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Sandia
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Ready for Production: Solve the Design & Development Problems by Predicting Them Early



Savvy Consortium®

The Savvy Consortium

New Product Development and Engineering
Conference XXIV

Execution: Fuzzy Start – Design to Value – Flow to
Production

Focus on Innovation, Customer Value, Agile Flow,
and Finish

PRESENTED BY

Christopher DiAntonio, Sandia National Laboratories, Albuquerque, NM

Thursday, April 19, 2018, Lisle, IL



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Ready for Production: Solve the Design & Development Problems by Predicting Them Early



Chris DiAntonio, Neutron Generator Design Engineer, Sandia National Laboratories: Albuquerque, NM

Achieving operating excellence for any production system starts in the Kentou learning cycle, the early work that begins new product development process. Many problem solving challenges and many learning cycles drive this investigative phase. Moreover, the design space is larger, thus enabling innovation in this Kentou phase. The investigation during the problem solving learning cycles focuses and results in predictors that link to the design problems faced during production. Chris DiAntonio presents a compelling understanding of these predictors. He presents his experiences utilizing them to enable the design engineer to collaborate with manufacturing engineering thus to maximize the impact that make for the successful production commercialization. Chris presents several project experiences that demonstrate the complexity yet valuable benefits these predictors leverage in the 'ready for production' processes. PDCA, TRIZ and DTIP (design thinking for Innovation Process) make execution successful in this "Predictor Driven" agile, lean and innovation process.



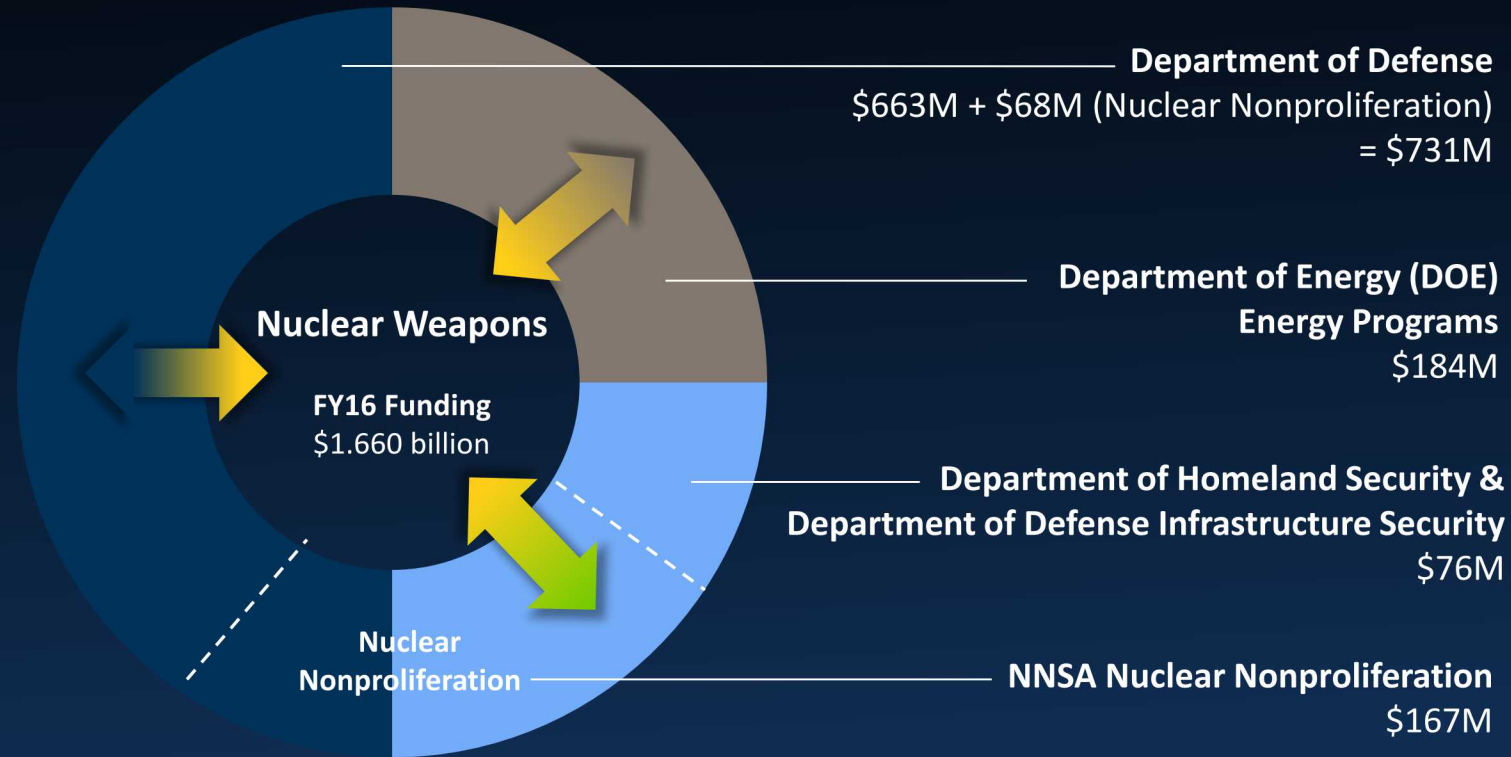
“To champion a culture and quality policy of continuous improvement ensures the Neutron Generator Enterprise will continue to evolve to be even more capable and efficient for the future.”

- Design Engineer in the Neutron Generator Enterprise for the Component Science, Engineering and Production Organization at Sandia National Laboratories, Albuquerque, New Mexico.
- Responsibility for research, design, qualification, production, and surveillance of multiple products across the neutron generator production lines.
 - The products support both Nuclear Deterrence and Strategic Partnership Program customers.
- Joined Sandia National Laboratories in 2001 as a post-doctoral appointee
 - Several years as a process/product engineer in the Active Ceramics Value Stream department as a member of the technical staff
 - Fundamental and applied research and development role
 - Design Engineer for the Neutron Generator Value Stream.
- Lean Six-Sigma Green Belt certified and a Distinguished Member of the Technical Staff.
- Committed to develop and apply advanced manufacturing processes and methodologies for realization of products in support of Sandia’s primary mission of ensuring that the nation’s nuclear weapons stockpile is safe, secure, and reliable.
 - Realized by providing engineering support from development through dismantlement of ferroelectric neutron generators.
- Prior to joining Sandia, process/product engineer position at Ferro Filtros, Ferro Corporation, (Rochester, NY), and CertainTeed Corporation (MountainTop, PA).
- Education - B.S. in Materials Science and Engineering, M.S. in Ceramic Engineering and Science, Ph.D. in Ceramic Engineering from Alfred University (Alfred, NY).

Sandia is a National Laboratory – consisting of two main locations



Sandia's Funding ~ \$3 Billion



Note: Other DOE and non-DOE Funding
\$202M

High reliability, high consequence of failure, challenging environments, and technology solutions

Fulfilling Our National Security Mission



Nuclear Deterrence



National Security Programs



Energy & Homeland Security



Defense Nuclear Non-Proliferation

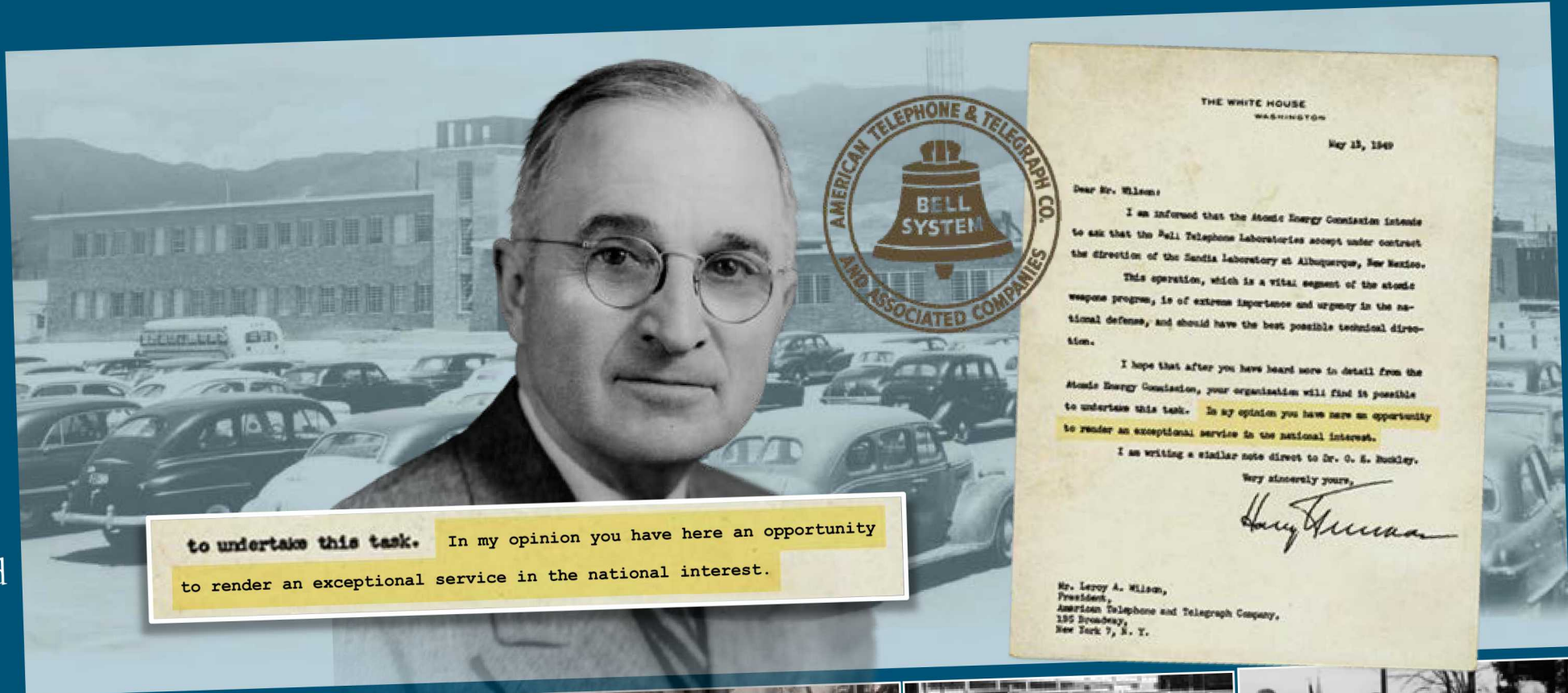
“Exceptional Service in the national interest”



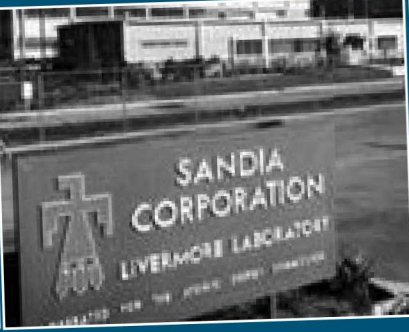
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In 1949, at the urging of the Atomic Energy Commission, President Truman encouraged the American Telephone and Telegraph Company, AT&T, to accept management and operating responsibility for the Sandia operation.

In his letter to AT&T President Leroy Wilson, Truman (pictured) captured the ethos of Sandia that has remained relevant to this day: *“In my opinion, you have here an opportunity to render an exceptional service in the national interest.”*



to undertake this task. In my opinion you have here an opportunity to render an exceptional service in the national interest.



Neutron Generator Enterprise (NGE)



- Mission – Responsive to deterrence needs, through science-enabled production realization and stewardship of non-nuclear products of today and tomorrow.
- Design and Production Influence Factors:
 - Complex product
 - High consequence environment
 - Highly professional environment
 - Regulations
 - Infrastructure
 - Cost pressures – fiscal budgets
 - System complexity
 - Highly technical fields
 - Exceptional level of rigor

9 Neutron Generator Enterprise – “Burning Platform”, Year 2000



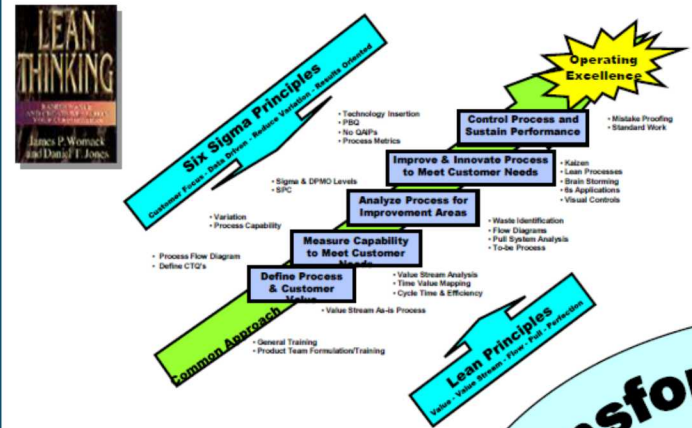
“Orchestrating pain messages throughout the institution is the first step in developing organizational commitment to (major) change.” - Rosabeth Moss Kantor: former editor, Harvard Business Review

- Failure to meet required starts and inventory plan
- Production rates were very low:
 - Low yields
 - High levels of work in progress (WIP)
 - Excessive and unnecessary long span times
- Production demands and requirements were increasing
- Unresolved technical issues continued to surface and resurface
- Major redesigns on one of the product lines
- Shipment deadlines were fast approaching
- NG production infrastructure modifications
- Budgetary issues prevented necessary personnel increase
- “Code Blue” status was imminent and eventually occurred

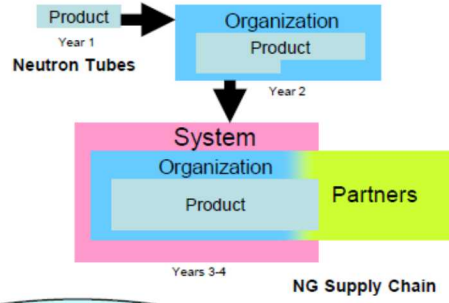




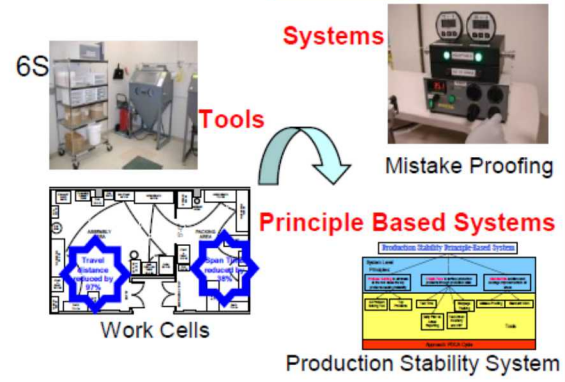
The Methodology



The Path



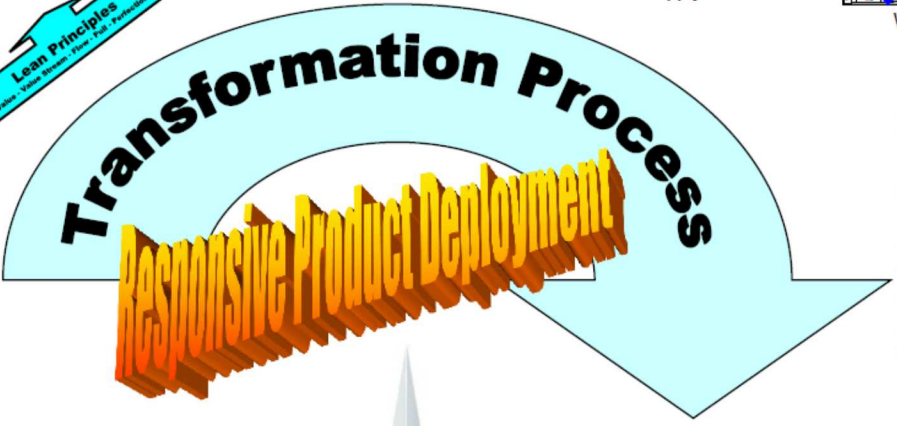
Results



Burning Platform



- Failure to meet required starts
- Poor production rates
 - Low yields
 - High WIP
 - Long span times
- Increasing production demands
- Continuing technical issues on Neutron Tube
- Major redesign on Neutron Generator
- Relocating NG production requiring re-qualification
- Budget would not allow required ramp up in personnel

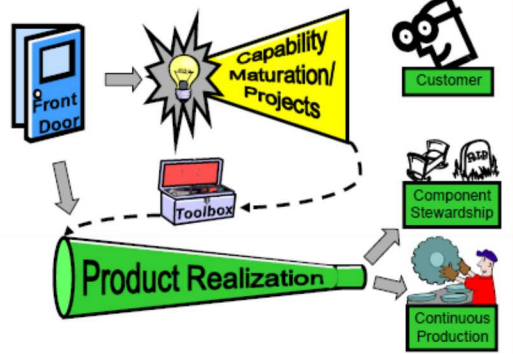


- 150% ↑ productivity in 2 yrs
- Nine new mission assignments in 4 yrs without increasing employees
- 78% ↓ span time on Neutron Generator
- 26% ↓ on Neutron Tube line over 2 yrs
- Enterprise and product cost reductions
- 65% ↓ in inspection costs over 5 yrs
- 61% ↓ work in process (WIP) in 3 yrs
- 36% ↓ hazardous waste in 3 yrs
- 17% ↑ employee satisfaction

Awards



Center Value Stream



- The Conversion
- Strategy alignment
- Focus on people
- Tools, systems and principle based systems
- Leadership
- Benchmarks
- Metrics
- Organizational Flow



Problem Solving – a pillar in any production system

- Problem with the legacy approach to problem solving: We thought we were doing “good” problem solving, but:
 - Problems continued to reoccur – incomplete approach, dependent on the individual, not always following a process
 - Problems were expensive
 - Solutions were based on “expert” opinions
 - The wrong problems were being “solved”, no root cause analysis
 - Insufficient analysis was performed, immediately formulating solutions, analysis paralysis
 - Solutions implemented as ‘band-aid’ fix as opposed to implementing permanent countermeasures
 - Work-arounds or excess assurance as part of the work processes
 - Lack of prioritization
 - Lack of documentation and communication (lessons learned)
 - Operating in “Fire-fighting” mode – expending limited resources and not addressing knowledge gaps



Benefits of Problem Solving (Ref – Sobek, 2008)

- **Logical thinking process**
 - Discipline in the methodology and scientific method
- **Objectivity**
 - Data driven decisions and details to frame the problem
 - Test for biases, assumptions, and misconceptions
- **Results and Process**
 - Achieve excellent results using an excellent process
- **Synthesis, Distillation and Visualization**
 - No brevity for the sake of brevity
 - Display visually the key information that was distilled from all of the available data
- **Alignment**
 - Consensus among stakeholders at all levels of the problem
- **Coherency with and consistency across**



PRINCIPLES

- Problems are a gap from a standard or lack of a standard
- Work has to flow and abnormal conditions must be recognized
- Problems must be prioritized with respect to metric goals and resources
- Enable people development
- Build a problem solving culture
- Rigorous root cause analysis
- Peer review
- Validation
- Integrity



SYSTEM

- 1.INPUTS - metrics, goals, abnormal work signal
- 2.IDENTIFY PROBLEMS
 - Prioritize problems
 - Assign problems to individuals/teams
- 3.SOLVE PROBLEMS
 - Plan-Do-Check-Act (PDCA)
 - TRIZ
 - DTIP
 - Review progress with focus on coaching and mentoring
 - Evaluate progress based on problem solving elements of success:
 - Understand the problem clearly
 - Show cause and effect
 - Validate results
 - Implement a permanent solution
 - Tell a story with data
 - Be concise
 - Share results and improve standards
- 4.ACHIEVE RESULTS
 - Improve performance
- 5.ASSESS PROGRESS
 - Review problems solved to identify systemic issues
 - Reflect on accomplishments and lessons learned
- 6.CONTINUOUS COACHING AND MENTORING



TOOLS

- Fill the toolbox
- Quality control tools - cause and effect and scatter diagrams, control, pareto and run charts, histograms, check sheets)
- Five Why's
- Kepner Tregoe - Decision Analysis, Problem Solving
- Kaizen
- Design of Experiments
- Issue Trees
- Affinity Diagrams
- Probability Tree Diagrams
-

Plan-Do-Check-Act (PDCA)



| P D C A | Step / Category | Purpose / Key Points for Consideration | Details / Probe Questions |
|------------------|------------------------------|---|---|
| P l a n | 1. Background | <p>Provide context and alignment</p> <ul style="list-style-type: none"> • Relevant background information • Ease in communication | <p>Provide historical data & context. Keep it relevant, recent, and simple. Describe why the problem is a priority and what goal does it aligns to. Describe the current situation (knowing there's something wrong). <i>Can a typical 3rd party relate to the contents?</i></p> |
| P l a n | 2. Problem Definition | <p>Understanding and breaking down the problem</p> <ul style="list-style-type: none"> • Gap from standard • Analytic • Quantitative • Detailed | <p>Compare to standard & identify the gap. Focus the problem (process flows, trends, and pareto charts are helpful tools). Quantify the gap (know what's wrong). Clearly define the problem statement. <i>Is there a gap from standard?</i> <i>Is there no standard?</i> <i>Is there an opportunity to improve upon standard?</i> <i>Is it more of a project? Or a specific hypothesis to test?</i> <i>Is the problem broken down enough?</i> <i>Is the problem quantitative or at least qualitative and clear?</i> <i>Is it detailed enough?</i></p> |
| P l a n | 3. Goals | <p>Establish what you are trying to achieve</p> <ul style="list-style-type: none"> • Set S.M.A.R.T. goals - Specific, Measurable, Attainable, Relevant, Timely • No action items in disguise | <p>Don't write goals in action item language or as steps along the way. <i>Is there a clear goal to attain?</i> <i>Is it specific enough?</i> <i>Is it measureable?</i> <i>Is it attainable?</i> <i>Is it realistic?</i> <i>Is it timely?</i> <i>Is there a target date?</i></p> |
| P l a n | 4. Analysis and Action Items | <p>Perform Causal Analysis</p> <ul style="list-style-type: none"> • Root cause oriented • Analytic • Quantitative • Detailed | <p>Explore and explain why the gap exists. Can use any tool that is appropriate to analyze the problem. Identify action items needed to show cause and effect (what, who, when, results). Demonstrate cause and effect. <i>Is there a plan for analysis with assignments?</i> <i>Do we have the right people involved from an expertise point of view?</i> <i>Is the cause broken down analytically?</i> <i>Is the cause measured quantitatively?</i> <i>Is the cause sufficiently detailed (e.g. 5 Why test)?</i> <i>Is there a legitimate cause and effect mechanism?</i></p> |



| P D C A | Step / Category | Purpose / Key Points for Consideration | Details / Probe Questions |
|-----------------------|------------------------------|---|--|
| D o | 5. Countermeasures | <p>Develop, select, prioritize, and implement countermeasures</p> <ul style="list-style-type: none"> • Short term versus Long Term • Temporary versus Permanent • Containment • True recurrence prevention | <p>Develop multiple countermeasure options. Critically evaluate countermeasure options and determine which ones to implement. Identify how the check will be done. Develop implementation plan: Identify what to do, by whom, and by when. Implement countermeasure(s).</p> <p><i>Are there immediate containment actions to be taken?</i> <i>Are there quick temporary measures to be taken?</i> <i>What are the best long term solutions?</i> <i>Do we have a true recurrence prevention countermeasure?</i></p> |
| C h e c k | 6. Check Method | <p>Verify that countermeasures have been effective at eliminating the root cause</p> <ul style="list-style-type: none"> • Goal alignment • Measurable • Establishes cause and effect | <p>Evaluate effectiveness (or not) of each countermeasure (individually if possible). Document countermeasure results.</p> <p><i>Does the check match the goal statement?</i> <i>Is the check sufficiently measureable and specific?</i> <i>Does the check method verify the improvement?</i> <i>Does the timing of any improvement support the conclusions?</i></p> |
| A c t | 7. Follow Up and Standardize | <p>Make the solution permanent and share</p> <ul style="list-style-type: none"> • Design Change • Process Change • Work Instructions • Other Documentation • Training • Communication • Other applications • Lessons Learned | <p>Standardize the countermeasure (make it permanent). Include actions needed to sustain and control (it can't be dependent on you, it has to be part of the system). Remove "temporary countermeasures" that were implemented earlier on to mitigate risks. Share lessons learned with appropriate people.</p> <p><i>Will this involve any type of design change?</i> <i>Will this involve any type of process change?</i> <i>Will any work instructions change?</i> <i>Will any other documentation need to be changed?</i> <i>Does any type of training need to be scheduled?</i> <i>Does any type of communication need to be conducted?</i> <i>Is this applicable to any other situations or places?</i> <i>What lessons did we learn from this?</i></p> |



- What were the major lessons learned
 1. Exercise disciplined rigor for problem solving
 - Need to rigorously follow the problem solving methodologies
 - Cannot cut corners, no excuses that justify for skipping steps
 2. Properly resourcing the solving problem solving effort(s) is crucial
 - The correct resources (subject matter experts, funding allocation, management, support personnel, mentors, coaches) are crucial for realizing success
 - Resources need to be supplied at the appropriate level
 - How much financial support?
 - How many people? What types of people?
 - How much time/commitment?
 3. Management reassurance throughout the process
 - The product realization team (PRT) needs to provide fortitude to the management team that the problem is being worked properly
 4. Lean Sustainment



○ Predictors

○ Performance

- Product capabilities – margins and reliability, assumption of risk
- Product efficiency – trimming waste without sacrificing capabilities and quality
- Product failures – product complexity drives failure probability
 - Extreme conditions and abnormal environments

○ Law of Scaling – myth of proportional reasoning

- Concept that scale must be understood and not assumed

○ Deflection – system viewpoint consideration

- Understanding how the proposed countermeasures effect the whole (fixing one problem that induces another is not acceptable)
- Solution generates a problem (displacement, shifting)

○ Artisan – artistic expression