nuclear power projects were not so very risky, often leaving unhappy rate-payers to absorb huge overruns and delays
- But shaping is not the biggest problem facing nuclear power station development—that is reserved for front-end definition

Megaproject Front-end Development Process

Stream Three



Good Front-end Definition Requires

- A strong owner project organization with all owner functional capability accounted for:
  - Engineering
  - Estimating
  - Scheduling
  - Construction management
  - Controls
  - Project leadership
  - Operations
  - Etc.
- A typical industrial project equivalent to a nuclear power project would be staffed by about 200 *owner* personnel during late development and execution
- A sound owner front-end work process
  - Elaborates all the work that must be done
  - Articulates the order in which work must be completed

Measuring Front-End Loading

Site Factors

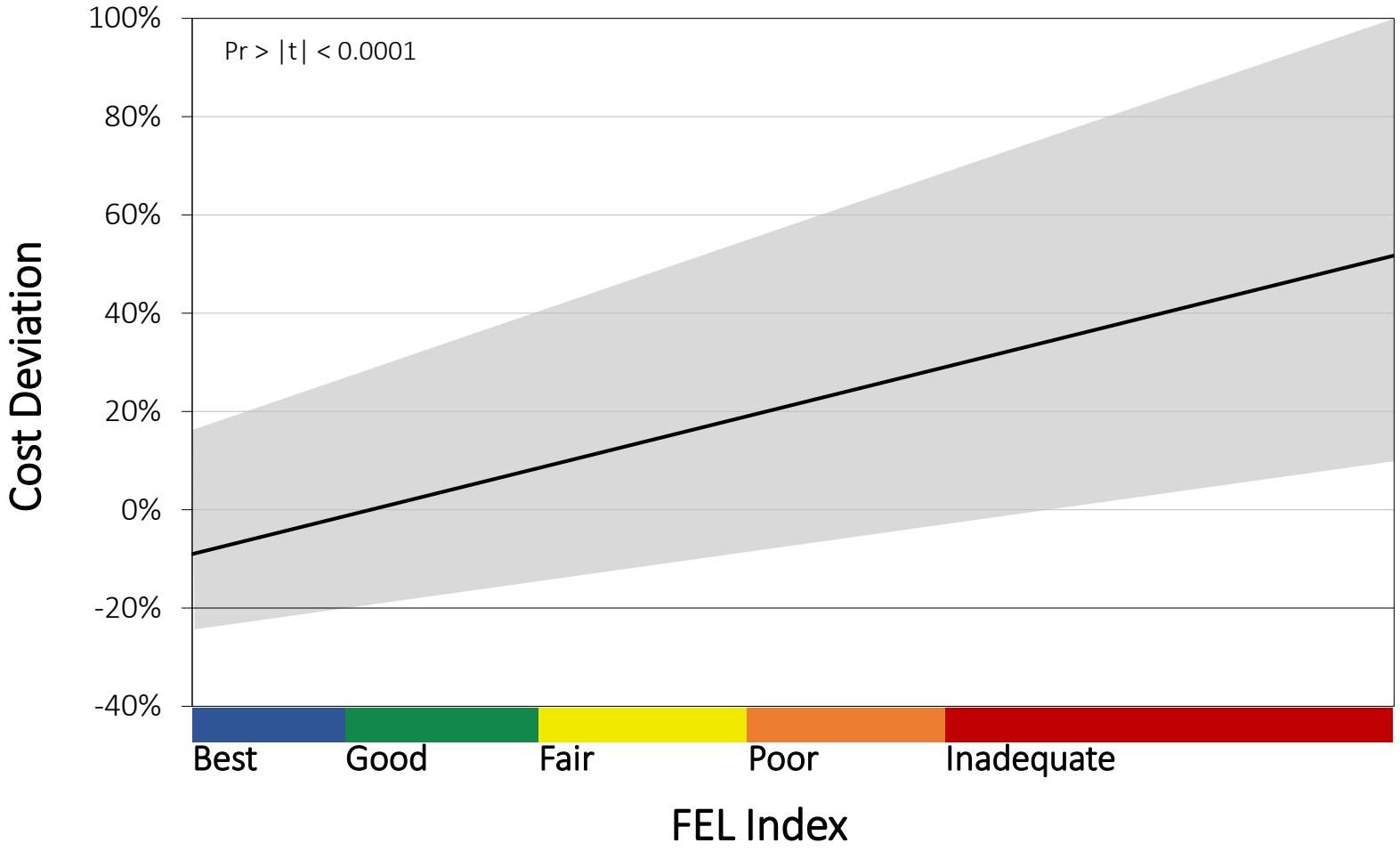
Design Status

Project Execution Plan

Over 100 measures of definition are combined into a numerical index

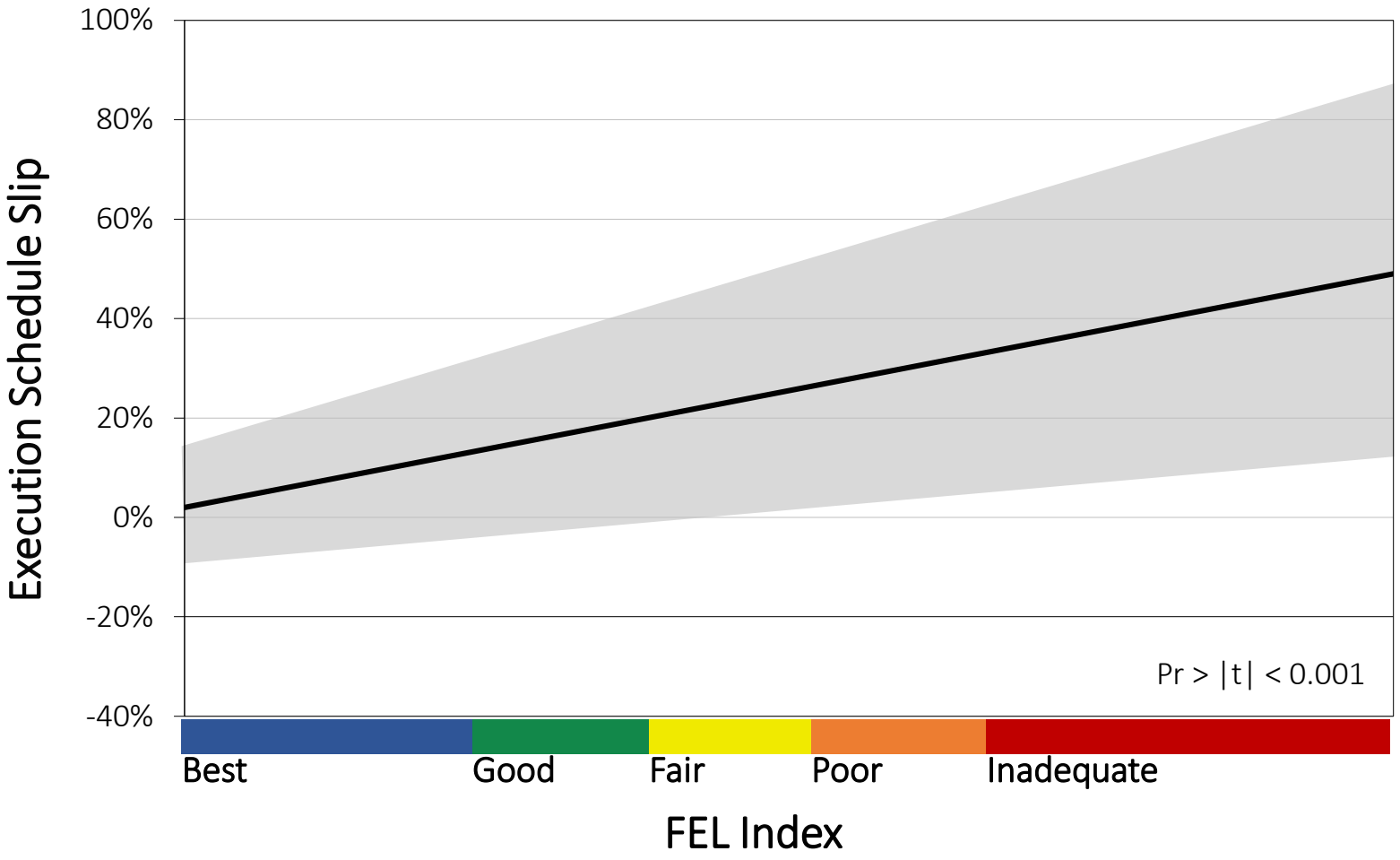
This is owner's work, not contractors'

FEL Drives Cost Predictability



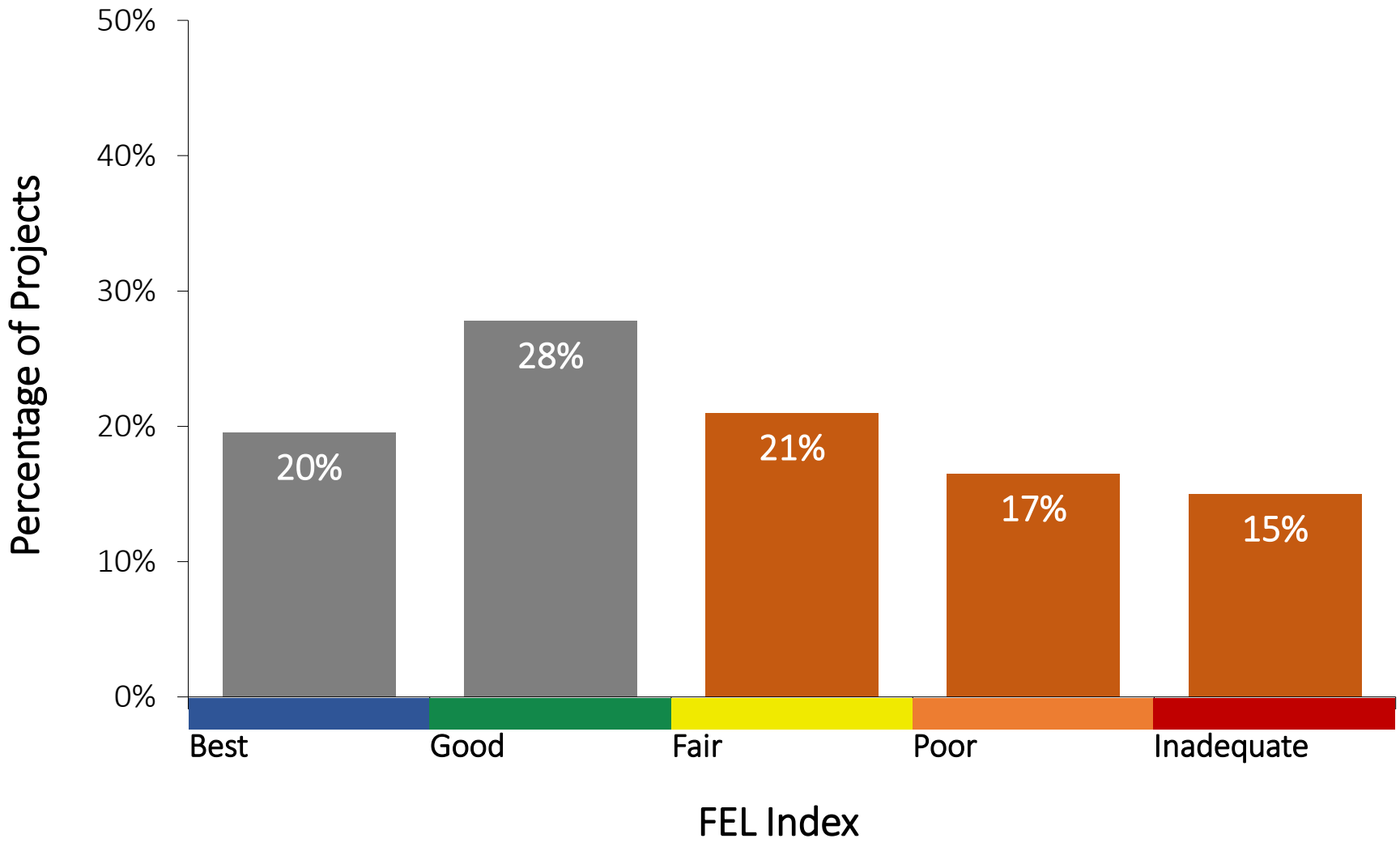
Shading represents ±1 standard deviation

FEL Drives Schedule Predictability



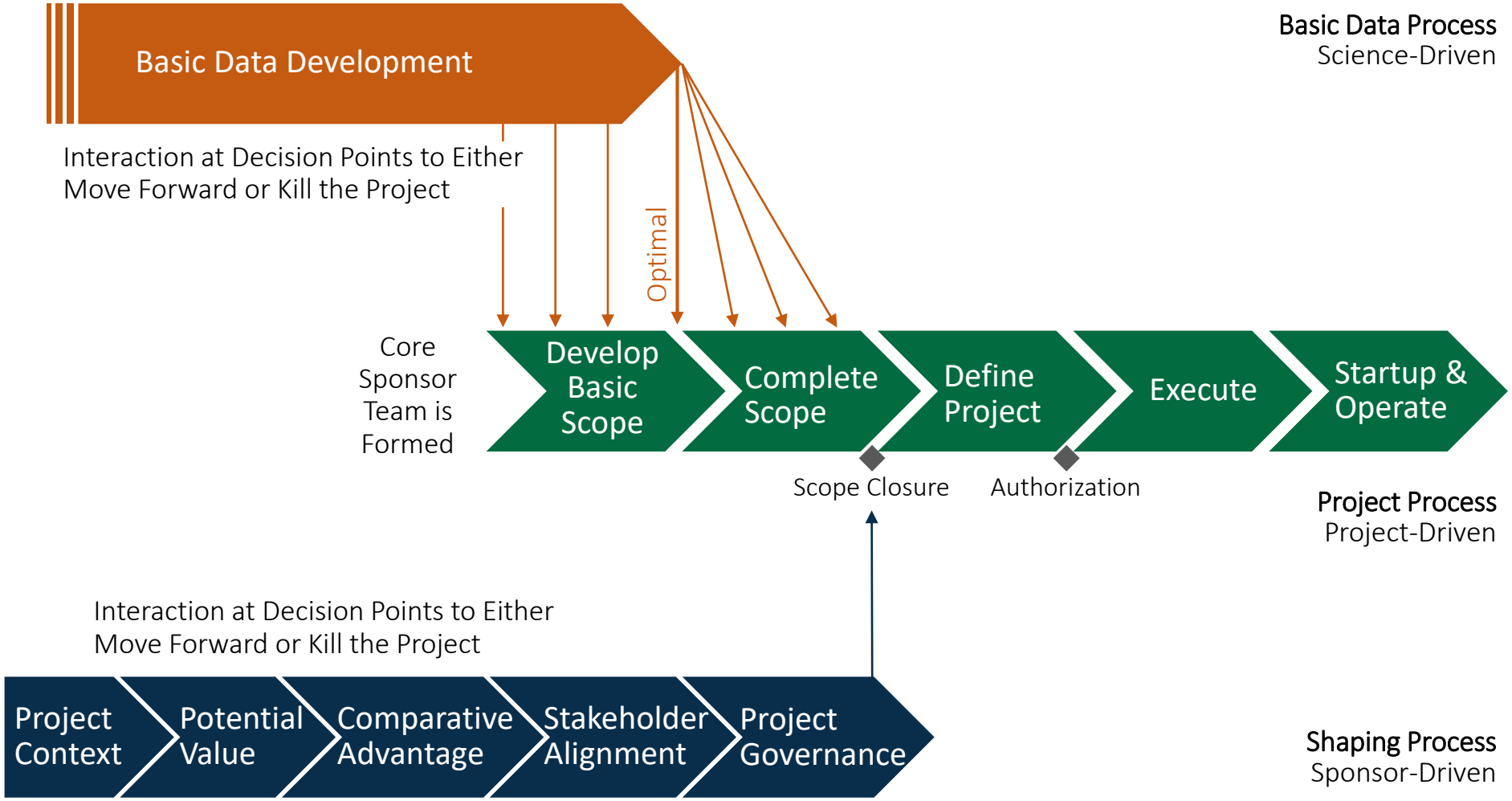
Shading represents ±1 standard deviation

How Well Are Megaprojects Defined at Authorization?



Megaproject Front-end Development Process

A Complex Braid



Three Streams of Work

- Must be braided together to form the project
- Each stream is led by a different function, but the work is highly interdependent
- Gaps in a single work stream can unravel the entire project
- Regardless of industrial sector, if owners cannot do this work, the project is highly likely to fail
- The great majority of regulated utility companies in Europe and North America do not maintain the kinds of project organizations that can prepare a megaproject for execution
- But if they could…

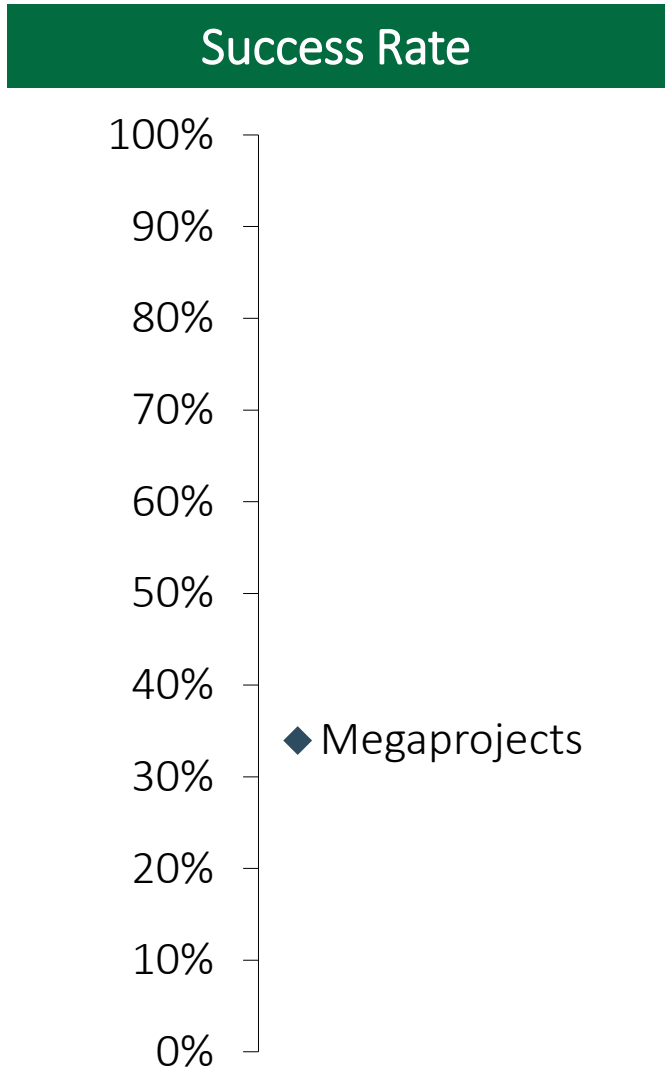
When the Basic Data are correct, *and*

Stakeholders are in agreement with the allocation of value, *and*

The front-end loading is complete

When the 3 work streams were executed fully, the success rate climbs from 34 percent to 83 percent and the average performance is:

Costs Grew (real)	-2%
Cost Competitiveness	.93 of Industry Average
Execution Schedule Slipped	4%
Severe and Continuing Production Problems (First two years)	None



Requirements

Requirements	Nuclear Projects
1. Basic Data must be complete and stable	
2. Project context must be shaped to minimize turbulence	
3. Owner must fully define the project and prepare for execution	

Thank you