LFTR Development Lessons Learned

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Quick Recap

- LFTR is an architecture class – not a specific design
- Technologist's salient points:
  - Power density
    - Smaller & less massive, less losses, mobility, eases of manufacture, higher temperatures...
  - Efficiency
    - Less waste heat, better thermodynamics, useful byproducts...
- General public salient points:
  - Inherent safety
    - Reduced operator errors, less inventory to contaminate, easy of shutdown and startup...
  - Economical
    - Lower utility bills, less waste to store, fits into existing grid & future electric cars, abundant and stable domestic supply...

Education

- “101” Class for every new team member, for senior leadership, etc.
- Classic first slide fits almost all technologies:
  - “But the critics said these couldn’t be done!”
    - Heavier than air flight
    - Landing on the moon
    - Flying faster than the sound barrier
    - A stealth plane
    - A terabyte of storage in a $200 cigar box
- Lesson from John Houbolt – recognized the fundamental significance of LOR and for several years presented the engineering/physics argument to NASA; being thrown out the door and told “His figures lie, he doesn’t know what he’s talking about.”

Motivate

Sir Arthur Clark's Three Laws

1. If an elderly but distinguished scientist tells you that something is possible, he is usually correct, but if he tells you it is impossible, he is very probably wrong!
2. The only way of testing the limits of the possible is to venture beyond them into the impossible.
3. Any sufficiently advanced technology is indistinguishable from magic!

Thorium is something like this but to the researchers who have work this technology, they know the secret is simple – run it in a LIQUID form

What might you need?

- Resources, particularly “long-lead” items
- We envision a reactor and maybe acknowledge the power conversion component
- But to be successful we need a way to:
  - Fill and extract the fluid, store it, filter and process it
  - Lesson Learned: Pay attention to the ground support infrastructure. The speed at which you can service the basic fluid - the key to the whole concept – will be the a determining factor when issues pop up.

Safety Critical Software

- Expensive to produce and more expensive to validate
- Lesson Learned: Do not design the reactor with any safety critical software!
- Corollary – have a separate and redundant diagnostic and health monitoring system to have insight into what is happening as the system is operated

Diagnostic Tools

- Data is needed for failure review analysis and to recreate test anomalies
- Lesson Learned: Insist on a hardware lab and active modeling center even when things are going well (i.e., a DSIL or Distributed S/W Integration Lab)
- A LFTR program should maintain active:
  - Full-scale thermal/mechanical working model
  - High-fidelity CFD/neutronic simulation code
  - Diagnostic intense prototype nuclear power plant

Managing Risk

- Start early tackling the hardest issues
- Lesson Learned: Run a pathfinder
  - Boeing Flex Blue Program did data collect on the real world environment of a 747 before modifying it (round the world 6 times in 6 weeks)
- Put money in risk reduction early
  - Corollary is finish risk data before down select or major decision points

More Lessons Learned

- Don’t forget the obvious things
  - Personnel, power, cooling, etc...
  - The real world field environment
- Mobility leads to vibration issues
  - Joints leak, valves stick, connectors come loose...
- Diagnostic wiring
  - You must have ample sensors and data collection
  - Video imagery is also very important
- Access to all parts:
  - Need human access to almost everything or specific remote access capabilities
- COTS Vulnerability
  - Cheap and available almost is never suited to the new technology’s environment and will likely not have the reliability
    - Be ready to replace them often
    - The “new & improved” model no longer works for your application

Final Lessons Learned

- Start and IRT and plan for them over the long term
- Develop the necessary long-term vendor/technology base
- Higher believers, not mercenaries
- Never let a known defect be deferred because of unfounded fear of creating an issue fixing it
  - Do the engineering right
- Never tolerate an unexplained mystery in any test result – it will eventually show up
- Pray a lot!