In 2004, Dr. Jeffrey Liker, a University of Michigan professor of industrial engineering, published *The Toyota Way*. In his book Liker calls the Toyota Way "a system designed to provide the tools for people to continually improve their work." The system can be summarized in 14 principles.
Using Six-Sigma to Correlate the Toyota 14 Principles to the USA 3 Principles

In tonight's presentation I will convince you to go beyond “pull systems” and embrace the other 13 Toyota Principles.

And if I do a good job tonight, you will say “oh, they make widgets its the same as construction”

Using Six-Sigma to measure the positive impact that “Lean” has to offer in project delivery

The presentation covers 13 modules and can best be described as a “sampler plate”, I am available by phone to fill in any blanks that I leave!

My challenge tonight is to take two different industries and demonstrate to you that the processes and building blocks (except for the each industries slang language) are the same!

I will also discuss “should we continue to self certify”?
1. The construction industry has adopted the Toyota Production System (TPS) as its model to deploy “Lean Construction”.

2. The construction industry, spearheaded by LCI has focused on the “vital few” of the 14 Toyota principles, namely “Pull Systems”.

3. I am here tonight to talk, “Observations”, “Measurement” and “Standards” that you might adopt for your quality journey!

4. I will present my point of view in 13 modules, starting out by showing a correlation between manufacturing / CQI terms.

5. My intent today is to suggest by example that you use “statistical thinking”, that means using metrics & analysis to assist you in managing your projects as an additive to the experience of past projects.

6. By using “statistical thinking” you can analyze potential issues at a macro level (30,000 ft) very early in the project life cycle, getting more bang for the buck.

7. I will present to you a case study that was completed utilizing the design & build (D&B) delivery method and measured with Six-Sigma.

8. I will discuss with you the manufacturing industries (SME) Lean certificate program, and later I will discuss 4 of the 20 tools that I use in my work.

9. I will conclude describing how Six-Sigma performance measures/metric will demonstrate to your customers that you are “Lean”.

---

**AGENDA**

**PART-1, LEAN IN MANUFACTURING & CONSTRUCTION**

- MOD-01 THE EVOLUTION OF QUALITY WITHIN MANUFACTURING
- MOD-02 (TOYOTA) DIAL-A-CAR vs (CONSTRUCTION) STATIC LINE ASSEMBLY & CONSTRUCTION
- MOD-03 THE EVOLUTION OF LEAN / SIX SIGMA
- MOD-04 14 PRINCIPLES OF THE TOYOTA WAY

---

**ROSETTA STONE DISCOVERED IN 1799 IN EGYPT**

- GREEK (CONSTRUCTION) TERMS
- HIEROGLYPHICS (QUALITY / MANUFACTURING) TERMS

---

Tonight I will try to be the Rosetta Stone between (Construction & Manufacturing).
**AGENDA**

**PART-1, LEAN IN MANUFACTURING & CONSTRUCTION**
- MOD-01_THE EVOLUTION OF QUALITY WITHIN MANUFACTURING
- MOD-02_MOD-02_(TOYOTA) DIAL-A-CAR vs (CONSTRUCTION) STATIC LINE ASSEMBLY & CONSTRUCTION
- MOD-03_THE EVOLUTION OF LEAN / SIX SIGMA
- MOD-04_14 PRINCIPLES OF THE TOYOTA WAY
- MOD-05_POINT & INDUSTRY COUNTERPOINT
- MOD-06_WHAT OTHERS ARE DOING:THE S.M.E. LEAN MANUFACTURING CERTIFICATE PROGRAM-121 BODIES OF KNOWLEDGE
- MOD-07_QUALITY CERTIFICATES THAT DENOTE “LEAN” TO YOUR CUSTOMERS
- BREAK

**PART-2, SIX-SIGMA IN MANUFACTURING & CONSTRUCTION**
- MOD-08_HOW CAN SIX SIGMA (THE METRIC) BE USED AND ADAPTED TO CONSTRUCTION.
- MOD-09 THE COST OF PRECISION vs ACCURACY
- MOD-10_TOYOTA PRINCIPLE #6, STANDARDIZED TASKS ARE THE FOUNDATION OF C.Q.I.
- MOD-11_I PREPARED A DESIGN & BUILD CONSTRUCTION CASE STUDY FOR THE SIX-SIGMA INSTITUTE, I WILL DISCUSS THE RESULTS.
- MOD-12_MEANS & METHODS _ONE PIECE FLOW REMOVES (MUDA)
- MOD-13_4 QUALITY TOOLS TO FIND SOLUTIONS (MACRO LEVEL PLANNING)
- PLUS / DELTA

---

**POINT “A”**

**#1-Long-term Philosophy**

**#9,#10 & #11**
Value to Organization by developing people

**#3, Pull Systems**

**POINT “B”**

Dr. Joseph Juran, working in the US in the 1930s and 40s recognized a universal 80/30 rule he called the “vital few and trivial many” and reduced it to writing.
The Evolution of Quality within Manufacturing

In 2004, Dr. Jeffrey Liker, a University of Michigan professor of industrial engineering, published The Toyota Way. In his book Liker calls the Toyota Way "a system designed to provide the tools for people to continually improve their work." The system can be summarized in 14 principles.
NOTICE THAT 80% OF THE FATHERS OF QUALITY ARE STATISTICIANS & 20% ARE MANUFACTURERS

DR DEMINGS CONTRIBUTION TO JAPAN

1950-DEMING TEACHES SPC TO JAPAN

1965-TOYOTA WINS DEMING APPLICATION PRIZE

In 1960, the Prime Minister of Japan (Nobusuke Kishi), acting on behalf of Emperor Hirohito, awarded Deming Japan’s Order of the Sacred Treasure, Second Class.

The citation on the medal recognizes Deming’s contributions to Japan’s industrial rebirth and its worldwide success.
Vilfredo Pareto

In 1906, Italian economist Vilfredo Pareto created a mathematical formula to describe the unequal distribution of wealth in his country, observing that twenty percent of the people owned eighty percent of the wealth.

Where Vital Few & Trivial Many came from?

Dr. Joseph Juran, working in the US in the 1930s and 40s recognized a universal principle he called the "vital few and trivial many" and reduced it to writing.

As a result, Dr. Juran's observation of the "vital few and trivial many", the principle that 20 percent of something always are responsible for 80 percent of the results, became known as Pareto's Principle or the 80/20 Rule.

THERE ARE ONLY 4 "LOGIC" TYPES IN SCHEDULING!

CONSTRUCTION IS A "STATIC LINE"
There are only 3 types of assembly lines in manufacturing:

1. Dial-a-Car Production Line
2. Manufacturing (3) Building Blocks
3. Construction is a "Static Line"

Remember—think building blocks, don’t let throughput, cost ($), or volume deter you.
THE "DIAL-A-CAR" CONCEPT DROVE SINGLE PIECE FLOW

IN MODULE 02-A I WILL DISCUSS "DIAL-A-CAR" AND THEN SHOW AN IDEALIZED MANUFACTURING FLOW,

"DIAL-A-CAR" CONCEPT DROVE SINGLE PIECE FLOW!
"DIAL-A-CAR"
THE ORDER IS THE VOICE
OF THE CUSTOMER

THE "CAR ORDER" IS THE
VOICE OF THE CUSTOMER
MANUFACTURING FROM THE “ORDER” TO THE SINGLE PIECE FLOW

IN MODULE 02-B I WILL SHOW AN IDEALIZED MANUFACTURING FLOW,
Bucket Shops Ship—Receive—Warehouse

Hogging Machines = (Rough-In)

Finishing Machines = (Finishes)

Cellular Manufacturing

Machining Shops or Centers:

In machining centers parts move between “single purpose” operations and returned to stores after each operation.

One operator runs 3 machine tools (eliminates “dwell” time) where operator is idle.

Cellular Manufacturing:

In cellular manuf parts move between “single purpose” operations and move to the next operation without going to stores.
CELLULAR MANUFACTURING

MACHINING CENTER

SUB-ASSEMBLY, ASSEMBLY

MANUFACTURING

SUB-ASSEMBLY ASSEMBLY:

HEAVY ASSEMBLIES ARE "STATIC STANDS" AND PARTS MOVE TO THE SUB-ASSEMBLY, BASICALLY A HAND DONE ASSEMBLY, NOT GOOD FOR LARGE THROUGHPUT ASSEMBLIES

SUB-ASSEMBLY, ASSEMBLY

BUCKET SHOPS SHIP

BUCKET SHOPS BUFFER STORE OR JIT SHIP

MACHINING CENTER

BUCKET SHOPS BUFFER STORE OR JIT SHIP

PULL SYSTEMS

CELLULAR MANUFACTURING

BUCKET SHOPS_SHIP-RECEIVE-WAREHOUSE

SUB-ASSEMBLY, ASSEMBLY

MANUFACTURING
This says it all!
FLYING SQUADS PROTECT THE LINE AND RESTART THE LINE WHEN POSSIBLE

FIXING LINE STOPPAGE:
FLYING SQUADS SPOTTED THROUGHOUT A PLANT, RESPOND LIKE PARA-MEDICS TO AN INCIDENT!

DIAL-A-CAR VS MOD-02C

CONSTRUCTION IS A “STATIC LINE”

IN MODULE 02-C I WILL DISCUSS “CONSTRUCTION” IN AN IDEALIZED FLOW TO DEMONSTRATE THE SIMILARITY TO MANUFACTURING
"STATIC LINE" CONSTRUCTION IN THE FIELD HAS NOT ADOPTED GATELINE, CELLULAR OR PRODUCTION LINE CONCEPTS.
In 2004, Dr. Jeffrey Liker, a University of Michigan professor of industrial engineering, published The Toyota Way. In his book Liker calls the Toyota Way "a system designed to provide the tools for people to continually improve their work." The system can be summarized in 14 principles.
The Toyota Way is a set of principles and behaviors that underlie the Toyota Motor Corporation's managerial approach and production system.

Toyota first summed up its philosophy, values and manufacturing ideals in 2001, calling it "The Toyota Way 2001". It consists of principles in two key areas: continuous improvement, and respect for people.
Guiding Principles at Toyota

Honor the language and spirit of the law of every nation and undertake open and fair business activities to be a good corporate citizen of the world.

Respect the culture and customs of every nation and contribute to economic and social development through corporate activities in their respective communities.

Dedicate our business to providing clean and safe products and to enhancing the quality of life everywhere through all of our activities.

Create and develop advanced technologies and provide outstanding products and services that fulfill the needs of customers worldwide.

Foster a corporate culture that enhances both individual creativity and the value of teamwork, while honoring mutual trust and respect between labor and management. Pursue growth through harmony with the global community via innovative management.

Work with business partners in research and manufacture to achieve stable, long-term growth and mutual benefits, while keeping ourselves open to new partnerships.

Established in 1992, revised in 1997. (Translation from original Japanese)

The Toyota Way is a set of principles and behaviors that underlie the Toyota Motor Corporation's managerial approach and production system.

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14 PRINCIPLES OF THE TOYOTA WAY

In 2004, Dr. Jeffrey Liker, a University of Michigan professor of industrial engineering, published The Toyota Way. In his book Liker calls the Toyota Way "a system designed to provide the tools for people to continually improve their work." The system can be summarized in 14 principles.
14 PRINCIPLES OF THE TOYOTA WAY

**Long-term philosophy**

Principle 1. Base your management decisions on a long-term philosophy, even at the expense of short-term financial goals.

**Right process will produce right results**

Principle 2. Create continuous process flow to bring problems to the surface.

Principle 3. Use pull systems to avoid overproduction.

Principle 4. Level out the workload (heijunka).

(Work like the tortoise, not the hare.)

Principle 5. Build a culture of stopping to fix problems, to get quality right the first time.

Principle 6. Standardized tasks are the foundation for continuous improvement and employee empowerment.

Principle 7. Use visual control so no problems are hidden.

Principle 8. Use only reliable, thoroughly tested technology that serves your people and processes.

In 2004, Dr. Jeffrey Liker, a University of Michigan professor of industrial engineering, published *The Toyota Way*. In his book Liker calls the Toyota Way "a system designed to provide the tools for people to continually improve their work." The system can be summarized in 14 principles.

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**Value to organization by developing people**

Principle 9. Grow leaders who thoroughly understand the work, live the philosophy, and teach it to others.

Principle 10. Develop exceptional people and teams who follow your companys philosophy.

Principle 11. Respect your extended network of partners and suppliers by challenging them and helping them improve.

**Solving root problems drives organizational learning**

Principle 12. Go and see for yourself to thoroughly understand the situation (genchi genbutsu).

Principle 13. Make decisions slowly by consensus, thoroughly considering all options; implement decisions rapidly (nemawashi).

Principle 14. Become a learning organization through relentless reflection (hansei) and continuous improvement (kaizen).

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DO YOU A&E / GC’s “WALK YOUR TALK”?

WILL A&E & GC FLOW DOWN IPD D&B, PPP TYPE CONTRACTS TO THEIR SUB-CONTRACTORS?

AS OWNERS FLOW DOWN IPD, D&B & PPT TO A&E / GC
In 2004, Dr. Jeffrey Liker, a University of Michigan professor of industrial engineering, published *The Toyota Way*. In his book Liker calls the Toyota Way "a system designed to provide the tools for people to continually improve their work." The system can be summarized in 14 principles.
CONTINUOUS QUALITY IMPROVEMENTS (CQI) LIKE ISO-9001 WILL NOT BUBBLE UP FROM THE BOTTOM.

THE CONSTRUCTION COMPANIES NEED TO BE CONVINCED THAT (CQI) IS A CUSTOMER DEMAND AND THAT IT WILL IMPROVE THEIR BOTTOM LINE.

- MANY A&E, CM’s AND CG’s IN THE MIDDLE-WEST HAVE ISO-9001 CERTIFICATION, FORD QI CERTIFICATION, LET’S NOT BE OBVIOUS BY OUR ABSENCE, SHOULD CUSTOMERS DEMAND DEMONSTRATED CQI.

What Others are doing: The S.M.E., LEAN Manufacturing Certificate Program

121 bodies of knowledge
THE LEAN ALLIANCE

Consider using the S.M.E. Alliance Criteria as a "Pick List", and let the "Voice of Your Customer" (VOC) & the "Vital Few" select the requirements / criteria.

The Society of Manufacturing Engineers (SME), is the world’s leading professional society supporting manufacturing education. SME influences more than half a million manufacturing engineers and executives annually. The Society has members in 70 countries and is supported by a network of hundreds of chapters worldwide. www.sme.org

The Association for Manufacturing Excellence (AME), founded in 1985, is the premier organization for the exchange of knowledge in enterprise excellence. AME members come together to explore Lean thinking and other enterprise improvement methods, exchange best practices, and network in order to advance their careers and improve the performance of their organizations. AME sponsors the annual International Lean Conference and publishes the award winning Target magazine. www.ame.org

The Shingo Prize, was established in 1988 to promote awareness of lean concepts and to recognize companies that achieve world-class operational excellence status around the globe. The Shingo Prize philosophy is that world-class business performance is achieved through a deep understanding and integration of lean principles, lean systems of management, and the wise application of lean tools and techniques to create a sustainable culture of continuous improvement. www.shingoprize.org

American Society for Quality (ASQ), has been the world’s leading authority on quality for more than 60 years. With more than 85,000 individual and organizational members, the professional association advances learning, quality improvement and knowledge exchange to improve business results and to create better workplaces and communities worldwide. As a champion of the quality movement, ASQ offers technologies, concepts, tools and training to quality professionals, quality practitioners and everyday consumers. www.asq.org

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Society of Manufacturing Engineers

THE LEAN ALLIANCE IN MANUFACTURING IS BIG!

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• CONSIDER USING THE SME ALLIANCE CRITERIA AS A “PICK LIST”, AND LET THE “VOICE OF YOUR CUSTOMER” (VOC) SELECT THE REQUIREMENTS / CRITERIA

Lean Certification Body of Knowledge

(Version 3.0, December 2008)

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Society of Manufacturing Engineers

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Lean Certification 121 Body of Knowledge

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<td>3. Cultural Enabler Techniques and Practices</td>
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<td>3. Continuous Process Improvement Technique &amp; Practice</td>
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<td>3. Consistent Enterprise Culture Techniques &amp; Practices</td>
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<td>2. Measurement Systems</td>
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<tr>
<td>3. Key Lean related measures</td>
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121 BOK

SIX-SIGMA AS A MEASURE IS A BUSINESS METRIC!
### WHAT DOES A SME-LEAN BRONZE CANDIDATE NEED TO KNOW?

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<thead>
<tr>
<th>Event</th>
<th>Description</th>
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<tbody>
<tr>
<td>L1</td>
<td>Factory, Office and Service</td>
</tr>
<tr>
<td>L2</td>
<td>Team Facilitation</td>
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<td>L3</td>
<td>Project Management</td>
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<td>L4</td>
<td>Appropriate Measurement of Results</td>
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<td>L5</td>
<td>Activities where the work happens</td>
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<td>L6</td>
<td>Cause and Corrective Actions</td>
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<td>L7</td>
<td>Cellular Layout/Concepts</td>
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<td>L8</td>
<td>Flow</td>
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<td>L9</td>
<td>Jidoka</td>
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<td>L10</td>
<td>Mistake Proofing</td>
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<td>L11</td>
<td>Problem solving</td>
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<td>L12</td>
<td>Pull/Kanban</td>
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<td>SMED</td>
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<td>Standard Work</td>
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<td>L15</td>
<td>Tactical results measurement</td>
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<td>L16</td>
<td>Takt time/customer demand</td>
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<td>Value</td>
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<td>Visual Management</td>
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<td>L21</td>
<td>Waste</td>
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<td>L22</td>
<td>Gap analysis</td>
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<tr>
<td>L23</td>
<td>Team dynamics</td>
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<tr>
<td>L24</td>
<td>Planning methods/control methods</td>
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</tbody>
</table>

### WHAT DOES A SME-LEAN SILVER CANDIDATE NEED TO KNOW?

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<tr>
<td>S2</td>
<td>Analyzing and understanding organizational dynamics</td>
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<tr>
<td>S3</td>
<td>Applying lean tools at a tactical level and integrating the tools into a value stream</td>
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<tr>
<td>S4</td>
<td>Awareness of external assessment vehicles</td>
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<td>S5</td>
<td>Benchmarking</td>
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<tr>
<td>S6</td>
<td>Cell development, implementation and integration</td>
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<td>S7</td>
<td>Creating basic pull relationships for beginning and ending of the value stream</td>
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<tr>
<td>S8</td>
<td>Creating Lean financial models for their value stream</td>
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<td>S9</td>
<td>Creating, managing and tracking improvement results within a value stream</td>
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<td>S10</td>
<td>Effective communication</td>
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<td>S11</td>
<td>Employee/supplier/customer involvement and empowerment</td>
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<td>S12</td>
<td>Environment/Sustainability within the value stream</td>
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<tr>
<td>S13</td>
<td>Establishing information flows</td>
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<tr>
<td>S14</td>
<td>Evaluating human capabilities, identifying skill gaps and developing multi-skilled people</td>
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<tr>
<td>S15</td>
<td>Influencing the organization to align with and support the value stream</td>
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<tr>
<td>S16</td>
<td>Lean in Administration/Transactional</td>
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<tr>
<td>S17</td>
<td>Leveling</td>
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<td>S18</td>
<td>Managing for daily improvement</td>
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<tr>
<td>S19</td>
<td>Mentoring others on the lean journey</td>
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<td>S20</td>
<td>Planning lean workshops and events</td>
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<tr>
<td>S21</td>
<td>Point of use: material and information</td>
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<tr>
<td>S22</td>
<td>Selecting, organizing and leading multiple cross-functional teams</td>
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<tr>
<td>S23</td>
<td>Value stream mapping and analysis</td>
</tr>
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Bulls Eye Charts, the Best tool to use to evaluate how to deploy a Quality Process/Manual.

DIFFICULTY and IMPORTANCE, there is no template for determining DIFFICULTY and IMPORTANCE.

It's for a Company to determine based on the Voice of their Customer (internal & external)!

Their culture!

Let's not forget the benefit to the bottom line!

Principle 7. Use visual control so no problems are hidden.

HOW IN THE WORLD DID I GET FROM SME's 12 PRINCIPLES (POINT "A") TO POINT "B"?
Principle 7. Use visual control so no problems are hidden.

How can the “BULLS-EYE” Charts help to know what Certificate to go after?

- Manufacturing is very “VISUAL” industry
- (Bulls Eye charting, Visual Control Boards etc.)
- Construction should follow suite.

* MOST IMPORTANT & LEAST DIFFICULT TO DO IS THE PLACE TO BE!
FOCUS ON THE “VITAL FEW”

- The Pareto effect or Pareto’s law: a small proportion of causes produce a large proportion of results.

- It is this phrase that is most commonly used in talking about the Pareto effect – “the vital few and the trivial many”

**USING DIFFICULTY / IMPORTANCE TO FIND “LOW HANGING FRUIT”, GETS THERE QUICKLY**

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<thead>
<tr>
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<tbody>
<tr>
<td>L3 Project Management</td>
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<tr>
<td>L7 Cellular Layout/Concepts</td>
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<td>L6 Flow</td>
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<tr>
<td>L11 Problem solving</td>
<td>3</td>
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<td>L12 Purchasing</td>
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<tr>
<td>L13 Out of stock</td>
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<td>L14 Quality</td>
<td>1</td>
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<tr>
<td>L21 Waste</td>
<td>6</td>
</tr>
<tr>
<td>L24 Planning methods/Control methods</td>
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<td>TOTAL</td>
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<tr>
<td>L7 Cellular Layout/Concepts</td>
<td>9</td>
</tr>
<tr>
<td>L6 Flow</td>
<td>9</td>
</tr>
<tr>
<td>L11 Problem solving</td>
<td>3</td>
</tr>
<tr>
<td>L12 Purchasing</td>
<td>9</td>
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<tr>
<td>L13 Out of stock</td>
<td>3</td>
</tr>
<tr>
<td>L14 Quality</td>
<td>1</td>
</tr>
<tr>
<td>L15 HED</td>
<td>3</td>
</tr>
<tr>
<td>L19 SPC</td>
<td>1</td>
</tr>
<tr>
<td>L21 Waste</td>
<td>6</td>
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<tr>
<td>L24 Planning methods/Control methods</td>
<td>6</td>
</tr>
<tr>
<td>TOTAL</td>
<td>100</td>
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</tbody>
</table>

**EVERY COMPANY HAS ENABLERS & CONSTRAINTS**

A BENCHMARK & QFD SHOULD BE DONE TO FIND THE “LOW HANGING FRUIT”

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QUALITY FUNCTION DELOYMENT (QFD)

(THE HOUSE OF QUALITY)

Module #1-Cultural Enablers

Point “A”

Module #2-Continuous Process Improvement

Module #3-Consistent Lean Enterprise Culture

Module #4-Business Results

Point “B”

SME 12 Principles

SME 12 Principles

SME 12 Principles

SME 12 Principles

SME 12 Principles

SME 12 Principles

SME 12 Principles

SME 12 Principles

SME 12 Principles

How in the world did I get from SME’s 12 Principles (Point “A”) to Point “B”?
Principle 7. Use visual control so no problems are hidden.
Module #1 - Cultural Enablers

SME 12 Principles

Module #3 - Consistent Lean Enterprise Culture

HOW IN THE WORLD DID I GET FROM SME’s 12 PRINCIPLES (POINT “A”) TO POINT “B”?

Module #4 - Business Results

POINT “A”

QFD (5 TIMES)

BULLS EYE CHARTS

POINT “B”

BENCHMARKING

WHAT IS IT?

VOICE OF THE CUSTOMER

CRITICAL SUCCESS FACTORS

WHAT TO BENCHMARK

DATA ANALYSIS

INTERNAL DATA

EXTERNAL DATA

Who Is Best?

ENABLERS

How Do They Do It?

How Do We Do It?

COMPETITION
BENCHMARKING DEFINED

- BENCHMARKING DEFINED BY DAVID KEARNS –XEROX:
  - COMPETITIVE BENCHMARKING IS THE CONTINUOUS PROCESS OF MEASURING OUR PRODUCTS, SERVICES AND PRACTICES AGAINST OUR TOUGHEST COMPETITORS OR THOSE COMPANIES RECOGNIZED AS THE LEADERS:

- IN 1993 MIKE WAS HIRED TO BENCHMARK –NEW PLANT CONSTRUCTION BEST PRACTICES.
- BENCHMARKING CONCLUSIONS WERE PEER REVIEWED AND DEPLOYED

Finding the Quality Membership or Certificate that suites “YOU”

MOD-7D
Finding the Quality Membership or Certificate that suits “YOU”

ISO-9001 is the high water mark of quality standards

ISO-9001, like “Precision vs. Accuracy” it will be discussed later in this presentation?

- TBD
- TBD
- 4 MONTHS
- 2 YEARS
- 1 YEAR
- 2 YEARS

The Principles of Quality Management and ISO 9001

ISO 9001 is based on EIGHT principles of quality management, and these in effect underpin the standard and help to define its purpose and direction. They are:

**Customer focus**
For any forward thinking business concerned about quality improvement, customers and their requirements should dictate much of their strategy. Without customer satisfaction the business will ultimately fail, or at best tread water. Organisations should understand their customers’ needs and strive to meet or even exceed them.

**Leadership**
The strategy, direction and ultimate success of any business is to a great degree dependent upon its leadership. The strategy, direction and ultimate success of any business is to a great degree dependent upon its leadership, along with the environment and even the culture that they encourage within the organisation. A clearly communicated vision and constancy of purpose on the part of management is key to business improvement.

**Involvement of people**
It is an organisation’s people that will actually provide the front line customer service and follow the vision of the leadership, but they need to be encouraged and involved.

**Process approach**
Some businesses are seemingly more process oriented than others (e.g. car manufacturing), however it is possible to see virtually all business activities and resources in terms of process. Managing in this way will enable greater efficiencies through a clearer view of what is happening.

**System approach to management**
Management should view all business activities and interrelated processes as an integrated system. This will then encourage greater efficiency and effectiveness throughout the organisation.

**Continual improvement**
This should be a permanent objective of any organisation that really wishes to succeed and excel within its marketplace. Whatever the organisation does to improve quality and performance should be subject to a continuing cycle of review, and this should result in the further raising of targets and goals to new levels. This is simply necessary to keep ahead of the competition.

**Factual approach to decision making**
Any key decisions made about direction or strategy should be based on sound data that has been gathered via predetermined business measures.

**Mutually beneficial supplier relationships**
Traditionally, smaller firms supplied parts or materials to larger manufacturers to meet a specified order. More however can be derived from this kind of relationship by seeing it instead as an interdependent partnership that provides mutual benefits to both sides.
BREAK
In 2004, Dr. Jeffrey Liker, a University of Michigan professor of industrial engineering, published *The Toyota Way*. In his book Liker calls the Toyota Way "a system designed to provide the tools for people to continually improve their work." The system can be summarized in 14 principles.
SIX SIGMA-AS A METRIC

USE ONE DOLLAR ($) AS ONE DEFECT PER MILLION OPPORTUNITIES

$1.00 = 1 - D.P.M.O.

HOW SIX SIGMA
(THE METRIC PORTION)

WITH A 3.0 SIGMA SHIFT CAN BE ADAPTED
TO CONSTRUCTION

In 2004, Dr. Jeffrey Liker, a University of Michigan professor of industrial
engineering, published The Toyota Way. In his book Liker calls the Toyota Way "a
system designed to provide the tools for people to continually improve their
work." The system can be summarized in 14 principles.
SIX-SIGMA TARGET A-E-P-C

MOTOROLA INVENTED 1.5 SIGMA SHIFT

CONSTRUCTION SHOULD INVENT 3.0 SIGMA SHIFT

The Guide to LEAN ENABLERS for MANAGING ENGINEERING PROGRAMS

Target Sigma for Design services!

Target 4.9 sigma

CONSTRUCTION SHOULD INVENT 3.0 SIGMA SHIFT
Target Sigma for Design services!

Target 4.9 sigma

Target Sigma for Construction

Target 4.5 sigma

COSTS CAN GROW 4 TO 10 TIMES WHEN DEMANDING PRECISION VS ACCURACY

The COST of Precision vs Accuracy
AISC Specification: Code of Standard Practice for Steel Buildings and Bridges

BEFORE USING SIGMA TO MEASURE PERFORMANCE!

LOOK AT WHAT THE CONSTRUCTION INDUSTRY “MARKET” WILL ACCEPT

WE SHOULD CONSIDER A 3.0 SIGMA SHIFT TO ADJUST FOR COMMON AND SPECIAL CAUSE VARIATION)

Column Plumb Criteria

Aircraft “Precision” - a 747 airliner

Construction “Accuracy” - 20 story bldg column

747 Standing on end (20 stories)

1,500 Sold

$250 + million each

2,500 + Built in

HONG KONG

$120 + million each

<>0" INCH

20 STORY BLDG

2" INCHES

GROUND

20 story building

<>0" INCH
Manufacturing “Precision”, a car door

Construction “Accuracy”, a Girder – Beam connection

IMAGINE USING A DRIFT PIN TO ALIGN A CAR DOOR!
In 2004, Dr. Jeffrey Liker, a University of Michigan professor of industrial engineering, published *The Toyota Way*. In his book Liker calls the Toyota Way "a system designed to provide the tools for people to continually improve their work." The system can be summarized in 14 principles.
HOW DO YOU READ SIX SIGMA & BULLS EYE CHARTS TOGETHER

GREEK

SIX SIGMA

SUCCESS %

60% 30% 30%

30% 30% 30%

20% 50% 50%

10% 80% 80%

GREEK

HIEROGLYPHICS

SIGMA

0.2 SIGMA

0.7 SIGMA

1.2 SIGMA

1.3 SIGMA

1.5 SIGMA

1.6 SIGMA

2.0 SIGMA

2.4 SIGMA

3.0 SIGMA

3.6 SIGMA

4.0 SIGMA

CORRELATING P.S. & P.C. (ES) TO SUBSTANTIAL COMPLETION OF PROJECTS

LEAST=0%

MOST=100%

PPC

SUCCESS

SIGMA

1.0

1.3

1.5

1.8

2.0

2.4

2.8

6.0

MONTHS BEHIND

MONTHS AHEAD

DON'T GO HERE!

OK TO BE HERE!

2ND PLACE TO START

WHERE YOU WANT TO BE!
TOYOTA PRINCIPLE #6
STANDARDIZED TASKS ARE THE
FOUADATION OF CQI
READING THE MANUFACTURING
(1.5 SIGMA SHIFT)

HOW DO YOU READ
SIX SIGMA IN MANUFACTURING
(WITH A 1.5 SIGMA SHIFT)

GREEK HIEROGLYPHICS

SUCCESS %

<table>
<thead>
<tr>
<th>SIGMA</th>
<th>SUCCESS %</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.98</td>
<td>90%</td>
</tr>
<tr>
<td>1.5</td>
<td>55%</td>
</tr>
<tr>
<td>2.2</td>
<td>30%</td>
</tr>
<tr>
<td>2.34</td>
<td>10%</td>
</tr>
<tr>
<td>2.78</td>
<td>3%</td>
</tr>
<tr>
<td>6.0</td>
<td>0.3%</td>
</tr>
</tbody>
</table>

0.98 SIGMA=700,000 DPMO
1.5 SIGMA=500,000 DPMO
2.2 SIGMA=300,000 DPMO
2.34 SIGMA=200,000 DPMO
2.78 SIGMA=100,000 DPMO
6.0 SIGMA=3.4 DPMO
In 2004, Dr. Jeffrey Liker, a University of Michigan professor of industrial engineering, published *The Toyota Way*. In his book Liker calls the Toyota Way "a system designed to provide the tools for people to continually improve their work." The system can be summarized in 14 principles.

PEELING THE ONION OF WORK BREAKDOWN STRUCTURE (WBS)

METRIC levels are like ONIONS LAYERS. Each layer is more detailed. The closer to core the more detail. Too many levels and you will cry.
OUR “HOLY GRAIL” HOW TO TRANSFER THE MANUFACTURING CONCEPTS TO CONSTRUCTION

HOGGING MACHINES IN MANUFACTURING = (ROUGH-IN) IN CONSTRUCTION

FINISHING MACHINES = (FINISHES) IN CONSTRUCTION

DON’T FORGET THE SCHEDULING UNIVERSE IS ONLY (FS-FF-SS-SF)
AND SOMEHOW WE ACCEPT, MAINTAIN 1,500 TO 12,000 ACTIVITY SCHEDULES, WHERE 70% OF THE ACTIVITIES ARE THE “TRIVIAL MANY”
ITS IN YOUR POWER TO OBJECT & STOP THIS!

THE “TRIVIAL MANY”:
In 2004, Dr. Jeffrey Liker, a University of Michigan professor of industrial engineering, published *The Toyota Way*. In his book Liker calls the Toyota Way “a system designed to provide the tools for people to continually improve their work.” The system can be summarized in 14 principles.
A Six Sigma Construction Case Study
A Design & Build (D&B) Test Cell
A CASE STUDY

BENCHMARKING & SIX-SIGMA FOR ARCHITECT-ENGINEERING DESIGN SERVICES:

A CASE STUDY

by

Craig R. Smith
Facilities Systems Engineering Corporation

and

Michael F. Vega
AllResearch Los Angeles Division
Allied-Signal Aerospace Company

for Submission to
Motorola University
Six-Sigma Research Institute

November 1991

SIX SIGMA METRICS MUST BE “TAILORED” FOR CONSTRUCTION

TODAY, LEAN & SIX-SIGMA are Institutionalized in Manufacturing
So not much is said!

1991 Data - Design & Build (D&B) Test Cell

TEST CELLS
• DESIGN & BUILD COST $ 9.9 MILLION
• TEST & ENERGIES EQUIPMENT $20.0 MILLION
• SCHEDULE-12 MONTHS CRITERIA & LONG LEAD EQUIP, 24 MONTHS DESIGN & BUILD
The 3 Candidate Design Measurements!

- Measuring using the Construction Specifications:
  - 250 words/pages 1332 pages = 330,000 (Potential DPMO)
- Measuring using the Drawings:
  - 1,200 symbols/valves, etc. X 80 drawings = 96,000
  - 250 word/information, etc. X 80 drawings = 20,000
- Measuring using the Building Code:
  - Building Code = 800 pages
  - Electrical/Mechanical Code = 1,200 pages
  - Local Building Code = 800 pages
  - Total 2,800 pages X 250 words = 700,000

Calculating the Design & Build (D&B) Test Cell Six Sigma

**Design**
- Actual Cost $1,360,000
- Plan check errors $78,000
- Design errors $95,000

**Opportunities**
- 1.5 Sigma Shift: 9,910,000
- 3.0 Sigma Shift: 9,910,000

**Defects**
- 1.5 Sigma Shift: 270,000
- 3.0 Sigma Shift: 2,750

**DPMO**
- 1.5 Sigma Shift: 27,245
- 3.0 Sigma Shift: 277

**Defects (%)**
- 1.5 Sigma Shift: 2.72%
- 3.0 Sigma Shift: 0.03%

**Yield (%)**
- 1.5 Sigma Shift: 97.28%
- 3.0 Sigma Shift: 99.97%

**Process Sigma**
- 1.5 Sigma Shift: 3.423
- 3.0 Sigma Shift: 4.953

**Construction**
- Actual Cost $8,550,000
- Constr errors. $97,000

A DPMO is a project dollar ($), a defect is each dollar ($) of a error or omission.
A Six Sigma Construction Case Study

OTHER CRITERIA & ISSUES TO USE TO MEASURE PERFORMANCE

WHERE DID THE TERM “PUNCH LIST” COME FROM:

The phrase takes its name from the historical process of “punching” a hole in the margin of the document, next to one of the items on the list.

This indicated that the work was completed for that particular construction task.

Two copies of the list were “punched” at the same time to provide an identical record for the architect and contractor.

WE HAVE MADE A INSTITUTION FOR “DEFECTS” TO RESIDE IN!
USING THE "PUNCH LIST" TO MEASURE THE PROJECT SIGMA!

**DURING CONSTRUCTION**

- Determine severity of each item in the current "punchlist" (NC/D) or whatever it's called by you.
- Use 10-6-2-1 to indicate severity. Use these plug numbers to obtain the D.P.M.O:
  - 10=$50,000.00
  - 6=$30,000.00
  - 2=$10,000.00
  - 1=$1,000.00
- Now extend the price the individual D.P.M.O. of each (X) the number of punch list items.
- Then obtain the current pay application and find the current stored in place (minus GC/GR), this becomes your "opportunity".
- Now go to the sigma calculator enter the data.
- Now read your sigma.

**AT SUBSTANTIAL COMPLETION**

- Determine severity of each item in the current "punchlist" (NC/D) or whatever it's called by you.
- Use 10-6-2-1 to indicate severity. Use these plug numbers to obtain the D.P.M.O:
  - 10=$50,000.00
  - 6=$30,000.00
  - 2=$10,000.00
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- Now extend the price the individual D.P.M.O. of each (X) the number of punch list items.
- Then obtain the current pay application and find the current stored in place (minus GC/GR), this becomes your "opportunity".
- Now go to the sigma calculator enter the data.
- Now read your sigma.

FREE SIGMA CALCULATORS ABOUND

<table>
<thead>
<tr>
<th>Sigma Calculator</th>
<th>1.5 Sigma Shift</th>
<th>3.0 Sigma Shift</th>
</tr>
</thead>
<tbody>
<tr>
<td>Opportunities</td>
<td>9,910,000</td>
<td>9,910,000</td>
</tr>
<tr>
<td>Defects</td>
<td>*270,000</td>
<td>2,750</td>
</tr>
<tr>
<td>D.P.M.O.</td>
<td>27,245</td>
<td>277</td>
</tr>
<tr>
<td>Defects (%)</td>
<td>0.03%</td>
<td>0.03%</td>
</tr>
<tr>
<td>Yield (%)</td>
<td>99.97%</td>
<td>99.97%</td>
</tr>
<tr>
<td>Process Sigma</td>
<td>3.42</td>
<td>4.953</td>
</tr>
</tbody>
</table>

© this Sigma 2000-2007
MEANS & METHODS_ONE PIECE
FLOW REMOVES (MUDA)

CONSTRUCTION IS A “STATIC LINE”!

FLYING FORMS, SIMILAR IN MANUFACTURING TO SINGLE MINUTE EXCHANGE OF DIES (SMED)

“FLYING FORMS” ALSO CALLED “GANG FORMS” IS SMED

2.3.7. Countermeasure Activities
• 2.3.7.1. Mistake and Error Proofing (Poka Yoke)
• 2.3.7.2. Quick Changeover/Setup Reduction (SMED)

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THINK PRE-FABRICATION

OUR INDUSTRY IS NOW STARTING TO SPOOL PIPE, "CUBE/MODULARIZE" LOOSE COMPONENTS INTO ONE PIECE EQUIPMENT!

IMPROVE THE SCHEDULE; SKID MOUNT THE FIRE PUMP & PUMP HOUSE

FIRE PUMP MANUFACTURING, WE TRUST, BUT WE VERIFY!

The Fire pump sub-system are fabricated in 5 cities in the USA

The Fire pump sub-system are final assembled & tested in Texas

NO FIREPUMP-NO PERMIT
4 Quality Tools I use to Find Solutions
(MACRO LEVEL PLANNING)

Principle 4: Level out the workload (heijunka). (Work like the tortoise, not the hare.)

Quality Tools
PRIOR ATTEMPTS TO DEPLOY LEAN CONSTRUCTION & SIX-SIGMA
(THE PROCESS)

JURAN SAID.....
• “All quality improvement occurs on a project-by-project basis and in no other way.”
**Quality Tools**

**ISHIKAWA DIAGRAMS**
(also called Fishbone Charts)

1. A CUSTOMER SURVEY OF PLANT ENGINEERING & MAINTENANCE SERVICES WAS PERFORMED!
2. THE DATA WAS REDUCED BY USING THE "FISH BONE" CHARTS
3. IF DONE AGAIN TODAY I’LL BET THE RESPONSES WON’T BE MUCH DIFFERENT, WHAT DO YOU THINK?

---

**Principle 7.** Use visual control so no problems are hidden.
1991 FISHBONE OF CUSTOMER SERVICE SURVEY

HOW CLOSE IS THIS SURVEY TO YOUR SITUATION?

USING SIX-SIGMA TO MEASURE THE POSITIVE IMPACT THAT “LEAN” HAS TO OFFER IN PROJECT DELIVERY

Michael Vega, PE / CPE
LCI San Diego,
Community of Practices (CoP)
January 16, 2014

NOTICE: THE CHARTS, ISSUES & POINTS OF VIEW PRESENTED ARE MINE ALONE

Plus/Delta