What nuclear energy can learn from space technology advancement

The creation of new industries is always exciting. The entrepreneurial grit required for this degree of advancement is inspirational. It captures our imagination and inspires further growth.

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One industry that is beginning to break into our collective consciousness is the emerging industry of small modular nuclear reactors (SMRs). This industry is notable because of its technological potential and its potential ability to alleviate problems facing the entire planet and everything living on it.

In fact, there are two urgent needs being solved: 1) closing the gap between the amount of energy we need and the amount we will have (even if all forecasted renewables work out perfectly) and 2) decarbonising the world. SMRs can provide continuous, affordable, secure energy that is clean and that will allow us to reach our net-zero goals. The time for SMRs is now.

Like many great challenges, we all know the word *nuclear* comes with its share of baggage. This word conjures up emotional thoughts and feelings of reactor explosions in places like Fukushima, Chernobyl, and Three Mile Island, as well as the idea of nuclear weapons. Even now, due to the ongoing Ukraine crisis, some European countries recognise SMRs would give them a greater degree of energy independence and security, but

also worry about increasing the presence of nuclear energy and what it could mean from a risk perspective.

What makes SMR technology so exciting, though, is how it changes the paradigm of what has defined nuclear energy before. First, the passive nature of the newest (Gen-IV) reactors makes them “walk-away safe” and thus incapable of a “meltdown” that is possible with older reactors. Many systems exist in legacy reactor designs specifically to prevent meltdown, so SMR designs can be simplified substantially as compared to legacy systems. The availability of simpler modular systems also means further risks of cost overruns are reduced because these components can be manufactured offsite and then delivered, reducing the civil engineering load and construction complexity. Additionally, meaningful concerns about proliferation and potential structural damage from a kinetic attack have largely due to the increasingly health and stabilisation of fuel form factors.

SMRs are a game changer, but the market is still developing. To predict or validate how the potential success of the SMR market may develop, it could be useful to examine another industry that shares similar characteristics: New Space.

SpaceX has emerged as the dominant creator in this industry. How are the development of SpaceX and the SMR industry similar, and what might SMR innovators learn from SpaceX's journey?

SpaceX and the SMR innovators share several common patterns:

- Mission-driven private capital combined with public capital: These companies have founders who used their privately created wealth to solve some of the most challenging problems that exist. These efforts were then supported by the U.S. Government through awards (the Department of Energy Advanced Reactor Demonstration Program) or

contract mechanisms which offer funding that gave broad leeway to the contractor to develop a system.

- Regulated environment: Both industries are highly regulated globally, and given many SMR companies are US-based, space and energy have been overseen by the U.S. Government.
- Technology-first approaches: Rather than “space” or “energy” companies, they consider themselves to be technology companies first. It is exciting to see – and remember – what happens when a strong need drives “bottom up, first principles” innovation, starting with a “clean sheet,” applying basic scientific principles and proven technologies, unconstrained by previous assumptions or design, to develop a simpler, cheaper, and more effective solution.
- Entrepreneurial mindsets: Much of this approach is centred on mindset: a willingness to ask how things could be done differently and not be constrained by rules and embedded issues of the past.

In his founding of Spacex, Elon Musk is an example of these principles embodied. Even before he joined Tesla, Mr. Musk was recirculating his ecommerce-created cash into space travel disruption with the founding of SpaceX. It may be hard to remember today, given SpaceX’s massive success, but the number of voices that proclaimed his task was impossible were vast.

Similarly, Kam Ghaffarian, founder of SMR company X-energy, has doubled down on his commercial success by applying significant private capital to create a unique Gen IV SMR company called X-energy, one that is moving very quickly to solve problems for commercial and government customers. A third example is a capital provider like Bill Gates. Gates has been a longtime backer of the need for decarbonisation, and he has supported another SMR company called Terrapower.

The patterns above and the leaders engaged give us confidence that these ingredients increase the probability of future success. With these

inputs, we expect the technological benefits to outweigh the risks, and that progress can be sustained. However, the similarities of these examples may also provide clues and questions we should ask. What can the future SMR industry learn from SpaceX's 20 year-track record? What patterns and questions should it consider? Here are a few possibilities:

- Uneven progress in elements of the value chain. Following the retirement of the shuttle on July 21, 2011, the U.S. surrendered its capability in human transport for the better part of a decade. As a former lead in this arena, the U.S. was now dependent on Russia for transporting U.S. astronauts into space. Similarly, the U.S. has abdicated its leadership in uranium enrichment to Russia, and – unless bold and creative changes are made - may be dependent on Russia for an increasingly essential uranium supply
- Inspiration of new talent. SpaceX has inspired a whole generation of engineers to re-engage in the space industry. The war for talent is as strong in the space industry as anywhere else. The number of SpaceX veterans who now work for space companies in launch or other parts of the space value chain is immense and has benefited the industry. Will the same thing happen in the nuclear industry? Can we the United States engage its education system from K-12 on up to inspire a new generation of not only nuclear engineers, but a wide diversity of leaders and capabilities needed to make this ecosystem grow?
- Commercial market penetration following government engagement. SpaceX now controls almost 50% of the launch market and is seen as the central industry player. The company's success has secured a cheaper launch capability for the U.S. and its allies as well as a range of commercial market players. This success was despite years of consistent skepticism and conviction that a guy with zero space experience could succeed in this highly technical field. It also followed a relentless focus on experimentation, learning, and trying again. This willingness to fail and to learn is a hallmark tenet of any successful innovation. Despite the simplicity, modularity, computer-aided design,

and other best engineering practices that will most certainly reduce the final design and construction costs orders of magnitude less than historical reactor projects, there will be delays, adjustments, and modifications. Will the U.S. be willing to continue to advance in this industry development, even if the path to development is not perfect?

- Education of the populace. SpaceX has done an excellent job of attracting its share of headliners, including a charismatic leadership presence, rocket-launched Teslas into the solar system and snazzily produced marketing pieces. How will the SMR industry educate citizens to understand the value and reduce the traditional fear?

So, which patterns will hold, and which will change?

Companies like SpaceX and leaders like Elon Musk have reminded us of the power of innovation, inspiration, conviction, competence, and execution in the pursuit of a worthwhile goal. Leaders like Kam Ghaffarian and Bill Gates have picked up this mantle by taking on a new, massively challenging problem. Understanding the power and importance of these industries and then recognising the patterns they share and challenges they face will shape the future of the United States. It will also offer necessary clarity into the solutions needed to solve some of the world's greatest problems.

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