The New York Times

U.S. Nuclear Comeback Stalls as Two Reactors Are Abandoned

"In a major blow to the future of nuclear power in the United States, a South Carolina utility has said that it would abandon two unfinished nuclear reactors, putting an end to what was once expected to showcase advanced nuclear technology but has since been plagued by delays and cost overruns."

New York Times, July 31, 2017

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My Perspectives are Based on Nuclear Design, Analysis, Construction and Research Experience

- 24 years Nuclear Engineering and Risk Management with Westinghouse and Pittsburgh Technical
- Advanced Nuclear Committee, National Academies of Engineering and Science
- Westinghouse AP 1000 Risk Manager
  - China (Sanmen & Haiyang), V.C. Summer and Vogtle. Barakah I&C
- Designed, analyzed, fabricated and commissioned the Pittsburgh Technical SMR experimental facility
- Nuclear Construction Cost and Schedule Research

- **Academic Credentials:**
  - PhD., Engineering and Public Policy, Carnegie Mellon University
  - MSc., Mechanical Engineering, Carnegie Mellon University
  - MBA, Carnegie Mellon University
  - B.Sc. Mechanical Engineering, University of Pittsburgh
  - Certified Risk Professional

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Think of a word that summarizes how investors feel about nuclear?

RISK

- What is RISK?
- Awareness, Assessment, Action and Accountability on issues of uncertainty that affect planned project performance
- Awareness: What can go wrong?
- Assessment: What's most important?
- Action: What to do about it?
- Accountability: Who is responsible? – assigned and demonstrated

- Objective: Ensure that V.C. Summer project has awareness, assessment, action and accountability on outstanding issues of uncertainty that could affect planned, project performance.

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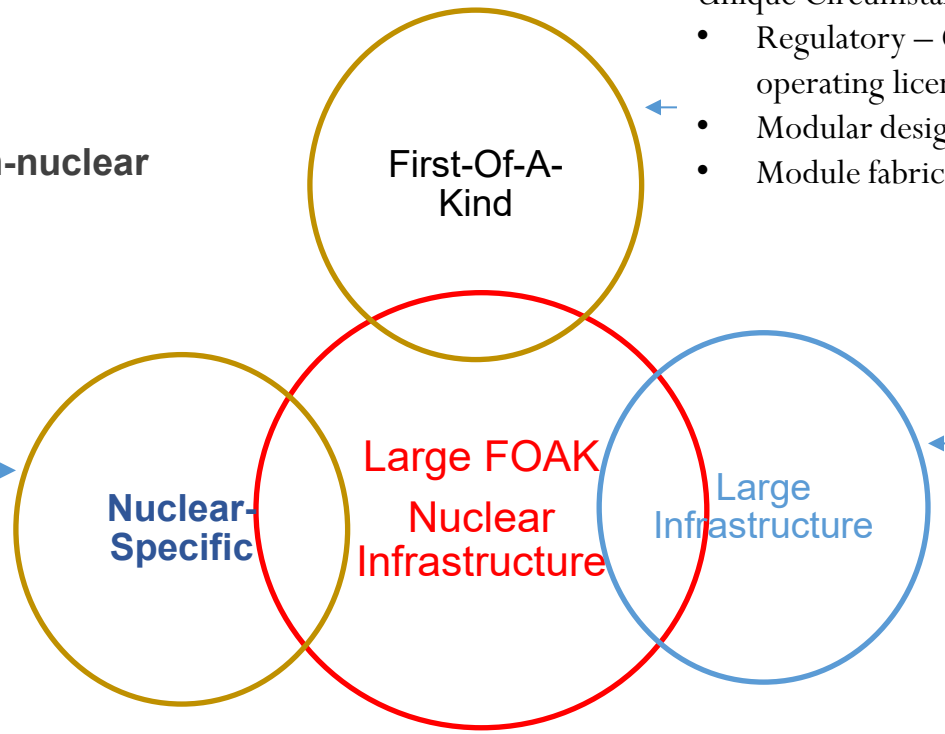
Overview of Large Nuclear Power Plant Cost and Schedule Overrun Risks

- Three major categories: Institutional, Scale-Based and First-Of-A-Kind
  - **Institutional risks: Nuclear-specific**
    - Regulatory, supply chain, quality assurance
  - **Scale-based: Common to large infrastructure projects (non-nuclear example: NASA)**
    - Engineering, procurement, construction, delivery
  - **First-of-a-kind**
    - People, Processes and Tools

Unique Circumstances: First-Of-A-Kind
- Regulatory – Combined construction and operating license
- Modular design
- Module fabrication facility

Nuclear-Specific:
- Regulatory
- Supply Chain
- Quality Assurance
- Public perception



Large Infrastructure:
- Engineering
- Procurement
- Construction
- Delivery
- Financing

High risk driven by complexity at intersection of fist-of-a-kind large infrastructure nuclear project: Effects are multiplicative!

Examples:
- Over-conservatism in engineering to address regulations
- Supply chain documentation burden
- Inspection-related construction delays

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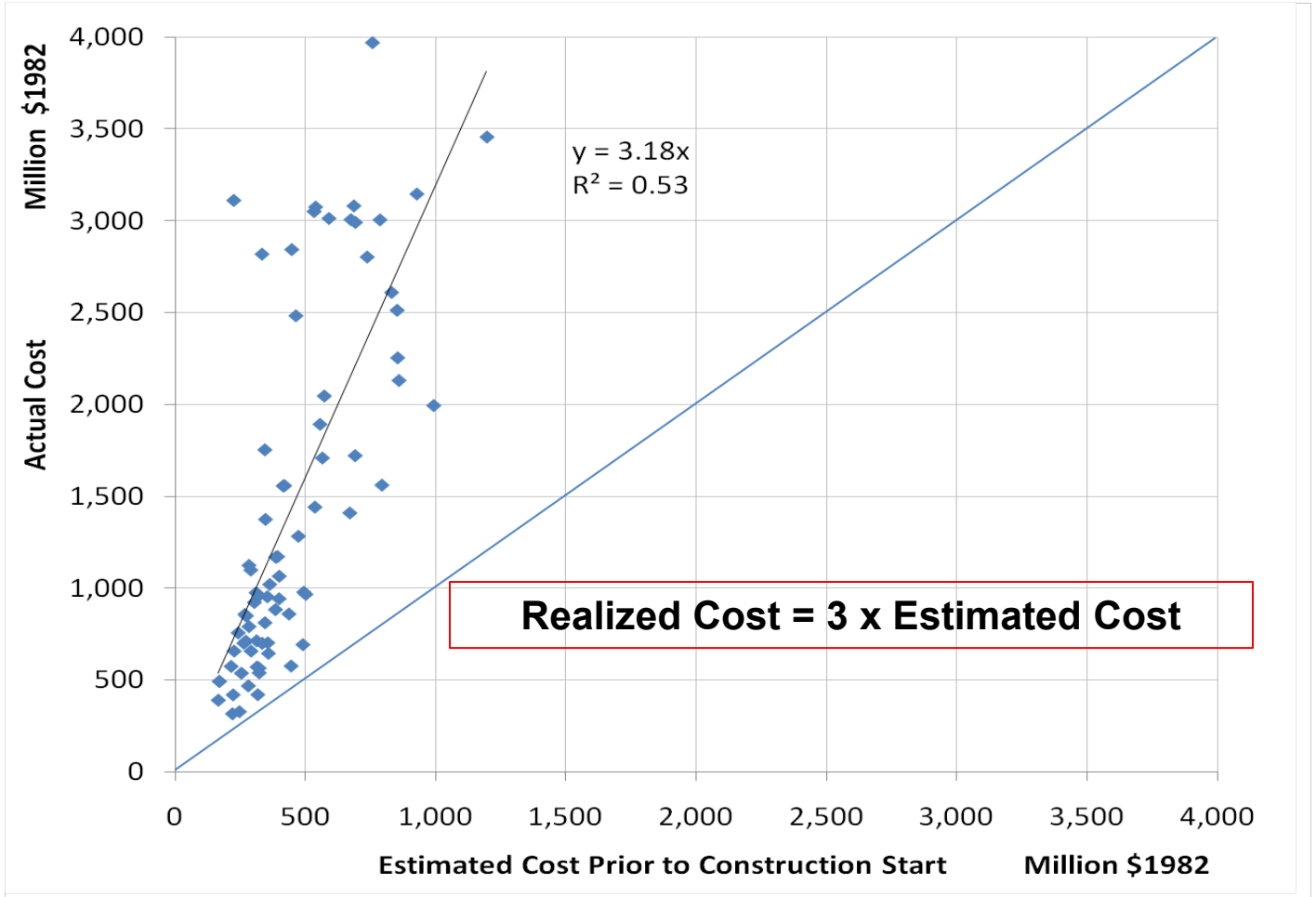
Insights: Nuclear Power Plant Cost has Historically Been Underestimated



Nuclear power plant construction cost comparison of planned to actual costs, for plants with construction start dates from 1970 to 1984, source: (EIA, 1986)

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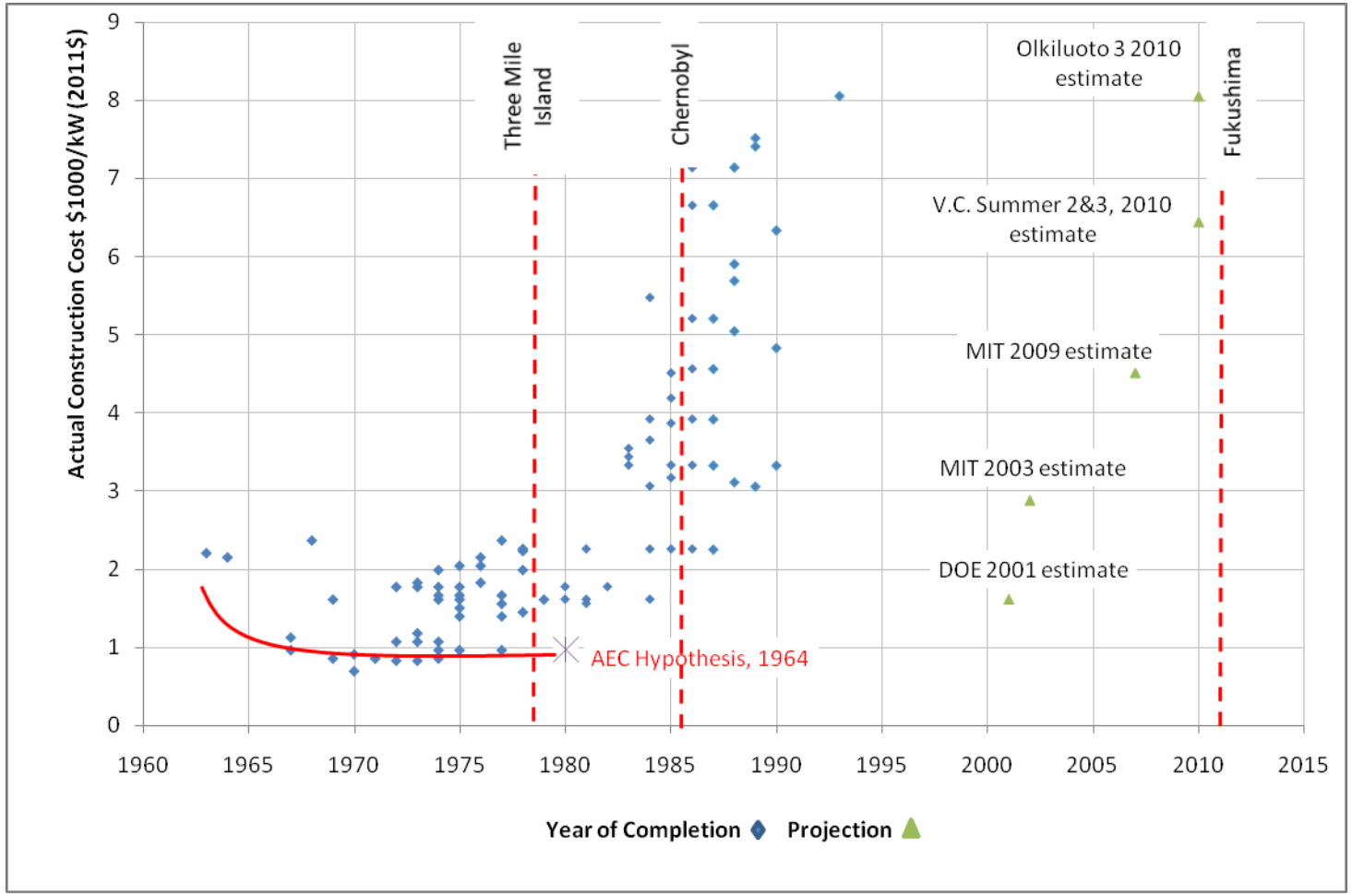
Insights: Nuclear power construction costs have increased contrary to expected reductions based on hypothesized learning



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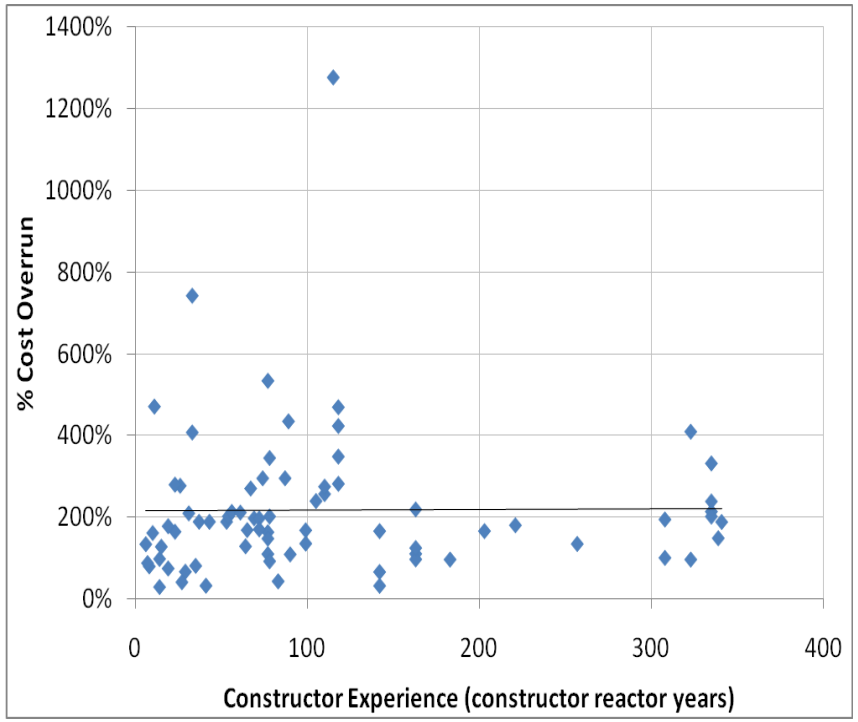
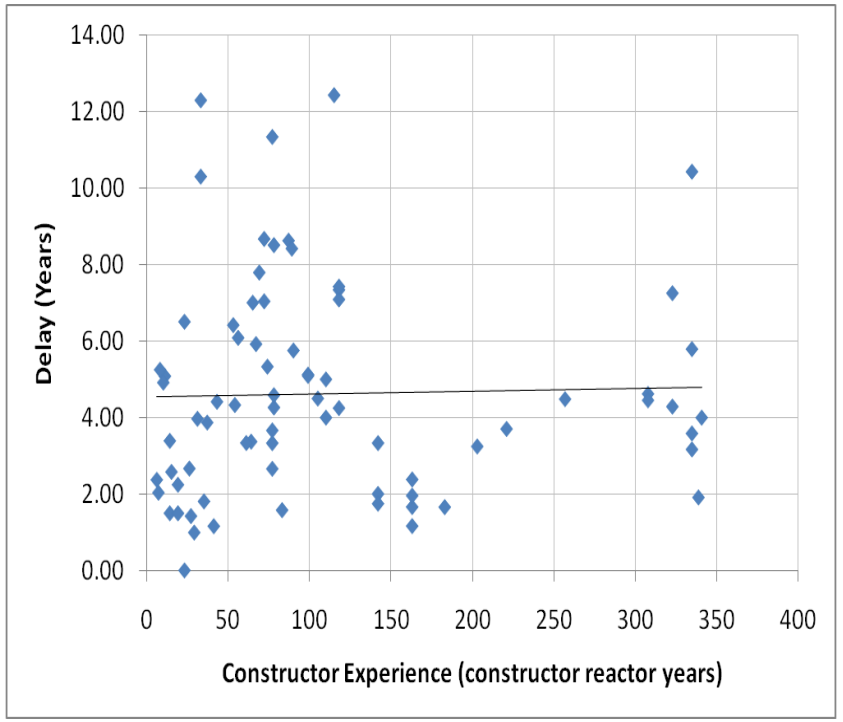
Insights: Learning may not occur organically – No evidence of learning based on repetition for large reactors





No evidence of association between experience and cost / schedule overruns

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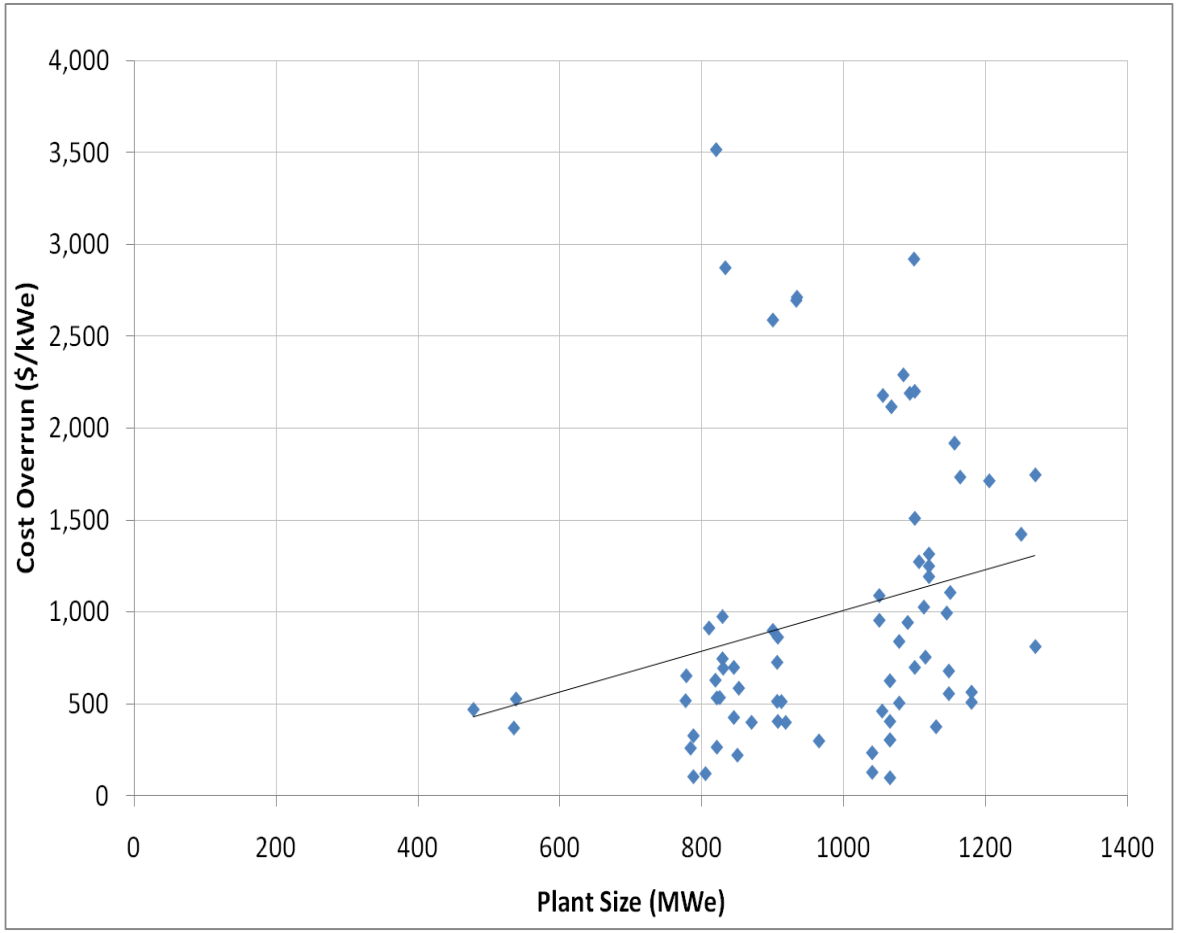
Insights: Beware of diseconomies of scale in nuclear plant construction

To understand effect of size on cost:

- Review of plant size and cost overruns
- Data are not negatively correlated
- Cost increases as size increases



Diseconomies of scale exist
Bigger ≠ Cheaper/kWe

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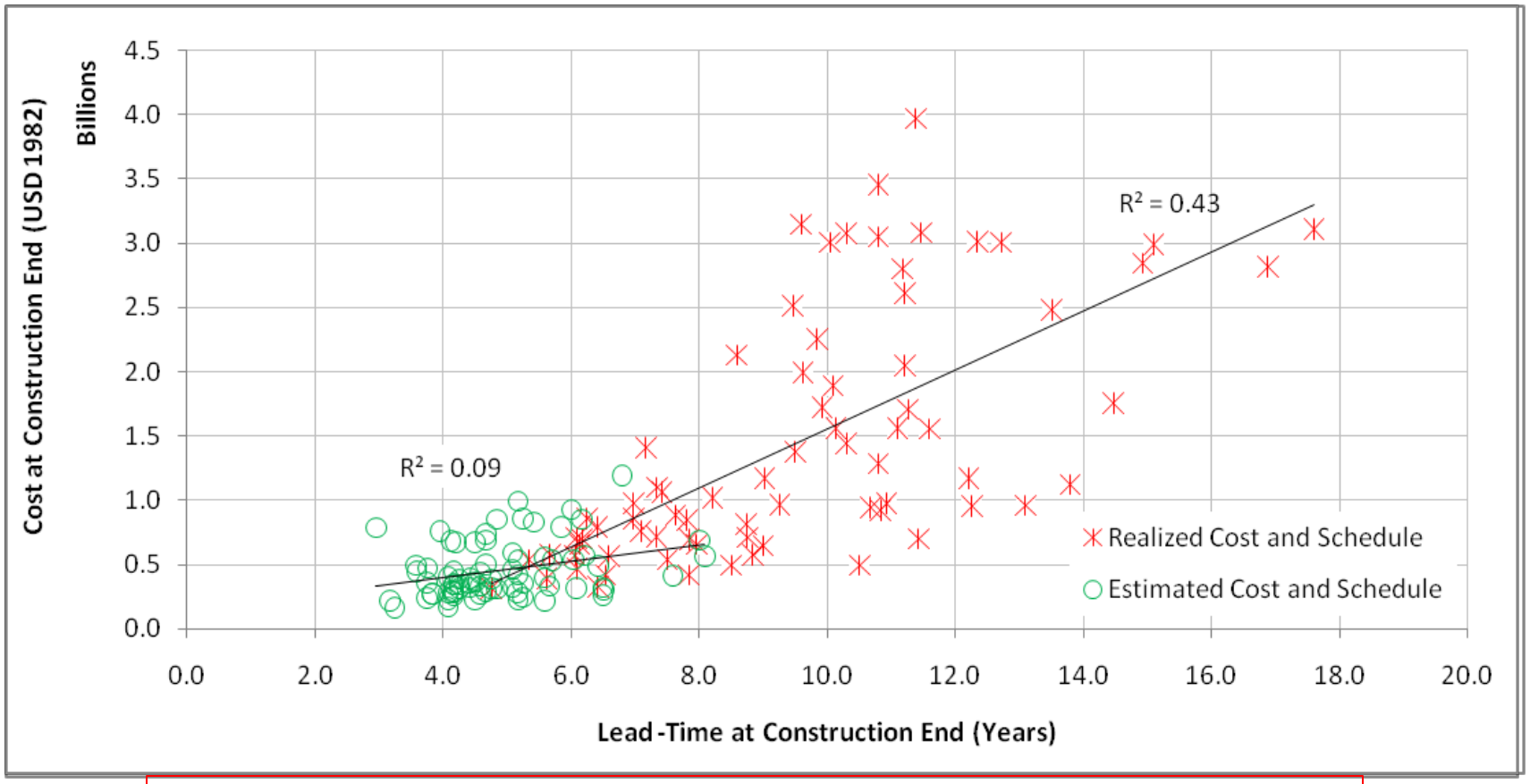
Insights: Project management practices have been inadequate for nuclear



Estimators did not reflect the underlying relationship between cost and lead-times

- Inadequate and unintegrated planning and activity scheduling caused high cost overruns
- Inefficient activity logic and sequencing caused a lot of “hurry up and wait!”
  - Major components ordered and delivered years before they were required
  - Motivational biases such as commercial and financial objectives influenced activity scheduling due to associated payment milestones
- Planning and scheduling is an important but underappreciated discipline

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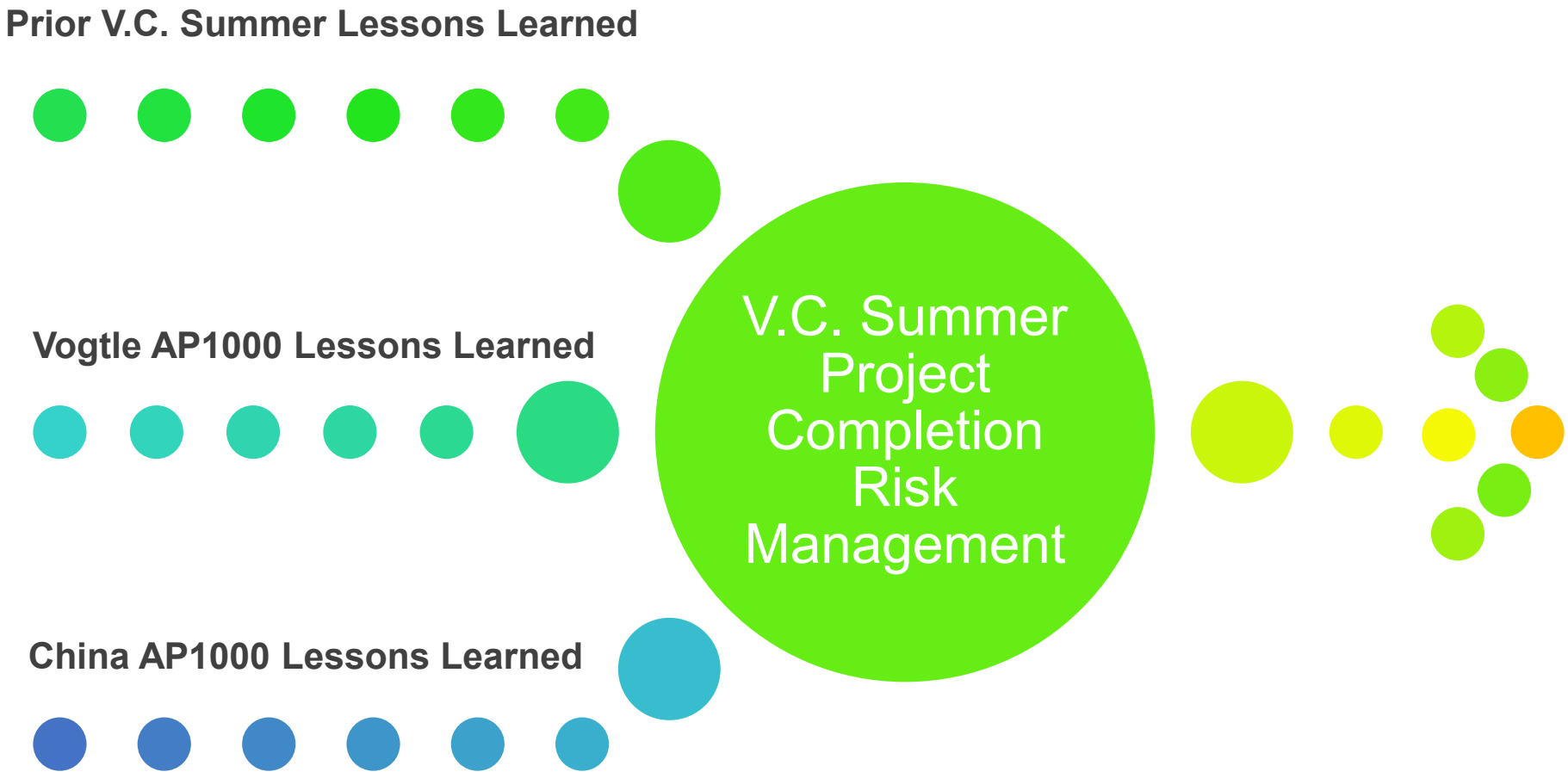
Can we craft a new narrative for V.C. Summer?
Future New York Times cover story?: “Rapid Nuclear Completion by Incorporating Lessons Learned?”



Risk-informed Management:
- **Contracts**
- **Project management – Cost and Schedule**

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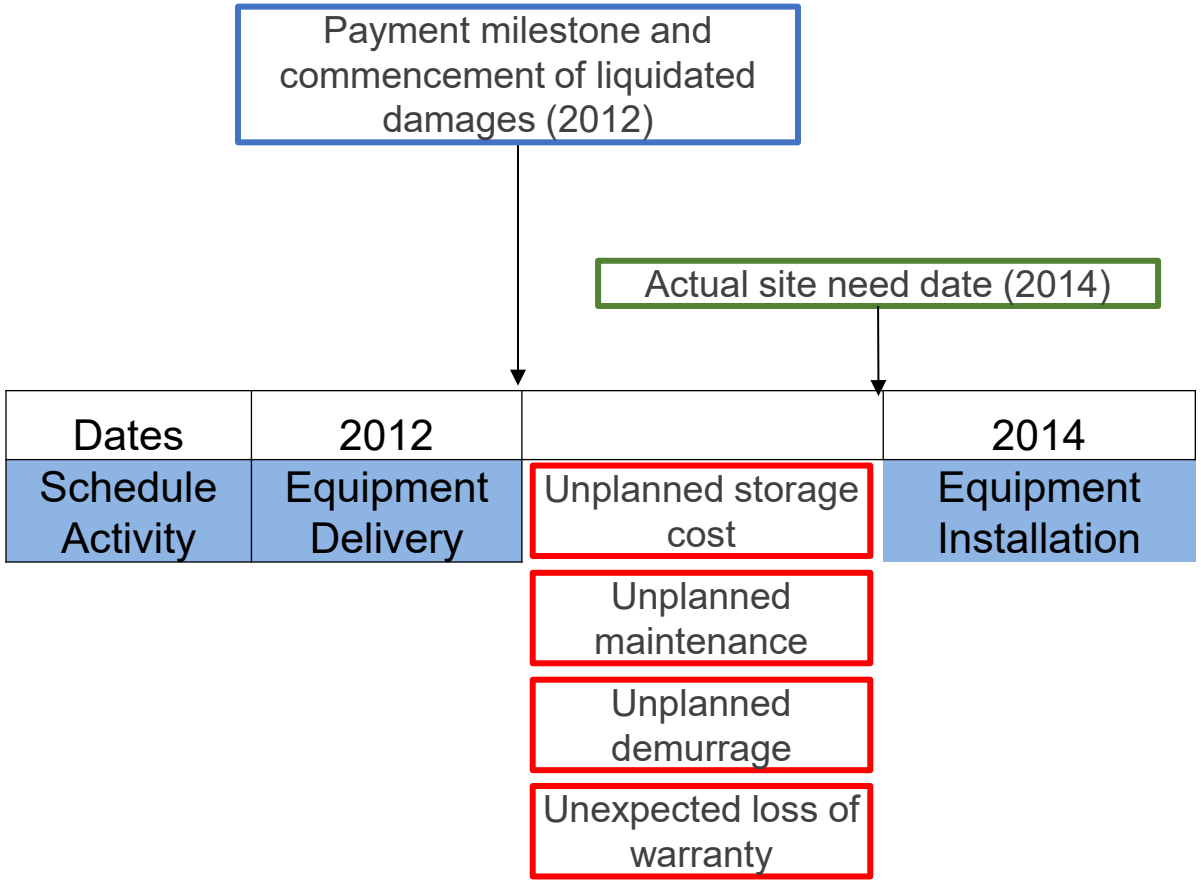
Starting with the contracts: “The contract served none of the parties” – Bechtel Contractual frameworks disincentivized best-practices

- Nuclear construction projects necessitate multiple entities and partnerships
- Legal doctrines drive defensive terms in contract language focused on minimizing liability rather than project success
- Example: Equipment contractual delivery dates were met years before components were installed
- But significant unplanned costs realized



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An Enhanced Risk-Informed Approach to Nuclear Construction Contract Development

Aspect	Standard Contract	Risk-Informed Contract
Primary Focus		
Objective		
Key Activities		
Stakeholder Engagement		
End Goal		

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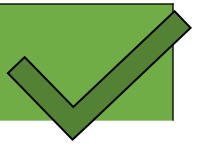
An Enhanced Risk-Informed Approach to Nuclear Construction Contract Development – Implementation to drive the culture

Aspect	Standard Contract	Risk-Informed Contract
Metrics & KPIs		
Tools & Frameworks		
Examples of Tools		
Treatment of Regulatory Issues		
Change Management		



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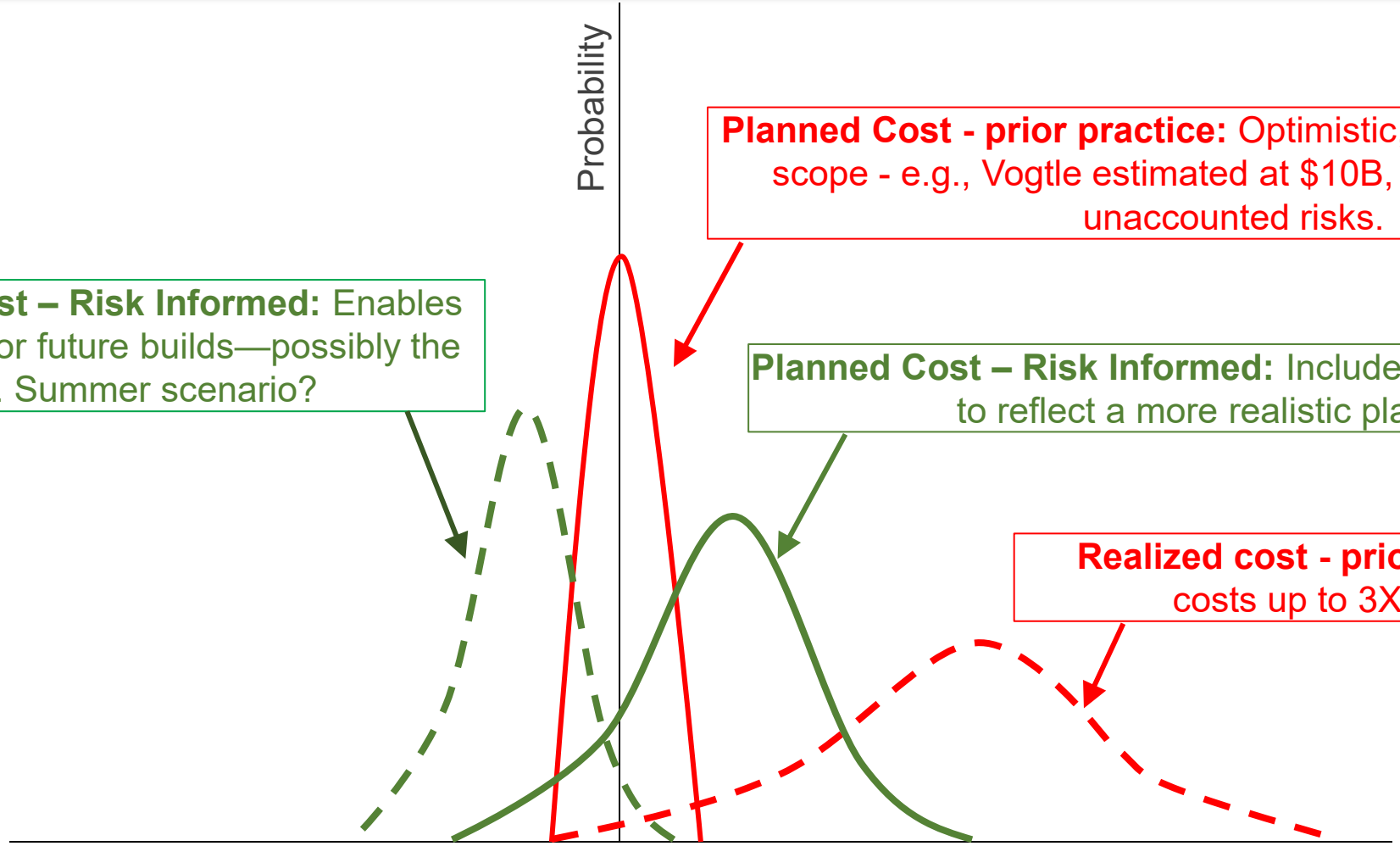
A Risk-Informed Project Management Approach – Example: Integrate Risk and Schedule into Cost Estimates



Planned Cost - prior practice: Optimistic, based only on known scope - e.g., Vogtle estimated at $10B, actual $30B due to unaccounted risks.

Realized Cost – Risk Informed: Enables lower costs for future builds—possibly the V.C. Summer scenario?

Planned Cost – Risk Informed: Include uncertainties and risks to reflect a more realistic planned cost

Realized cost - prior practice: Often triples costs up to 3X. E.g. Vogtle case.

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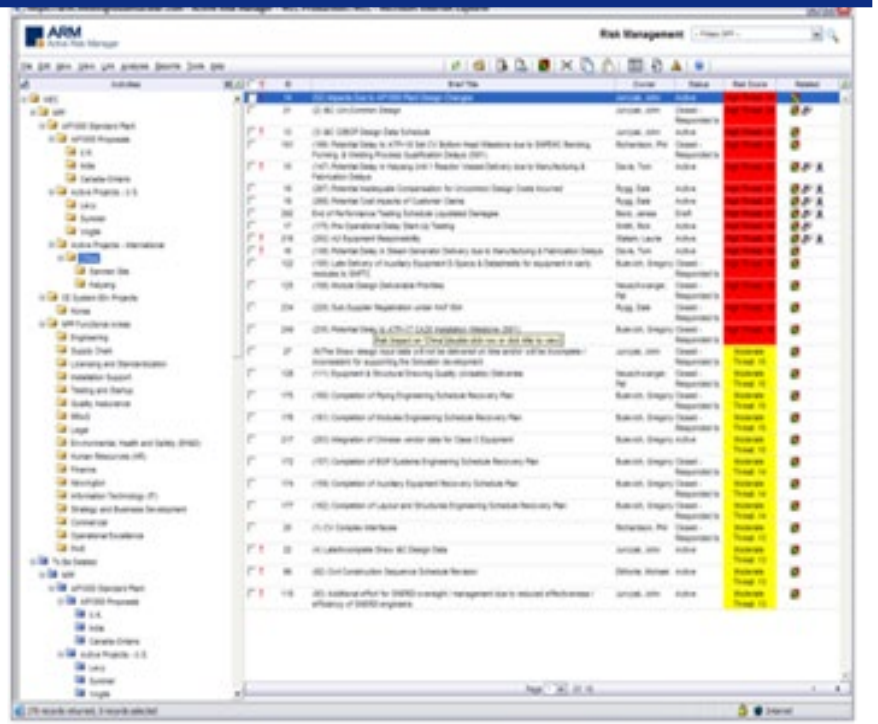
Enhanced Methods and Tools: Risk Registers (Records / Lessons from Prior Experience)

1. Allows integration of risk management and cost estimation
2. Quantifies and monetizes technology risk
3. Informs efficient and objective decision-making
4. Reduces bias
5. Facilitates decision-making on cost to mitigate risks
6. Captures lessons-learned and supports industry-wide knowledge sharing on risks

•Identification of risks: Ability to input specific risks, categorization, prioritization



•Qualitative Assessment of risks: Advanced analytics, sensitivity etc.

•Quantitative Assessment of risks: Advanced analytics, sensitivity etc.

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Major Takeaways: Nuclear Projects have high risk that require enhanced risk management practices – 4As and Risk Informed Contracts, Schedule and Cost