A Few Words First

Courtesy – Please mute your phone (*6 toggle).

Jan 13, Chapter Board annual strategic planning session (input welcome)

Jan 28-31, INCOSE International Workshop, Torrance, CA (LA area).

FREE SEP Certification Exam session at IW17 – sign up on registration page

Feb 08, Transforming Systems Engineering through a Holistic Approach to Model-Centric Systems Engineering, Mark Blackburn, Stevens Institute of Technology

Mar 08, Integration of Agile Principles into the Systems Engineering Lifecycle Model, Alan Benson, Caltrans (California Dept. of Transportation)

CSEP Courses by *Certification Training International:*
Course details | Course brochure
2017 Course Schedule (close by, but many more locations and dates):
February 27 – March 3 | Las Vegas, NV
April 24-28 | Albuquerque, NM

First slide, not recorded but retained in pdf presentation.

And Now - Introductions

Enchantment Chapter Monthly Meeting

11 January 2017 – 4:45-6:00 pm:

A Mission Assurance Framework for R&D Organizations

Dr. Heidi Hahn, Senior Executive Advisor, Los Alamos National Laboratory
hahn@lanl.gov

Abstract: Research and development (R&D) organizations such as the National Nuclear Security Administration's national security laboratories span a spectrum of R&D from basic scientific research to demonstration of actual system prototypes in an operational environment. Application of systems engineering (SE), engineering quality and rigor, and project management is often critical to successful R&D outcomes, but a graded approach is key – neither the type of project being performed nor the funding profile provided by the customer may support the application of very formal processes. To address these challenges, the Los Alamos National Laboratory (LANL) has developed and is implementing a Mission Assurance Framework that applies the concepts of systems engineering, project management, and engineering quality and rigor using a risk-based graded approach. This talk describes the LANL approach to developing and implementing the Mission Assurance Framework and discusses the policies, tools, and training that support the diverse set of projects performed across the Laboratory's mission space. Emphasis is placed on the SE and engineering quality aspects of the Framework.

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NOTE: This meeting is being recorded

Today's Presentation

Things to Think About

How can this be applied in your work environment?

What did you hear that will influence your thinking?

What is your take away from this presentation?

Speaker Bio

Dr. Heidi Ann Hahn is Senior Executive Advisor to the Associate Director for Engineering Sciences at the Los Alamos National Laboratory (LANL). In her current role, she is responsible for development of processes and tools to promote engineering capability; professional development of R&D engineers and technicians; and engineering capability assessment.

She is the author of the enterprise-wide Conduct of Engineering for R&D programs and the developer of and instructor for the R&D Engineering Primer. The latter is a professional development course for entry-level R&D engineers that trains them on the LANL Mission Assurance Framework.

She previously served as the Deputy Project Director for an enterprise-wide business process reengineering and software implementation, and as Group Leader for the Human Factors Engineering Group.

Her primary research interests are modeling and analysis of complex socio-technical systems and prediction and prevention of human errors.

Dr. Hahn recently was a Visiting Research Professor at the Naval Postgraduate School serving as mentor for an engineering tool development project. She has also served as an adjunct faculty member in the University of New Mexico's Mechanical Engineering Department, developing and teaching graduate courses in human factors engineering.

She holds a Ph. D. in Industrial Engineering and Operations Research (Human Factors Option) from Virginia Tech, and a M. S. in Project Management from Colorado Technical University. She is a Certified Expert Systems Engineering Professional (ESEP-Acq) as well as a certified Project Management Professional (PMP).

The Los Alamos Mission Assurance Framework

Subtitle: Systems Engineering is a Necessary, but Not Alone Sufficient, Enabler of Mission Success

Dr. Heidi Ann Hahn, ESEP, PMP

Presentation for INCOSE Enchantment Chapter

January 11, 2017

LA-UR-16-22196

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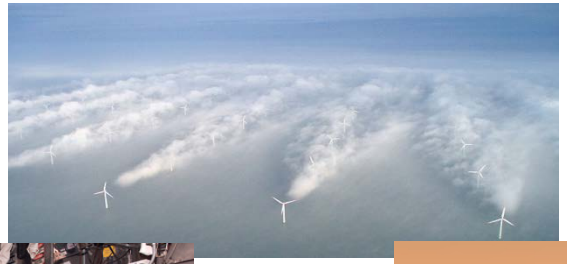
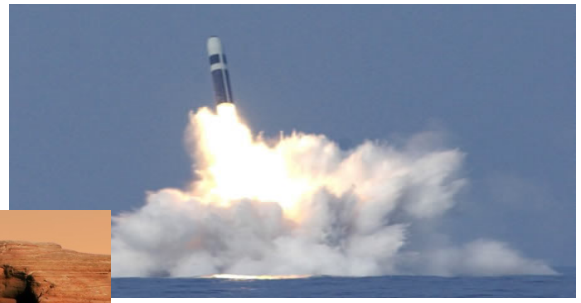
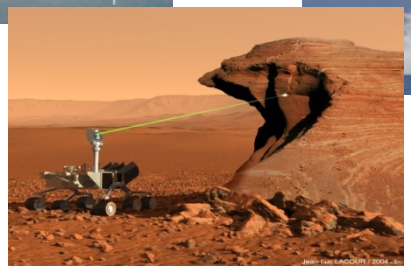
Outline

- Context – LANL Mission, Campus, and Organizational Demographics
- The Mission Assurance Framework
- Implementation Strategy and Artifacts
  - Policies and procedures
  - Tools
  - Training
- Lessons Learned and Current Status
- Next Steps

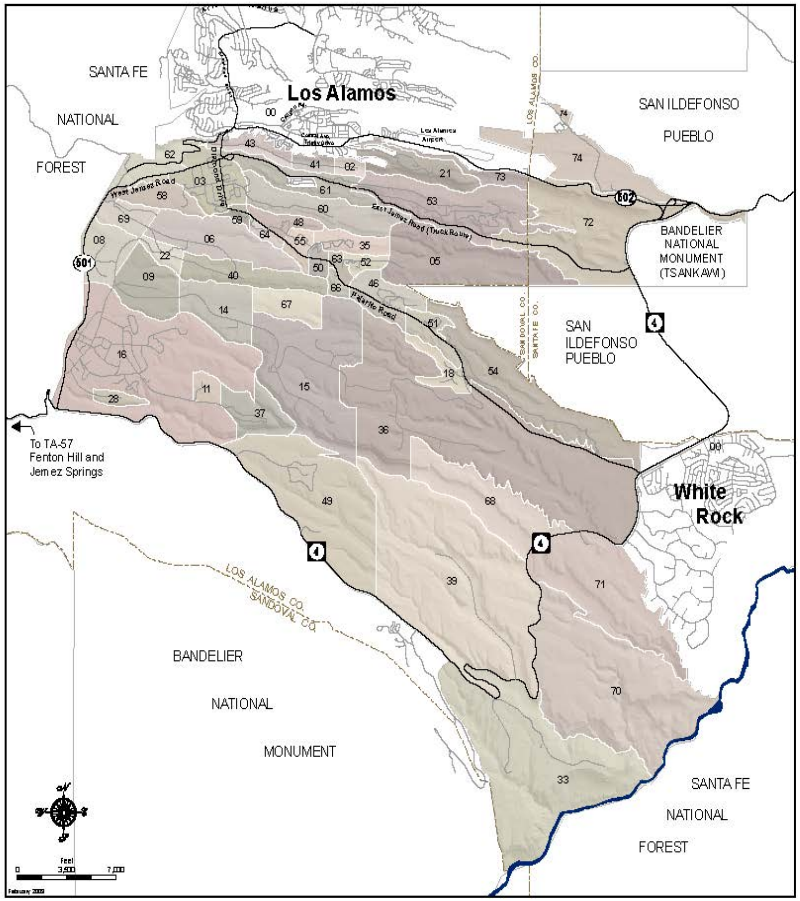
LANL's Mission

- National security laboratory where multidisciplinary science and engineering teams focus on a broad mission space
  - Annual budget is approximately $2.5B
  - Projects range from as little as $25K to over $100M



Campus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PUEBLO
To TA-57
Fenton Hill and
Jemez Springs
White
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LOS ALAMOS CO.
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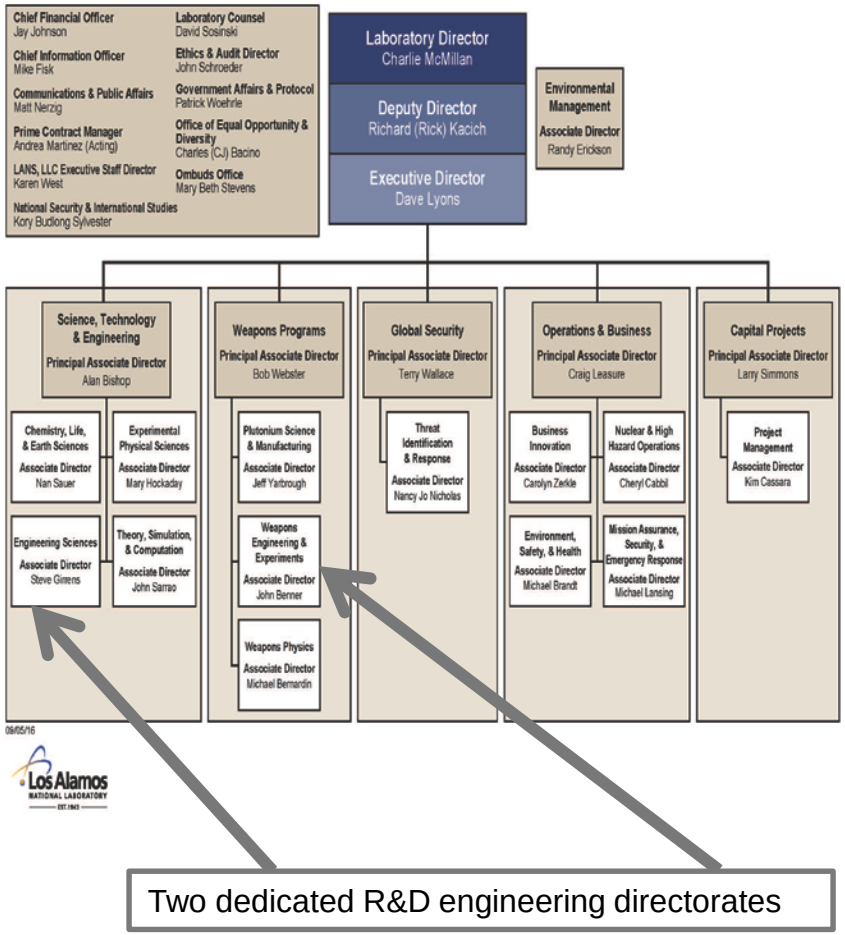
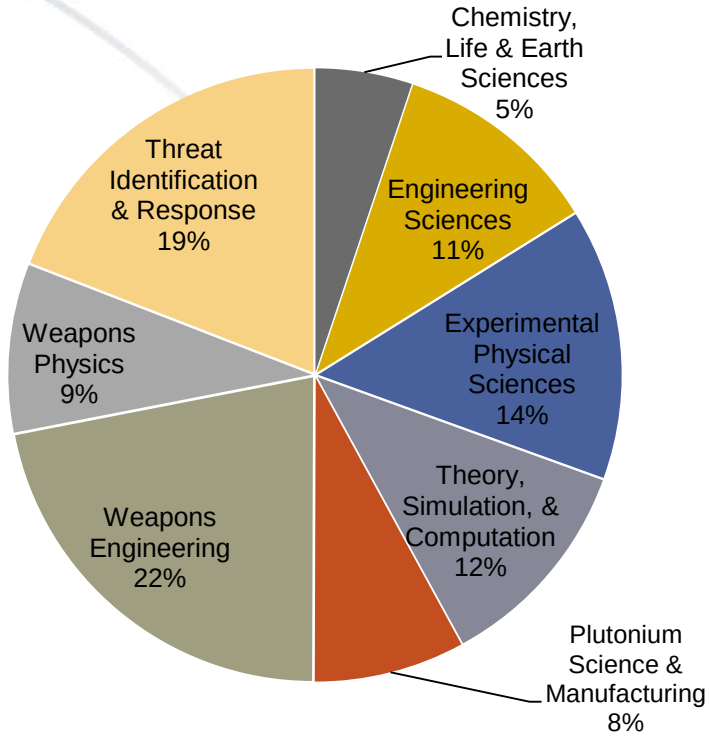
Demographics



Two dedicated R&D engineering directorates

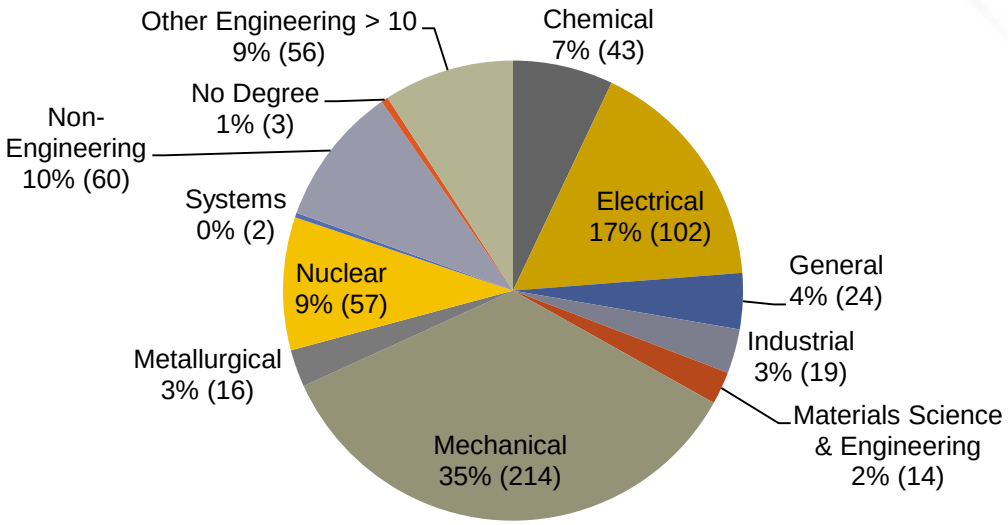


Distribution of R&D Engineers by Directorate

N=1003 (Staff, PDs, GRAs)

Demographics (Cont'd)

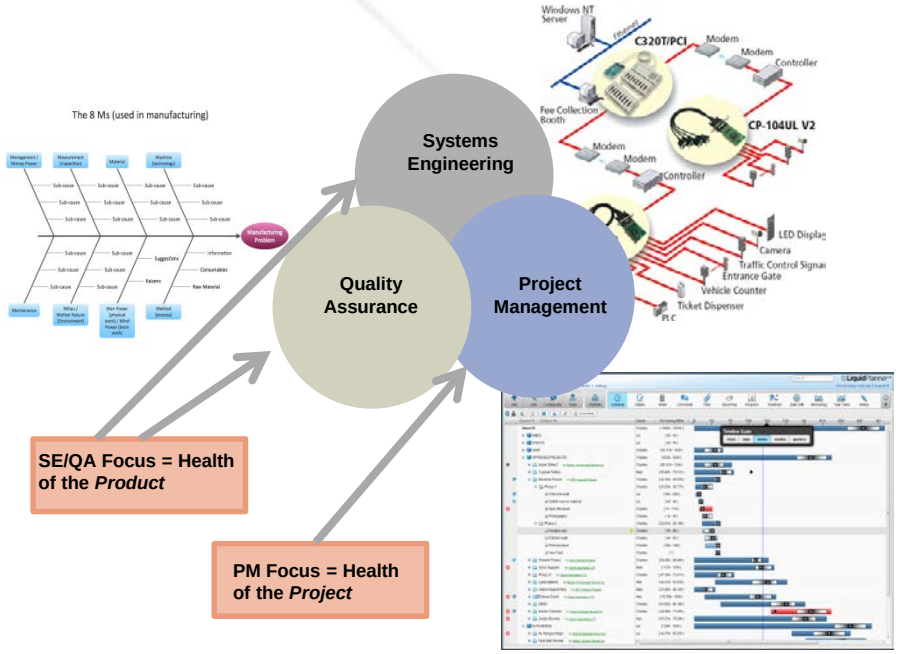
Terminal Degree Disciplines of R&D Engineers (N = 608)



There are very few R&D Engineers with a terminal degree in Systems Engineering at LANL, and very few of the discipline engineers would identify themselves as SEs

Mission Assurance Framework

The graded application of Systems Engineering (SE), Project Management (PM), and engineering quality and rigor (QA) ensures that we deliver quality products and services to our customers, on schedule and within budget, to achieve mission success



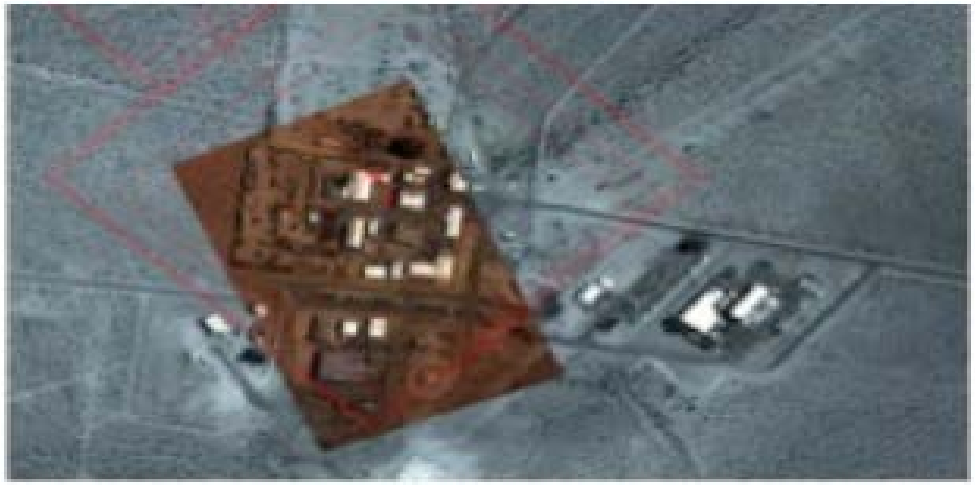
Integration of SE, PM, and QA Leads to Increased Assurance of Mission Success
(figure adapted from Hodges, 2013)

Hodges, A. 2013. "Bricks for a Lean Systems Engineering Yellow Brick Road." 23rd Annual INCOSE International Symposium (IS2013), Philadelphia, PA (US).

Angel Fire: Why a Mission Assurance Framework is Needed

Angel Fire

Angel Fire consists of a system of advanced optics and computers. Angel Fire provides broad-area, real-time, and high-resolution surveillance that enables warfighters to search for IEDs.



Angel Fire was deployed in Iraq in to 2008 and was the first device of its king to provide wide-area intelligence, surveillance, and reconnaissance to ground commanders at a tactical level.

Drivers for Adopting a Risk-based Enterprise SEM

- Applying a disciplined engineering and engineering management approach
  - Produces better engineering solutions
  - Mitigates project risks, especially those related to stakeholder management
  - Reduces project cost and schedule overruns
- Adequate documentation and configuration control ensures repeatability and reduces rework
- Peer review adds credibility to the products produced

Implementation Strategy

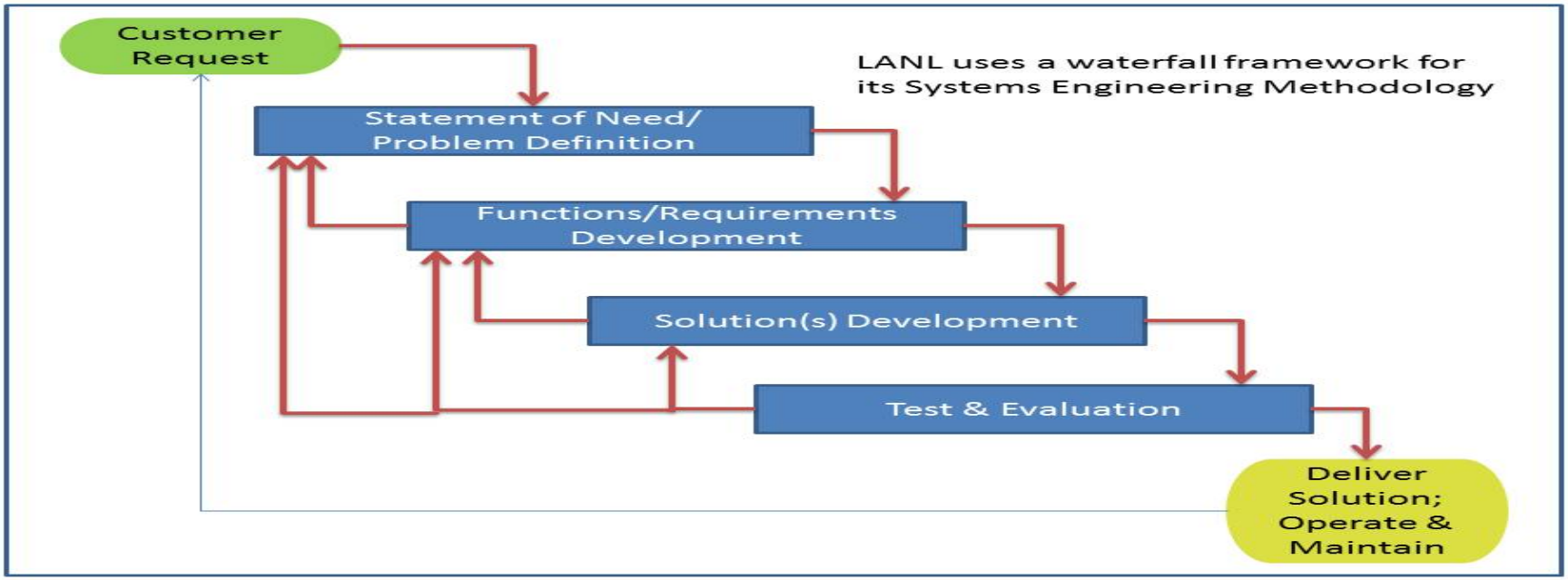
- Policies, procedures, and implementation guides
- Tools that support implementation
- Training courses that support implementation

Policies, Procedures, and Guides

- *Conduct of Engineering for R&D*
- *Determining Needed Engineering Rigor for R&D*
- 7 Implementation Guides:
  - Needs
  - Requirements
  - Design
  - Project Reviews
  - Risk Management
  - V&V
  - Transition to Operations
- *Project Management for Programmatic and R&D Work*

Conduct of Engineering for R&D

- *Conduct of Engineering for R&D* (CoE for R&D) is the governance document that defines "how we do R&D Engineering at LANL"
  - Based on ISO/IEC 15288, *Systems engineering – systems lifecycle processes*



Rationale for Use of the Waterfall Model

- The LANL waterfall-based SEM contains all of the same SE elements as the Vee-model, but uses simpler concepts to express them
- Best practices (from Miller, 2003)
  - Start with a systems development life-cycle model
    - Select a model that can facilitate a common understanding across discipline and application domains
  - The amount of SE introduced must always be suitable for the organization's SE needs
    - Start with the foundation practices first then grow the methodology as SE maturity grows (over several years)
    - In establishing foundation practices, look for areas where problems have been identified on previous projects – typically, requirements, interfaces, V&V, and configuration management
  - Use language familiar to the R&D Engineering community, not SE jargon ("Stealth SE")

Miller, P. (2003). *The Introduction of Systems Engineering Practices into the Work Place – Do's & Don'ts.* Presentation to the Systems Engineering and Test and Evaluation Conference, Canberra, Australia, July 29.

Engineering Quality and Rigor

- *Los Alamos National Laboratory Quality Assurance Program* defines various work types and sets out QA program requirements by type using 10 criteria
  - QA Program
  - Personnel Training and Qualification
  - Documents and Records
  - Work Processes
  - Design
  - Procurement
  - Inspection and Acceptance Testing
  - Management Assessment
  - Independent Assessment
- R&D work is “work performed in order to increase the stock of knowledge, and the use of such knowledge to devise new applications, including but not limited to work where the output is knowledge, information, data, or proof of concept”
- QA requirements for R&D work derive from ANSI/ASQ Z 1.13-1999, *Quality Guidelines for Research*
- *Conduct of Engineering for R&D* implements the Design chapter of the QA Program

Risk Level Determination and Quality Requirements

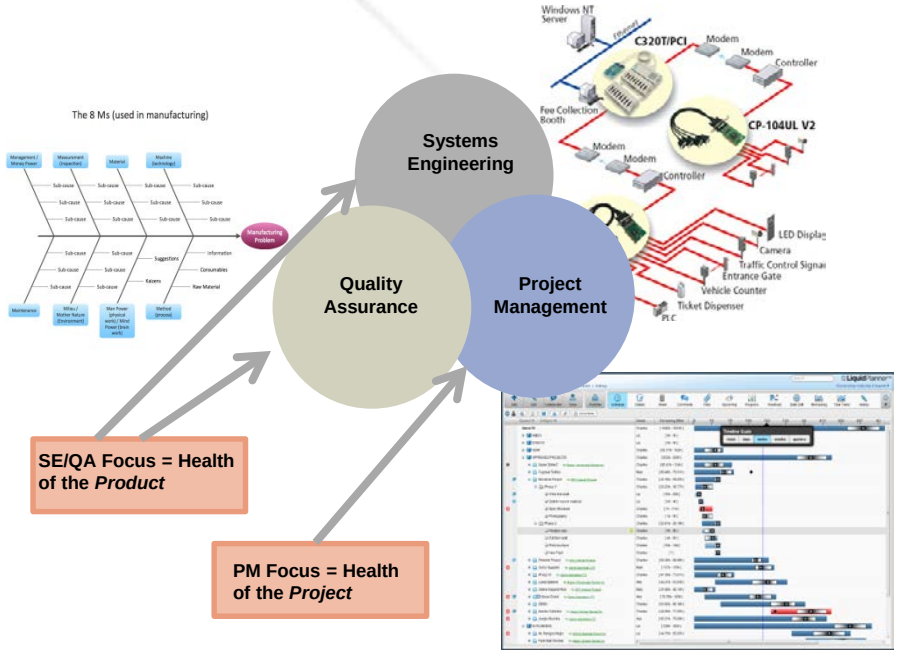
- *Determining Needed Engineering Rigor for R&D* does just what the name says using a risk-based graded approach
  - Required for R&D that delivers an engineered product to an external customer or produces a product for internal use that the Responsible Line Manager judges to warrant additional rigor to reduce research quality or ESH risks
- Risk Level Determination drives the level of review, documentation and approval
  - All risk levels require technical baseline documents to be configuration controlled, although the level of formality varies

Determining Required Levels of Engineering Quality and Rigor

Requirements Grading Based on Risk Level			
Risk Level	**Reviews**	**Default R&D Design Authority Representative (DAR)**	**Documentation Note: Documentation requirements are cumulative as risk level increases.**
High	Formal design review Division Leader participates in reviews	Group Leader	Formal design review
Moderate	▪ In-process reviews by subject matter experts (may be project team members or peers) conducted at conceptual, preliminary (50%), and pre-final (90%) design stages ▪ Independent peer input to reviews ▪ Group Leader participates in reviews	First Line Manager	▪ Alternatives considered ▪ Calculations ▪ In-process reviews
Low	▪ At least one in-process review by subject matter experts (may be project team members or peers); frequency and timing as determined by Responsible Line Manager (RLM) ▪ Review by the responsible CSE is required prior to work initiation for R&D work that interfaces with a safety class or safety significant system ▪ First Line Manager or designee participates in reviews	Principal Investigator/ Project Leader (PI/PL)	▪ Written statement of need/problem definition ▪ Applicable standards ▪ Risk level determination

Evolution to the Mission Assurance Framework

- As implementation progressed, it became clear that SE and engineering quality and rigor alone were not sufficient alone to ensure mission success
- LANL's PM processes were facility-focused
  - Developed *Project Management for Programmatic and R&D Work*



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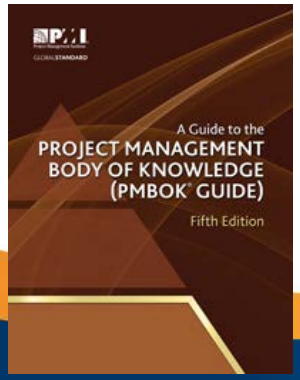
Project Management for Programmatic and R&D Work

- *Project Management for Programmatic and R&D Work* describes five key PM processes and 10 PM knowledge areas and their application to R&D projects
  - Based on the Project Management Institute's *Project Management Body of Knowledge, fifth edition, 2013* (an ANSI standard)

Knowledge Areas / Processes	Integration	Scope	Time	Cost	Quality	Human Resource	Communication	Risk	Procurement	Stakeholder Management
Initiating Process	✓						✓			✓
Planning Process	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Executing Process	✓				✓	✓	✓		✓	✓
Monitoring and Control	✓	✓	✓	✓	✓		✓	✓	✓	✓
Closing Process	✓								✓	



Tools That Support Implementation

- Mission Assurance Support Tool (MAST)
- Requirements Generation Tool

Mission Assurance Support Tool (MAST)

Goal: To enable engineers and applied scientists who have little or no expertise in systems engineering to tailor and apply the LANL mission assurance processes.

Requirements:

- **Scalable to any size project, although most suitable for smaller projects requiring less rigor**
- **Tailorable to R&D projects ranging from design of an apparatus for bench experiments to demonstration of an actual prototype in an operational environment**
- **Usable by persons having little or no SE experience**
- **Maintainable by a non-programmer**

Features:

- **Query-based "ticklers"**
- **Uses a MS Word template**
- **Includes tool tips and an example for user guidance**
- **Implements all steps outlined in CoE for R&D**
- **Addresses full scope of a project, from problem definition through verification**
- **Collects (or cross-references) all technical baseline documentation in one place**

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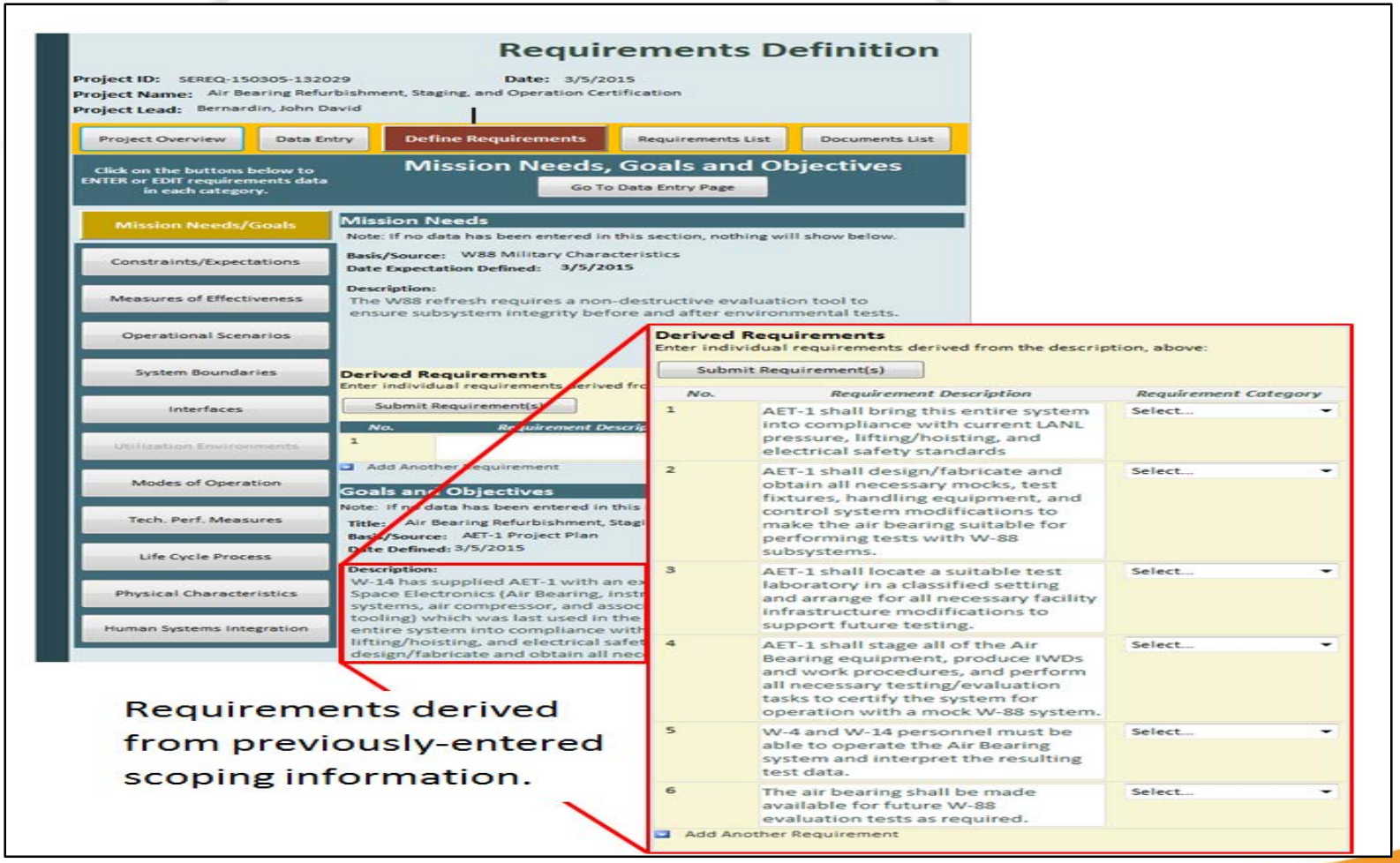
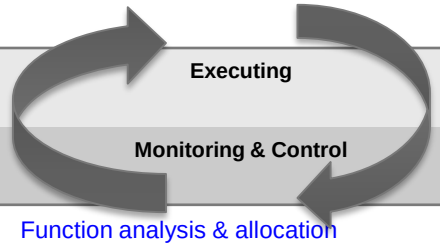
Requirements Generation Tool



Training That Supports Implementation

- R&D Engineering Primer

Key Artifacts for the Project and SE Lifecycles



Initiating	Planning	Executing	Closing
		Monitoring & Control	
• **Statement of need** • **High level problem definition** • **Stakeholder list** • SOW • **Summary budget** • Summary milestone chart • **Risk level determination** • **Approval, review, documentation, CM level requirements**	• **Functional & performance requirements** • **Support requirements** • Preliminary technical baseline • **MOP** & V&V plans • Project team identified • Cost & schedule baselines • **WBS** • Risk register • Project/product scope statement • Change & CM plans • Key management review plans	• Function analysis & allocation • Architecture design • **Prototypes** • **Trade studies** • Manage, monitor, & control project work, scope, schedule, costs, human resources, communications, risks, and stakeholder engagement • Execute change control and CM • Execute key management reviews • System integration • V&V	• Transition to operations and maintenance • Customer acceptance testing • Document customer acceptance • Conduct post-project reviews • **Document lessons learned** • Disposition organizational assets • Contract/FIN system closeout • Procurement closure • Final management review

Blue = Systems Engineering;
Green = Project Management;
Red = Quality
Bold = Covered in training

Conceive	Design	Implement	Operate	Retire

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Example Scenario Part 1 – Need

(Adapted from Braakhuis, J., Janssen, W., Koudenburg, F., de Liefde, J., Malotaux, N., Rens, C., and Stevenson, J. (2010). *Home improvements! Systems Engineering in a familiar setting*. INCOSE Netherlands.)

"We are living in a shoebox," Valerie said as a joke but she suddenly realized that it was true. This was the second time that she and Robert had rearranged the furniture and then decided to put everything back in their original positions. The first time started just like tonight: first a discussion about how nice it would be to have a large dining table with six chairs and a play area for their toddler, Cas. The TV would look fine against the other wall but what could be done with the two armchairs, the sideboard and the dining table without them being in the way or making it difficult to walk into the dining room. "I think it's high time to start looking for a bigger house," said Robert. "When the new baby arrives it's only going to get more confined…" (pg. 8)

- Statement of need: Robert and Valerie need a bigger house!
- Better alternative: Robert and Valerie need living spaces that will accommodate their lifestyle preferences.

Example Scenario Part 3 – Requirements

(Adapted from Braakhuis, J., Janssen, W., Koudenburg, F., de Liefde, J., Malotaux, N., Rens, C., and Stevenson, J. (2010). *Home improvements! Systems Engineering in a familiar setting*. INCOSE Netherlands.)

A few days later, Robert and Valerie finally found time to work out their ideas further. Robert had called their bank to find out how much money they would be able to borrow if they wanted to buy a bigger house. "I am rather disappointed with the amount of space one gets in a house for that money" said Valerie while she skipped once more through the houses she had found on the Internet.

"While you were surfing, I've been doing some sketching and it seems that with a 12-foot extension, we'll have enough space to fit in everything we want", said Robert. "So we're going to renovate," concluded Valerie after they had once again reviewed their wishes and possibilities. "But only on the condition that we'll be finished two months before the baby is due." (pg. 10)

- Add the bank to the list of stakeholders
- Requirements and constraints are beginning to emerge

Example Scenario Part 3 – Requirements

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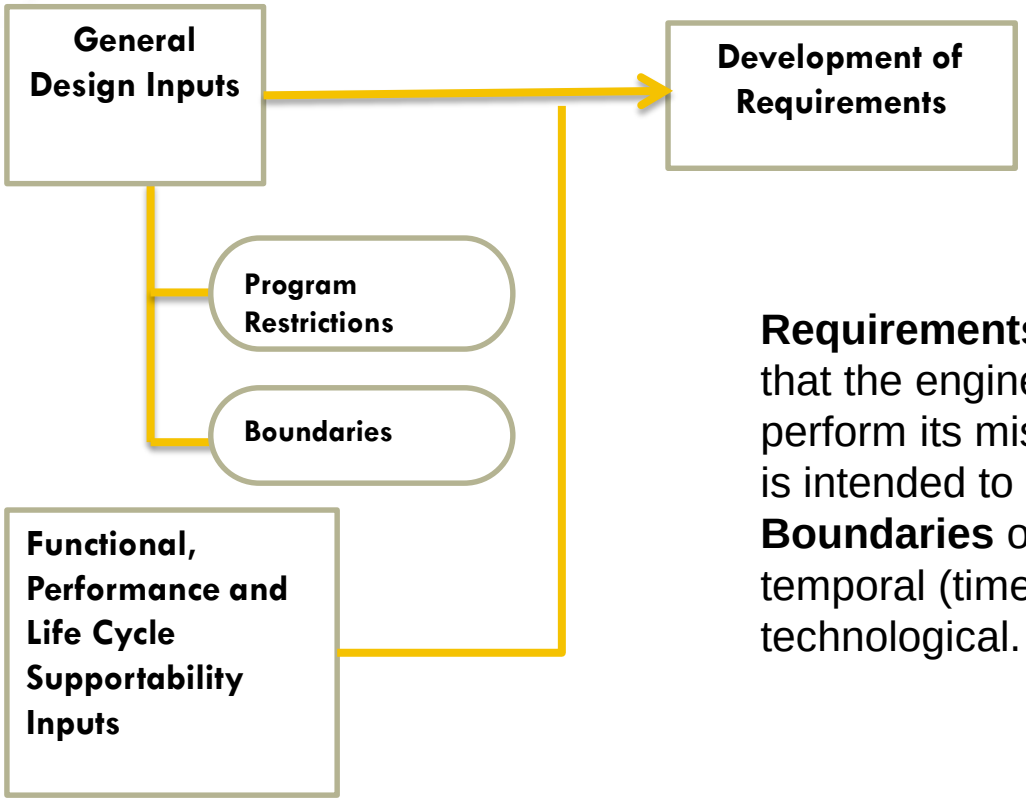
Determining Functional and Performance Requirements and Constraints

Process diagram for requirements development:



Requirements are characteristics or capabilities that the engineered item must have in order to perform its mission in the environment in which it is intended to operate

Boundaries or **constraints** can be physical; temporal (time); cost; environmental; or technological.

Requirements Overview

(from Ruskin, 2006)

- Some key characteristics of a good requirements statement
  - Separate requirements from the design
    - Requirements define *what*
    - The design tells *how*
  - Express requirements as functions (verbs and objects)
    - "Supply Power" not "Power Supply"
    - "Store Information" not "Data Base"
  - Express requirements using *shall* or *shall not* (not *should*, *will*, or *may*)
- Maintain traceability of requirements
- Develop Measures of Performance (MOPs) for requirements as you develop them
- Freeze requirements early, but change them when necessary

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Example Scenario Part 3 – Requirements (Cont'd)

(Adapted from Braakhuis, J., Janssen, W., Koudenburg, F., de Liefde, J., Malotaux, N., Rens, C., and Stevenson, J. (2010). *Home improvements! Systems Engineering in a familiar setting*. INCOSE Netherlands.)

- Constraints for Robert and Valerie's project include their available budget and Valerie's desire for the project to be completed two months before their baby is due
- Requirements
  - The project shall enlarge Robert and Valerie's existing house
    - The renovation shall accommodate a large dining table with six chairs
      - The open kitchen floor space shall be no smaller than 8 ft by 12 ft
    - The renovation shall provide a play area for Robert and Valerie's toddler
      - The floor in the play area shall be constructed with playground flooring tiles
- Measures of Performance
  - The schematics for the kitchen show an 8 ft by 12 ft open area
  - The kitchen as built includes an 8 ft by 12 ft open area
  - The bill of materials for the play area floor shows playground flooring tiles
  - The play area floor as built has playground flooring tiles installed

Lessons Learned and Current Status

- The need for “Stealth SE” was evident from internal stakeholder feedback
  - SE “Vee” rejected in favor of waterfall model as the basis for the SEM
  - Eliminated virtually all SE and PM process description from the Primer based on feedback received during a pilot; focus is on what and how, not why
- Informal self-assessment found implementation maturity to be somewhere between CMMI® Level 0 “Incomplete” and Level 1 “Performed”
  - Need to move to Level 2 “Managed” before even considering evolving the Framework to a more strict standards-based expression of SE, PM, and QA

Next Steps

- Implementing Documents
- Risk Grading
- Tools
- Training
- Metrics

Today's Presentation

Things to Think About

How can this be applied in your work environment?

What did you hear that will influence your thinking?

What is your take away from this presentation?

Please

The link for the online survey for this meeting is

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www.surveymonkey.com/r/enchant_01_11_17

Look in GlobalMeet chat box for cut & paste link.

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The library page at: www.incose.org/enchantment.

Recording will be there in the library tomorrow.

Stop Recording