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Extended Lifecycle System Engineering

Principles and a strategy for an improved approach to high consequence system sustainment

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Outline

- Objectives
- Why extended lifecycle sustainment has become important
- Principles for Extended Lifecycle System Engineering
- Path forward
- Summary and discussion

Why do we care?

- US weapon systems are increasingly being required to remain in the stockpile longer than originally required, without a life extension program (LEP) and occasionally *after* an LEP was anticipated
  - For example, W80-3 and W78 LEP
- SNL has recognized the need to develop a foundational set of principles to support extended weapon lifecycles
- A desirable outcome includes assertions and assessments being supported by more objective, systematic, and rigorous evidence

> *I recommend that decisions to extend the weapon lifetimes be made with the highest discernment and technical rigor because the weapon systems will be extended to ages well beyond our experience.*
>
> Dr. Paul Hommert
> *Laboratory Director, Sandia National Laboratories*

Extended weapon lifecycle precedes life extension

Extended Weapon Lifecycle

- Extension of current system design beyond original design requirements
  - No known performance issues that require an LEP
- Same system architecture
  - Limited Life Component Exchange (LLCE)
  - Major Alterations (ALTs) to address specific issues
  - Full component reuse

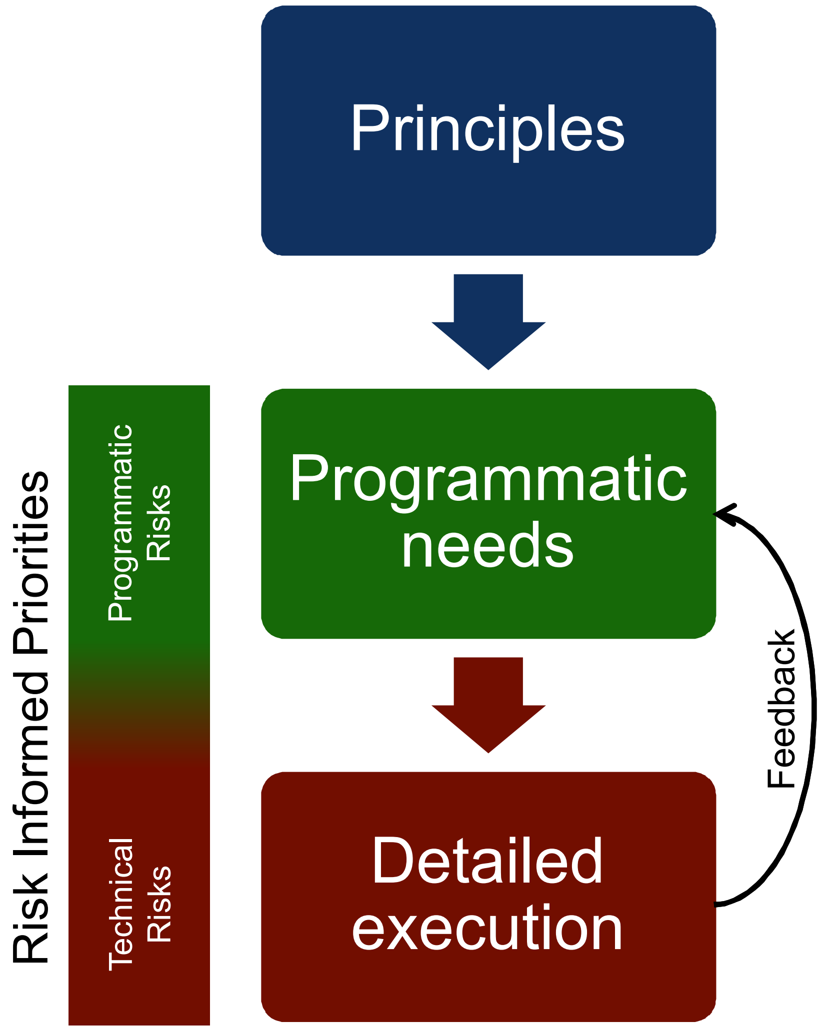
Life Extension Program (LEP)

- Required by the emergence of performance issues or new stockpile management strategies
- New system architectures
  - Component and material replacements
  - Some reuse of legacy components

The drivers for life extension activities are addressing aging and performance issues, while meeting strategic deterrence requirements with a reduced stockpile size and retaining reliability and improving performance margins.

FY2016 Stockpile Stewardship and Management Plan

SNL has developed an overarching strategy for executing Extended Lifecycle System Engineering



- Formalize a set of principles from which to base extended lifecycle statements

guides

- Weapon program needs and risk-informed priorities for supporting the system from now through forecasted end of life

determines

- Detailed execution of priorities for supporting the system from now through forecasted end of life

Principles for Extended Lifecycle System Engineering

Principles

SNL formed a multi-disciplinary team to develop and document eight principles for extended lifecycles

- Communication, coordination, and leveraging will enable success
- Extending weapon lifecycles is an active endeavor
- Challenge assumptions
- Decisions must have a technical basis
- Significant perturbations to the system are more important than age
- Risks associated with extending the life of a weapon system must be understood
- Understanding requirements is key
- Resources must support an extended lifecycle

- Multi-organization team within SNL
  - Weapon System Engineering
  - Independent Assessment
  - Surveillance
  - Science and Technology
- Core Themes
  - Careful planning and collection of surveillance data
    - Anticipated constraints on surveillance programs
  - State of health assessments must be objectively-based and defendable
    - Require careful coordination with internal and external stakeholders

Communication with internal and external stakeholders is key to success

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- Ensure communication and alignment between all Department of Defense and Department of Energy agencies that are affected
- Each agency must evaluate the parts, processes, and components for which they are responsible
- Inability of one agency to meet technical and logistical requirements may be a showstopper or require significant changes when extending weapon lifecycles

When two organizations are *truly* collaborating, if one organization fails, then both organizations have failed.

Expect extended lifecycles to be dynamic

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- There is no discrete endpoint and regular re-evaluations will be necessary
- Identify significant perturbations to your system
- Utilize ongoing system level testing results to know where to focus and prioritize work

Glory Trip 207

Avoid mental ruts and learn from others

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- Conduct peer reviews to evaluate robustness of assertions and decisions
- Leverage other NNSA and non-NNSA sustainment engineering activities – learn from their techniques
- New and sometimes unexpected information will continue to flow and system engineers will need to be able to act on it
- Cyclical re-evaluations can inform and update the other principals and methods applied to extended life
- Verify and validate hypothesized failure modes

Support your conclusions

- Communication, coordination, and leveraging will enable success
- Extending weapon lifecycles is an active endeavor
- Challenge assumptions
- **Decisions must have a technical basis**
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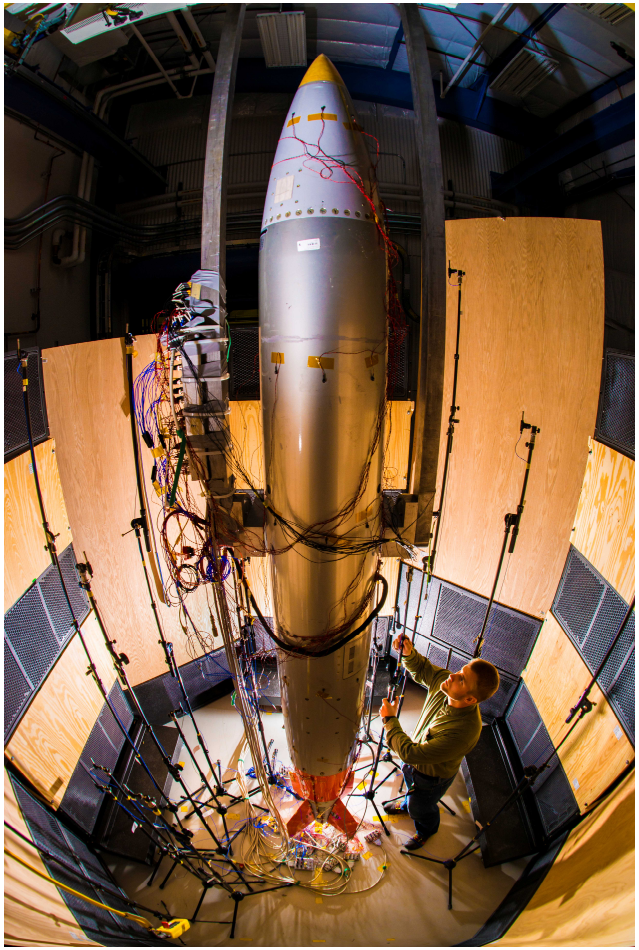
▪ Technical basis studies must encompass reliability, safety, and security aspects of materials, components, subsystems, and systems
▪ Explore widely, focus deliberately
▪ Use the technical basis to make risk-informed decisions
▪ Ensure appropriate test programs are in place to monitor material, component, and system state-of-health encompassing reliability, safety, surety, and survivability

Decisions must have a technical basis



Measure what's important, not just what's easy to measure…

System perturbations can have more impact than age

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- Events such as Limited Life Component Exchange (LLCE) operations have been shown to influence system state *more* than simply the passage of time
- Perturbations can involve important and higher probability failure modes that can inform technical basis activities
- Consequential changes to system state may not be defined in the environmental specifications (e.g., Stockpile-to-Target Sequence (STS))
- Defining explanatory and performance critical mechanisms of failure will better support technical basis work

Risk-informed approach

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- Use risk analysis to support prioritizing issues and setting the stage for failure analysis
- Communicate your knowledge and concerns
  - There will *never* be enough data
  - Communicate assertions as well as caveats, knowledge gaps, and uncertainties

Understand and follow your requirements

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- **Understanding requirements is key**
- Resources must support an extended lifecycle

- Revisit system level requirements and environments specifications (e.g., STS, Military Characteristics), and traceable requirements to determine what updates may be needed to support extended lifecycles
  - Identify areas of limited margin when validated against requirements
  - Determine if surveillance testing should be modified to ensure testing covers the requirements space

Understand your infrastructure needs

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- Challenge assumptions
- Decisions must have a technical basis
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- Risks associated with extending the life of a weapon system must be understood
- Understanding requirements is key
- **Resources must support an extended lifecycle**

- Logistical/ Infrastructure
  - Production agency qualification and safety basis
  - Sufficient hardware
  - Software
  - Computer codes
  - Computer hardware
  - Subject matter expertise
- Sufficient funding to
  - Develop/implement strategy to get a decision on extended weapon lifecycles
  - Support the weapon throughout its extended lifecycle phase

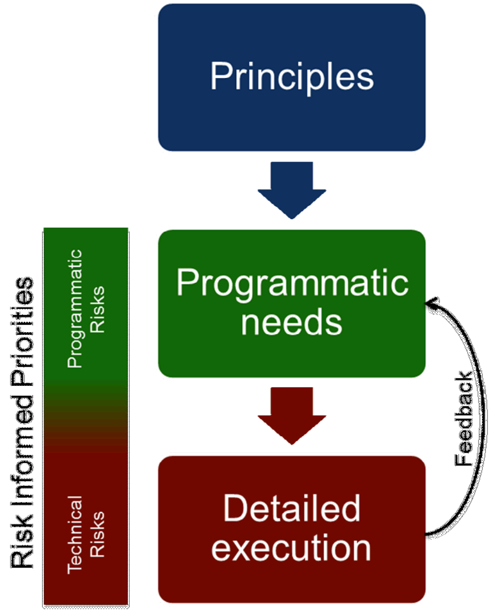
What’s Different in the Approach?

OLD	NEW
Discrete assessments	Continuous assessments and risk management
Component by component assessments	Component and cross component assessments
Look for change	More specific inspection criteria traceable to high consequence failures
Measure everything available	Measure what’s important (not just what’s easy to measure)
Budget centric surveillance	Integrating risk management and failure modes and effects analysis
Investigate all anomalies	Investigate anomalies of higher risk to system performance
Standardized approach to surveillance across stockpile	Surveillance based on respective lifecycle phase
Repeat qualification tests	Test based on historical data and current lifecycle phase

While many of the new processes *have* been performed in the past, the updated strategy facilitates more systematic and consistent execution.

Path Forward

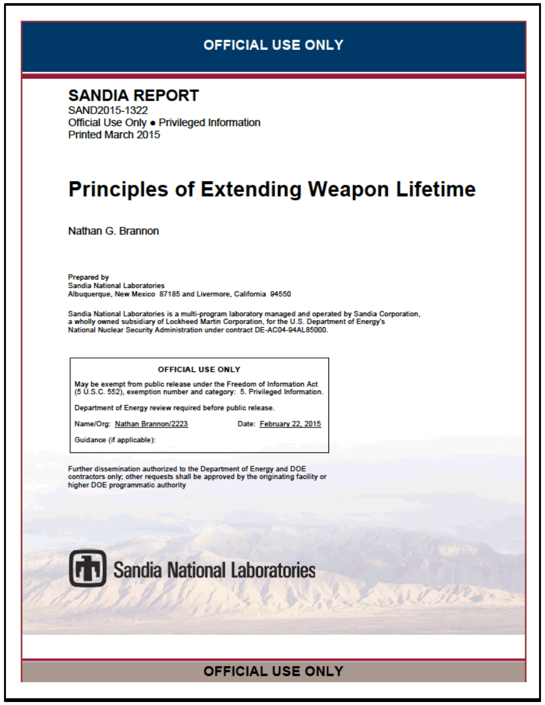
- More work is needed in benchmarking
  - Many other, high-consequence systems have endured extended lifecycles.
  - We are seeking collaboration with other programs to learn what has worked and what has not worked.
- Coordination across agencies continues
- NNSA briefed the Nuclear Weapons Council Action Officers on the updated approach on 23 March 2017
- Sandia is the furthest along in detailed execution.



Summary

- Many systems are being required to meet requirements well beyond their original design life
- The high consequence nature of such systems demands a deliberate approach to state of health monitoring, management, and communication
- The principles provided are intended to facilitate a more objective, systematic, and rigorous approach to extended lifecycle system engineering.

➢ More details available in Sandia Report (OUO) SAND2015-2032



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Principles of Extending Weapon Lifetime

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