NUCLEAR QUALITY REQUIREMENTS

A STRUCTURAL ENGINEER'S PERSPECTIVE

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Principal

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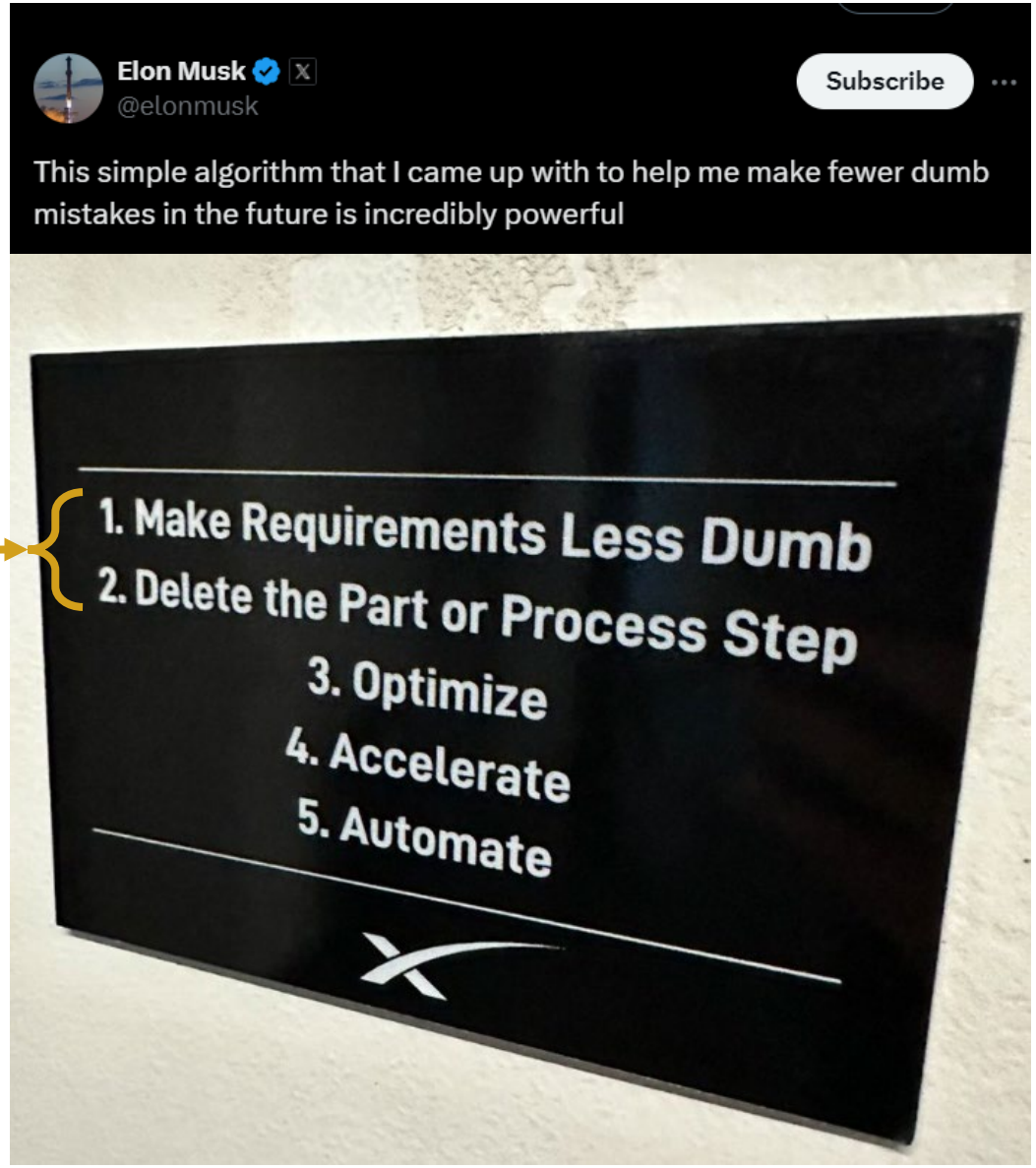
Scope & Perspective

- Scope: structure design & construction
- Perspective:
  - Structural engineer working on the “front lines” with AR developers to develop cost effective structure designs
  - Background in structural risk & reliability (seismic PRA, structure fragility)
  - Beyond the nuclear industry, SGH’s business: ensuring commercial, industrial, & institutional structures are high quality & reliable
    - Highly effective, tested
    - Does not result in 1.2x-3x cost premiums & 2x cost/schedule overruns
    - Little resemblance to current state of nuclear structure design & construction

QUALITY ASSURANCE: MAKE FEWER DUMB MISTAKES

- Dumb quality requirements:
  - → Ineffective at making structures safer
  - → Expensive, e.g.:
    - 2x-10x "nuclear factor" on costs
    - 2x-3x cost overruns
    - 2x-3x schedule delays
    - Cancelled projects
  - → No commensurate public safety benefit



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AR Developers Need Highly Effective Structures

- Cannot afford dumb requirements

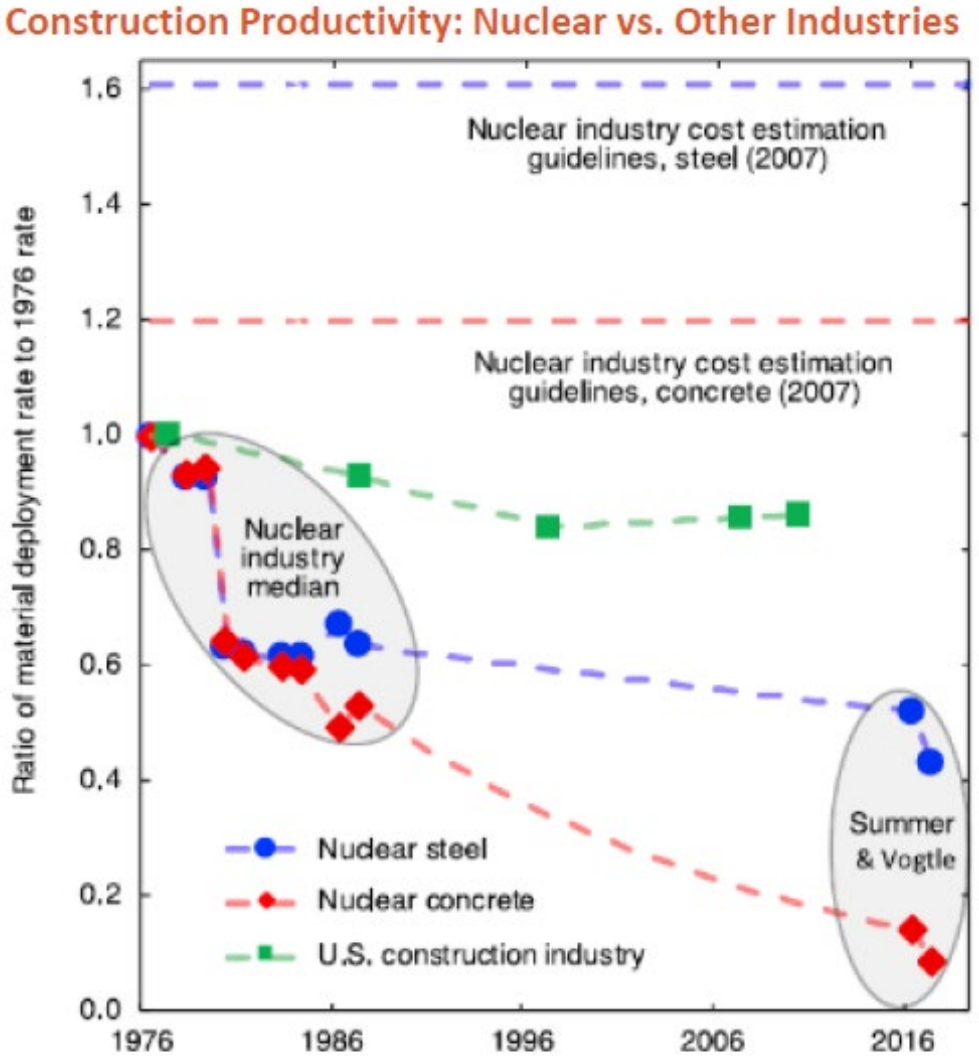
Effectiveness ←

Cost ↓

Inexpensive & Effective • This is where we want to be • Commercial/industrial best practices, e.g., peer review, special inspections	**Inexpensive & Ineffective** • Lower priority
Expensive & Effective • Less dumb - some necessary evils? • Look for inexpensive alternatives, e.g., trade inexpensive margin for expensive certainty (“assurance”) to achieve same reliability	**Expensive & Ineffective** • Dumb

Expensive? Yes… Effective??

- Many operating fleet structures designed before cur paradigm of nuclear quality requirements:
  - ACI 349 (1976)
  - AISC Spec. for SR Nuclear Structures (1974?)
  - ANSI N45.2 (NQA-1 precursor) (endorsed 1973)
- RG 1.142 (1981): "ACI 318 has long been the basis for design of concrete buildings in the United States an used by the NRC staff as a starting point in evaluati adequacy of concrete structures in nuclear power p
- Any major structural reliability problems that would l prevented by current special nuclear quality require
- Any PRAs – seismic or otherwise – that identified structural failures as important due to lack of special nuclear c requirements?
- No "QA factor" in structural fragility analysis



(Eash-Gates, 2020)

Understand Cost Impacts

- NQA-1 gets a bad rap, but to what extent is it actually responsible for costs?
  - vs. other special nuclear req's (e.g., req's in design/construction codes, NRC inspection
  - vs. ineffective / inefficient implementation of NQA-1
- Efforts to reduce costs (enabled or otherwise) are only as good as the cost estimate
  - Cost estimates often use simplified "nuclear factor" for SR structures. Little/no visibility requirements drive those costs.
- Some good work has been done: MIT studies, EPRI study, etc.
  - MIT study on probabilistic cost (led by Robb Stewart) is good. Can/should be developed
- Itemize and analyze the requirements & cost impacts
- Ask the experts – workshops, interviews, etc.
- Bid designs with nuclear & non-nuclear requirements

Understand Effectiveness

- What quality measures actually affect structural reliability?
  - Failure to implement basic quality measures (ineffective management, culture)
  - Schedule and budget pressure (expensive quality measures can backfire!)
  - Inexperienced / unqualified engineers; lack of oversight
  - Rational, sensible, simple, understandable, and constructible structural designs
  - …
- Suspected expensive & ineffective requirements… needs confirmation
  - Material traceability requirements & associated paperwork
  - Special, tighter nuclear construction tolerances
  - Increased inspection, testing, NDE requirements & frequencies
  - Special nuclear concrete & steel material requirements (strength, durability)

SGH

Less Expensive and More Effective Alternatives

- Alternative ways to meet 10CFR50 Appendix B
  - Learn from experts in commercial & industrial structures
    - Decades of experience while nuclear business was hibernating
    - Best practices for delivering quality, mission-critical structures with reasonable assurance
  - Focus on performance: e.g., can some QA measures be replaced by increasing reducing uncertainty?
    - For structures, reliability (safety) is a function of margin and uncertainty.
    - Assurance → assure → make sure or certain, i.e., reduce uncertainty (in theory)
    - Margin can sometimes be far more cost effective, e.g., concrete strength is cheap
  - Structure-specific guidance / examples for effective graded application of NQA-1
- Whatever we do, it has to be quick, like yesterday.
- (RIPB design to limit scope of SSCs subject to App. B)