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Sandia National Laboratories

Engineered Safety at Sandia

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Elements of this presentation are based on the work of
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U.S. DEPARTMENT OF ENERGY

NNSA National Nuclear Security Administration

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Overview

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- Why Engineered Safety at Sandia?
- Engineered Safety Concepts
- Engineered Safety implementation at Sandia's Z Accelerator

Rocket Sled Track Accident

- Unexpected ignition of a rocket motor (2008)
- Government Accident Investigation Board
  - Numerous issues related to conduct of operations and work planning and control
- Executive Safety Review Board
  - “evaluate and modify technical processes to ensure they include the safety principles and requirements necessary to achieve safe operations through engineering design”

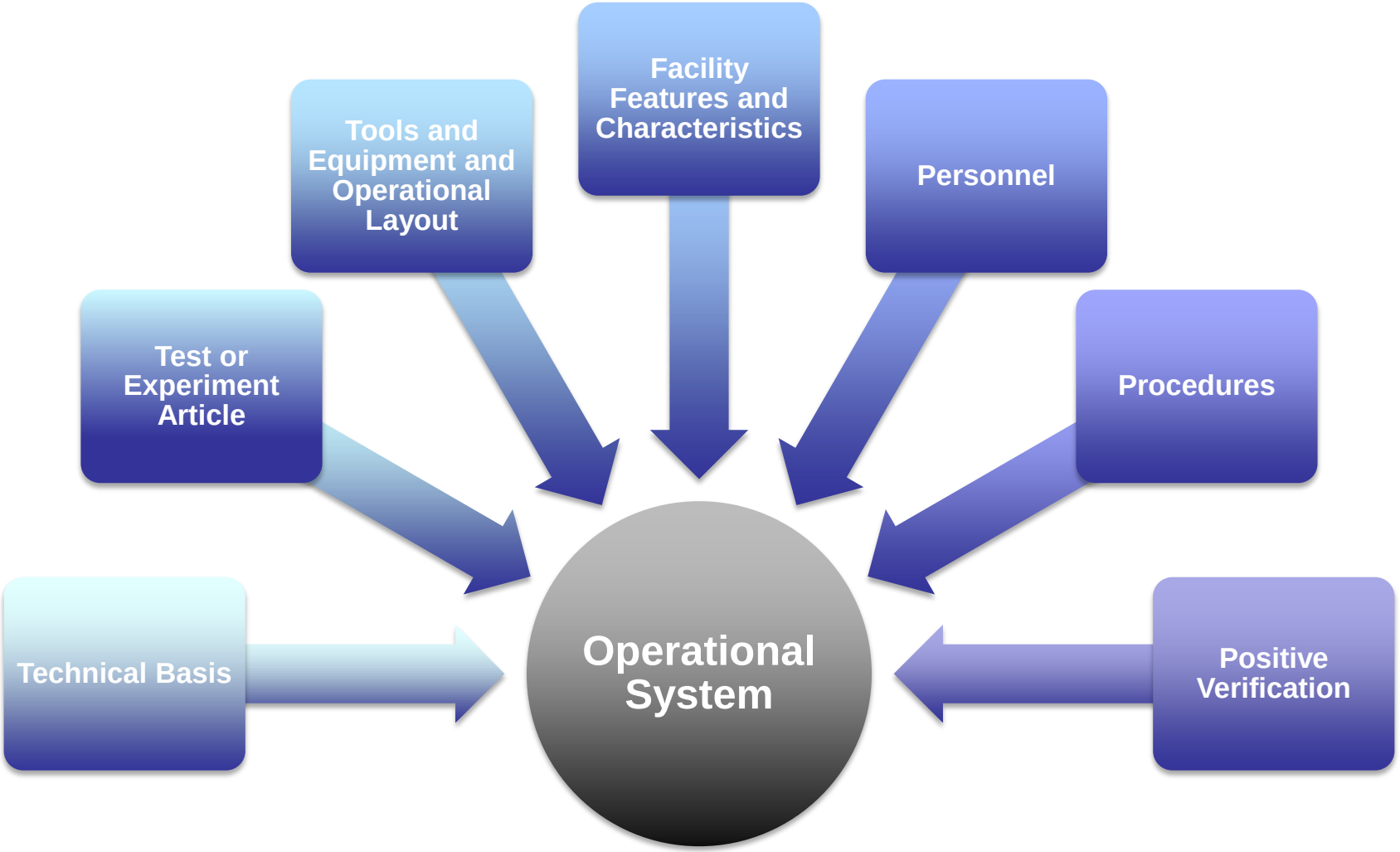
Problem Statement

- The underlying technical basis for the “design safety features” of an activity may be taken for granted or receive inadequate technical review

- Work planning and controls practices cannot be relied upon to detect technical design flaws affecting the safety of an activity

- Safety is not defined in a “systems engineering” context, which is more appropriate for an R&D laboratory

The “Operational System”



What is Engineered Safety?

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- Employs a principle- and assurance-based approach for designing safe “operational systems”

- Safety is an attribute of an operational system achieved by intent
- The operational system is systematically and critically analyzed to identify ways in which it can fail to perform as intended
- The operational system is designed and validated to prevent identified potential failure modes and mitigate the consequences of a failure should one occur

Engineered Safety Objective 1

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- Design and conduct activities as an operational system
  - Analyze and control the operational system
  - Establish safety martin criteria and verify they are achieved
  - Ensure direct and unambiguous communication, especially at interfaces
  - Provide positive verification that the system is in its intended configuration

Engineered Safety Objective 2

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- Develop the technical basis for controlling an activity
  - Understand how the system fails to an unsafe condition
  - Develop a “safety theme”
  - Use credible failure mode and fault tree analyses to clearly identify accident pathways
  - Eliminate single point failures leading to the unacceptable consequences
  - Mitigate failure modes that cannot be eliminated and lead to unacceptable consequences

Engineered Safety Objective 3

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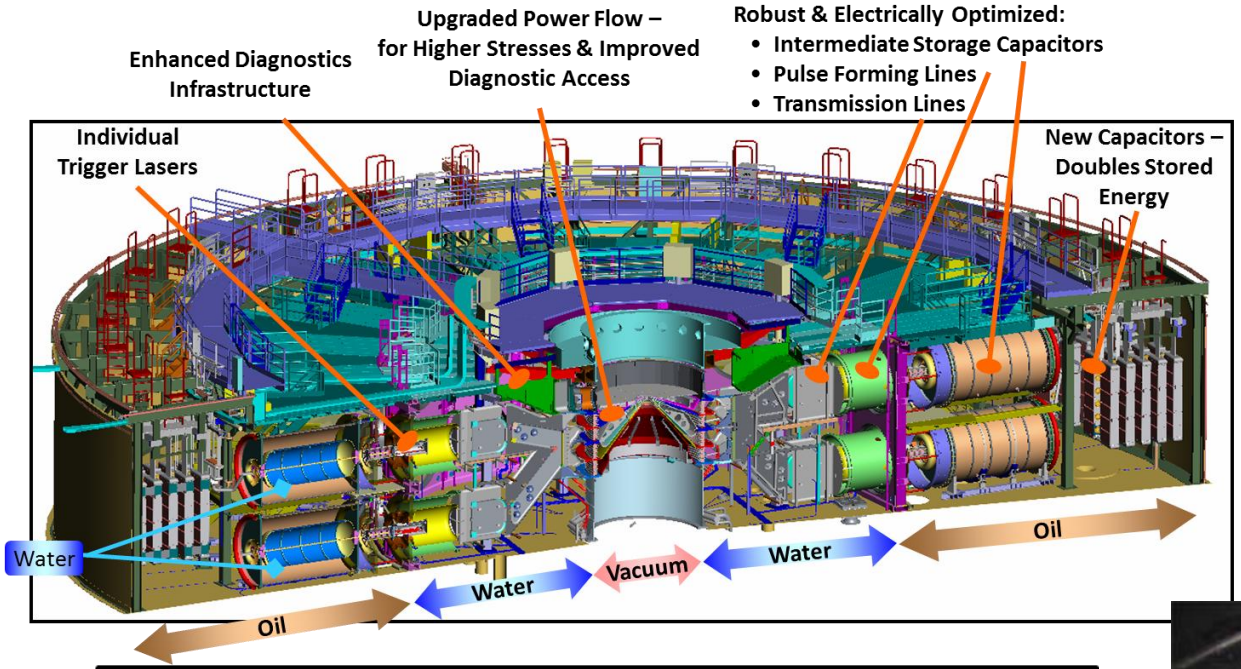
- Establish clear management expectations
  - Explicitly define the unacceptable outcomes
  - Specify a target level of engineered and administrative controls
  - Designate technical requirements for engineered controls
  - Define process requirements for administrative controls
  - Review and approve the technical basis and controls

Sandia's Z Accelerator



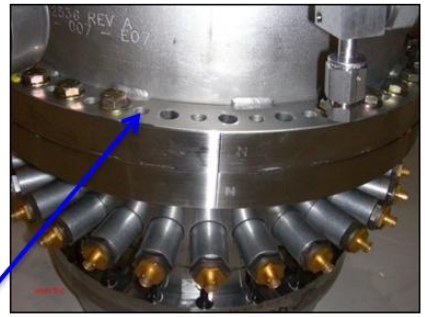
22 MJ stored energy, 26 MA peak current, 100-600 ns rise times

Energy equivalent of 2.5 lbs of high explosive released in few ns

The Z Problem

- The plutonium containment system was designed and fielded to protect workers, equipment, and the environment
  - A hermetic seal on the containment system was breached during a Z shot in March 2009 (26 MA experimental system; no Pu)

vacuum interface seal



6 bolts sheared off

Baffle system

Engineered Safety with Z

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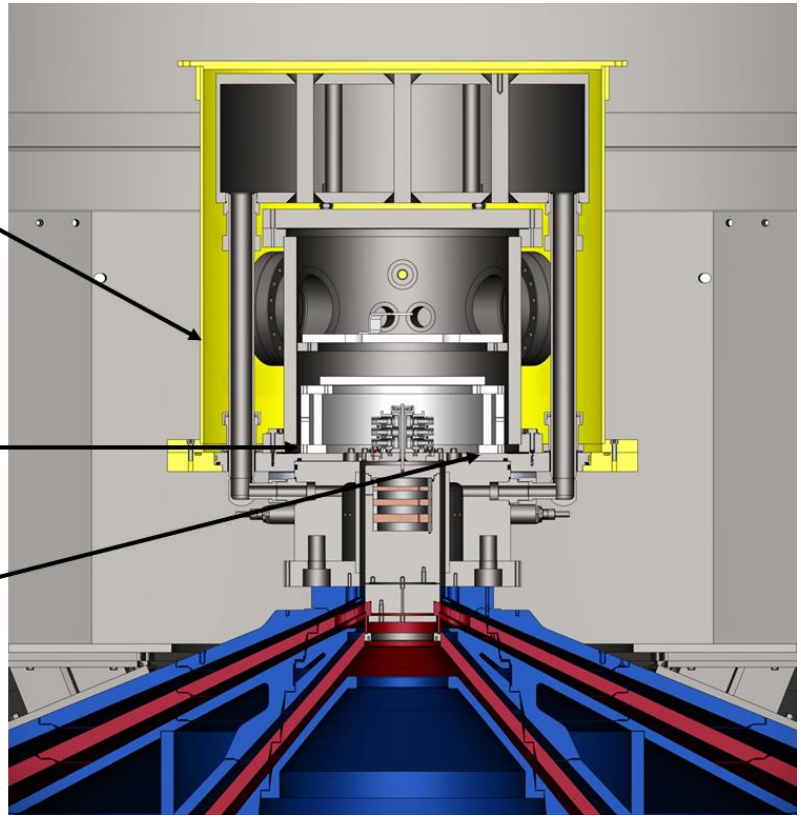
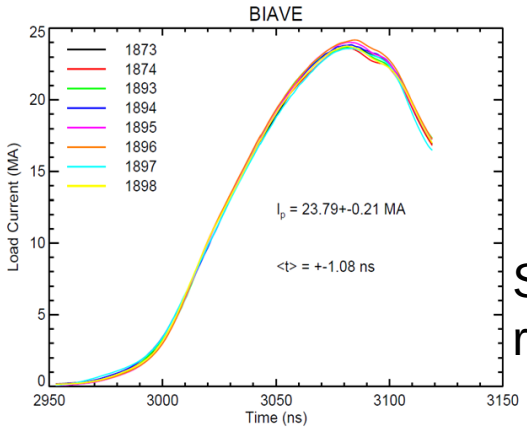
- Unacceptable consequences
  - Radiation dose to a worker
  - Contamination of the environment
  - Pause in operation of Z for more than 6 months
- Failure Mode Effects Analysis and Fault Tree Analysis
  - 33 single point failure modes

Eliminate Single Point Failures

- Added a containment chamber that surrounds the Upper Containment Chamber (UCC)
- Changed from a rigid copper gasket to an elastomeric gasket at the UCC interface seal that leaked
- Standardized a welded radial baffle system inside the UCC





Setting a current limit of 11MA reduces the chance of Pu dispersal

What if the system fails anyway?

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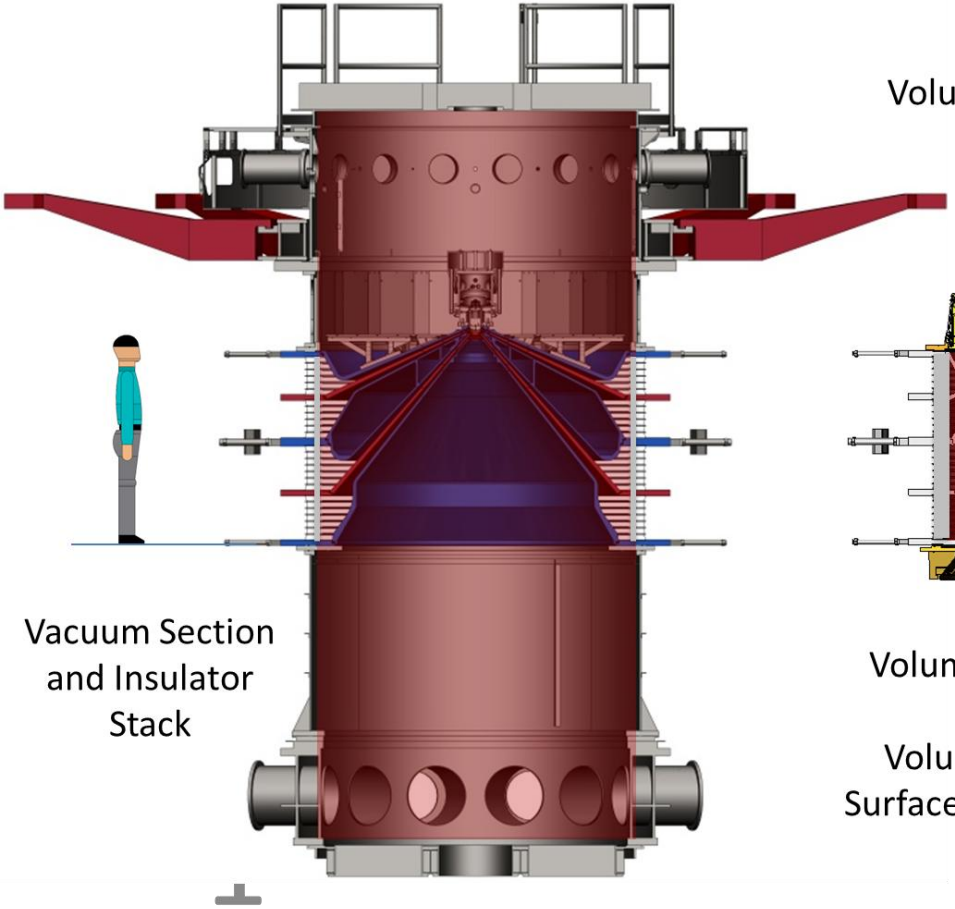
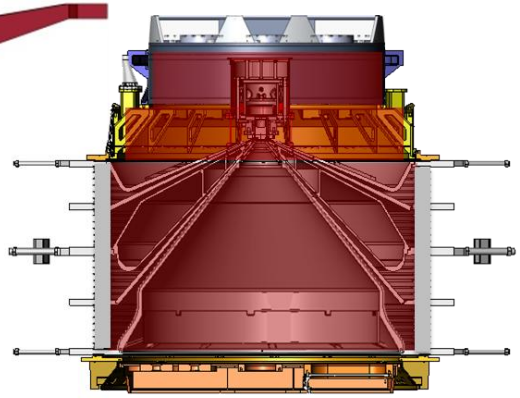


Vacuum Section and Insulator Stack

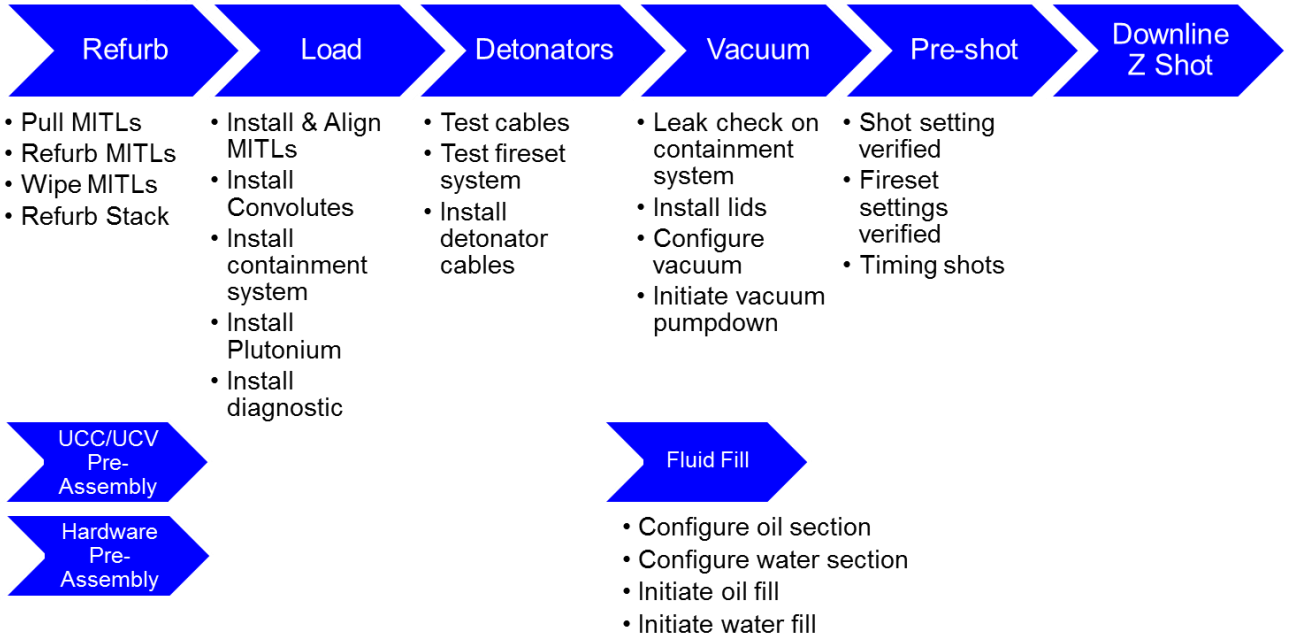
Volume Reduced Secondary Containment



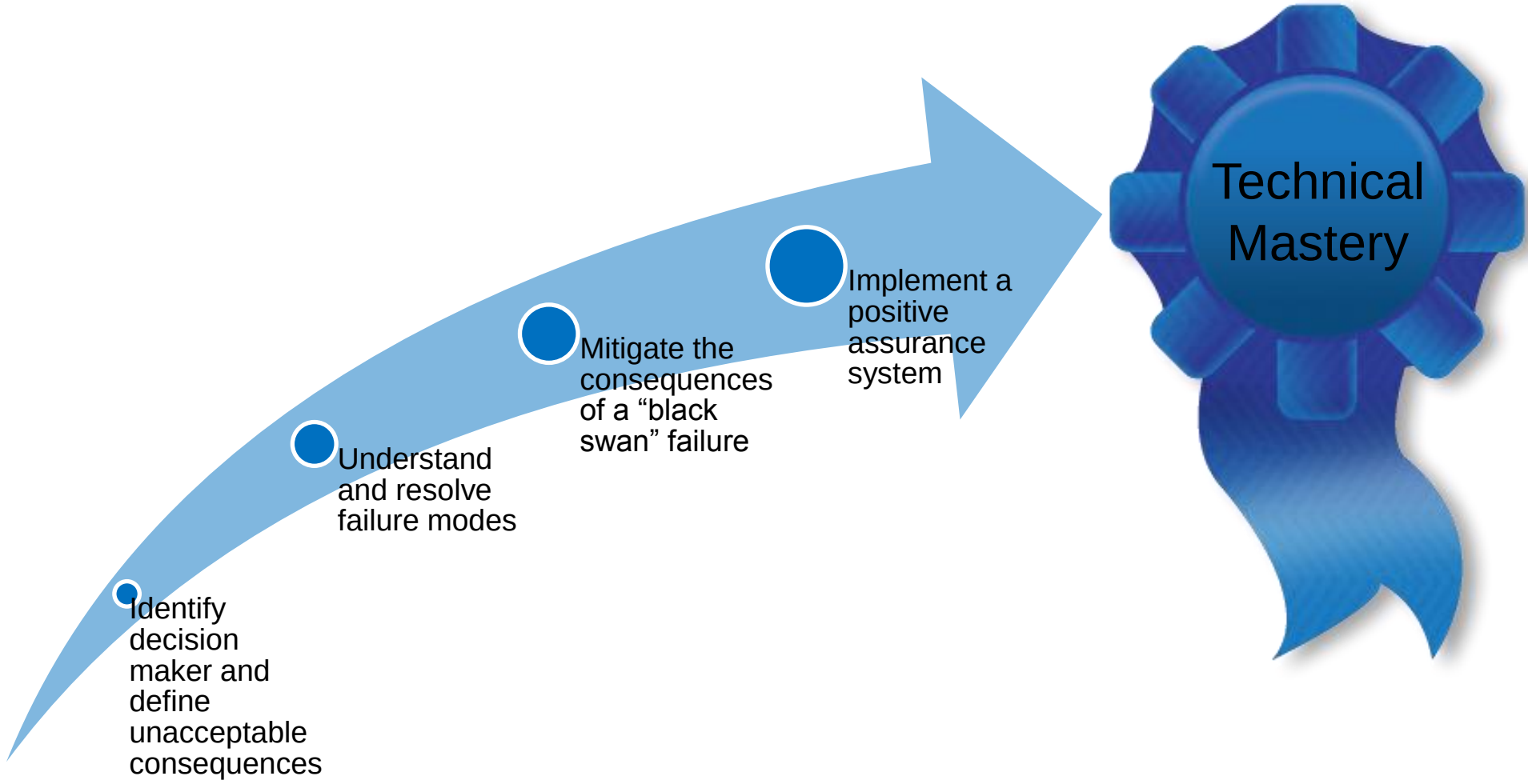
Volume Reduced Secondary Containment
Volume Reduction by 60%
Surface Area Reduction by 50%

Positive Assurance

- Require 18 formal assurances from individuals responsible for critical subsystems to the Z Shot Director prior to five key activities in the shot setup timeline
- Z Shot Director is responsible for granting final authorization immediately prior to the Pu shot



Engineered Safety Workflow



Questions

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