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Modeling Large-Scale Critical Enterprises

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Conference on Systems Engineering Research (CSER)

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National Nuclear Security Administration (NNSA) and

Sandia National Laboratories

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Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

Nuclear Weapons Enterprise

- Evolving Nuclear Security Enterprise (NSE)
- The enterprise has been significantly downsized and consolidated since the end of the Cold War.
- Government oversight Management Evolution

1946 → 1974 → 1977 → 2000

National Nuclear Security Administration

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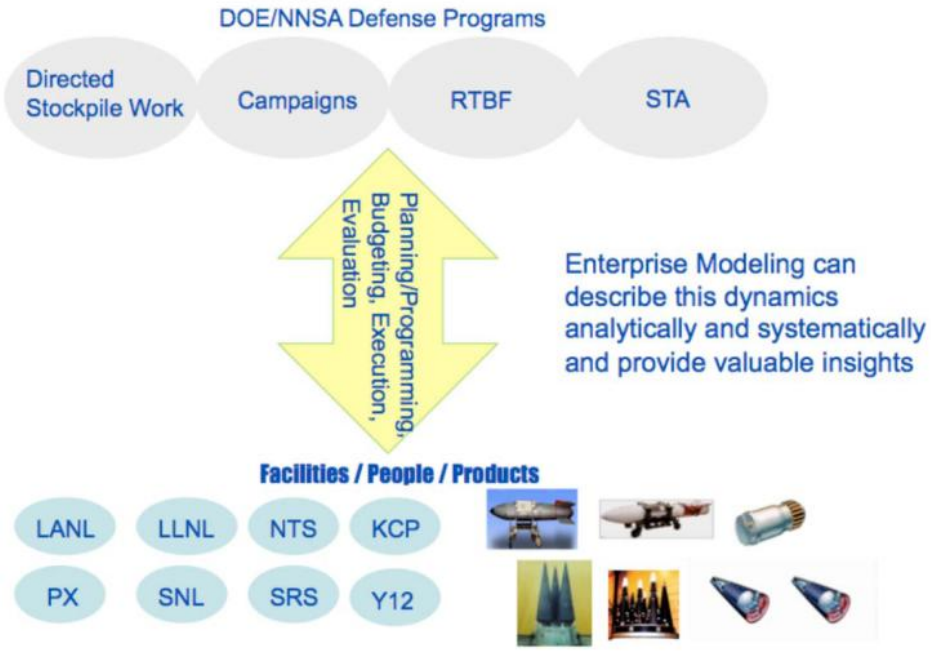
The NNSA/DP Enterprise Modeling Problem Space

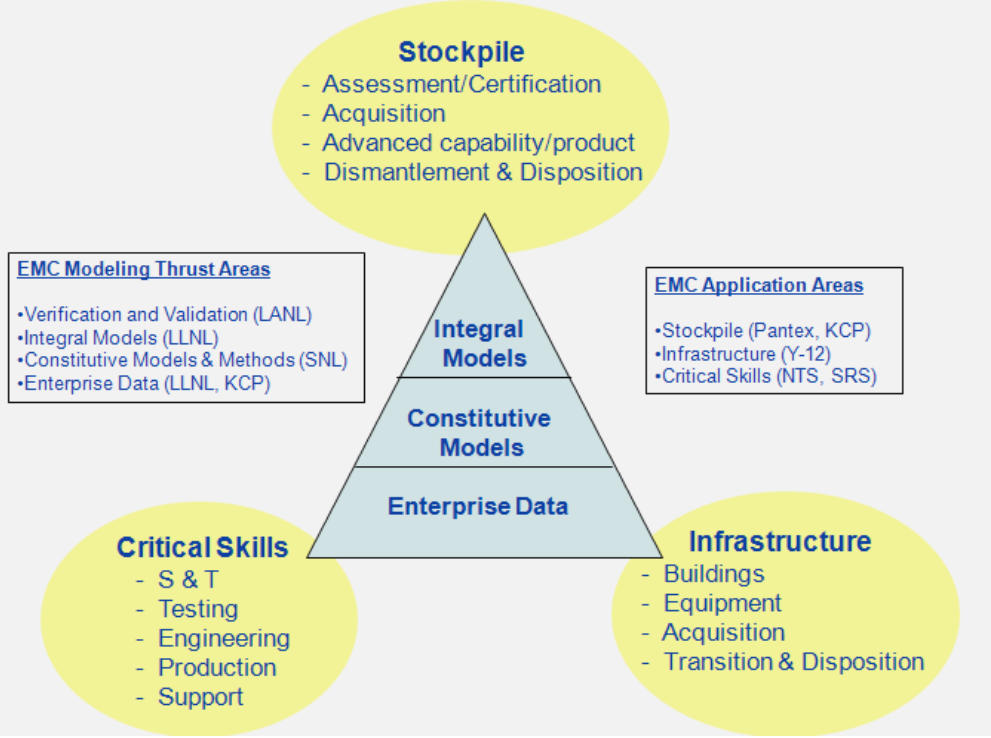
- Programs within NNSA (27% of DOE Budget)
  - Defense Programs; $7.6 B
  - Naval Reactors; $1.2 B
  - Defense Nuclear Nonproliferation; $2.5 B
- Programs under Defense Programs
  - Directed Stockpile Work
  - Campaigns
  - RTBF
  - STA
- Workforce
  - Eight agencies
  - Eight DOE site offices
  - Federal Program Management staff in DC and Albuquerque

"The FY 2012 President's Budget Request provides $11.78 billion to invest in a modern, 21st century nuclear security enterprise, implement the President's nuclear security agenda, and improve the way the NNSA does business and manages its resources." ***Mar 2, 2011, testimony by NNSA Administrator D'Agostino***



Enterprise Modeling Consortium (EMC) in the Nuclear Security Enterprise

- Stockpile
  - Aging systems
  - Four missions
  - High consequence
- Infrastructure
  - Aging infrastructure
  - Eight sites with 1000's of buildings
  - Program equipment like fusion reactors
- Critical Skills
  - Aging workforce
  - Competency-based organization
  - Specialized knowledge



EMC is engaged in informing decision makers about programmatic and technical decisions that have long-term effects

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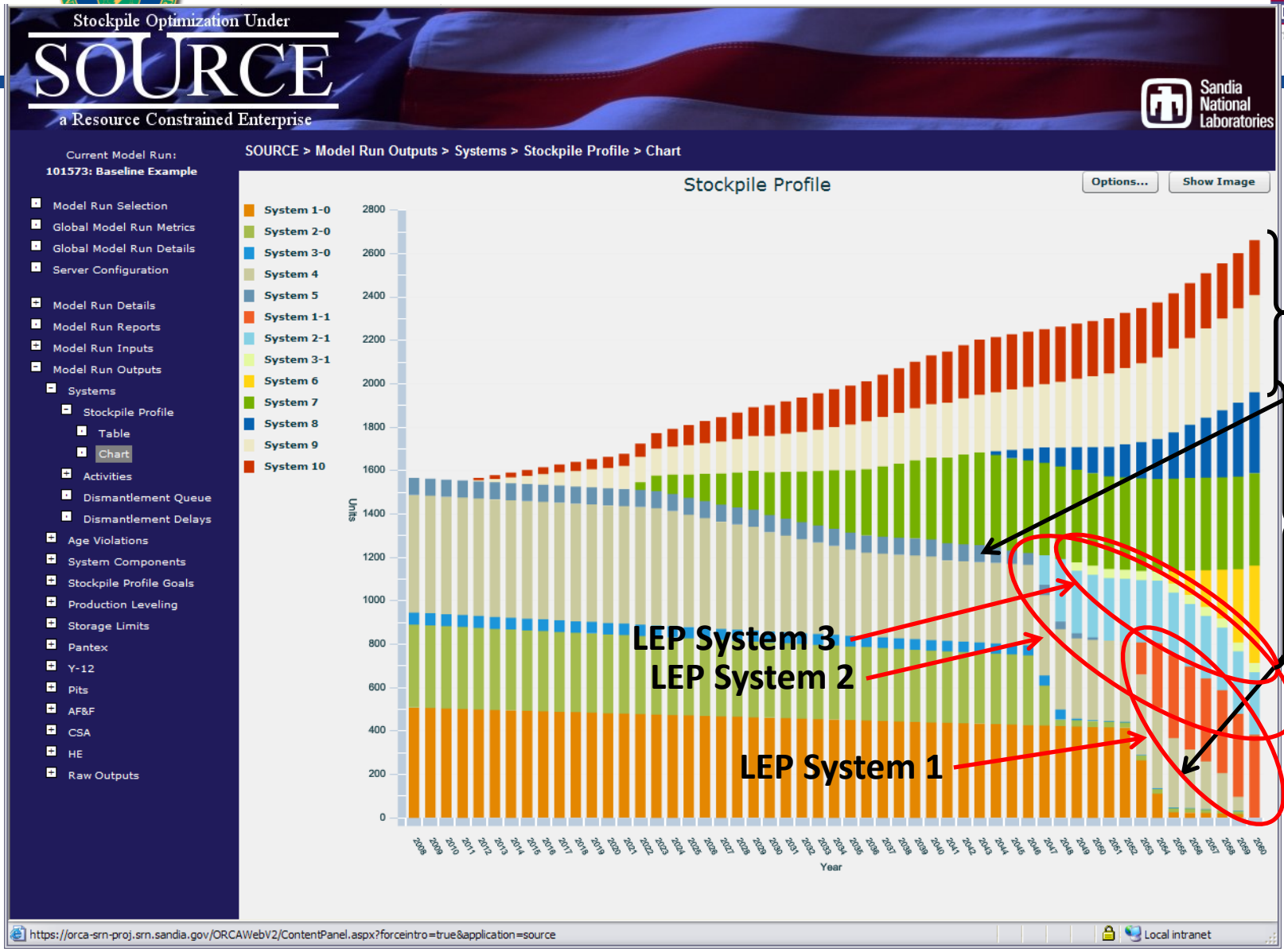
Stockpile Modeling Vision

- Throughput model for the NSE including laboratories and plants for all stockpile work
  - Life-extension Programs (LEP's) (Phases 6.1-6.6)
  - Limited Component Exchanges (LLCE's) (Phase 6)
  - Surveillance (Stockpile Evaluation) (Phase 6)
  - Dismantlement (Phase 7)
- Output is sets of river charts or sand charts that show the following
  - Activity by site and overall in the NSE
  - Capacity by site and overall in the NSE
- Model should facilitate "what if" analysis including
  - Interference and bottlenecks
    - Critical skills
    - Program equipment, e.g. special tooling, containers, etc.
    - Test and qualification capabilities
    - Constraints associated with start-up, regulations, etc.
  - Ability to add resources, shift resources, etc.
  - Easily changing and moving scope, e.g. change FPU date, duration of an LEP, etc.



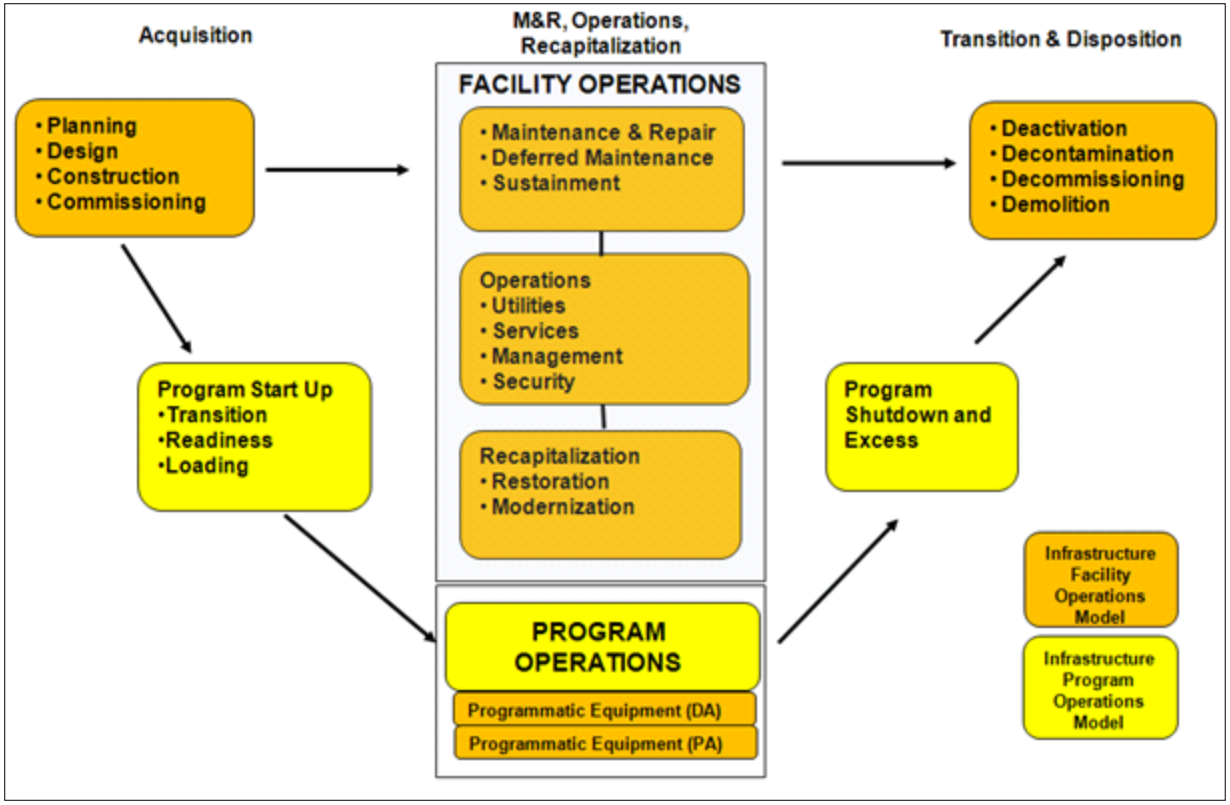
New Builds eUse

System 5 Retirement

New Builds

System 4 Retirement

Facility Life-Cycle Modeling, Programmatic Equipment, and Programmatic Transition

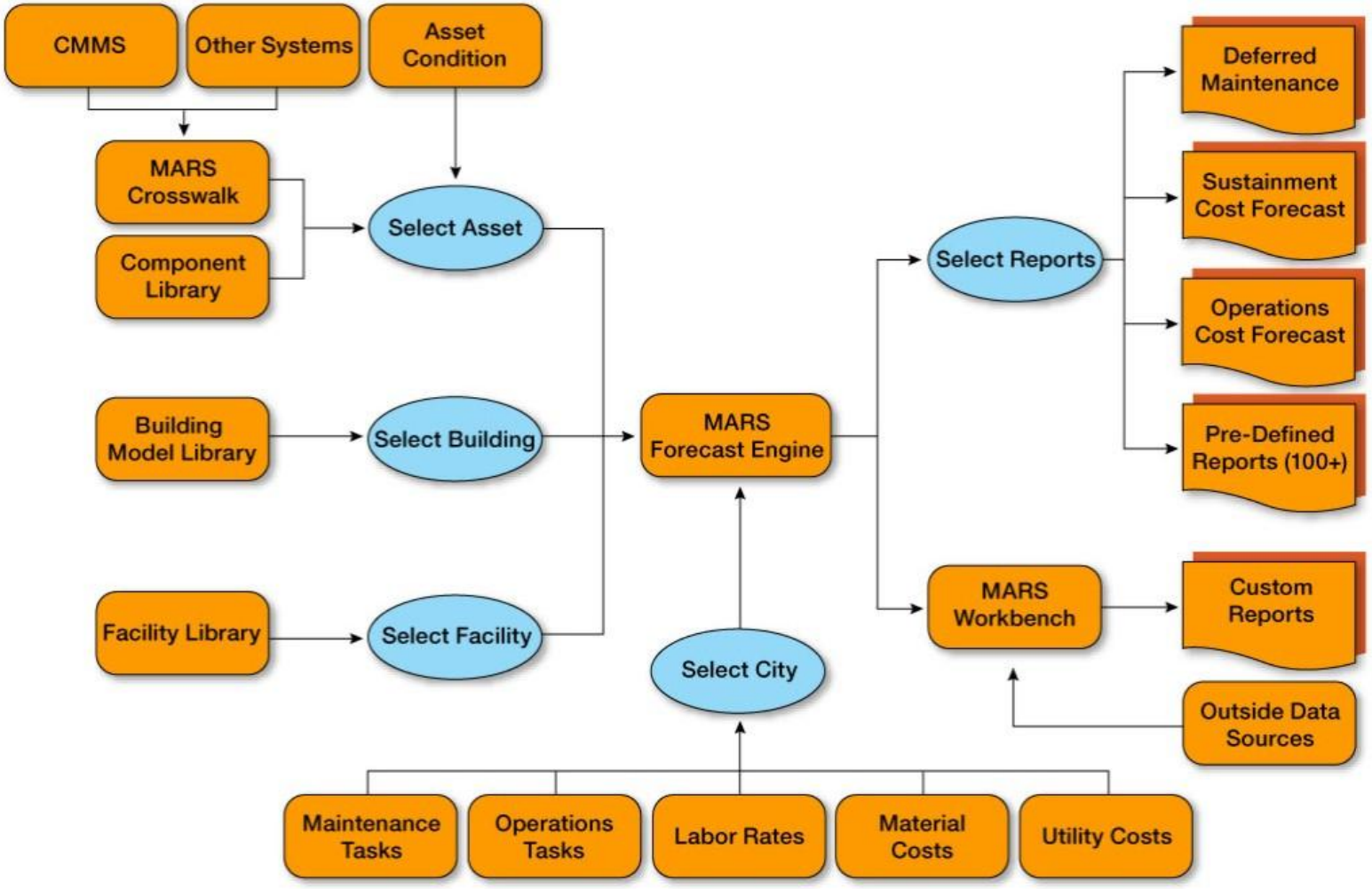


DOE Facility Information Management System (FIMS)
Summary of Site Inventories

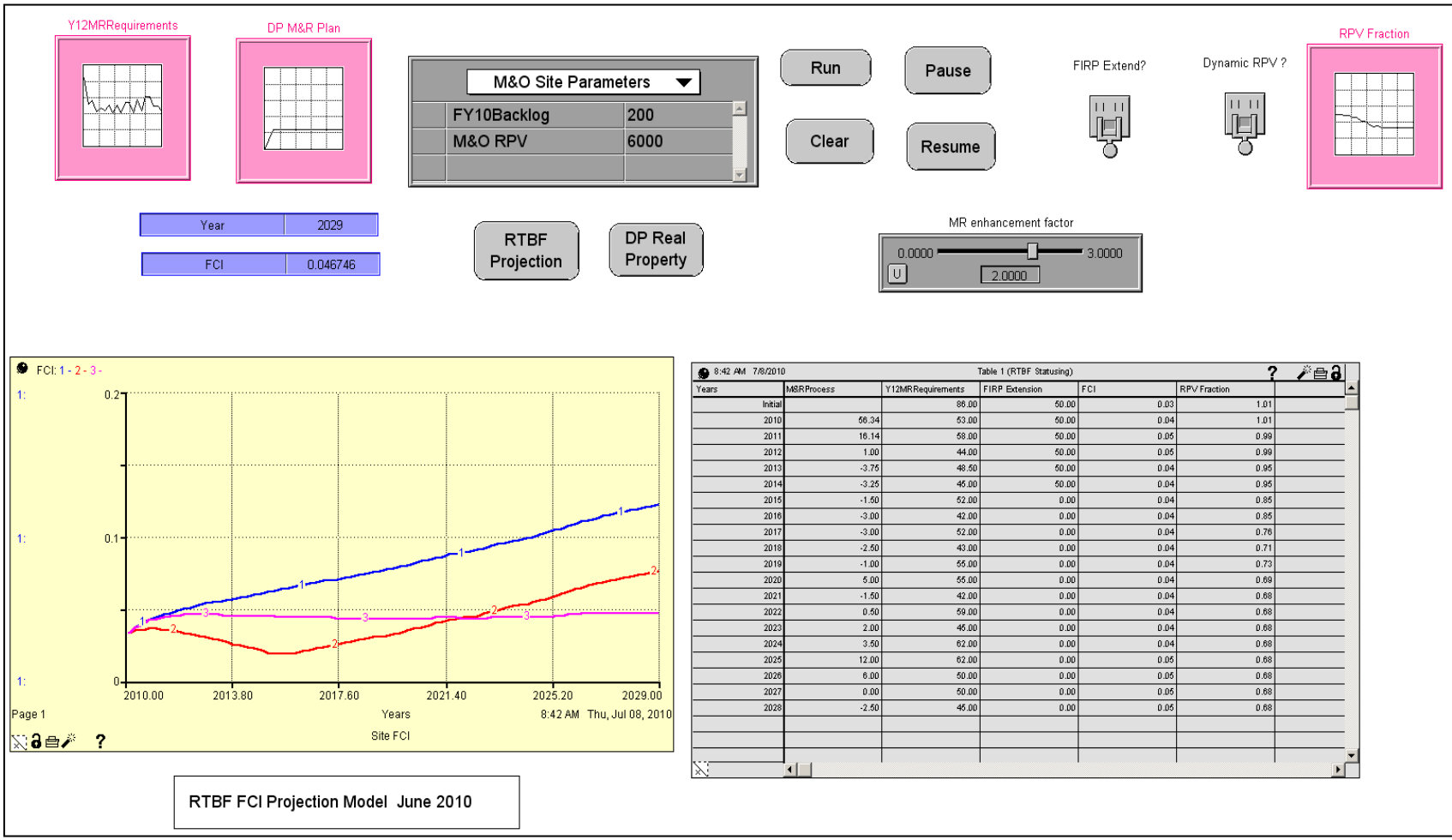
Scenario: Base Scenario

	Buildings		Trailers		OSFs		
Site	**RPV**	**Count**	**RPV**	**Count**	**RPV**	**Count**	**Total RPV**
Kansas City Plant	$1,362,799,463	48			$397,363,915	20	$1,760,163,378
Lawrence Livermore Lab Site 300	$271,727,369	109	$2,842,018	13	$204,608,865	94	$479,178,252
Lawrence Livermore National Laborator	$3,755,293,951	296	$10,266,609	45	$1,566,081,562	101	$5,331,642,122
Los Alamos National Laboratory	$9,822,743,382	878	$111,810,422	289	$1,851,228,528	878	$11,785,782,332
Nevada Test Site	$1,098,424,044	373	$16,982,557	33	$1,466,494,387	725	$2,581,900,988
Pantex Site Office	$3,014,412,870	557	$8,906,998	70	$632,276,260	86	$3,655,596,128
Savannah River Site	$1,759,457,607	32	$1,981,897	7	$17,485,150	16	$1,778,924,654
SNL - California	$334,018,432	58	$8,694,857	14	$67,951,719	41	$410,665,008
SNL - New Mexico	$2,645,581,719	706	$85,391,487	154	$916,158,254	322	$3,647,131,460
Y-12 Site Office	$5,686,768,291	339	$8,682,997	18	$2,524,249,317	258	$8,219,700,605
Site Total	**$29,751,227,128**	**3,396**	**$255,559,842**	**643**	**$9,643,897,957**	**2,541**	**$39,650,684,927**

MARS Facility Cost Forecast System

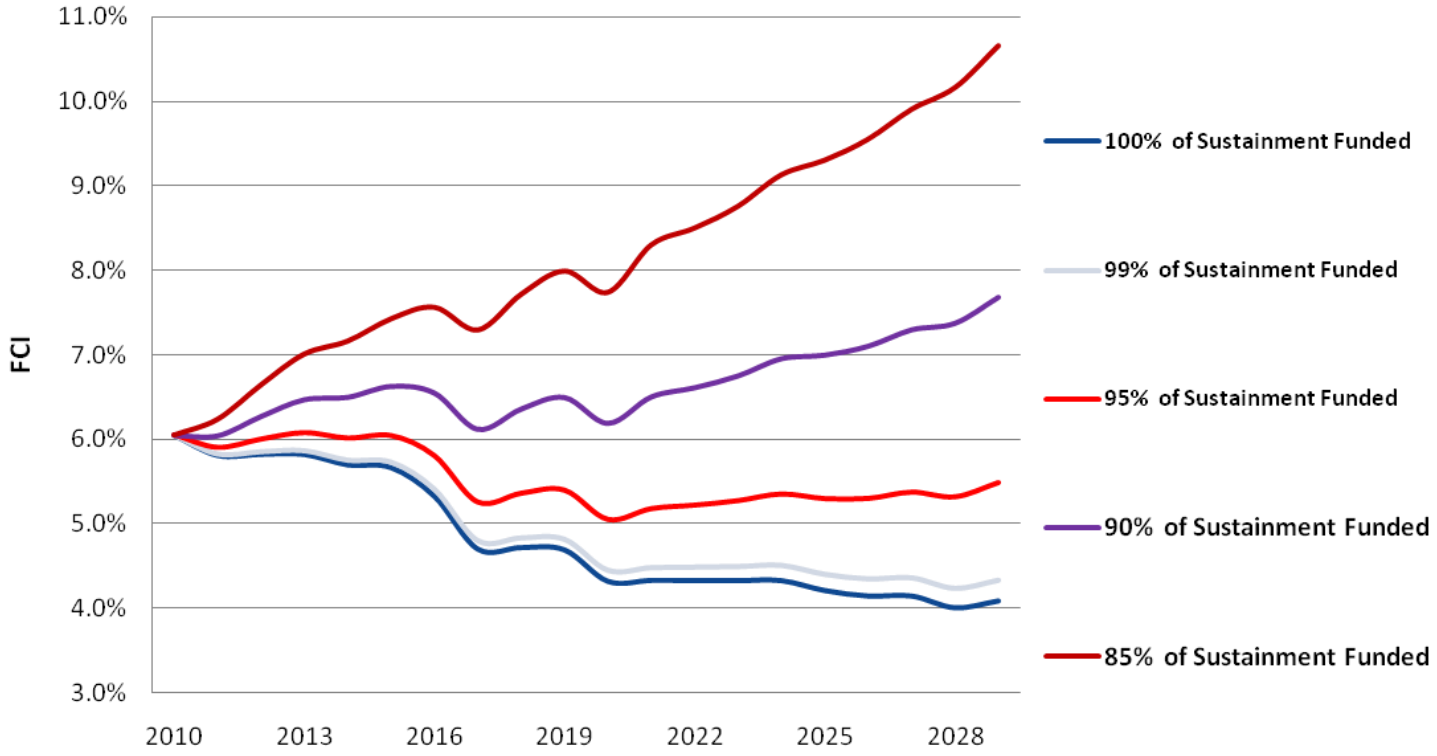


Metrics and Economic Projection



Years	M&R Process	Y12MR Requirements	FIRP Extension	FCI	RPV Fraction
Initial		86.00	50.00	0.03	1.01
2010	56.34	53.00	50.00	0.04	1.01
2011	16.14	58.00	50.00	0.05	0.99
2012	1.00	44.00	50.00	0.05	0.99
2013	-3.75	48.50	50.00	0.04	0.95
2014	-3.25	45.00	50.00	0.04	0.95
2015	-1.50	52.00	0.00	0.04	0.85
2016	-3.00	42.00	0.00	0.04	0.85
2017	-3.00	52.00	0.00	0.04	0.76
2018	-2.50	43.00	0.00	0.04	0.71
2019	-1.00	55.00	0.00	0.04	0.73
2020	5.00	55.00	0.00	0.04	0.69
2021	-1.50	42.00	0.00	0.04	0.68
2022	0.50	59.00	0.00	0.04	0.68
2023	2.00	45.00	0.00	0.04	0.68
2024	3.50	62.00	0.00	0.04	0.68
2025	12.00	62.00	0.00	0.05	0.68
2026	6.00	50.00	0.00	0.05	0.68
2027	0.00	50.00	0.00	0.05	0.68
2028	-2.50	45.00	0.00	0.05	0.68

Total NNSA Facility Condition Index (FCI)



In a cost constrained environment trade-offs between people, product, and infrastructure are required

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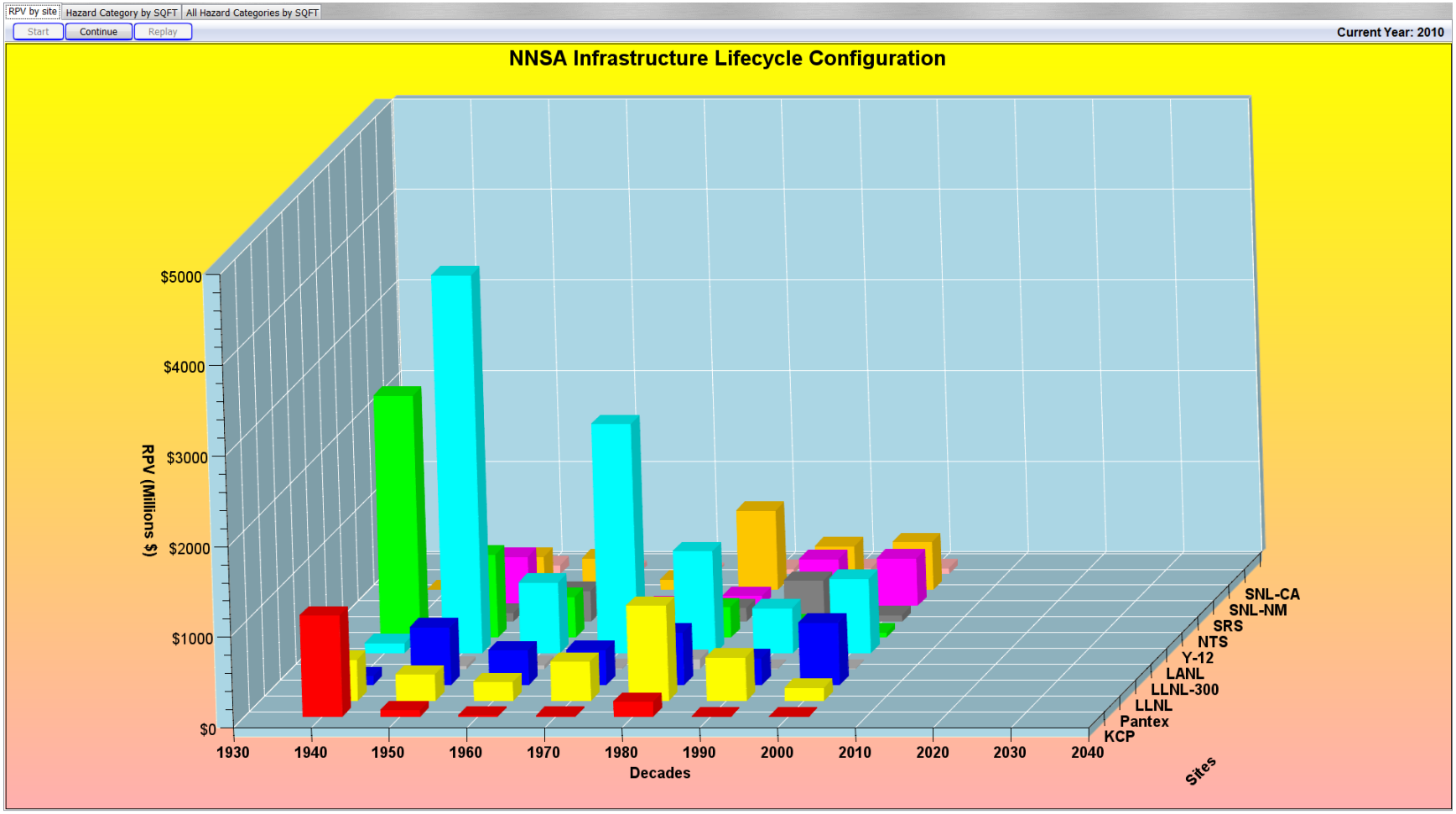
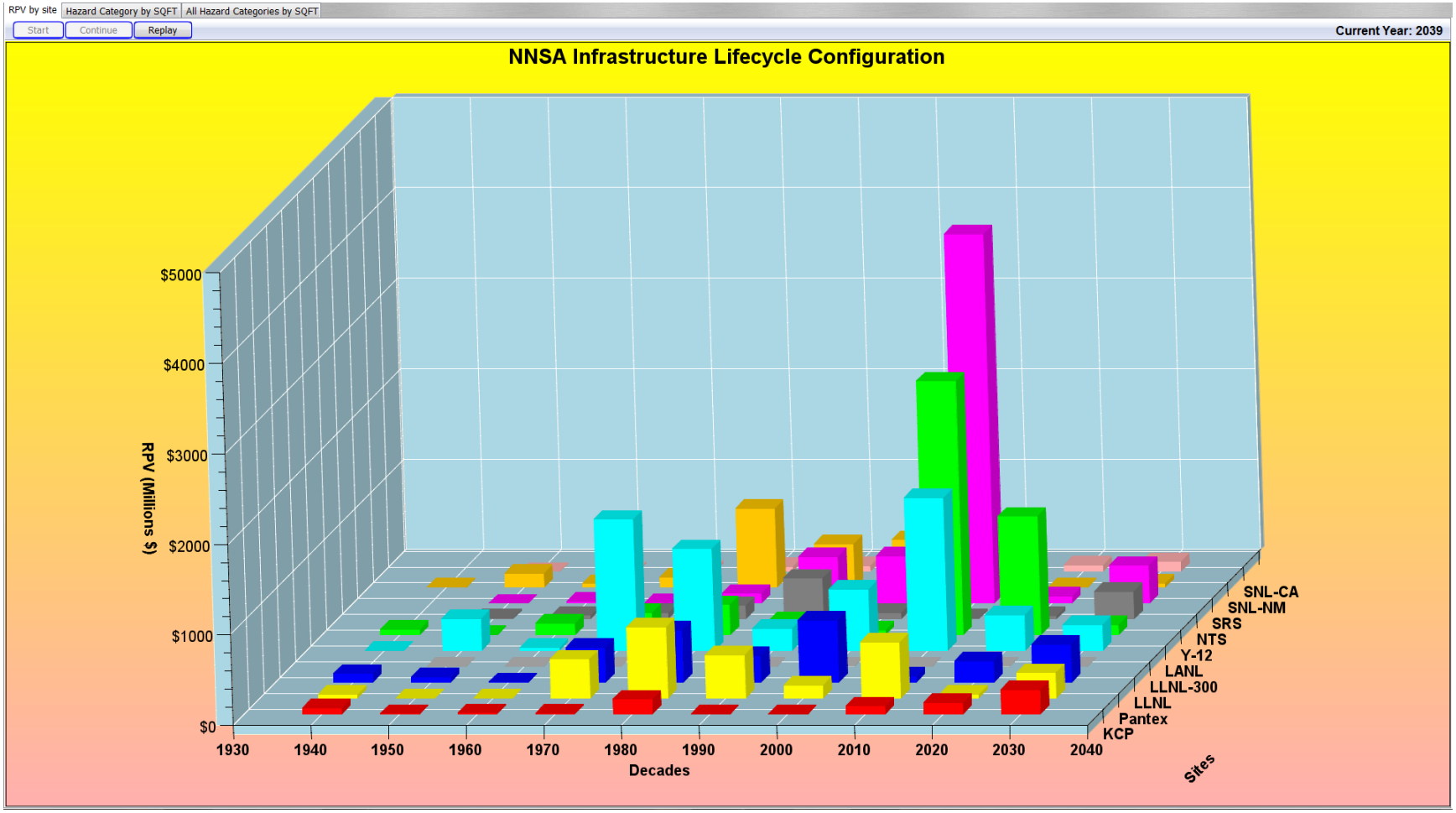
Initial Age Configuration of Real Property (c. 2010)

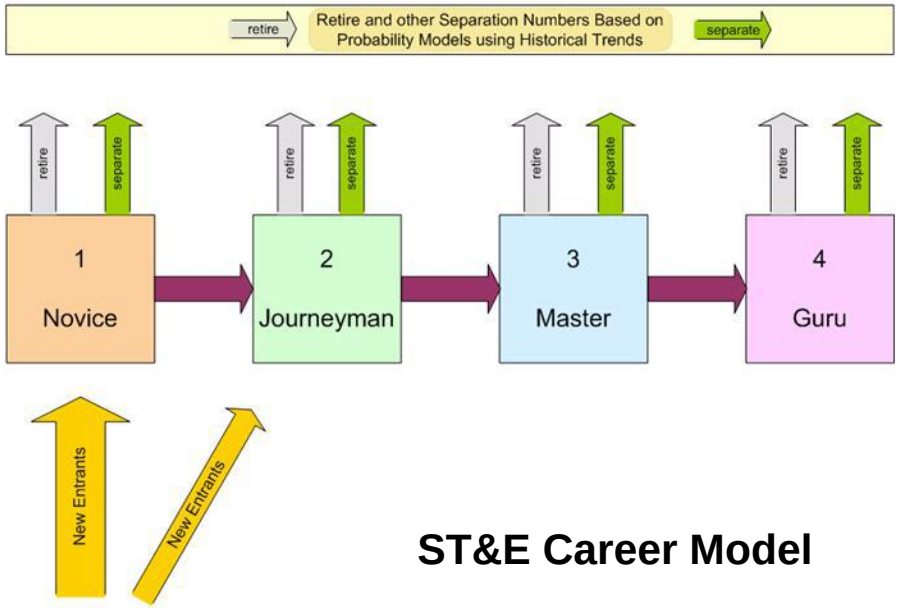


Projection and Distribution of Real Property (c. 2030s)

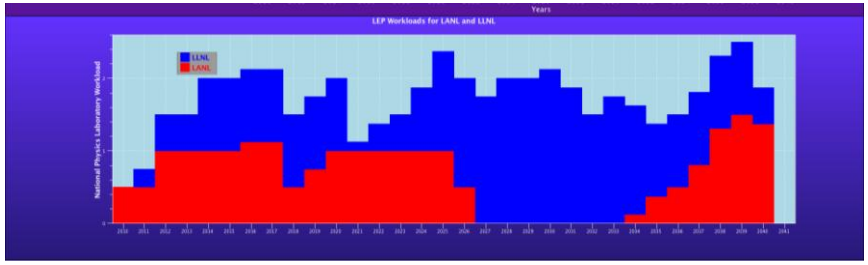


NSE critical skills are the foundation of all DP activities

- Supply- and Demand-side Modeling
- HR Tracking
  - Demographics
  - Retention
  - Hiring
  - Retirement
- Programmatic Specialization (i.e., what do they know and level of mastery)
  - Critical skills categories
  - Critical skills specialization
  - Career models



ST&E Career Model

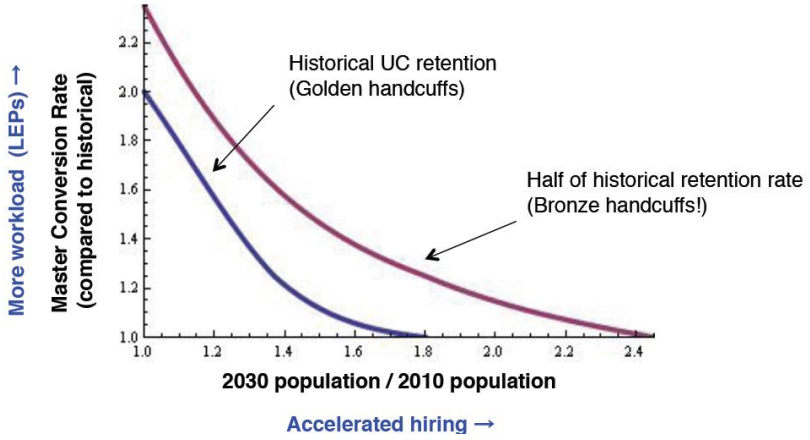


DA Workload Example (LLNL/LANL)

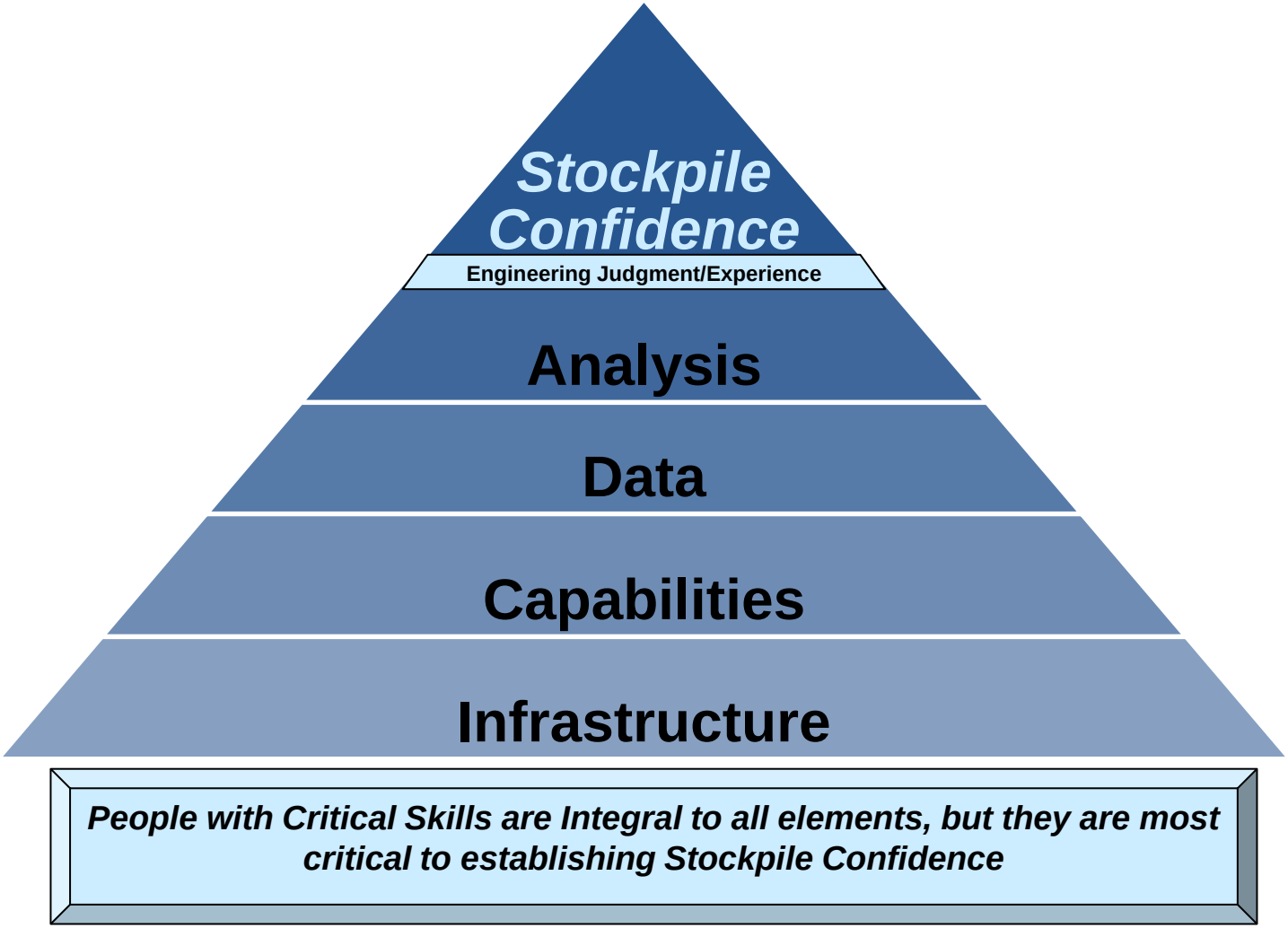
Knowledge-base Representation of Critical Skills Mastery

- Analysis of hundreds of resumes suggests that the transition time from “Pipeline” to “Master” is nominally 8-12 years
- An initial estimate of the aggregate investment in the Physics Design Agencies critical skill base is $30B-$44B
- Maintaining capability requires investment in the pipeline

more than two knowledge areas	NOVICE	JOURNEY MAN	MASTER	MASTER or GURU
two	NOVICE	JOURNEY MAN	MASTER	MASTER
one	NOVICE	JOURNEY MAN	JOURNEY MAN	JOURNEY MAN
none	NOVICE	NOVICE	NOVICE	NOVICE
	Exp < 5 yrs	5 ≤ Exp < 10	10 ≤ Exp < 15	Exp ≥ 15



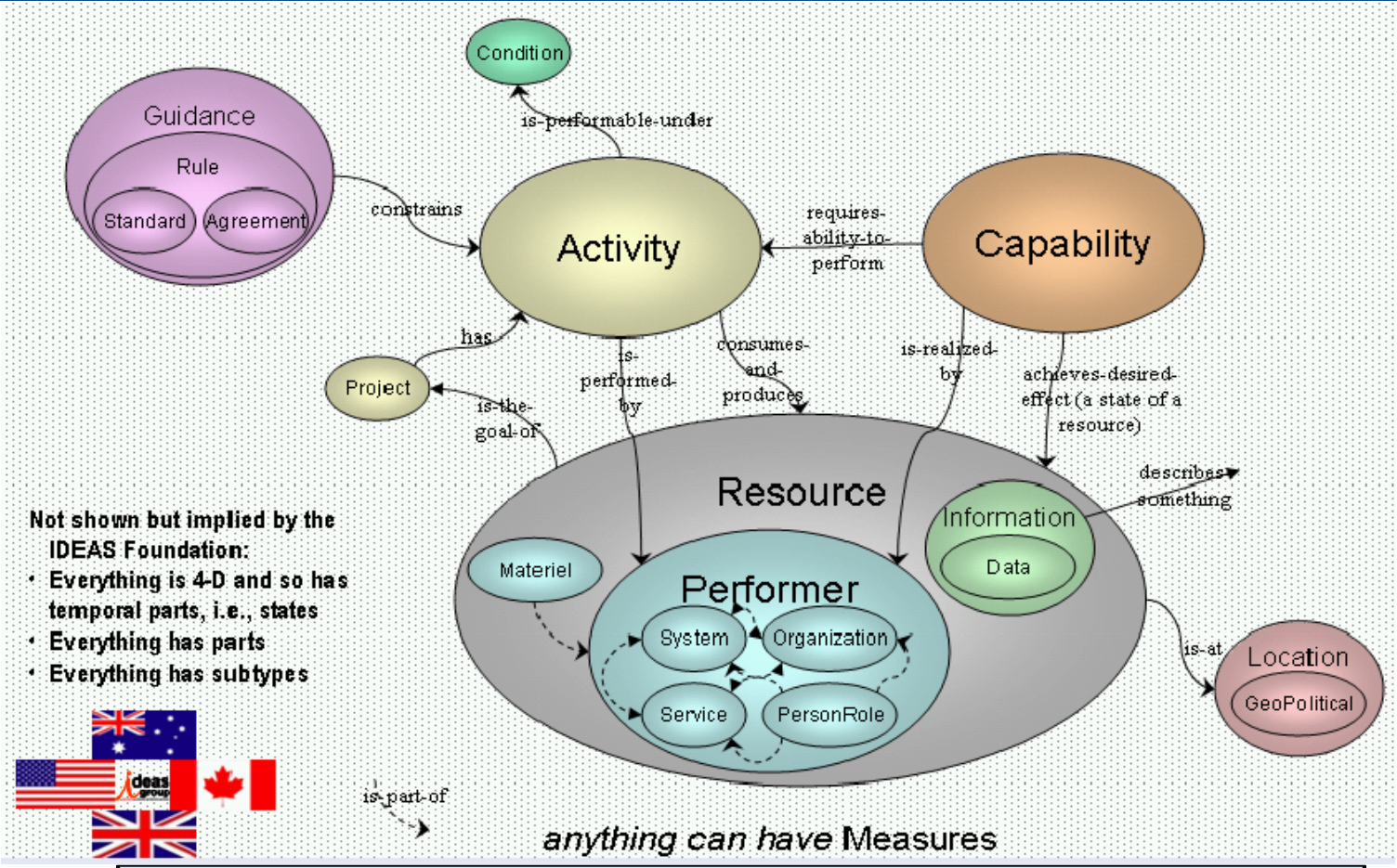
Simple Pyramid Supporting Deterrence



Example Capabilities

- Program Management
- Systems Engineering
- Enterprise Technical Infrastructure
  - Enterprise Technical Processes
  - Enterprise Modeling and Analysis
  - Enterprise Technical Communication, Scheduling, and Records Systems
- Fundamental Science Core Competencies
  - Develop, Maintain, & Operate Experimental Facilities
  - Perform Experiments, Acquire & Analyze Data
  - Develop/Maintain Physics & Engineering Codes
  - Develop Models, Algorithms, & Visualization
  - Develop, maintain and operate experimental facilities
- Engineering Design/Assessment/Certification
  - NEP Physics Design/Assessment/Certification
  - NEP Engineering Design/Assessment/Certification
  - Weapon Engineering Design/Integration/Qualification
- System Certification, Test & Qualification
  - Dynamic Test Capability
  - Weapons Physics Test Capability
  - Environmental Test Capability
  - Operational Test Capability
  - Underground Test Capability
  - SNM Test Capability
  - Non-Nuclear Material Test Capability
- Stockpile Maintenance, Evaluation, and Support
  - Maintenance and Military Liaison
  - Stockpile Surveillance and Assessment
- Operational/Site Activation/ Facilities
  - Computation Infrastructure
  - Enterprise Security and Transportation
  - Uranium Processing
  - Plutonium Processing
  - Tritium Operations
  - Other Special Materials Operations
  - High Explosives Operations
  - Component Production/Fabrication
  - Assembly/Disassembly
  - Material Recycle and Recovery
  - Container Research, Test, Design
  - Storage

IDEAS Foundation Ontology for Capability



NSE needs a more formal and consistent definition of "Capability" that includes Infrastructure & People

Program Roadmap and Desired Outcomes