Lean Six Sigma for the Environmental Manager

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Portland, Oregon
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Improvement needed everywhere

• Toyota Production System Improves Meals per Hour (7 mins)
  • https://www.youtube.com/watch?v=KtTQff7Uf_w
Agenda

- Introductions
- Sustainability and the Triple Bottom Line
- Lean Overview
- Six Sigma Overview
- Why Lean Six Sigma?
- Gaps with LSS
- See, Solve and Sustain Model
- W.A.S.T.E. Walks
- Kaizen events
- 5S
- One piece flow
- Visual Controls & SQDC
- Change Management
- FMEA
- Value Stream Mapping (VSM)
- SIPOC
- Kanban
- Measurement system analysis (MSA)
- Capability Analysis
- Regression analysis
- Design of Experiments (DOE)
- Statistical Process Control (SPC)
- Resources
- Next Steps

Breaks

Lunch

Restrooms

Emergency Exits
Introductions

• Why are you here?
  • Environmental? Personal Development? Other?
• Where do you work?
• What is your background and experience?
• Where were you born?
A global company operating from more than 60 locations in 27 countries
19,000 employees on our team
Provides navigation, communications and display products and systems for military and commercial customers
Heads Up Guidance Systems (HGS) facility in Wilsonville, OR
  • Achieved Clackamas County Gold Sustainability Certification
Sustainability
What is sustainability?

• Meeting the needs of the present without compromising the ability of future generations to meet their own needs

• Triple Bottom Line
Triple Bottom Line

- **Profit** – price listed on the item or the shelf, very clear
- **People** – nutritional value, calories/fat, cruelty-free, Fair Trade
- **Planet** – Local sources (low food miles), most only use words (organic, GMO-free, no additives/coloring)

[Images of products labeled with profit, people, and planet categories]

Carbon Reduction Label courtesy of [Carbon Trust](http://carbontrust.com)
Financial reasons for sustainability

- 7 areas of financial benefit for companies

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>1.</td>
<td>Increased revenue</td>
</tr>
<tr>
<td>2.</td>
<td>Reduced energy expenses</td>
</tr>
<tr>
<td>3.</td>
<td>Reduced waste expenses</td>
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<tr>
<td>4.</td>
<td>Reduced materials and water expenses</td>
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<td>5.</td>
<td>Increased employee productivity</td>
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<td>6.</td>
<td>Reduced employee attrition expenses</td>
</tr>
<tr>
<td>7.</td>
<td>Avoided risk to profit</td>
</tr>
</tbody>
</table>

“No environment, no consumers in society, no business”

From Bob Willard [http://www.sustainabilityadvantage.com](http://www.sustainabilityadvantage.com)
Lean and Six Sigma
What is Lean?

• The goal is to maximize **customer value** while minimizing waste
  • Results in fewer resources and costs to provide same value

• Result is an optimized flow of products and services **horizontally** across processes, equipment, and departments to customers, not vertically by functional area

• Leads to high flexibility, high quality and low cost for your customers with very fast response times

• Applies to every business and every process (not just manufacturing)

• A new way of thinking and acting for an entire organization
5 Lean Principles

- Value
- Value Stream
- Perfection
- Pull
- Flow
TIM WOOD is an acronym that represents the 7 forms of waste found in processes, that should be reduced or eliminated.

**TRANSPORTATION**
Moving items or information

**INVENTORY**
Items or information that customer has not received

**MOTION**
Excessive movement within workspace

**WAITING**
Waiting for information or items to arrive

**OVERPROCESSING**
Doing more work than necessary

**OVERPRODUCTION**
Doing work before it is needed

**DEFECTS**
Mistakes and errors that need to be reworked
7 Forms of Waste

<table>
<thead>
<tr>
<th>Waste Type</th>
<th>Environmental Impacts</th>
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<tbody>
<tr>
<td>Overproduction</td>
<td>• More raw materials consumed in making the unneeded products</td>
</tr>
<tr>
<td></td>
<td>• <strong>Extra products may spoil or become obsolete requiring disposal</strong></td>
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<td></td>
<td>• Extra hazardous materials used result in extra emissions, waste disposal, worker exposure, etc.</td>
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<tr>
<td>Inventory</td>
<td>• More packaging to store work-in-process</td>
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<td></td>
<td>• Waste from deterioration or damage to stored WIP</td>
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<td></td>
<td>• More materials needed to replace damaged WIP</td>
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<tr>
<td></td>
<td>• <strong>More energy used to heat, cool, and light inventory space</strong></td>
</tr>
<tr>
<td>Transportation and Excessive Motion</td>
<td>• More energy use for transport</td>
</tr>
<tr>
<td></td>
<td>• Emissions from transport</td>
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<tr>
<td></td>
<td>• More space required for WIP movement, increasing lighting, heating, and cooling demand and energy consumption</td>
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<tr>
<td></td>
<td>• <strong>More packaging required to protect components during movement</strong></td>
</tr>
<tr>
<td></td>
<td>• Damage and spills during transport</td>
</tr>
<tr>
<td></td>
<td>• Transportation of hazardous materials requires special shipping and packaging to prevent risk during accidents</td>
</tr>
<tr>
<td>Defects</td>
<td>• Raw materials consumed in making defective products</td>
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<tr>
<td></td>
<td>• <strong>Defective components require recycling or disposal</strong></td>
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<tr>
<td></td>
<td>• More space required for rework and repair, increasing energy use for heating, cooling, and lighting</td>
</tr>
<tr>
<td>Over Processing</td>
<td>• More parts and raw materials consumed per unit of production</td>
</tr>
<tr>
<td></td>
<td>• Unnecessary processing increases wastes, energy use, and emissions</td>
</tr>
<tr>
<td>Waiting</td>
<td>• <strong>Potential material spoilage or component damage causing waste</strong></td>
</tr>
<tr>
<td></td>
<td>• Wasted energy from heating, cooling, and lighting during production downtime</td>
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</tbody>
</table>
• How long does this entire process take today?
• How much of that time is work being applied to it?
Total time can be cut by 50-99% by taking out the delays between the processes, not speeding up the work within the process!
How to implement Lean

• Identify customers
• Define products and services
• Map value stream
• Identify waste
• Develop future state (without waste)
• Conduct improvement events
  • Flow: Define takt time, determine number of people needed, balance the lines to takt through waste reduction and work sequence, add inventory to maintain flow
  • Pull: Start with end customer, setup Kanban to limit work, stop when problems arise, suppliers provide input JIT
Lean and the Environment (Planet)

- Washington State Dept of Ecology Lean support at AccraFab (4 min)
  - [http://vimeo.com/43681916](http://vimeo.com/43681916)
What is Six Sigma?

• Critical to Quality: Defines attributes most important to the customer
• Defines Defects: Failing to deliver what the customer wants
• Process Capability: What your process can deliver and how often
• Variation: What the customer sees and feels (more than just the average)
• Stable Operations: Ensuring consistent, predictable processes to improve what the customer sees and feels
• Design for Six Sigma: Designing to meet customer needs and process capability
Six Sigma Defined

- The goal of six sigma is to have your process average at least 6 standard deviations from the nearest specification or tolerance limit.

Reduces the probability of exceeding limits due to common cause variation.
DMAIC

• Use DMAIC model as foundation
  • Successful methodology that uses data to confirm extent of problem, get to root cause, link solutions to causes, and maintain improvements
  • Define
  • Measure
  • Analyze
  • Improve
  • Control
<table>
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<tr>
<th><strong>DEFINE</strong></th>
<th><strong>MEASURE</strong></th>
<th><strong>ANALYZE</strong></th>
<th><strong>IMPROVE</strong></th>
<th><strong>CONTROL</strong></th>
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<tbody>
<tr>
<td>□ Gather data and identify largest problem in area (customer satisfaction/quality, cost, speed/delivery, risks)</td>
<td>□ Prioritize and focus on top drivers from data (Pareto chart)</td>
<td>□ Brainstorm potential causes of problem (Fishbone Diagram, FMEA)</td>
<td>□ Brainstorm possible solutions to reduce or eliminate the problem (Mistake Proofing)</td>
<td>□ Determine system and reports to monitor results over time (SPC, Visual Controls)</td>
</tr>
<tr>
<td>□ Review timeline and history of problem (Run Chart)</td>
<td>□ Observe and document current state of process (VsM, Process Map, Go and See)</td>
<td>□ if problem due to common cause, identify sources of variation:  - Multi-Vari Studies  - ANOVA  - Regression  - Design of Experiments (DOE)</td>
<td>□ Identify top actions to improve the problem (NGT, Multivoting)</td>
<td>□ Estimate financial benefits and improvement to metrics for 12 months</td>
</tr>
<tr>
<td>□ Identify stakeholders (SIPOC)</td>
<td>□ Collect additional data to understand problem (Check sheets, Pictogram)</td>
<td>□ if problem due to special cause, identify root cause:  - 5 Why’s</td>
<td>□ Conduct small-scale improvements to test out possible solutions</td>
<td>□ Complete Control Phase tollgate review</td>
</tr>
<tr>
<td>□ Fill out Project Charter draft</td>
<td>□ Validate whether data being utilized is valid (Gage R&amp;R)</td>
<td>□ Validate root cause or source(s) of variation with data</td>
<td>□ Determine statistical validity of improvements in data (Hypothesis Tests)</td>
<td>□ Schedule and review results for 30-60-90 days</td>
</tr>
<tr>
<td>□ Review project charter with sponsor and champion</td>
<td>□ Determine if problem is due to common or special cause (Capability, SPC)</td>
<td>□ Complete Analyze Phase tollgate review</td>
<td>□ Develop full scale implementation plan to include documentation, training, communication, risks, assignees and dates (Gantt, FMEA)</td>
<td>□ Communicate and share success and lessons learned</td>
</tr>
<tr>
<td>□ Obtain signed Project Charter</td>
<td>□ Complete Measure Phase tollgate review</td>
<td>□ Complete Analyze Phase tollgate review</td>
<td>□ Complete Improve Phase tollgate review</td>
<td>□ Perform final review after one year</td>
</tr>
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<td></td>
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<td>□ Complete project summary report</td>
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JEAs DMAGIC roadmap

• JEA added a “Green It Up” step to the DMAIC process, creating “DMAGIC”
  • designed to ensure that every improvement project addresses environmental concern
• In the “Green” phase of each project, the team explores areas such as air quality, water quality, and ecosystem-related issues.
• The team performs the “Green it Up” phase after identifying root causes and before developing any countermeasures.
• This assures that environmental and societal concerns are “baked into” every countermeasure explored before it is evaluated.

http://www.epa.gov/sustents/environment/studies/jea.pdf
How to implement Six Sigma

• Review financials
• Identify cost opportunities
• Measure process baseline
  • Confirm data integrity
  • Capability and sigma level
• Identify sources of variation or root causes
• Pilot solutions
• Statistically validate improvements
• Implement process controls
• Track for 6-12 months after improvement
Why LSS?
Two ways to solve problems

• Cut and slash
  • Eliminate resources, use inferior services or people, take away benefits, delay responses
  • Achieve savings, but reduce overall value to the customer
  • May push costs to others
  • Make changes and hope things get better

• Eliminate waste
  • Analyze process and remove inefficiencies
  • Hard to do, and takes time to complete
  • Requires problem solving skills and ability to change behaviors
  • Maintains or increases value to customer
  • Experimentation and data to validate changes

Reduces value to employee
BAD!

Maintains or increases value to employee
GOOD!
Example: Employee Health Care Costs

- Cut and slash
  - Increase co-pay
  - Increase deductible
  - Decrease quality of number of services
  - Restrict access
  - Use inferior suppliers
  - Employee may delay care, leading to higher costs

- Eliminate waste
  - Identify top drivers of cost
  - Investigate root causes of issues
  - Change process and incentives for customers
  - Track and monitor costs to identify when changes occur
Suboptimization case study

**Improvement and savings**

<table>
<thead>
<tr>
<th>Wastes</th>
<th>Improvements</th>
<th>Annual results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overprocessing</td>
<td>Widened orifices in glass bead blast cabinets, reducing cleaning time per cylinder by 50%, overall energy use and material (glass bead) and nonhazardous waste.</td>
<td>Reduced labor hours</td>
</tr>
<tr>
<td>Defects</td>
<td>In-process inspection moved to the beginning of process, thereby identifying bad parts at the start of the process instead of passing defects to downstream processes, thus reducing rework. Implemented quality at the source (for example, transferred responsibility for quality from inspectors to assemblers). This required cross-training and visual standard work procedures.</td>
<td>Less detergent used: 41 gallons; Less water used: 1,480 gallons</td>
</tr>
<tr>
<td>Overprocessing</td>
<td>Boring, honing and cross-hatching now performed on an automatic honing machine instead of doing one cylinder at a time manually.</td>
<td>Less nonhazardous wastewater: 259 gallons</td>
</tr>
<tr>
<td>Unnecessary motion</td>
<td>Parts repackaged in special crates to minimize handling.</td>
<td>Less glass bead: 3,631 pounds</td>
</tr>
<tr>
<td>Overprocessing</td>
<td>Eliminated one process-cleaning step, reducing electricity use (less use of high-pressure spray washer).</td>
<td>Less nonhazardous solid waste: 5,791 pounds</td>
</tr>
<tr>
<td>Waiting and scrap</td>
<td>Reused (clean and plate) formerly discarded hardware, resulting in less work stoppage due to unavailable parts.</td>
<td>$64,335 in total cost savings</td>
</tr>
</tbody>
</table>

http://asq.org/quality-progress/2010/03/lean/leaning-toward-green.html?WT.dcsvid=OTAKNDMxNDY0MgS2&WT.mc_id=EM118436
Goal: Optimize Process Flow

- Eliminate or reduce variation (Six Sigma)
- Improve process flow (Lean)
Case Studies

• Reduce chemicals through just-in-time inventory (Lockheed Martin)
• Use 5S and visual controls to reduce spills and material waste (Robins Air Force Base)
• Use Value Stream Mapping (VSM) to see the waste and identify improvement opportunities (Baxter Healthcare)
• Use statistical analysis to optimize processes to reduce material waste (ROSTAR)
• Use kaizen events to dramatically reduce application process backlogs (Idaho Department of Environmental Quality)
• Implement process controls to reduce material waste (Kahiki Foods)
• Use Gemba Walks to identify opportunities for improved recycling (Kirkland Air Force Base)
• Use DMAIC framework to methodically reduce food waste (Rose-Hulman Institute of Technology)
More Case Studies

- General Motors
- DTE Energy
- Del Monte Foods
- City of Irving, TX
- Blue Cross Blue Shield
- JEA Utilities
- Apollo Hardwoods
- Columbia Paint
- Lasco Bathware
- Univ of North Carolina

Download over 20 case studies for free at:
http://www.leansixsigmaenvironment.org/index.php/free-stuff/
Employee Engagement

• Your people know what to improve, you just haven’t asked them or involved them

• First effort will be focused on engaging them in finding “low-hanging fruit” opportunities

• We will help them implement their ideas, not get passed off into suggestion box or committee review
Gaps with LSS
What is the problem?

Lean Six Sigma identifies waste within the value stream processes.

“Green” identifies waste outside the processes.
LSS approach gaps

• Improvement opportunities may be found outside of normal working hours and areas
  • “Cost of doing business,” not viewed as opportunity

• Small impact at process level
  • Look at impact across entire facility

• Costs and impacts can be blanketed across many areas, hard to isolate data to biggest users
LSS approach has some issues (cont’d)

• Using recycled content, cleaner energy or less harmful materials not typically in scope of improvements
  • Focus primarily on using right amount and just-in-time

• Environmental and human health risks are often not explicitly considered in business decisions
  • Turning externalities into internal business factors

• Side benefits of efforts not anticipated or factored in
  • Take-back, talent acquisition, employee engagement
Recipe for Success

ES&H
• “Bottoms Up” with People
  • Turn off equipment
  • Recycling and composting
  • Hazardous waste processes
  • Water conservation
  • Air leak prevention

Facilities
• “Top Down” with Infrastructure
  • Renewable Energy
  • Efficiency Upgrades
  • Green Cafeteria
  • Electric Charging Station
  • LEED buildings
  • Showers for bikers

Approach sustainability from both directions
Event Checklist

• Useful when ES&H or Facilities personnel cannot attend event

<table>
<thead>
<tr>
<th>Physical Environment</th>
<th>Unk</th>
<th>Yes</th>
<th>No</th>
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</thead>
<tbody>
<tr>
<td><strong>As a result of the Lean event, will there be:</strong></td>
<td></td>
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<tr>
<td>Any changes to the locations where either maintenance work or use of hazardous chemical/material will occur?</td>
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<tr>
<td>Any changes to your personnel’s work zone assignments?</td>
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<tr>
<td>Any new equipment or modifications to existing equipment, or movement of existing equipment that has the potential to produce air or water emissions (e.g., rinse equipment/operations, cleaning tank, heating ovens)?</td>
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<tr>
<td>Any changes to the facility (e.g., vents, stacks, floor drains, oil/water separators)?</td>
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<tr>
<td>Any changes in the location(s) of the current flammable storage locker/areas?</td>
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<tr>
<td>Any new confined space entry activities or procedures (e.g., personnel entering fuel tanks for cleaning)?</td>
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</table>
## Material/Chemical Use and Storage

<table>
<thead>
<tr>
<th>As a result of the Lean event, will there be:</th>
<th>Unk</th>
<th>Yes</th>
<th>No</th>
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</thead>
<tbody>
<tr>
<td>Any changes to the type or volume of materials issued to personnel and/or used? This includes the introduction of new chemicals, elimination of chemicals, etc.</td>
<td></td>
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<tr>
<td>Any changes to the chemical introduction or issuance procedure for chemicals/materials containing hazardous materials?</td>
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<tr>
<td>Any changes in the volume of chemicals/materials stored?</td>
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<tr>
<td>Any flammable materials that are not returned to the storage cabinets at the end of each shift?</td>
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</table>

## Waste Management

<table>
<thead>
<tr>
<th>As a result of the Lean event, will there be:</th>
<th>Unk</th>
<th>Yes</th>
<th>No</th>
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</thead>
<tbody>
<tr>
<td>Any change(s) to the waste profiles for wastes stored at any initial accumulation points?</td>
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<tr>
<td>Any change(s) to the location or number of initial waste accumulation points?</td>
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</tr>
<tr>
<td>Any change(s) to the volume of waste(s) that require disposal (i.e., wastewater, hazardous or solid waste) or to the volume of material that will be recycled or reused?</td>
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</tbody>
</table>
See, Solve and Sustain
Blended Lean Six Sigma approach to reduce environmental impacts
<table>
<thead>
<tr>
<th>Phase</th>
<th>Walk</th>
<th>Rapid</th>
<th>Problem Solving</th>
<th>VSM</th>
<th>Project</th>
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<tbody>
<tr>
<td>See</td>
<td>W.A.S.T.E.</td>
<td>Impact Matrix</td>
<td>Statements</td>
<td>VSM</td>
<td>Baseline Analysis</td>
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<tr>
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<td>Planning Worksheet</td>
<td>5 Lean Principles</td>
<td>Standards</td>
<td>SIPOC</td>
<td>Is / Is Not</td>
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<tr>
<td></td>
<td>VA vs NVA</td>
<td>8 wastes</td>
<td>8D/PDCA/A3</td>
<td>OEE</td>
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<td></td>
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<td>Check Sheets / Data</td>
<td>Common vs Special</td>
<td>Boundary Map</td>
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<td></td>
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<td>Pictograms</td>
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<tr>
<td>Solve</td>
<td>WASTE Walks (water, energy, solids)</td>
<td>5S</td>
<td>Pareto Charts</td>
<td>Supermarkets</td>
<td>MSA</td>
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<tr>
<td></td>
<td>Brainstorming</td>
<td>Process Mapping</td>
<td>AAA</td>
<td>Kanban</td>
<td>Capability</td>
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<td></td>
<td>Affinity Diagram</td>
<td>Current-Ideal-Future</td>
<td>Fishbone</td>
<td>SMED</td>
<td>Regression</td>
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<tr>
<td></td>
<td>Impact Ease Matrix</td>
<td>Single Piece Flow</td>
<td>Multi Vari Studies</td>
<td>Event Types</td>
<td>DOE/ANOVA</td>
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<td>Multivoting</td>
<td>Takt Time</td>
<td>Pivot Tables</td>
<td>3P and Biomimicry</td>
<td>Hypothesis Testing</td>
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<td>5 Why’s</td>
<td>Standard Work</td>
<td>FMEA</td>
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<td>Prioritization Matrix</td>
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<td>Cellular Layout</td>
<td>Timeline Analysis</td>
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<td>Monte Carlo Simulation</td>
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<td>Rapid experimentation</td>
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<td>Design for Six Sigma</td>
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<td>Facilitation</td>
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<td>Mistake proofing</td>
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<tr>
<td>Sustain</td>
<td>Track Results</td>
<td>Visual Controls (SQDC, Andon)</td>
<td>Long term results</td>
<td>Process Mgmt</td>
<td>SPC</td>
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<td></td>
<td>Earth Belt</td>
<td>Personal Lean</td>
<td>TPM</td>
<td>Comm. Board</td>
<td>Hard vs Soft Savings</td>
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<td>Video</td>
<td>Change Mgmt</td>
<td>Green Belt</td>
<td>Cross Training Matrix</td>
<td>Black Belt</td>
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## LSS Tools vs Phase

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We will address some pieces of each section, and go back and discuss topics you want at the end.
# LSS Tools vs Phase

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W.A.S.T.E. Walks

WALK
W.A.S.T.E.
Where do you start?

- Rockwell Collins Wilsonville
  - Water = $3,000 per month
  - Air Emission = Not Applicable
  - Solid Waste/Landfill = $300 per month
  - Toxins = Minimal
  - Electricity - $30,000 per month
Planning Worksheet

- Business Case
- Scope
- Team Members
- Schedule
- Approval
Lean Principles

Value

Perfection

Pull

Value Stream

Flow

See

Walk
Energy: Value vs Non-value Added

Value added

- Electricity to automatically place parts on a board
- Computer used to share screen with remote employees to solve a problem
- Electricity to create bid proposal
- Heat to keep employees comfortable
- Parking lot lighting at night for safety

Non-value added

- Lighting for office area on overtime to fix a document that wasn’t done right the first time
- Air conditioner replacement due to neglect
- Test equipment left on overnight when not being used
- Overhead projectors left on in conference room
- Cooling an area that is not being used

The customer does not want to pay for non-value added waste!
### LSS Tools vs Phase

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What is Gemba?

• Japanese word for “the real place”
• Go to where the actual work is being done, interact with the workers to improve decision making and problem solving
• Shows respect for the workers to understand what they do
• Referred to as “Gemba Walk” or “Go and See”

Courtesy aria-automobile-nord.com
What is a W.A.S.T.E. Walk?

• Structured process to identify environmental impacts (W.A.S.T.E.) in a business, organization or community through the “go and see” approach

• Captures observations and opportunities
Walk Process

Prepare
- Business Case
- Scope and location
- Schedule
- Team Members and Approvals

Event
- Conduct Event

Combine
- Gather ideas and opportunities
- Group ideas using Affinity Diagram

Decide
- Create Impact Ease Matrix for opportunities
- Select top 3 opportunities through Multivoting

Planning Worksheet
Event Process
Affinity Diagram
Impact Ease Matrix
Multivoting
Focus Areas

W A S T E

W A T E R  A I R  S O L I D S  T O X I N S  E N E R G Y

Dumpster Dive  Energy Walk

Walk  Solve
Current Issues

• Not sure how to get started
• Too many solutions and ideas to implement
• Solutions are high cost and require capital investment
• “We’ve done everything we can already”
• Costs too much to bring in experts
• Workers and employees are often too close to see the opportunities
• It seems that no one cares
Future Benefits

• Educated employees who can see opportunities every day
• Engaged employees in improvement efforts
• Identify “low hanging fruit” opportunities that might not be found otherwise
• Don’t need experts and upfront cost to get started
• Reduced list of improvements that will likely get implemented
Dumpster Dives
Dumpster Dive Process

• Volunteers gown up with Tyvex suits, gloves and safety glasses
• Training provided on how to sort into each category
• Dump trash bags on table
• Far side volunteers slowly reach in and separate items down to simplest items
• Near side volunteers put items in correct bin
• Bins are weighed, minus weight of bin
• Bins are reviewed by experts for final sort
  • See video at: http://www.youtube.com/watch?v=bzbCtJ6Ejfo
• Data analyzed, costs estimated and investigations conducted by team members
• Final report created showing breakdown of items by weight, cost impacts, analysis of results, and recommendations
Solid Waste Walk (Dumpster Dive)

Waste Audit – Collected trash cans after game, sorted and weighed all items to establish baseline of current state

![Waste Audit Results](image)

- **Trash Weight**: 31.0%
- **Compost Weight**: 27.2%
- **Recycling Weight**: 29.8%
- **Liquid Weight**: 12.0%
Waste Pyramid

Zero Waste

Refuse
Reduce
Reuse
Recycle
Recover
Dispose
Energy Walks

WATER  AIR  SOLIDS  TOXINS  ENERGY

Energy Walk
Energy Walk Success Stories

**Energy Treasure Hunts at General Electric** (Box 8)

With mentoring assistance from Toyota, General Electric (GE) launched an integrated Lean and energy initiative that has identified upwards of $110 million in energy savings through energy treasure hunts. GE’s corporate commitment to energy use and greenhouse gas reductions has helped drive this effort. As of March 2009, GE:

- Conducted over 200 energy treasure hunts at GE facilities worldwide, and trained over 3,500 employees on how to conduct treasure hunts
- Used energy treasure hunts to identify 5,000 related kaizen projects, most of which are funded and in various stages of implementation
- Through those project have identified opportunities to eliminate 700,000 metric tons of greenhouse gas emissions and $111 million operational cost.


http://www2.epa.gov/lean/lean-energy-and-climate-toolkit
Conducting Energy Walk

- Four primary “Walk” sessions (can vary by facility)
  - Off shift
    - Typically held on weekends
  - Start-up
    - Beginning of 1st shift
  - Working time
    - Including breaks
  - Shut down/Transfer
    - Between shifts or at end of shift

- Break into appropriate groups and review defined area
  - Need mix of process and technical experts, fresh set of eyes, and different levels of organization
Key Areas to Check

**Questions for Understanding Energy Use (Box 7)**

**Motors and Machines**
- Are machines left running when not in operation? If so, why?
- Are energy efficient motors, pumps, and equipment used?
- Are motors, pumps, and equipment sized according to their loads? Do motor systems use variable speed drive controls?

**Compressed Air**
- If compressed air is used, do you notice any leaks in the compressed air system?
- Do compressed air systems use the minimum pressure needed to operate equipment?

**Lighting**
- Is lighting focused where workers need it?
- Is lighting controlled by motion sensors in warehouses, storage areas, and other areas that are intermittently used?
- Is energy-efficient lighting used?

**Process Heating**
- Are oven and process heating temperatures maintained at higher levels than necessary?

**Facility Heating and Cooling**
- Are work areas heated or cooled more than necessary?
- Do employees have control over heating and cooling in their work areas?
- Are exterior windows or doors opened or closed to adjust heating and cooling?

[http://www2.epa.gov/lean/lean-energy-and-climate-toolkit](http://www2.epa.gov/lean/lean-energy-and-climate-toolkit)
Energy “Treasure Hunt” (Walk)

• GE Treasure Hunt Reveals How to Cut Energy Spend in Half at Citrus Bowl (3 min)
  • [http://www.youtube.com/watch?feature=player_embedded&v=vAiAvwEvBxQ](http://www.youtube.com/watch?feature=player_embedded&v=vAiAvwEvBxQ)
Walk Process

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Event
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Combine
- Gather ideas and opportunities
- Group ideas using Affinity Diagram

Decide
- Create Impact Ease Matrix for opportunities
- Select top 3 opportunities through Multivoting
Combine: Affinity Diagram

Category 1
- Idea 1
- Idea 2
- Idea 3

Category 2
- Idea 4
- Idea 5
- Idea 6
- Idea 7

Category 3
- Idea 8
- Idea 9
- Idea 10
- Idea 11

BRAINSTORMING

GROUP

Walk Solve
Walk Process

**Prepare**
- Business Case
- Scope and location
- Schedule
- Team Members and Approvals

**Event**
- Conduct Event

**Combine**
- Gather ideas and opportunities
- Group ideas using Affinity Diagram

**Decide**
- Create Impact Ease Matrix for opportunities
- Select top 3 opportunities through Multivoting

Planning Worksheet
Event Process
Affinity Diagram
Impact Ease Matrix
Multivoting
Decide: Impact Ease Matrix

1. Turn down water temp on part wash machine
2. Dry sweep implementation
3. Water flow in bathroom sinks
4. Drip irrigation in landscaping
5. Reuse water in stress testing equipment
6. Water flow in toilets
7. Part wash machine pipe insulation
8. Water pipe leak fixed
9. Upgrade chiller
10. Plug water pipe at end of each shift
Decide: Multivoting (3-5 dots each)

1. Turn down water temp on part wash machine
2. Dry sweep implementation
3. Water flow in bathroom sinks
4. Drip irrigation in landscaping
5. Reuse water in stress testing equipment
6. Water flow in toilets
7. Part wash machine pipe insulation
8. Water pipe leak fixed
9. Upgrade chiller
10. Plug water pipe at end of each shift
5 Why’s

• *Why are we using so much water?*
  The parts need to be cleaned before painting

• *Why do the parts need to be cleaned?*
  The parts fail quality checks if they aren’t cleaned before being painted

• *Why do the parts fail quality checks?*
  The paint doesn’t adhere when part surfaces are not prepared properly

• *Why do the surfaces of the part need to be prepared?*
  The surfaces get contaminated with oils used in the previous process

• *Why are oils used in the previous process?*
  The oils are used to prevent corrosion during storage

**Solution:** Protect parts during storage to prevent corrosion

---


[http://www2.epa.gov/lean/lean-water-toolkit](http://www2.epa.gov/lean/lean-water-toolkit)
Next Steps

• The top 3 ideas will be planned out and executed within 90 days using:
  • More detailed data collection
  • Benchmarking with other facilities
  • Problem Solving Process to get to root cause of behavior or cause of problem
  • Cost benefit analysis for management approval
  • Focused lean event to implement solution
Can’t get commitment?

• Conduct walk with 1-2 people to help convince management that it will be worth the effort

  • **Energy**: Take pictures or record what is left on and running after hours

  • **Solid Waste**: Take pictures inside a few trash bins to show what shouldn’t be there
Summary of W.A.S.T.E. Walks

• Simple and effective approach to find “low-hanging fruit” savings opportunities

• “Going to the gemba” (Go and See) is the best practice for process improvement

• Teaching and engaging employees in the work area will lead to both short and long term benefits

• Limits team to only 3 ideas to pursue and 90 days to maintain focus
Which one are you going to do?

WATER

AIR

SOLIDS

TOXINS

ENERGY

Dumpster Dive

Energy Walk
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2 Second Lean Videos

• Example: Recycling Bin (3 mins)
  • https://www.youtube.com/watch?v=6qhE4WicKoI
Rapid Improvement (Kaizen) Events
Kaizen Events

• A one-week (3-5 days) improvement workshop aimed at overhauling a core work process

• 3 major benefits of events
  • **INTENSITY** - Compressed time frame ensures continuity and efficiency
  • **IMMEDIACY** - Implementation is more immediate with daily leader updates
  • **IMPORTANCE** - Best candidate is a costly, complex, delay-ridden process

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<td>Finish mapping current process</td>
<td>Design new process</td>
<td>Review and refine changes</td>
<td>Present results and changes</td>
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<td>Develop ideas for improvement</td>
<td>Calculate measurable impact</td>
<td>Develop implementation plans</td>
<td>Schedule follow-ups</td>
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http://lean.ohio.gov
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5-S*

- **Sort** – identify needed from not needed
- **Straighten** – mark where things should go
- **Shine** – clean area and equipment, remove dirt sources
- **Stick to It** – create and adhere to cleaning activities
- **Sustain** – maintain it every day as way of life, improve & innovate
- **Safety?** – some companies include this as a 6th “S”, others assume it is embedded

Ex: Chemical storage, Ergo improvements, tool storage, PPE equipment, etc

* From [VisualWorkplace.com](http://VisualWorkplace.com)
5S Success Story

- City of Irving Texas Water Utilities (10 mins)
  - [https://www.youtube.com/watch?v=GtAVsAMqEc0](https://www.youtube.com/watch?v=GtAVsAMqEc0)
What is 5S Yellow-Tagging?

• Yellow-tagging is a simple strategy used to:
  • Identify environmental wastes and items that may be harmful to human health or the environment in the work area
  • Evaluate the need for these items
  • Evaluate potential alternatives for these items
  • Address them appropriately
  • This is a supplement to red-tagging--key differences include the scope of projects, criteria used, and options for disposal or reuse
Green Your 5S event

10 Tips for Greening Your 5S Workplace Organization Event

1) Include ES&H representatives
Invite a representative from your Environment, Safety, and Health (ES&H) organization (or an expert on waste that you know) to participate in the event, or have them check-in frequently if they can't attend the entire time. They are the experts on procedures and regulations that need to be followed, and can share best practices from other parts of the company.

2) Use safe cleaning supplies
Make sure you use natural or environmentally friendly cleaning supplies and products, that have little to no volatile organic compounds (VOC) emissions. Especially during an event, there are a lot of people cleaning all at the same time, which is probably more than normal. If alternative chemicals are not available, make sure gloves and masks are worn. Encourage your cleaning crew or maintenance to use these safer products as well during their regular cleaning.

3) Avoid disposable towels and wipes
Use old rags and cloth wipes, that can be cleaned and reused, instead of paper towels and cleaning wipes, that will end up in the landfill.

4) Isolate the trash before removal
Set the trash aside in its own designated area, don’t just put it in a dumpster and get rid of it. This staging area offers others (not directly involved in the event) a chance to see what is going to be removed, so they can make a case for why it should be saved, or put into storage. There are many horror stories of 5S events throwing out very important items, because the right people weren’t involved in the decision making.

In addition, we recommend taking the time to perform a waste audit on the trash, to understand where the items came from, how to avoid them in the future, and decide if there are other options to deal with them besides sending to the landfill. Make sure all recyclable items have been removed. We recommend using the following waste pyramid diagram to help you evaluate what can be done (note that disposal into the landfill is the last option).

5) Use eco-friendly tape to outline and mark off designated areas
For everything to have its place, tape is used often to mark areas, around desks, equipment, storage, walkways, and keep-out areas.

6) Implement a yellow tag system
Yellow tagging is similar to red tagging (identifying items that need to be removed from the area), but they are used to help identify items that may be harmful to human health or the environment in the work area, that may require further investigation. Items such as a smelly whiteboard marker, a toxic or dangerous cleaning chemical for a machine, or a chemical that requires protective equipment (gloves and masks) when handling. Perhaps the item can be reduced or removed completely. Maybe there is an alternative option. Ask your ES&H representative, the supplier of the item, or other departments or companies how they deal with similar concerns.

7) Laminate documents and papers
To avoid re-printing and using extra paper, consider laminating frequently used papers and documents to protect from damage, and reuse at a later time. Examples include: red tags (ready for disposal), yellow tags (hazardous items), 5S checklist, labels, and signs.

8) Use light and low-toxic paints
When putting on a fresh coat of paint on walls and floors, use low-toxic and low VOC emission paint suppliers, and select white or a light colors, which can help save lighting and energy costs.

9) Ask around before ordering new
Before ordering new shelving or storage containers, ask other areas or departments if they have something that will do the job. As a last resort, if you need to order something brand new, consider products that are made from recycled content. We recommend creating a very simple device from scrap paper or material, to make sure it will do the job, before spending money on a permanent solution.

10) Mark and properly label waste streams
Use different colored containers for hazardous waste, recycling, and other non-hazardous wastes to make sure differences are obvious to everyone who comes into the area. Mark aerosol cans with colored dots to indicate where to dispose of them when empty.
Batching vs Single Piece Flow

• Stuffing Envelope simulation (12 mins)
  • https://www.youtube.com/watch?v=Dr67i5SdXiM
Single Piece Flow

• The opposite of single piece flow is batching
• Batching = process more than one item at a time
• If you process 5 documents at a time, then you are slowing down the process for the customer for items 1 through 4
• This seems counterintuitive, but optimizing the time for an individual can cause delays for your customer
• Strive to work on items as they are requested
• Usually the time to setup takes too long, so intuitive to batch work
  • Focus should be to reduce setup time, to make it easier to achieve single piece flow
Single Piece Flow (cont’d)

• For office processes, think about completing a task **fully** before moving to something else
  • What does “complete” mean to your customer?
• Partial work not completed is inventory
• The longer it sits, the more “stale” the information becomes, and the less value it has to your customer
• You have spent company time and money working on something that is not evident to your customer
  • Emails, reports, analysis, brochure, invoice, quote, etc
## LSS Tools vs Phase

<table>
<thead>
<tr>
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<th>Project</th>
</tr>
</thead>
</table>
Visual controls

- Can someone tell what the status of your work area is quickly? Are we on track? Behind? Ahead?
- Where are the problems? They must be made visible, so we can resolve them.
- How can someone unfamiliar with the process quickly determine what is wrong?
- What information do you need to know and what do you need to share?
Football Game Recycling

- Handouts posted on recycling containers and given to game day volunteers

![Recycling Program Diagram](image-url)
## QDIP Visual Controls

### Safety
- No missed days
- No injuries

### Quality
- Less than 5 defects per day
- DPMO less than 50
- Test Yield greater than 95%

### Delivery
- 100% on-time to customers, schedule, next process, etc
- Complete 10 units per day

### Inventory
- WIP less than 10 units
- No more than 3 pieces at each station
- WIP less than $10,000

### Productivity
- $/hr greater than $150
- Less than 10 minutes of downtime
- Team met daily takt time goals

### Environment
- All equipment shut off at end of shift
- No recyclables in trash
- 100% Hazardous waste adherence

---

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| •No missed days
•No injuries | •Less than 5 defects per day
•DPMO less than 50
•Test Yield greater than 95% | •100% on-time to customers, schedule, next process, etc
•Complete 10 units per day | •WIP less than 10 units
•No more than 3 pieces at each station
•WIP less than $10,000 | •$/hr greater than $150
•Less than 10 minutes of downtime
•Team met daily takt time goals | •All equipment shut off at end of shift
•No recyclables in trash
•100% Hazardous waste adherence |
Change Management

- Influencer Model
- Need at least 4 of the elements covered

<table>
<thead>
<tr>
<th>Personal</th>
<th>Motivation</th>
<th>Ability</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Make the Undesirable Desirable</td>
<td>Surpass Your Limits</td>
</tr>
<tr>
<td>2</td>
<td>Align to job performance</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Harness Peer Pressure</td>
<td>Find Strength in Numbers</td>
</tr>
<tr>
<td>4</td>
<td>Design Rewards and Demand Accountability</td>
<td>Change the Environment</td>
</tr>
<tr>
<td>5</td>
<td>Behavior modeled by leaders</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Hold each other accountable</td>
<td>Physical barriers removed</td>
</tr>
</tbody>
</table>

Rapid Sustain
Behavior Change

• Hand washing video (7 mins)
  • http://www.youtube.com/watch?v=osUwukXSd0k
# LSS Tools vs Phase

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- VA vs NVA | - Impact Matrix  
- 5 Lean Principles  
- 8 wastes  
- Check Sheets / Data  
- Pictograms | - Statements  
- Standards  
- 8D/PDMA/A3  
- Common vs Special | - VSM  
- SIPOC  
- OEE  
- Boundary Map | - Baseline Analysis  
- Is / Is Not |
| **Solve** | - WASTE Walks (water, energy, solids)  
- Brainstorming  
- Affinity Diagram  
- Impact Ease Matrix  
- Multivoting  
- 5 Why’s | - 5S  
- Process Mapping  
- Current-Ideal-Future  
- Single Piece Flow  
- Takt Time  
- Standard Work  
- Cellular Layout  
- Rapid experimentation  
- TOC  
- Facilitation  
- Mistake proofing | - Pareto Charts  
- AAA  
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- Multi Vari Studies  
- Pivot Tables  
- FMEA  
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- SMED  
- Event Types  
- 3P and Biomimicry | - MSA  
- Capability  
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- Hypothesis Testing  
- Prioritization Matrix  
- Monte Carlo Simulation  
- Design for Six Sigma |
| **Sustain** | - Track Results  
- Earth Belt  
- Video | - Visual Controls (SQDC, Andon)  
- Personal Lean  
- Change Mgmt | - Long term results  
- TPM  
- Green Belt | - Process Mgmt  
- Comm. Board  
- Cross Training Matrix | - SPC  
- Hard vs Soft Savings  
- Black Belt |
Identifying Risk

1. Brainstorming
2. Walk the process (physically or virtually)
3. Cause and Effect Diagram
4. “Why won’t this work?” discussion
5. Discuss with Subject Matter Experts (SMEs)
6. Review past projects
7. Formal FMEA

FMEA

• Risk assessment based on 3 criteria
  • **Severity** – what happens if a failure occurs
  • **Occurrence** – how often the failure might occur
  • **Detection** – how likely will the failure be caught

• Each is rated on 1-10 scale (higher the rating, the bigger the risk)

• Multiply all 3 risks together to calculate **Risk Priority Number (RPN)**

\[
\text{Severity} \times \text{Occurrence} \times \text{Detection} = \text{RPN}
\]
## FMEA

<table>
<thead>
<tr>
<th>Process Input</th>
<th>Potential Failure Mode</th>
<th>Effects</th>
<th>Severity</th>
<th>Class</th>
<th>Causes</th>
<th>Occurrence</th>
<th>Current Process Controls</th>
<th>Detection</th>
<th>RPN</th>
<th>Recommended Action(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sunlight</td>
<td>Too Much</td>
<td>poor charging</td>
<td>7</td>
<td></td>
<td>Old worn-out panel</td>
<td>2</td>
<td>date</td>
<td>3</td>
<td>42</td>
<td>Check age of panel and warranty period.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Too Little</td>
<td>poor charging</td>
<td>7</td>
<td>debris / dust</td>
<td>5</td>
<td>none</td>
<td>6</td>
<td></td>
<td>210</td>
<td></td>
<td>O&amp;M manual should recommend to clean surface of panel every morning.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>solar panel angle and/or position</td>
<td>4</td>
<td>Initial setup</td>
<td>112</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intermittent</td>
<td>poor charging</td>
<td>cloudy conditions</td>
<td>0</td>
<td></td>
<td></td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrupted</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>no charging</td>
<td>blocked</td>
<td>0</td>
<td></td>
<td></td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>no charging</td>
<td>night</td>
<td>0</td>
<td></td>
<td></td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>no charging</td>
<td>stolen</td>
<td>2</td>
<td></td>
<td>none</td>
<td>8</td>
<td>128</td>
<td>Mount securely in hard to reach location with security</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Enhanced FMEA

- Include environmental risks into Severity rankings

<table>
<thead>
<tr>
<th>Rank</th>
<th>Severity Level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>Catastrophic I</td>
<td>A failure results in the major injury or death of personnel.</td>
</tr>
<tr>
<td>7–9</td>
<td>Critical II</td>
<td>A failure results in minor injury to personnel, personnel exposure to harmful chemicals or radiation, a fire or a release of chemicals into the environment.</td>
</tr>
<tr>
<td>4–6</td>
<td>Major III</td>
<td>A failure results in a low level exposure to personnel, or activates facility alarm system.</td>
</tr>
<tr>
<td>1–3</td>
<td>Minor IV</td>
<td>A failure results in minor system damage but does not cause injury to personnel, allow any kind of exposure to operational or service personnel or allow any release of chemicals into environment.</td>
</tr>
</tbody>
</table>

Do you currently track process changes?

- New containers from supplier
- Chemical handling training for new employees
- New gloves
- Re-training completed
- Training not effective?

Timeline Analysis

Chemical Spills

PS
Solve
Value Stream Mapping (VSM)
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Lean Principles

Value

Perfection

Value Stream

Pull

Flow
Value Stream Mapping (VSM)

• Visual means to depict and improve the flow of processes, as well as the information that controls the flow of materials and information through the process
• Starts from customer request for product or service, to delivery of item back to customer
• Developed in an event format, usually 3-5 days with a cross-functional team
Traditional VSM

INFORMATION FLOW

MATERIAL FLOW

DATA BOXES

TIMELINE

http://www.greensuppliers.gov/tech/tools.html?id=lean_clean
Traditional VSM with Water Data

http://www2.epa.gov/lean/lean-water-toolkit
Water VSM using water not timeline

http://www2.epa.gov/sites/production/files/2015-06/documents/module_3_vsm.pdf
VSM tie to Process Maps

- Breaks VSM process boxes into specific process steps
- Helps Lean teams see how the current process works and locate waste
## SIPOC – Community Recycling

<table>
<thead>
<tr>
<th>Supplier</th>
<th>Inputs</th>
<th>Process</th>
<th>Outputs</th>
<th>Customer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grocery store</td>
<td>Food and drinks</td>
<td>Purchase Items</td>
<td>Trash</td>
<td>Landfill</td>
</tr>
<tr>
<td>Department store</td>
<td>Gifts</td>
<td>Remove from packaging</td>
<td>Recycled Materials</td>
<td>Residents</td>
</tr>
<tr>
<td>Farmer’s Market</td>
<td>Household items</td>
<td>Sort out waste into bins</td>
<td>Compost Dirt</td>
<td>Community</td>
</tr>
<tr>
<td>Gas station</td>
<td>Tools</td>
<td>Bins collected</td>
<td>Greenhouse Gas Emissions</td>
<td></td>
</tr>
<tr>
<td>Department store</td>
<td>City website</td>
<td>Contents dropped off to correct location</td>
<td>Lechete</td>
<td></td>
</tr>
<tr>
<td>Restaurant</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>City Officials</td>
<td></td>
<td></td>
<td></td>
<td></td>
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Make sure Earth is included as a Customer!
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Kanban cards (Animation)

No more than 6 of this part number can be in Assembly

No more than 4 of this part number can be in Test

No more than 3 of this part number can be in Shipping

View in slide show mode, click to animate
Tea runs out!

Take card from last remaining box

Card goes to employee who orders tea, card placed in box when it arrives

## Event Types

<table>
<thead>
<tr>
<th>Phase</th>
<th>Walk</th>
<th>Rapid</th>
<th>Problem Solving</th>
<th>VSM</th>
<th>Project</th>
</tr>
</thead>
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<td>See</td>
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<td>- 5 Lean Principles</td>
<td>- Standards</td>
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<td></td>
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<td></td>
<td></td>
<td>- Pictograms</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Solve</td>
<td>- WASTE Walks</td>
<td>- 5S</td>
<td>- Pareto Charts</td>
<td>- Supermarkets</td>
<td>- MSA</td>
</tr>
<tr>
<td></td>
<td>(water, energy, solids)</td>
<td>- Process Mapping</td>
<td>- AAA</td>
<td>- Kanban</td>
<td>- Capability</td>
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<td></td>
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<td></td>
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<td>- Multi Vari</td>
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<td>- Track Results</td>
<td>- Visual Controls (SQDC,</td>
<td>- Long term</td>
<td>- Process Mgmt</td>
<td>- SPC</td>
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<tr>
<td></td>
<td>- Earth Belt</td>
<td>- Andon)</td>
<td>results</td>
<td>- Comm. Board</td>
<td>- Hard vs Soft Savings</td>
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<td>- Personal Lean</td>
<td>- TPM</td>
<td>- Cross Training</td>
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<td></td>
<td></td>
<td>- Change Mgmt</td>
<td>- Green Belt</td>
<td>Matrix</td>
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MSA: Variable Gage R&R

• Purpose of study: to validate that the KWH results coming from either power meter or electrician (measurement process) will not add excessive variation into the data
  • 2 electricians/power meters
  • 3 repeat readings
  • 10 different items

• Only thing that should vary are the 10 different items
  • no variation from meters, repeats, or electricians
Variable Gage R&R

- Electrical Fluke meter results – No difference

Comparison of Meters - KWH

- 400Hz generator
- boiler
- Liebert
- PNLF31
- PNLF31A
- PUMP4
- salt pot
- water pump cap
- water pump line side
- west comp

Project Solve
Gage R&R Summary Charts

Gage R&R (ANOVA) for KWH

Gage name: Date of study:

Only 2% of variation coming from measurement system, which is excellent!
Capability

• pH level for waste water discharge

Problem: If we don’t make a change, we have a 4% risk of pH being below 5.5
Regression

• Regression analysis is widely used for prediction and forecasting, to understand relationships among the independent variables (inputs) are related to the dependent variable (output).

What variables affect KWH usage?

Project Solve
Let’s try Average High Temp per Month

The regression equation is

\[ \text{KWH Usage} = 141885 + 6047 \text{ Avg High Temp} \]

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Coef</th>
<th>SE Coef</th>
<th>T</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>141885</td>
<td>130237</td>
<td>1.09</td>
<td>0.285</td>
</tr>
<tr>
<td>Avg High Temp</td>
<td>6047</td>
<td>1570</td>
<td>3.85</td>
<td>0.001</td>
</tr>
</tbody>
</table>

\[ S = 52069.1 \quad \text{R-Sq} = 34.6\% \quad \text{R-Sq(adj)} = 32.3\% \]

Good, but we can do better...
Add Employee Count and Spares Output

The regression equation is

\[ \text{KWH Usage} = -740670 + 6500 \text{ Avg High Temp} - 33.6 \text{ Spares Output Qty} + 647 \text{ Employees} \]

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<thead>
<tr>
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<th>T</th>
<th>P</th>
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</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-740670</td>
<td>145555</td>
<td>-5.09</td>
<td>0.000</td>
</tr>
<tr>
<td>Avg High Temp</td>
<td>6499.6</td>
<td>944.8</td>
<td>6.88</td>
<td>0.000</td>
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<tr>
<td>Spares Output Qty</td>
<td>-33.56</td>
<td>11.17</td>
<td>-3.00</td>
<td>0.006</td>
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<tr>
<td>Employees</td>
<td>646.71</td>
<td>91.93</td>
<td>7.03</td>
<td>0.000</td>
</tr>
</tbody>
</table>

\[ S = 31255.4 \quad R-Sq = 78.1\% \quad R-Sq(adj) = 75.6\% \]

Much more accurate...how would you address these?
Solar Panel DOE

Glass

EVA or AS

Silicon Cells

EVA or AS

PVF

Project  Solve
## Solar Panel Factors

<table>
<thead>
<tr>
<th>Factors</th>
<th>Low Setting</th>
<th>High Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glass</td>
<td>PV</td>
<td>PVAR</td>
</tr>
<tr>
<td>Glass Thickness (mm)</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Adhesive Type</td>
<td>EVA</td>
<td>AS</td>
</tr>
<tr>
<td>Adhesive Thickness (in)</td>
<td>0.02</td>
<td>0.04</td>
</tr>
</tbody>
</table>

Output: Which settings generated the highest amount of efficiency?
## Full Factorial

<table>
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<th>Adhesive Thickness</th>
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<tr>
<td>PV</td>
<td>2</td>
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<td>0.02</td>
</tr>
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DOE Results

Pareto Chart of the Effects
(response is Efficiency, $\alpha = 0.05$)

Factor Name
A Glass
B Glass Thickness
C Adhesive
D Adhesive Thickness

Main Effects Plot for Efficiency
Fitted Means

Mean of Efficiency

Lenth's PSE = 0.391922
## LSS Tools vs Phase

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Run Charts

Water Usage on Weekends

What about the baseload of 40,000 when no one is working?

What happened on this weekend 2/26/11 and 2/27/11? Can we do that every weekend?
Statistical Process Control (SPC)

• SPC is the application of statistical methods to identify and control the special cause of variation in a process

• SPC is a preventative tool to:
  • Assess the consistency of a process
  • Monitor a process to determine when it has changed
  • Reduce variation in a process
Process Stability – Control Charts

- pH level for waste water discharge

Helps separate common cause variation from special cause variation
Tips to Green Your Lean Event

Handouts and facilitation materials

- Capture notes using computer and overhead projector, instead of writing on flip charts and easel pads
- If you need to write on paper pads, use static cling reusable easel pads instead of large post-it notepads and flip chart paper to reduce paper consumption
- Order Pocket-size Notes made from recycled paper, instead of those produced from new trees
- Email files and handouts to attendees before event, so they can review on their computer, and avoid printing the files.
- If you must print paper for handouts, consider the following (tips provided by Harvard):
  - Print on paper with recycled content (100% ideal)
  - Print only what you need before each day, as things change and may not be needed
  - Print double-sided to reduce paper usage
  - Reduce font sizes, margins and line spacing to reduce paper (while making sure it is still legible)
  - Use print preview options to make sure you don’t print pages that are not usable
  - Use soy-based ink to minimize chemicals and toxins
  - Print black and white instead of color, to reduce ink usage

- Conducting a 5S event? Read our guide for greening these types of events.
- Explain the “green” benefits you have integrated into the event on the first day

Room Selection

- Select a meeting location with natural light to reduce lighting (electricity)
- Select a room with updated temperature controls and newer HVAC equipment to reduce energy consumption
- Select a room with energy-efficient lighting (CFL and LEDs) to reduce electricity usage
- Select a location that minimizes the distance traveled for attendees
- Encourage attendees to carpool, walk, bike or take public transportation to the event in order to minimize vehicle emissions and gasoline usage
- Make sure lights and projectors are turned off when not in use

Food and drinks

- Cater food to avoid having participants leave the event and drive to get food, which also takes longer to get everyone back and started in the event
- Provide healthy snacks in bulk to reduce packaging, instead of individually packaged items, and to keep the energy level high during the event (not a sugar “crash”)
- When selecting food options, consider the following:
  - Choose local food catering options, to minimize “food miles” and support the local economy
  - Offer organic food options to minimize fertilizers and chemical usage
  - Offer meat-free (vegetarian) options to reduce the environmental impact of raising livestock
  - Offer buffet-style catering to minimize packaging from individual serving options
  - If you order individual packaged items, select options with compostable or recycled packaging to minimize trash to the landfill

- Provide a water cooler for people to refill their water bottles, instead of ordering bottled water, which reduces plastic bottles made from oil
- Provide real silverware and plates instead of disposable and flimsy plastic silverware and styrofoam plates
- Provide cloth napkins to reduce trash, or napkins made from recycled paper
- Provide recycling containers in the room for bottles, cans, cardboard and paper
- Provide a compost bin for leftover food

Business Performance Improvement - Contact us at http://www.biz-q.com
Open Topics
## Want more details?

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Summary
Sustainability and Lean Six Sigma

Strategy

- Focus improvement efforts specifically on social and environmental metrics
- Relate environmental and social issues to core business needs and priorities (money, risk, reputation, etc)
- All process improvements naturally reduce impact on the environment, so start capturing the benefits!
- Share this presentation with Facilities, ES&H and LSS personnel

Tools

- Add Earth as a customer on your SIPOC
- Add environmental usage and costs to data boxes on VSM
- Add environmental impacts to 7 forms of waste definitions
- Integrate environmental checklists into event templates
Resources
Books

[Image of book covers]
Websites

• US Environmental Protection Agency (EPA) Toolkits
• Lean Six Sigma for the Environment Blog
Next Steps
What are you going to do next?
Contact Information

Brion Hurley
Principal Lean Six Sigma Consultant
Wilsonville, Oregon (Portland)
503-404-7064
brion.hurley@rockwellcollins.com

Connect with me on LinkedIn
Backup
Why are companies “going green”?

**Financial**
- Reduced energy, waste and materials (reduced costs)
- Decision making focused on lifecycle costs
- Drives long term strategic planning
- Incentives and rebates

**Employees**
- More motivated, engaged and inspired workforce
- Retention and acquisition of employees

**Risks and Legal**
- Regulatory compliance (proactive and reactive)
- Reduce future risks to revenue and expenses

**Customers and Sales**
- Opening up new markets
- More loyal customers
- Product differentiation and innovation
- Managing competitors and industry perceptions
- Customer or stakeholder request

These were not the original intent, side benefit of green efforts