NAVIGANT CONSULTING

Lessons Learned from the Last Nuclear Construction Cycle

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Presented by:
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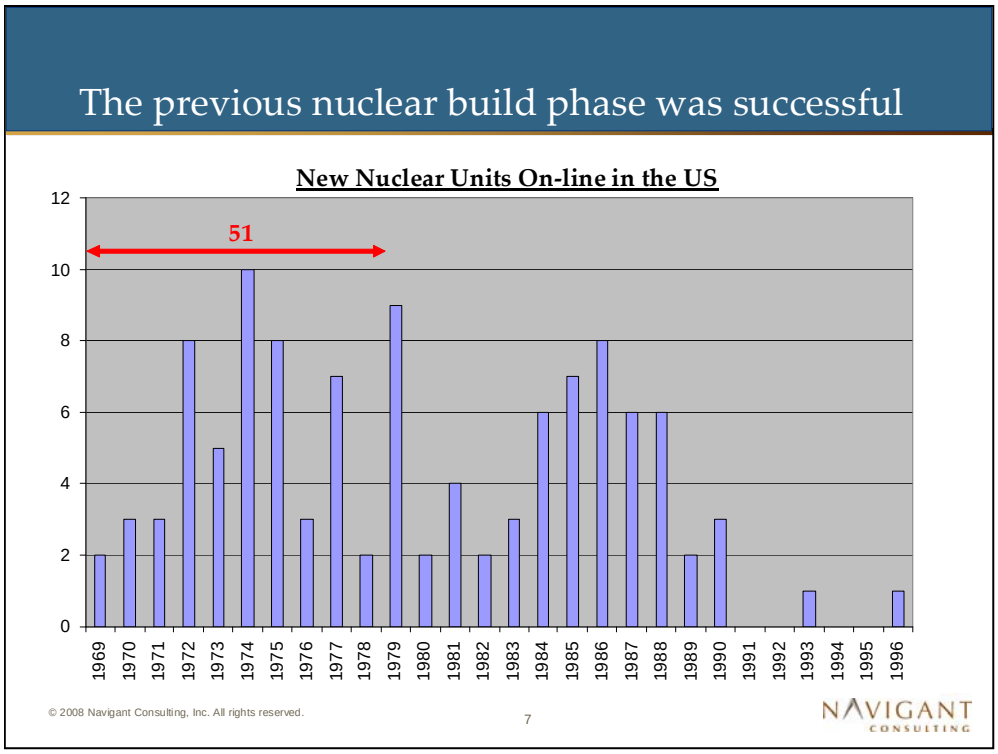

The last domestic nuclear build period spanned 25 years. During that period, over 100 units were placed in commercial operation. Fifty-one were put online in the first 10 years. Consider a point in the 60s comparable to where we are today and compare it to our present situation. **We started with nothing! Only a blank sheet and some ideas!**

- No nuclear component manufacturing infrastructure
- No prior commercial nuclear experience
- No proven commercial design (naval reactors, yes). With such new technology, numerous problems or concerns raised at one plant required evaluation and often changes on others.
- An industry expecting power "too cheap to meter"
- An industry familiar with building fossil steam plants, but not the complex nuclear plants with rigorous and newly developed (developing?) quality standards.
- A well-intended two phase licensing process that prompted numerous design changes.
- During this period we experienced double digit inflation and three economic recessions!!!

THAT was "first-of-a-kind" technology. I suggest that what we're embarking on TODAY IS NOT. We're dealing with "different" designs, "improved" designs, not radically different designs.

The nuclear build period of the past is viewed by many as a failure - - largely due to schedule delays and cost overruns.

Nonetheless, today…

- We have an extremely successful operating fleet with an average capacity factor over 90%.
- We have a one-step licensing process
- We have advanced project management and design tools

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- We have a strong commitment to standardization
- We have significantly improved construction methods
- We have precedence and …we have experience!!!

Are we on the verge of overwhelming success? No!
Are we well-poised to be successful? You bet!
We must, however, be rigorous in learning from the past. We must use our experience and avoid or at least anticipate and manage the problems that will arise.

I was deeply involved with the last nuclear build program. I was fortunate to have supervised or managed significant aspects of four of these projects. I saw the problems from the front row (More likely - from back stage). I also had the remarkable experience of closing the breaker and ramping up power.
It actually worked. It worked well. Many people did their jobs well!
Success and a great feeling of accomplishment after an extremely challenging effort.

As we embark on this next round of nuclear build, let us keep the opportunity in perspective. We are doing more than reconstituting an industry. We're taking on a significant responsibility, perhaps an obligation…
…to advance a technology the country and the world needs
…a technology that has a very negligible carbon footprint
…a technology that uses a plentiful fuel that can be recycled
…a technology that does not rely on fuel supply from cartels and countries that oppose our way of life.
Without sounding too sensational, we can truly make a huge difference in the world.

Today, I will share some of my observations of the past.
This will not be a sanitized version. My opinions and observations may not reflect the experience of all who participated in the past programs. I expect different points of view. Frankly however, I expect more agreement than disagreement.

Most of the issues I will discuss can and should be controlled by strong leadership planning and processes. They are not Force Majeure!

Let's look at the list…..

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- **Two phase licensing process**
  A. Construction Permit → B. Operating License
  This resulted in significant design and process changes as intervenors raised new issues and the industry proceeded along a steep technical and administrative learning curve….while construction was in progress! Changes after installation are extremely costly and disruptive.

- **Build before design completion**
  Following the lead of earlier fossil plants, utilities tried to build the more complex nuclear facilities with somewhat of a "design as you go" approach (perhaps hoping to achieve schedule compression, but actually
  -forcing schedule delays and cost increases.
  -precluding effective construction planning
  -rendering budgets and schedules inherently inaccurate.

- **Inadequately defined scope**
  - Due in part to design completion issues
  - Due in part to inadequate contract provisions
  - Due in part to lack of process for maintaining scope definition in the face of frequent and numerous changes
  - Result was: No benchmark to manage the project.

- **Poor scope control**
  - No baseline for managing the scope of the project
  - No structured process for managing scope
  - Not enough time to process scope changes…too busy to do the paperwork!

- **"Custom" designs**
  - Carry-over from fossil building approach
  - Owner initiated preference changes throughout project
  - Regulator initiated (preference?) changes throughout project
  - Lack of early input from experienced Operations, Maintenance, Test personnel
  - Accommodating contractors who had a commercial interest to custom design
  - Poor infrastructure and protocol for standardization
  - No acceptance of standardization
  - Limited success of "Reference Designs"

- **Overly aggressive schedules**
  - Unfounded optimism
  - Bid to win mentality - Promise the defensible (but improbable?)
  - Inconsistency from individual schedule input variations
  - Limited third party reviews and challenges to schedules
  - No risk analysis
  - No precedence. If there was, it was not well documented and had too many variations to be useful
  - "It will never happen anyway"…so why worry about schedule accuracy

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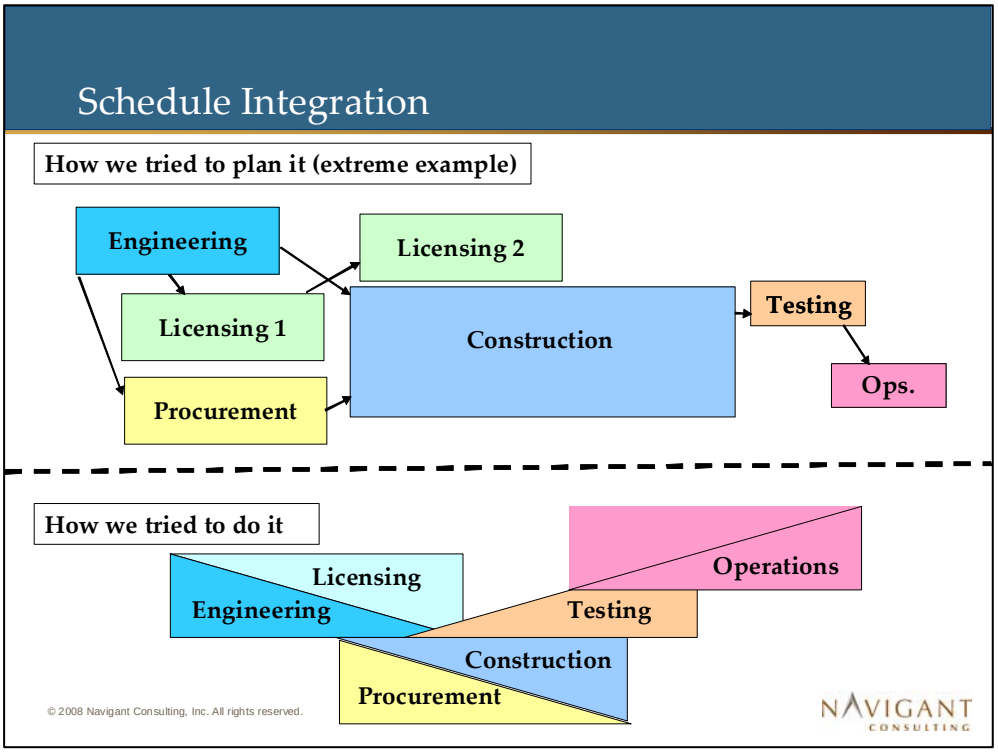

- **Poor schedule integration**
  - We tended to schedule in silos
  - Limited detailed coordination interfaces
  - Construction builds by "Area" - Big stuff in first
  - Engineering designs by system
  - Tests occur by components, subsystems and systems
  - An inherent conflict
  - Construction dominance in the scheduling process
  - Often mere allowances for critical schedule elements

- **Unachievable budgets**
  - Unfounded optimism
  - Bid to win - Promise the defensible (but improbable?)
  - Inconsistency from individual input variations
  - Limited third party reviews and challenges to schedules
  - No risk analysis
  - Inflation
  - "It will never happen anyway"…too many variables, so why worry about budget accuracy

- **Failure to adjust to changes**
  - Working with flawed schedules - No valid roadmap
  - Working with flawed budgets - No valid roadmap
  - Lack of tools to make timely changes (It was a massive effort to update budgets and schedules)

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- "It will never happen anyway"…too many variables, so why worry about budget accuracy
- Ineffective management/leadership

- **Lack of risk identification and management**
  - Risk management simply didn't exist
  - Reactive vs. Proactive
  - As a result, "Murphy" was all over the place, making real-time effective management very difficult.
  - Occasional application of contingency, but reluctance to be pessimistic

- **Poor constructability, operability, maintainability and testability**
  - Engineers had little appreciation for requirements of downstream organizations
  - Not enough time or money to do it right the first time
  - Legitimate need to balance capital cost vs. (future) O&M costs
  - Management focus on individual silos vs. whole project. The dominant force prevailed.

- **Inaccurate/ineffective status reporting**
  - Poor tools for rigorous updating. Manual methods and card decks.
  - Fear – Reluctance to convey bad news
  - Cat guarding the milk situation
  - Failure to verify

- **Limited accountability**
  - Lack of benchmarks for performance
  - Scarce resources led to tolerance of mediocrity
  - Utility timidity
  - Ineffective management/leadership

- **Unstructured problem identification, resolution and documentation**
  - Lack of well-defined processes
  - Dead messenger syndrome - - Reluctance to identify problems
  - "We'll deal with it later" syndrome
  - Silo protectionism (often many silos even w/in groups) No "one project one team" mentality.
  - Ineffective management/leadership (This changed toward the end on the period)

- **Marginal owner involvement**
  - Rely on Contractor (deemed expert)
  - Let the contractors do their jobs
  - Under-qualified utility teams
  - Good engineers presumed to be good managers
  - Individual success on smaller projects extrapolated to mean success on large complex nuclear projects
  - Weak executive involvement and support

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- **Organizational silos**
  - Between organizations
    - Owner – Engineer – Constructor
    - Subcontractors (Mechanical, electrical, civil) vying for space and priority
    - Quality Control vs. everybody
  - Within organizations
    - Engineering (Mechanical vs. Electrical vs. I&C)
    - Construction vs. engineering (How do they expect us to build that?)
    - Utility operations vs. utility E&C
  - Protectionism
  - Communication barriers
  - Distorted priorities (unwillingness to accept completed system because of paint splatter on gauge face)

- **Barriers to productive communication**
  - Dead messenger syndrome
  - Silos
  - Tolerance of silence
  - Ineffective communication protocols
  - Leadership failures

- **Ineffective contract administration**
  - Vague contract terms, difficult to track and oversee
  - CA considered an administrative function focused on invoice review and Accounts Payable
  - CAs were often mid-level administrators with limited authority
  - Marginal dedicated oversight of contract performance (Contrast with enormous oversight of technical quality control. For a multi-Billion dollar project wouldn't considerable **commercial quality control** be in order?)

- **Marginally qualified personnel (engineers, craftsmen, craft supervision, project management, operators, maintenance staff, test personnel, etc.)**
  - Sources
    - Fossil experience
    - Shipyard experience
    - Navy Nuke experience
    - Aerospace experience
    - Other industrial experience
    - New graduates
    - No experience
  - Very limited training (Mostly focused on safety and quality control programs - little on technical, project integration, schedule, budget or management matters)
  - High demand low supply of resources forcing acceptance of low performance (better than no performance)
  - Management and supervision often unqualified – exacerbating
  - Management and supervision often overwhelmed by day-to-day challenges couldn't do OJT or personnel management
  - These issues did not create plant safety issues because of the rigorous controls in place, but they probably did contribute to cost overruns and schedule delays

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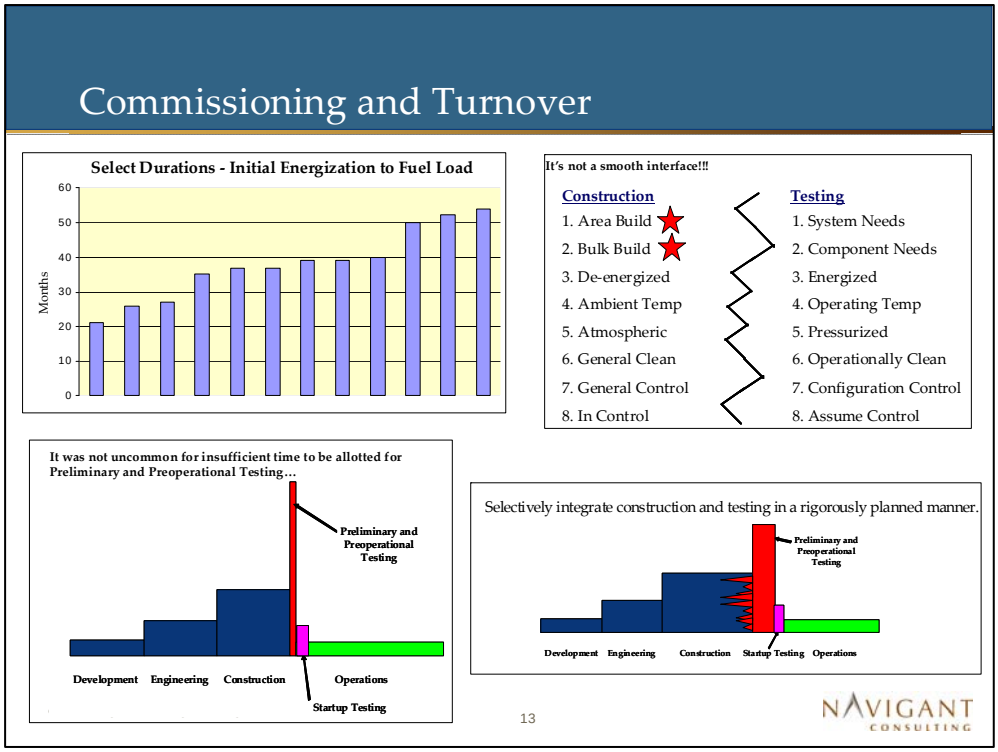

- **Inadequate provisions for commissioning & turnover**
  The period from Initial Energization to Fuel Load must be scheduled in detail and integrated with the construction schedule; and on the back end….with the transition to operations/fuel load/power ascension schedules.
  This is critical path activity and it is not an insignificant duration. In the past, two years was a very good duration. Are we appropriately considering that today?
  It was not uncommon for the test program to be overlooked until late in the project. A short "allowance" for testing proved to be extremely inadequate.
  Construction completion activities must be detailed and interfaced with detailed test program activities to achieve a logical and optimum approach to fuel load.
  This is a classic square peg and round hole situation. The interface between construction and testing is a difficult one. After years of operating in field construction conditions, the project must shift to test program conditions and ultimately to operating nuclear plant conditions.

- **Poor configuration control**
  - Lack of training
  - Lack of processes
  - Lack of tools and systems
  - Time and resource constraints- backlog of drawing and design document updates
  - Transition challenges from Bulk construction to Control program
    - Installed & Inspected
    - Certified clean
    - Pressure tested

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- Equipment initial operation complete
- Calibration complete

- **Cumbersome document control and retrievability**
  - Paper systems
  - Manual methods
  - Multiple hard copies to update and control
  - No word search capability

- **Lack of vendor O&M information**
  - Not required in procurement documents
  - Became "extra costs"
  - Impacted certain installations, tests, troubleshooting and maintenance activities
  - Spare parts recommendations not provided (startup spares, operational spares)

- **Poor dispute avoidance policies and practices**
  - Too busy to deal with causation in the middle of the battle
  - Retrospective reconstruction of facts vs. contemporaneous documentation of events
  - Issues carried over to stare regulatory Prudence Reviews

- **Vague contract language, unsupportive of ongoing project needs**
  - Issues Involved:
    - Responsibilities and authorities
    - Scope, schedule and budget
    - Change process
    - Reporting requirements
    - Problem identification and resolution
  - Some may argue that such details are inappropriate for contract. Consider ad contract mandated processes with defined minimum requirements and approvals.

In summary…the key foundation requirements are

- **Strong Leadership !!!!!**
- **Effective Planning !!!!!**
- **Great Processes !!!!!**
- **Strong Leadership !!!!!**
- **Strong Leadership !!!!!**