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NuScale Systems Engineering – Requirements Management

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Kevan Griffith, PE, CSEP
Supervisor, Systems Engineering – Analysis & Architecture

Outline

- Introduction to NuScale and our technology
- Overview of Systems Engineering at NuScale
- Requirements Management – Process Examples
- Requirements Management – Augmented by tool

NuScale’s Mission

NuScale Power provides scalable advanced nuclear technology for the production of electricity, heat, and clean water to **improve the quality of life for people around the world.**

We will achieve this mission by providing technology that is:

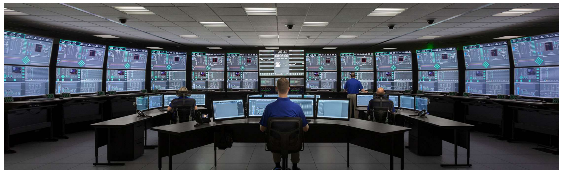
- SMARTER
- CLEANER
- SAFER
- COST COMPETITIVE

Who is NuScale Power?

- NuScale Power was formed in 2007 for the sole purpose of completing the design and commercializing a small modular reactor (SMR) – the NuScale Power Module™
- Initial concept was in development and testing since the 2000 U.S. Department of Energy (DOE) MASLWR program
- Fluor, global engineering and construction company, became lead investor in 2011
  - In 2013, NuScale won a competitive U.S. DOE Funding Opportunity for matching funds, and has been awarded over $400M in DOE funding since then
- >560 patents granted or pending in nearly 20 countries
- >400 employees in 5 offices in the U.S. and 1 office in the U.K.
- Rigorous design review by the U.S. Nuclear Regulatory Commission (NRC)—NuScale received Design Approval in August 2020
- Total investment in NuScale to date is greater than US$1B

NuScale Engineering Offices Corvallis

One-third Scale NIST-2 Test Facility



NuScale Control Room Simulator

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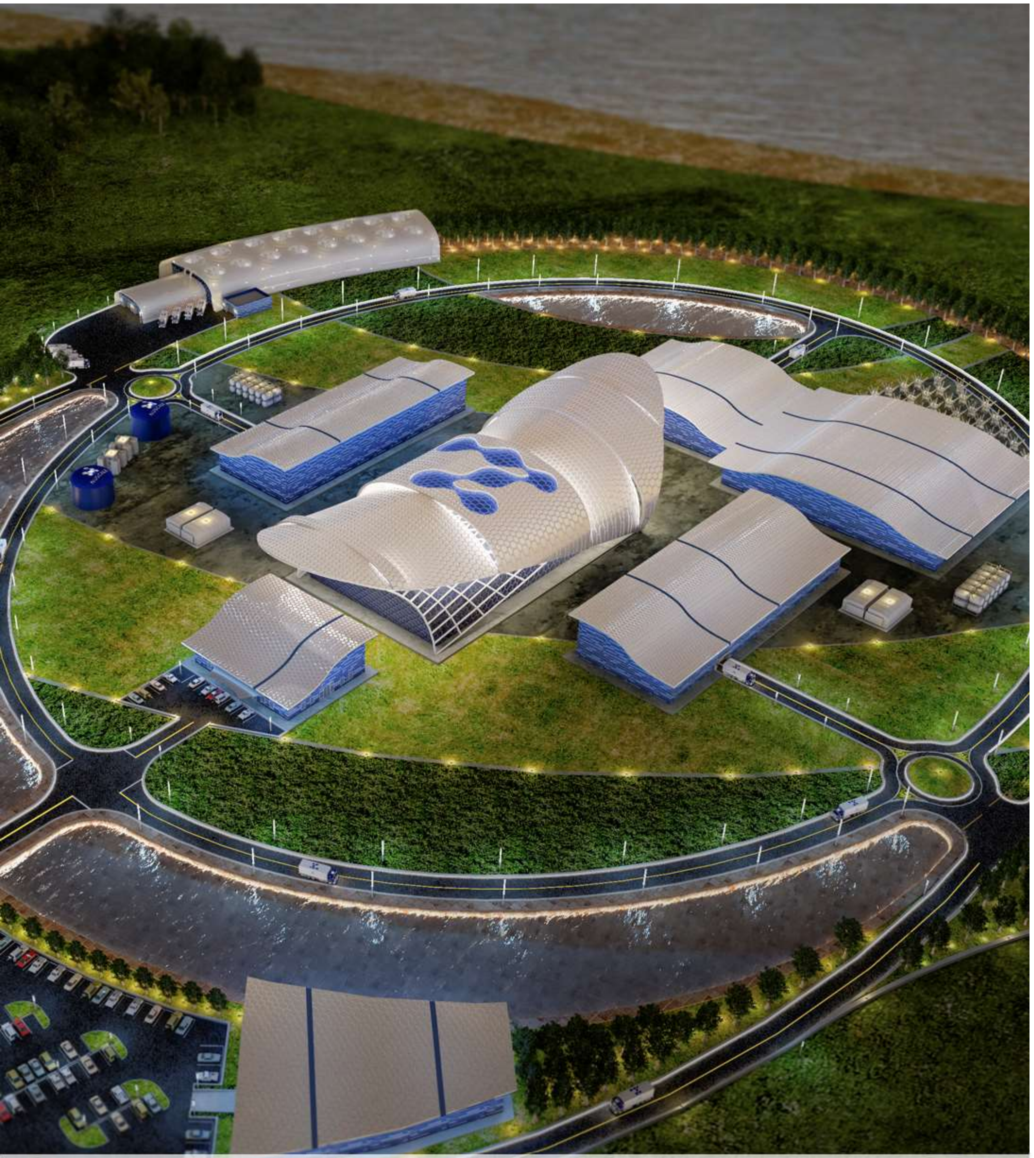
NuScale VOYGR™ Power Plant Solutions


Artistic concept of the NuScale Power Plant

- Each VOYGR plant is comprised of a different configuration of NuScale Power Modules and output:

12-Module (924 MWe)	6-Module (462 MWe)	4-Module (308 MWe)
VOYGR™-12	VOYGR™-6	VOYGR™-4

- Reference plant design
  - 924 Mwe VOYGR-12 plant
  - Design approved by U.S. NRC in August 2020
  - Certified in 2023
- VOYGR-4 and VOYGR-6 contain all features and capabilities of reference plant
- Flexibility in size and cost, with the same operational flexibility and unparalleled safety case.
  - Each module feeds one turbine generator train, eliminating single-shaft risk.
    - Demonstrated resiliency for every configuration (black-start, island mode, seismically robust, cyber secure, etc.)

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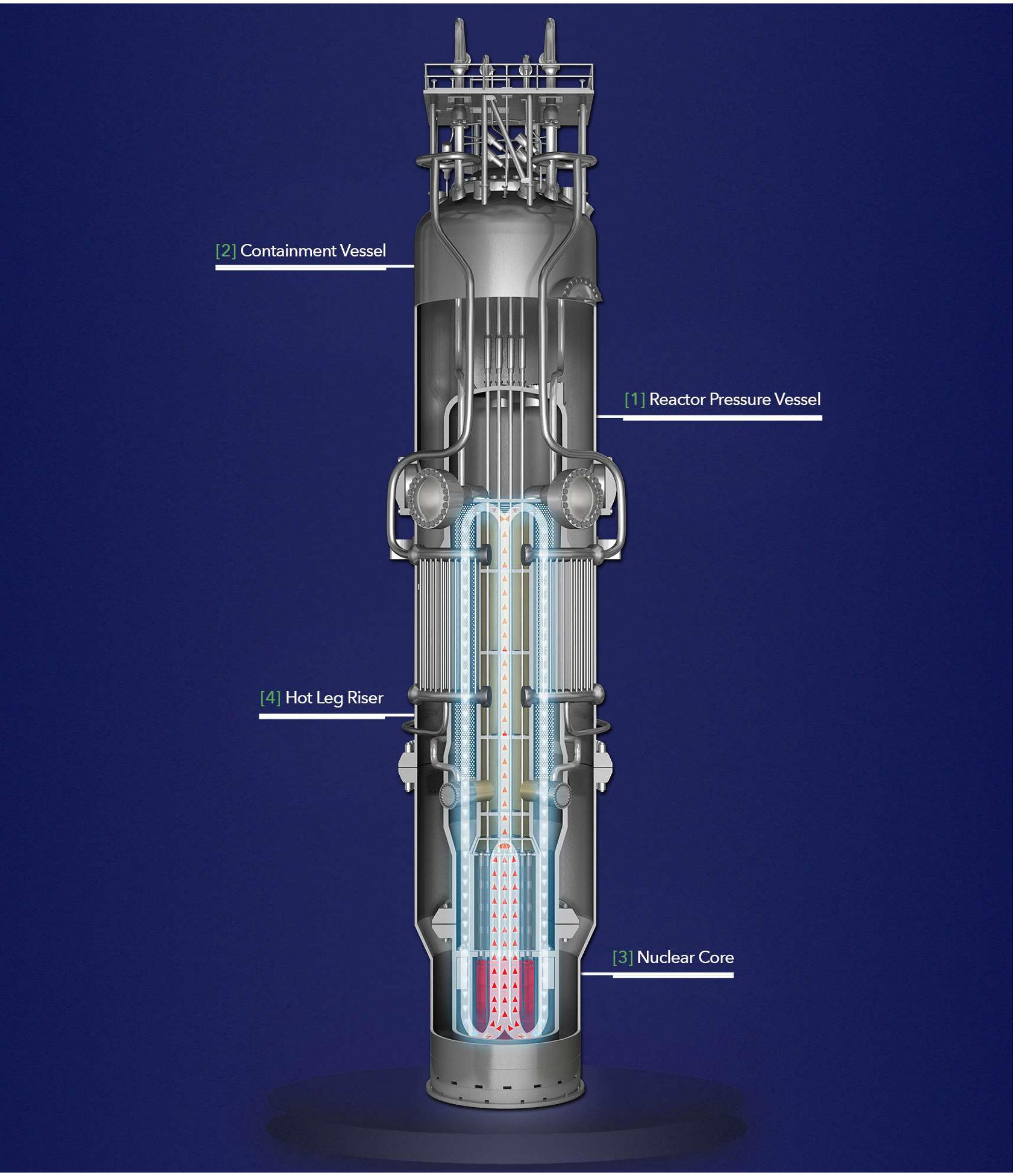

Core Technology: NuScale Power Module™

- Simple design in one integral package that includes:
  - Steam generators
  - Pressurizer
  - Containment
- Eliminates:
  - Reactor coolant pumps
  - Large bore piping
  - Other systems and components found in conventional reactors
- Each module produces up to 77 MWe
  - Factory built for easy transport and installation
  - Dedicated power conversion system for flexible, independent operation
- Modules are incrementally added to match load growth

Company History and Key Milestones

$1.4B Capital Invested[1]

FLUOR | DOOSAN | Sargent & Lundy | sarens | JGC | IHI | GS Energy | SAMSUNG C&T | JBIC

2007 | 2008 | … | 2011 | … | 2013 | 2014 | … | 2016 | … | 2019 | 2020 | 2021 | 2022

- **2007**: Formation of NuScale Power, LLC
- **2008**: Began NRC Pre-Application
- **2013**: UAMPS — Secured First Committed Customer; $226mm U.S. DOE SMR Award Recipient
- **2016**: UAMPS Site Selection; First-Ever SMR Design Certification Application (DCA) Submitted to NRC
- **2020**: $1.4B U.S. DOE cost share for UAMPS; NRC Approval of Final Safety Evaluation Report; NRC Standard Design Approval of 160 MWth (50 MWe), 12-module Plant Design
- **2022**: NUCLEARELECTRICA — Secured Next Committed Customer; Company Listed on the New York Stock Exchange
- **2022**: KGHM POLSKA MIEDŹ — First Task Order and Statement of Commencement Signed; Completed the Standard Plant Design Project; Submitted Standard Design Approval Application for 77 MWe VOYGR-6 Plant Design to the NRC

Note: Grey shaded area represents actual capital spend by NuScale over time, including both from private investor capital raised and funds received from the DOE cost sharing program. Logos represent first investment in NuScale.

1. Represents cumulative capital invested through September 30, 2022. Includes funding received from the DOE cost sharing program. Excludes any capital raised as part of a de-spac transaction.

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NuScale SE Value Proposition

- Ensure all stakeholder requirements for successful deployment are identified, decomposed, and allocated to the appropriate structures, systems and components (SSCs), thereby reducing future rework and ensuring a licensable, constructible, operable, and cost-effective nuclear power plant.
- Increase confidence in project cost and schedule in order to ensure NuScale products meet stakeholder needs, goals and objectives
- Support tailored requirements, functional, and product architectures for each major aspect of the plant, allowing for differences in repeatability, delivery mechanism (manufactured vs purchased vs constructed), and safety significance.

NuScale SE Internal Standard

- Purpose
  - Establish systems engineering process requirements for product management to reduce costs and accelerate schedules, while maintaining quality and creating products which delight our customers.
- Scope
  - Systems engineering processes in the areas of system design, technical management and control, and product realization for NuScale end-products to be delivered to customers
  - Addresses integration of specialty engineering disciplines and the overall systems engineering effort.
  - Although this standard provides process requirements for the entire product life cycle, subsequent implementation documents (e.g., plans, procedures, guides, etc.) are expected to focus on product development and realization.
  - Does not invoke requirements from the NuScale quality assurance program.
  - Subsequent procedures that are developed based on this standard will invoke appropriate quality requirements for that specific process area.

SE Group Roles and Responsibilities

- Support product lines with tailored SE management plans (and activities) by leveraging established SE best practice process, which could include:
  - Stakeholder needs elicitation and validation (e.g., product concept document)
  - Technical solution definition (e.g., plant design specification, top-level product specifications)
  - Product change leaders and technical planning
  - Product structure modeling
  - Product life cycle modeling
  - Functional architecture modeling
  - Operational concept modeling
  - Requirements architecture modeling
  - Requirements capture and centralized maintenance
  - Interface identification and management
  - Technical assessment (e.g., design reviews, product life cycle gate reviews, technical performance tracking and measurement, technical audits)
  - Technical risk assessment (e.g., technology readiness reviews, TRL maintenance, risk and opportunity database)
  - Technical decision analysis (e.g., trade studies, decision criteria, decision tools)
  - Product or system verification and validation planning
  - Product implementation, integration, and transition support (e.g., plans, requirements traceability matrices)

Successful SE Implementation

- **Tailored** to problem/opportunity set
- Early and frequent stakeholder involvement/education
- Change management planning
- Leverage SE Community of Practice and outside expertise
- Program requirements first, then product-specific plans
- SE-informed PLM architecture and configuration management process
- Common understanding of key concepts
- Strong Executive Leadership sponsorship

Plant Concept Document, Plant Technical Requirements Document

- The highest level description of our plant's key capabilities are established in a Plant Concept Document. This is a narrative-level discussion of the plant and its composition.
- The PCD forms the basis for the requirements in the Plant Technical Requirements Document, which is the highest level requirement specification generated for the plant.
- Paradigm has been very help in product development. Originally facilitated discussions between engineering and other groups.
- More recently, PCD and PTRD documents are beginning to be used to facilitate customer engagements.

Design Reliability Assurance Program

- Program is structured to ensure that structures, systems, and components are designed, manufactured, procured, installed, and operated in a manner that ensures their quality and reliability are commensurate with their risk significance.

- In the design phase, this intersects with requirements management as it creates a structured process to ensure that appropriate requirements are allocated to systems, and ultimately to components, as a function of their importance to safety.

- System functions are identified for systems in the plant. Functions are classified per internal procedure, but is strongly influenced by ANS 58.14. For us, this is initially performed by an SME, typically the system designer.

- Functions are classified as either safety-related, or nonsafety-related

- Functions are also classified as either risk significant or nonrisk-significant

- This is documented in a System Function Report

Design Reliability Assurance Program

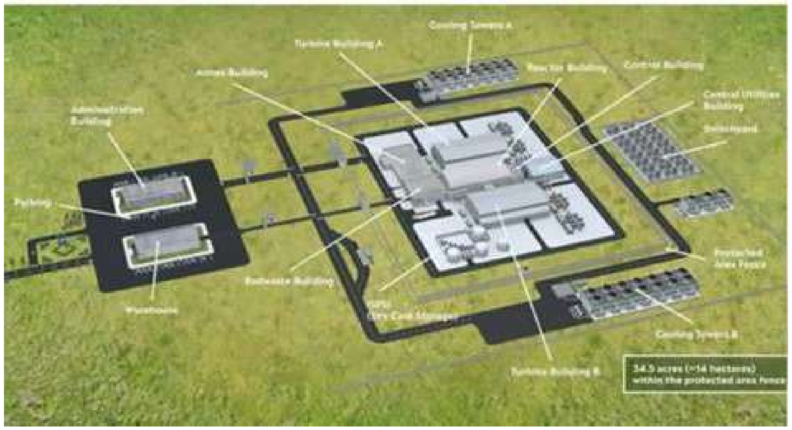
- The function classification establishes an important framework, but at that point is incomplete
- In particular, for functions that are nonsafety-related but still important they are evaluated for allocation of augmented requirements.
- As system design matures, equipment performing the functions is traced to the classification of the function, including any requirements allocated to the function to ensure that they are appropriately flow down.
- System function reports, including classification and augmenting requirements get cited/referenced/invoked by design specifications.

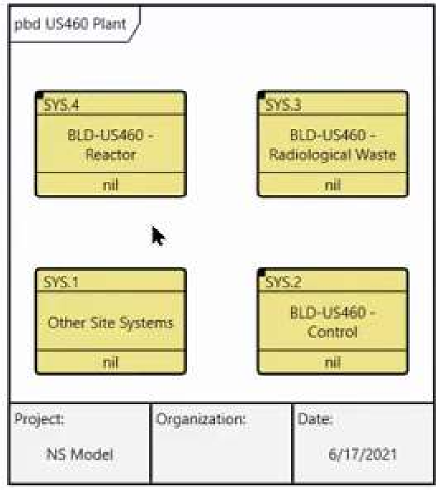
Design Reliability Assurance Program

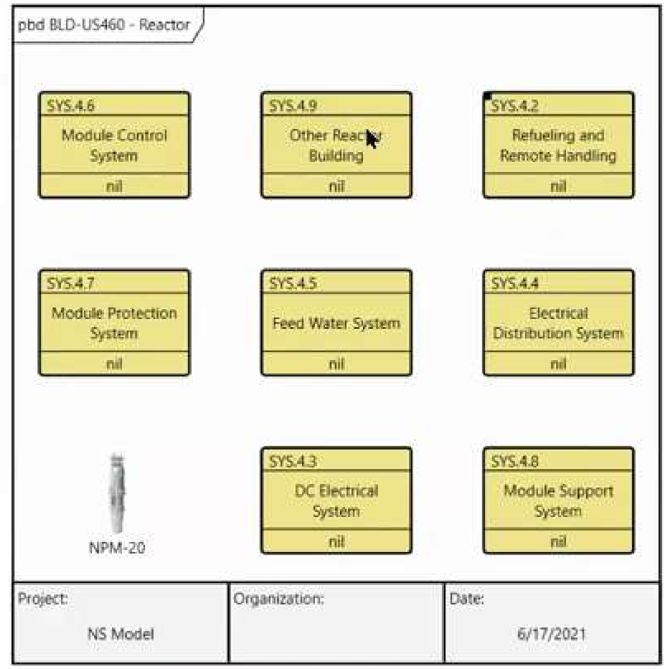
- On paper, relationships from SFR to design specification are tracked by references.

- In practice, this information is more efficiently evaluated in a database. By using a Model Based Systems Engineering tool, relationships between requirements, functions, and associated SSC can be evaluated in ways far less practical than if done on paper.

NuScale plant product structure







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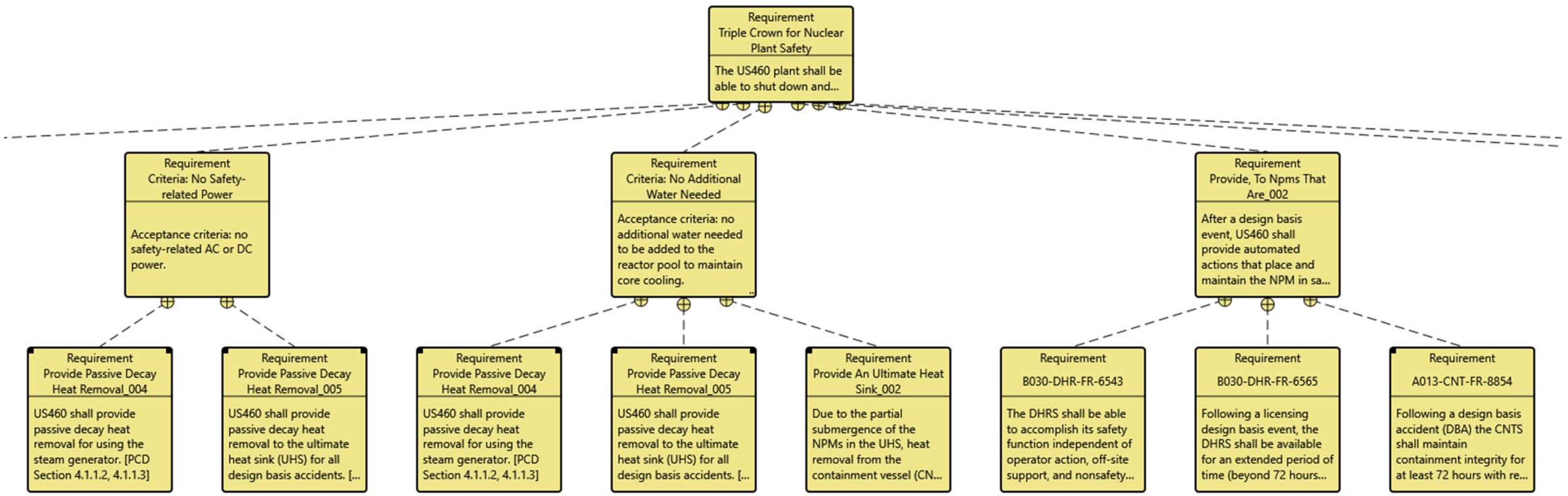
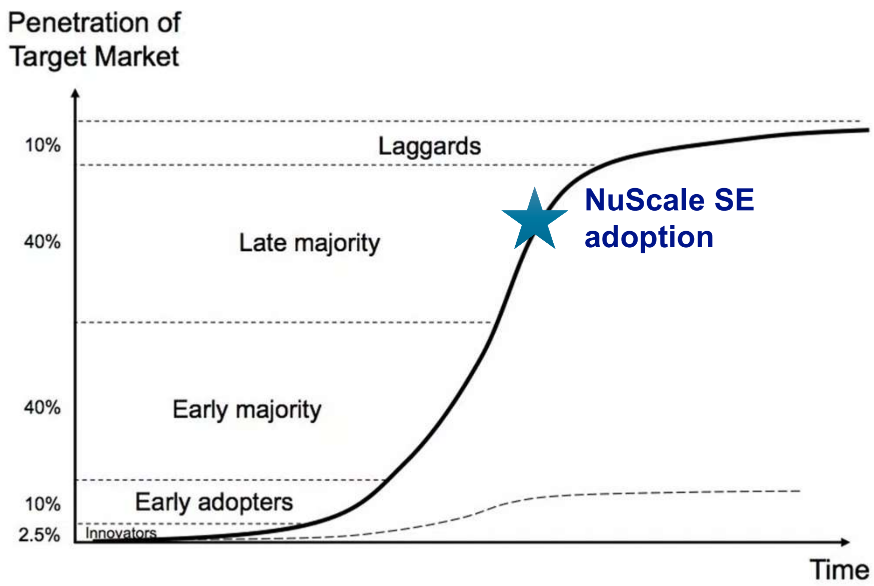
NuScale Triple Crown of Safety: Requirements Decomposition



Summary and conclusions

- NuScale formal SE program has been up and running for about 5 years and has gained wide acceptance within the company
- Digital transformation well underway at NuScale
  - Model-based engineering standard issued
  - MBSE tool selected
  - New PLM tool selected and implemented
- Continually becoming more efficient at requirements management, using proper methods and tools



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Kevan Griffith, PE, CSEP
kgriffith@nuscalepower.com
Supervisor, Systems Engineering – Analysis & Architecture