The Los Alamos Mission Assurance Framework

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

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Presentation for INCOSE International Symposium

July 21, 2016

LA-UR-16-22196

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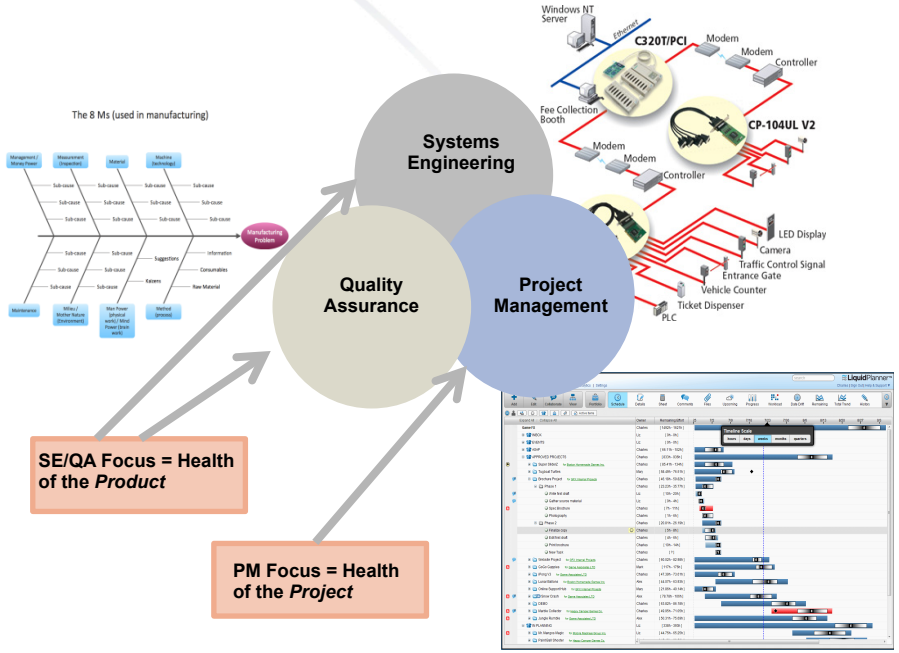
Outline

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

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

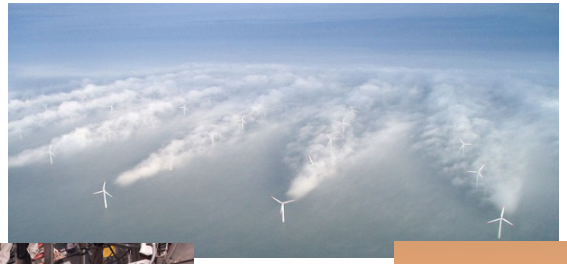


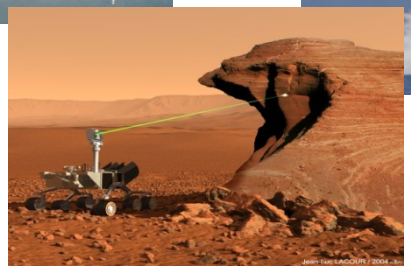
Integration of SE, PM, and QA Leads to Increased Assurance of Mission Success
(figure adapted from Hodges, 2013)

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

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

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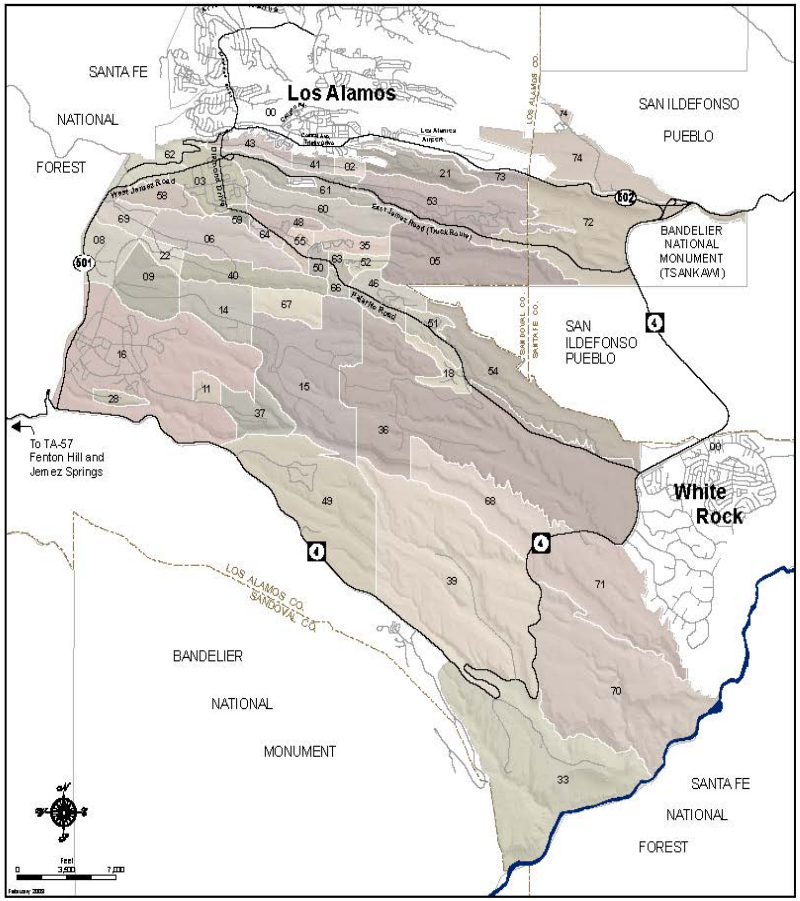
Campus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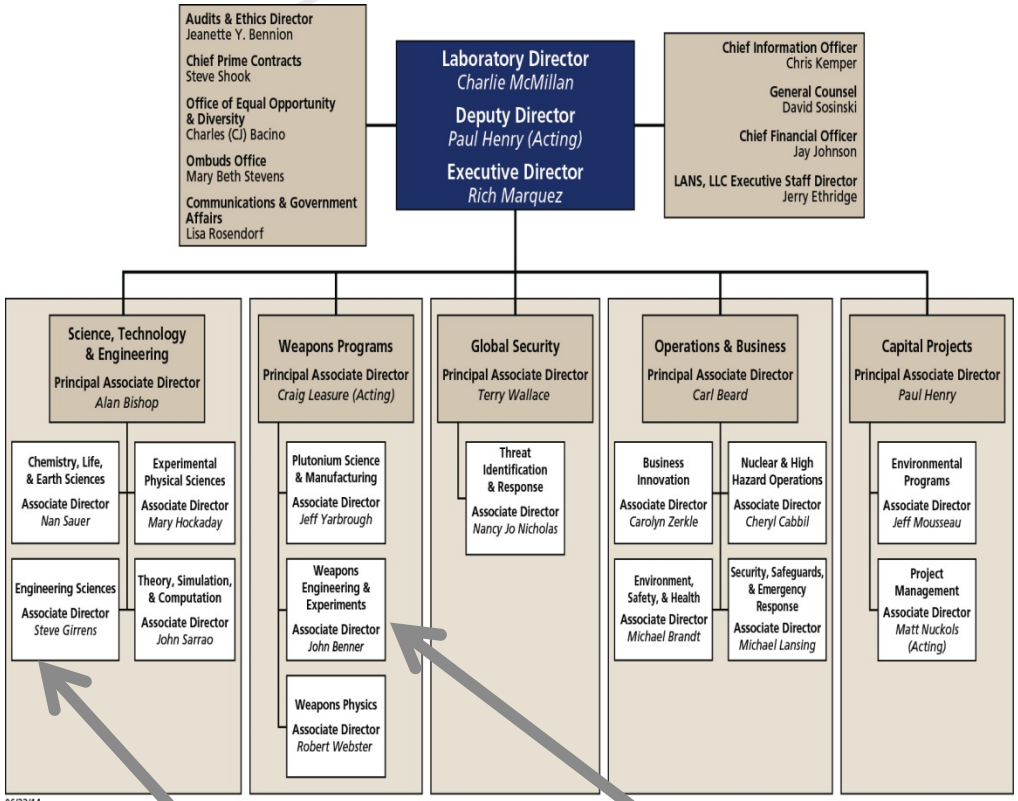
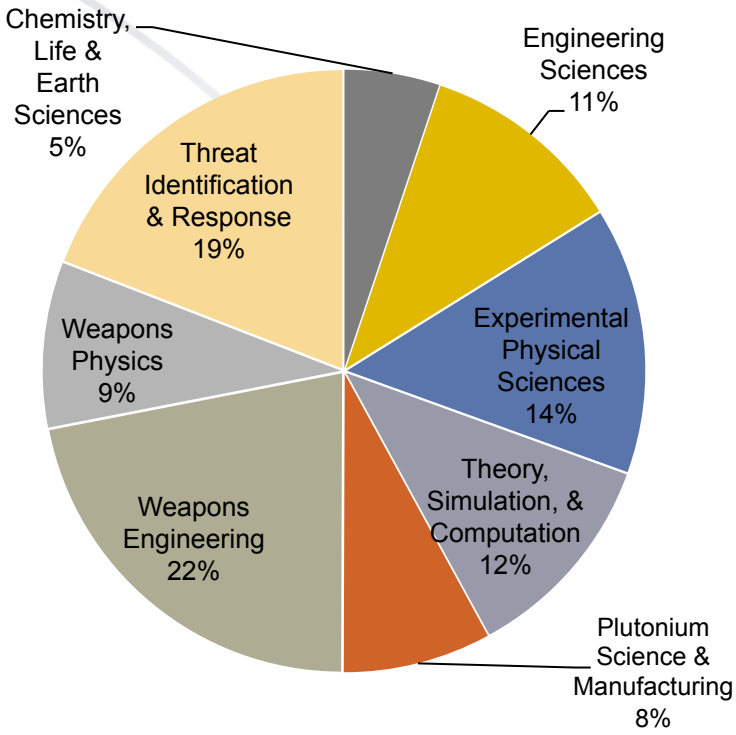
Demographics





Distribution of R&D Engineers by Directorate

N=1003 (Staff, PDs, GRAs)

Two dedicated R&D engineering directorates

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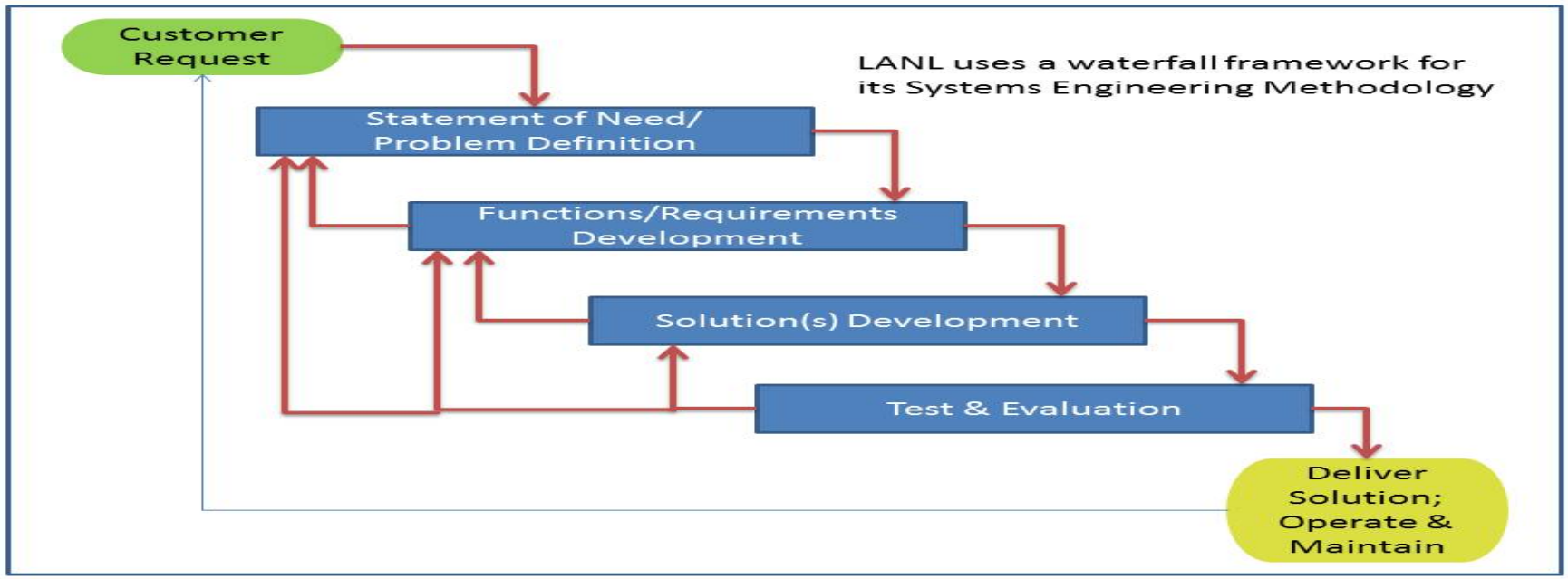
Implementation Strategy

- Policies, procedures, and implementation 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, and Transition to Operations
  - *Project Management for Programmatic and R&D Work*
- Tools that support implementation
  - Mission Assurance Support Tool (MAST)
  - Requirements Generation Tool
- Training courses that support implementation
  - R&D Engineering Primer

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.

Determining Required Levels of Engineering Quality and Rigor

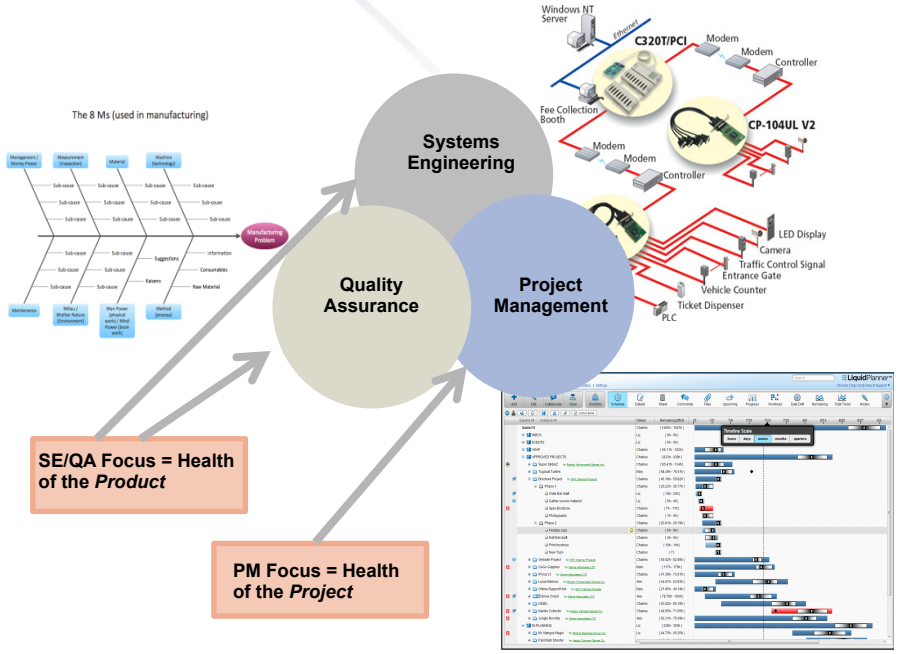
Requirements Grading Based on Risk Level			
Risk Level	**Reviews**	**Default R&D Design Authority Representative (DAR)**	**Documentation Note: Documentation requirements are cumulative as risk level increases.**
High	Formal design review Division Leader participates in reviews	Group Leader	Formal design 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

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

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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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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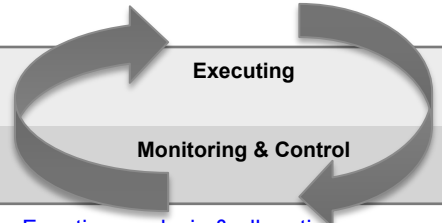
Key Artifacts for the Project and SE Lifecycles



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.

Discussion

- 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