Lawrence Livermore National Laboratory

Overview of Weapons Enterprise Transformation and Mathematical Assessment Tools

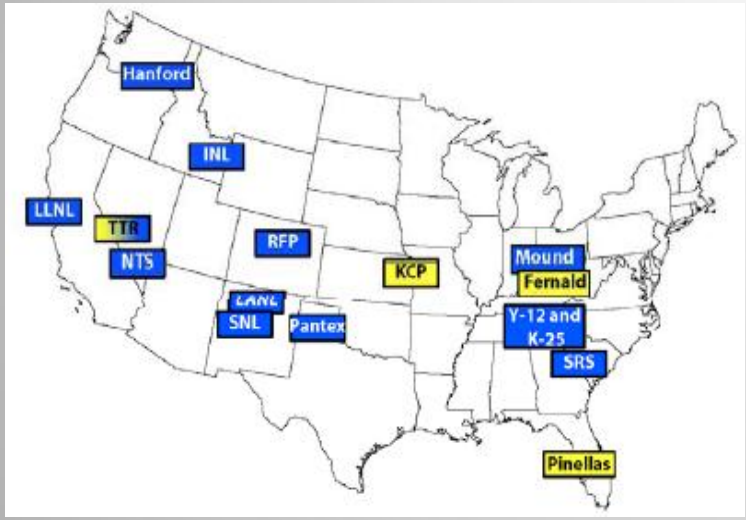
December 6, 2011

Carol Meyers

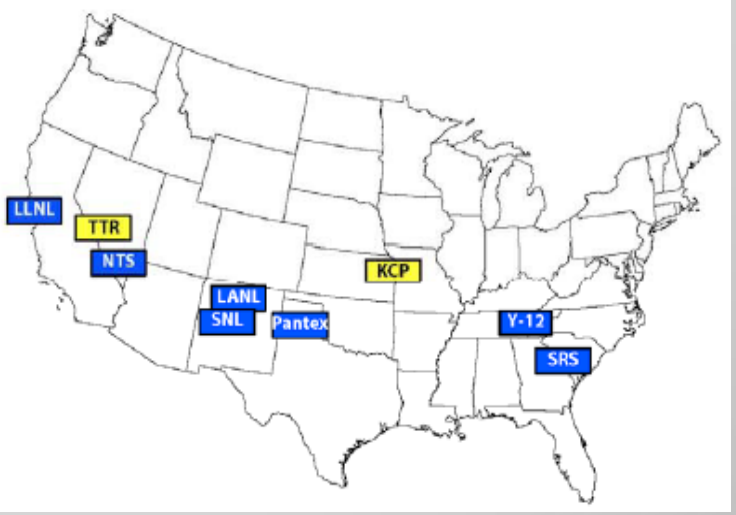
LLNL- PRES - 497491

This work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344.

The US DOE Nuclear weapons complex is shrinking, both in terms of weapons and infrastructure



Nuclear Weapons Complex (1980)



Nuclear Weapons Complex (2011)

B61

W62/W78/W87

B83

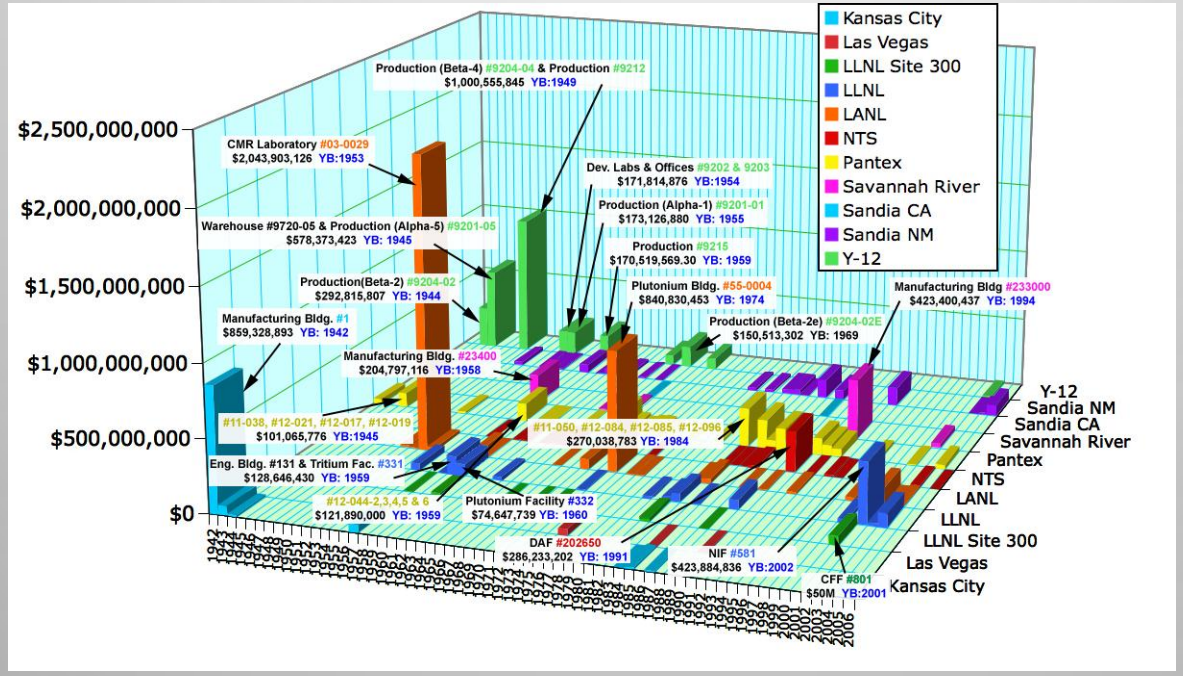
W76/W88

W80

- Fully 40% of all nuclear production and testing sites have closed.
- Nuclear weapons have not been tested in the United States since a national moratorium in 1992.

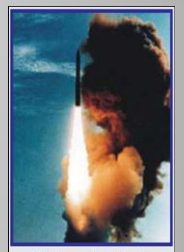
The US DOE Nuclear weapons complex is shrinking, both in terms of weapons and infrastructure

- Infrastructure within the complex was largely built during the Cold War, and is aging dramatically.



- One current goal is to reduce the total footprint of the complex from 35 million to 26 million square feet.

B61


W62/W78/W87

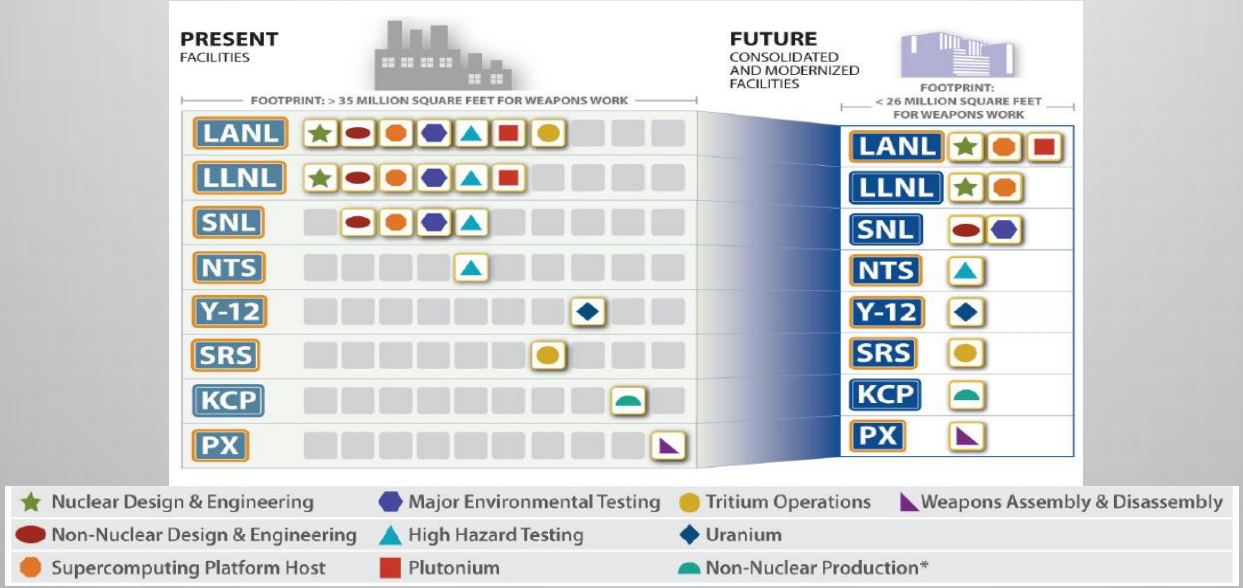
B83

W76/W88

W80

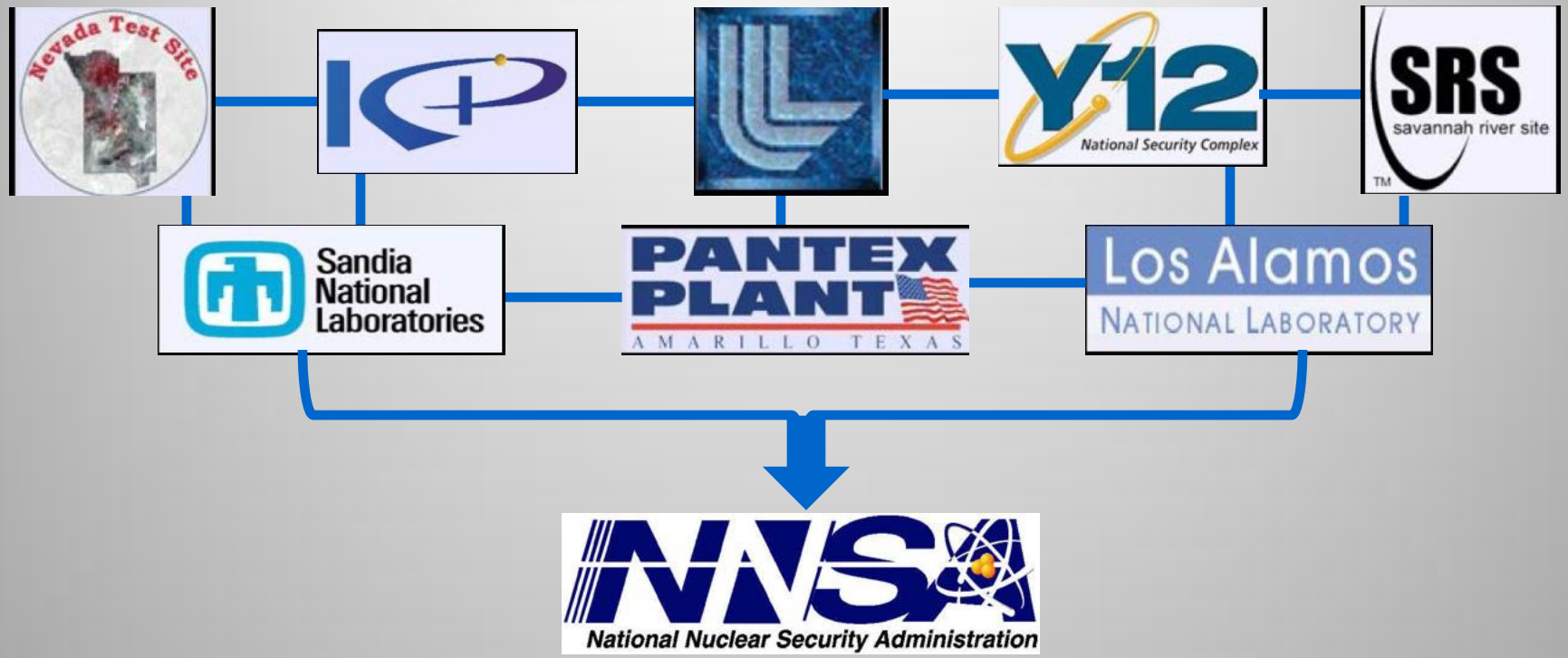
The US National Nuclear Security Administration (NNSA) must create a smaller, safer, secure, and less costly weapons enterprise

- As part of this, NNSA must evaluate different potential plans for complex transformation. Many such plans have been proposed.



Central Question. How can we evaluate the goodness of such plans? What is their risk? Would all plans even work?

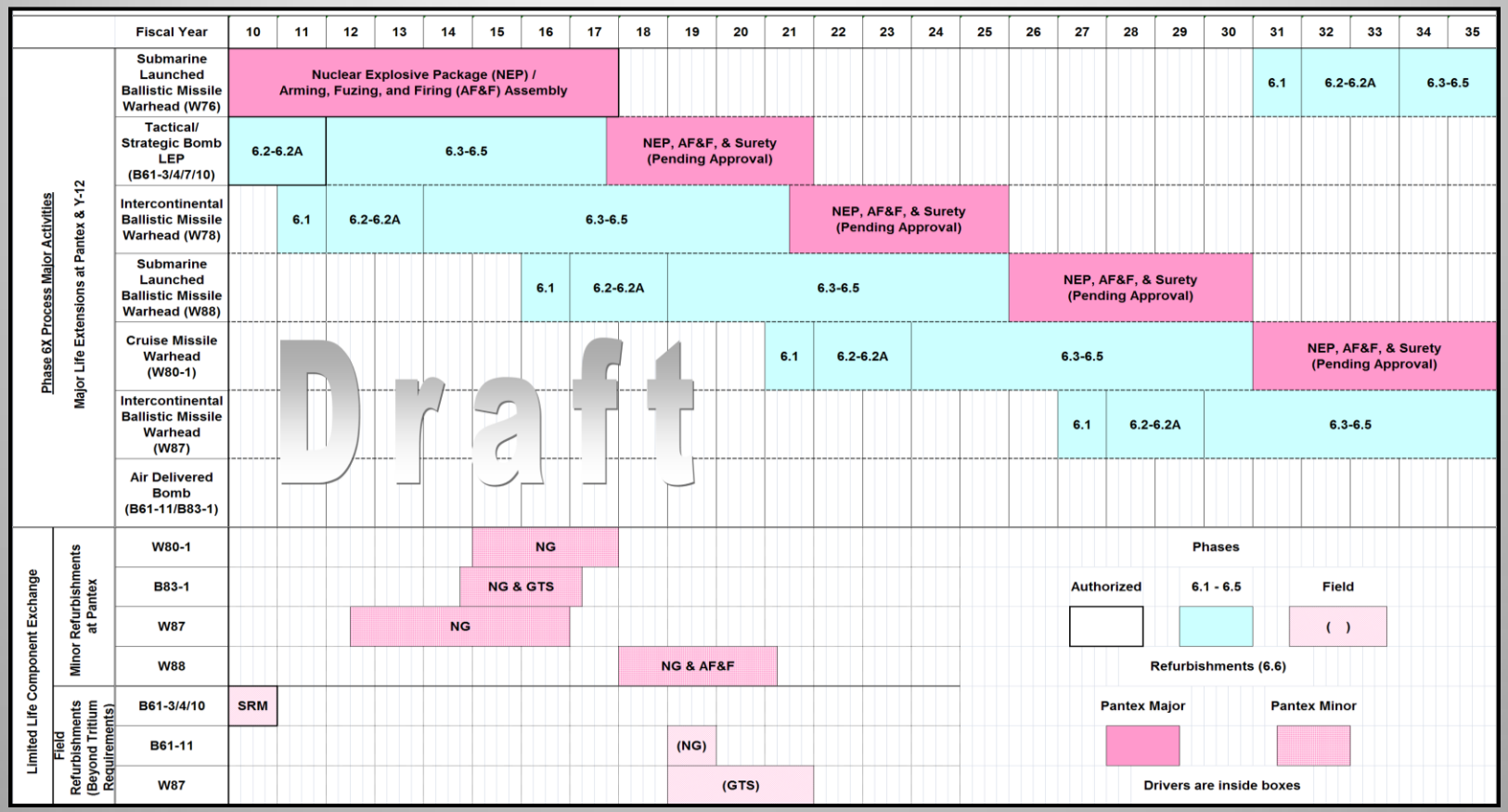
Teams from around the complex work together to provide quantitative input to NNSA on policy questions



- This involves sharing both data and site-specific knowledge and expertise.
- I am a member of the enterprise modeling team at LLNL.

NNSA provides to us sample courses of action, and we evaluate the feasibility and risk of such plans

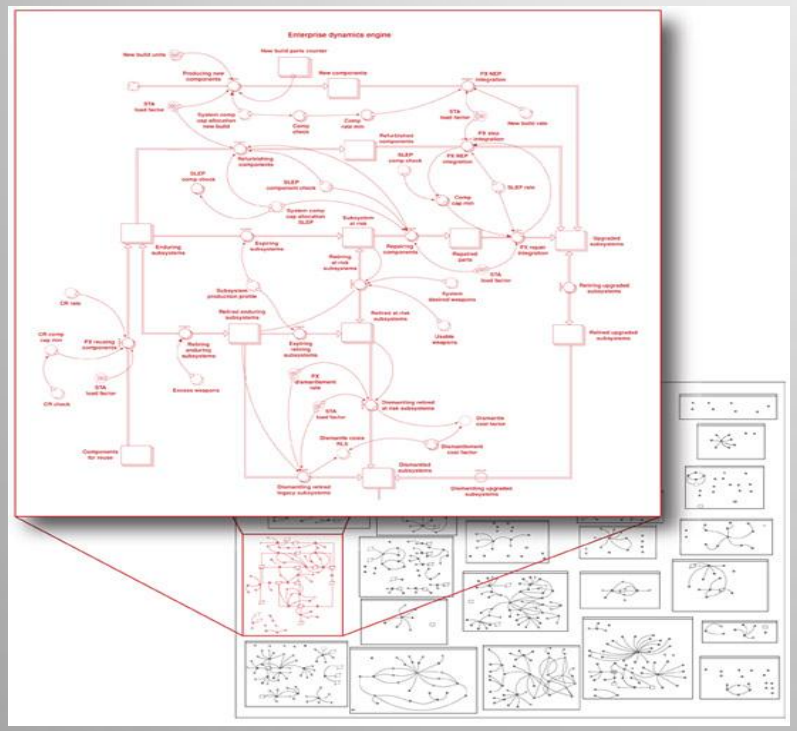
A Notional Planning Scenario



We use a wide variety of mathematical tools to help quantify the feasibility and risk of different plans

Mathematical Tools Used in Enterprise Transformation

- Physics-based Rate Equation tools:



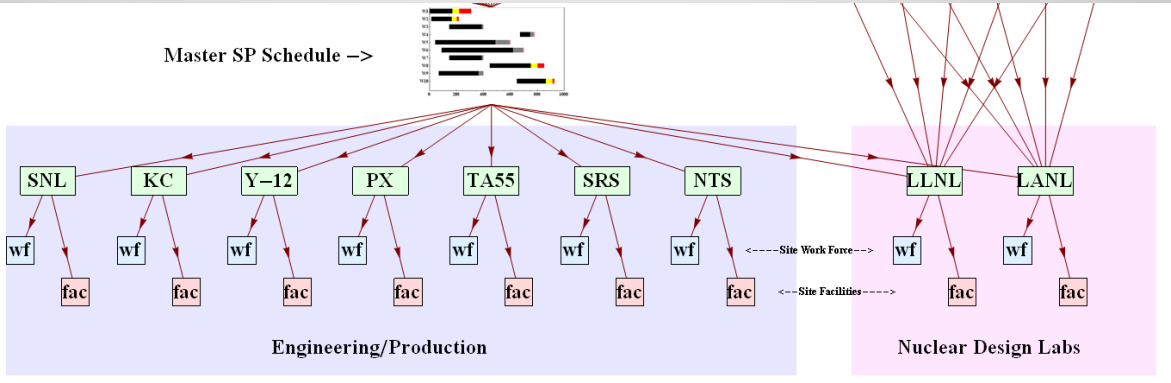
Treat weapons like flow moving through a complex system, governed by sets of differential equations.

Assess stockpile transformation plans by changing parameters of the complex system, and seeing how the flow changes.

We use a wide variety of mathematical tools to help quantify the feasibility and risk of different plans

Mathematical Tools Used in Enterprise Transformation

- Physics-based Rate Equation tools
- Discrete Event Simulation tools:



Treat weapons like individual entities, moving through a discrete system that is modeled in as great a level of detail as possible.

Assess stockpile transformation plans by changing parameters of the system, and seeing how the system throughput changes.

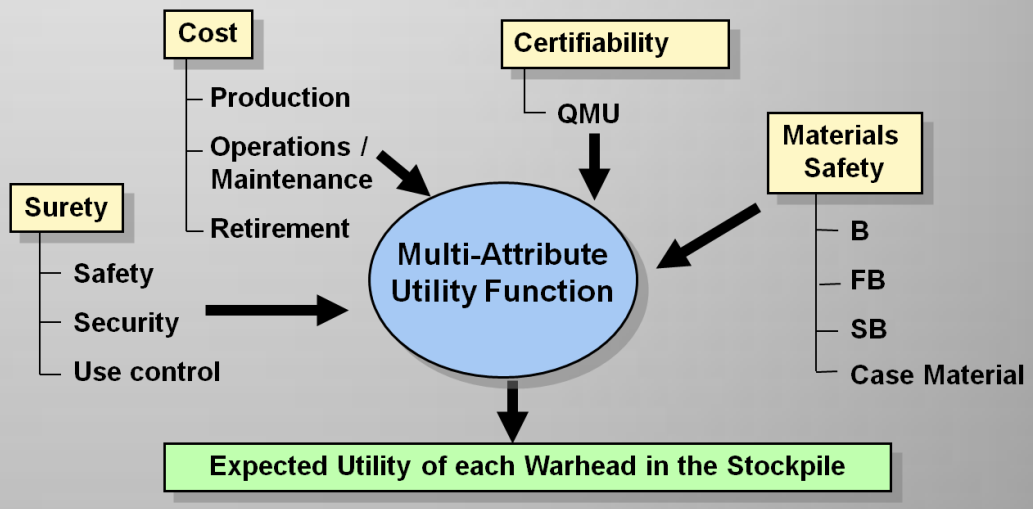
We use a wide variety of mathematical tools to help quantify the feasibility and risk of different plans

Mathematical Tools Used in Enterprise Transformation

- Physics-based Rate Equation tools
- Discrete Event Simulation tools
- Multi-Attribute Utility tools:

Use mathematical elicitation techniques to assess the benefits of different plans, according to decision maker preferences.

Can quantify the relative goodness of different plans and/or weapons.



We use a wide variety of mathematical tools to help quantify the feasibility and risk of different plans

Mathematical Tools Used in Enterprise Transformation

- Physics-based Rate Equation tools
- Discrete Event Simulation tools
- Multi-Attribute Utility tools
- Mixed Integer-Linear Optimization tools:

Model the weapons in the stockpile as mathematical variables, subject to linear constraints on the stockpile evolution over time.

Given a particular objective, we can calculate stockpile transformation.

(We also run in parallel on supercomputers.)

In summary: NNSA has a very challenging problem, for which mathematical tools are used to aid in making policy decisions

- These tools have been used to evaluate nuclear posture review scenarios, the program of record, and numerous hybrid scenarios.
- NNSA also interacts extensively with the DoD on issues of force structure and stockpile composition.
- Good policy decisions cannot be made in a vacuum: our technical input ensures that necessary implementation issues are addressed.
- Also essential to good policy making is having input from many sources and perspectives, which is why the collaboration of different sites is so valuable.