

# Application of New Ergonomic Tools and Methods to Lean, Ergonomics and Six Sigma (LESS)

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# Objective & Agenda of Workshop

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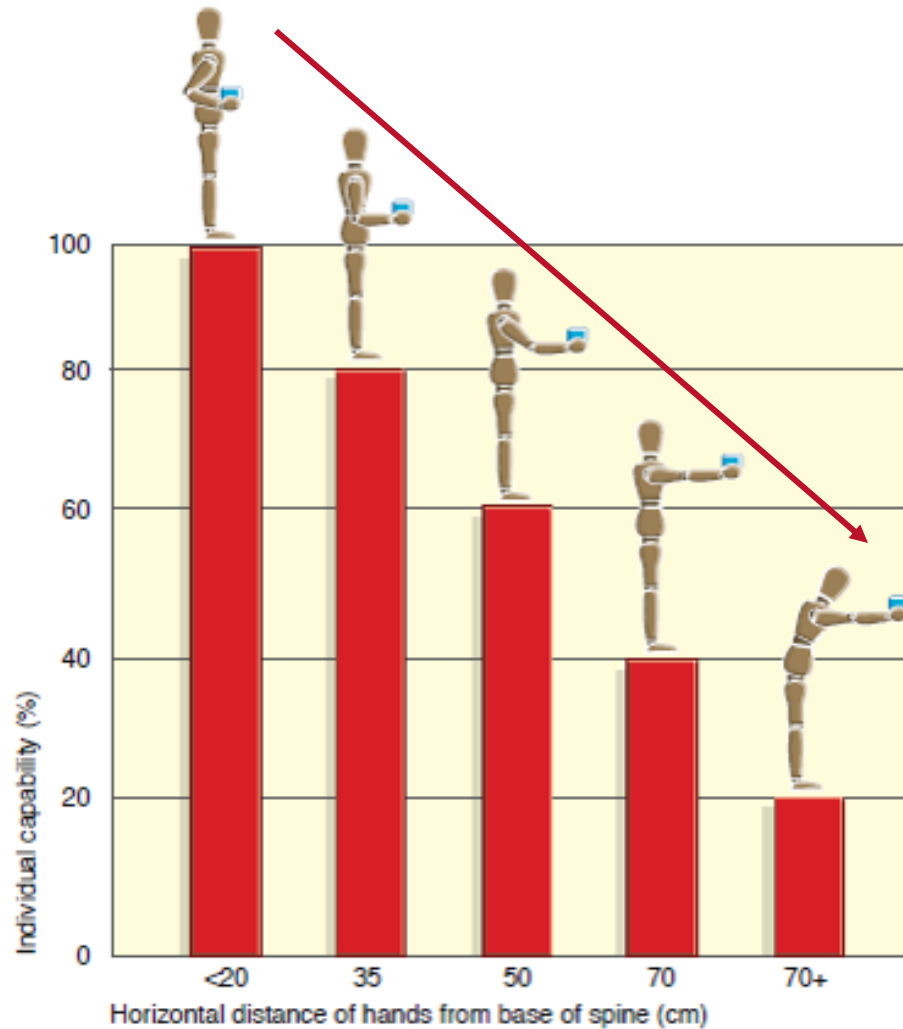
- Present some new tools and methods specifically designed to integrate ergonomics into Lean Six Sigma systems
  - Tools and methods to quantify risk, measure human performance, determine the impact of solutions, and demonstrate return-on-investment.
- Operational Human Excellence
  - Lean Manufacturing, Six Sigma, Risk Management, & How Ergonomics fits into it all

# Evolution of Ergonomics

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- Ramazinni
- Industrial Revolution
  - Agricultural Vs. Mfg based society
    - Frederick Taylor, Henry Ford, F. & J. Gilberth
- Human Factors Engineering / Applied Research
- OSHA & Injuries
- What about internal Productivity?
  - Doing the same or more amount of work with less effort and within the confines of the human musculoskeletal, physiological and psychological systems.

# Internal Productivity



**80% reduction in lifting capacity as horizontal distance increases**

# Boardroom Wants Vs. Safety

- Company Goals:
  - Improve efficiency of operations
  - Reduce defects related to the quality of products
  - Introduction of new products/services quicker to market
  - Basically – how to do what we do better, faster and cheaper
- Problem – What do employees want?

# Operational Human Excellence

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## Future State of Ergonomics

- Facts and data must drive the process
- Align with board room objectives and demonstrate impact ergonomics has on company goals:
  - Better, Faster, Cheaper and Safer
- Calculate the actual “Value to Operational Human Excellence” to create “pull” not “push

# Lean

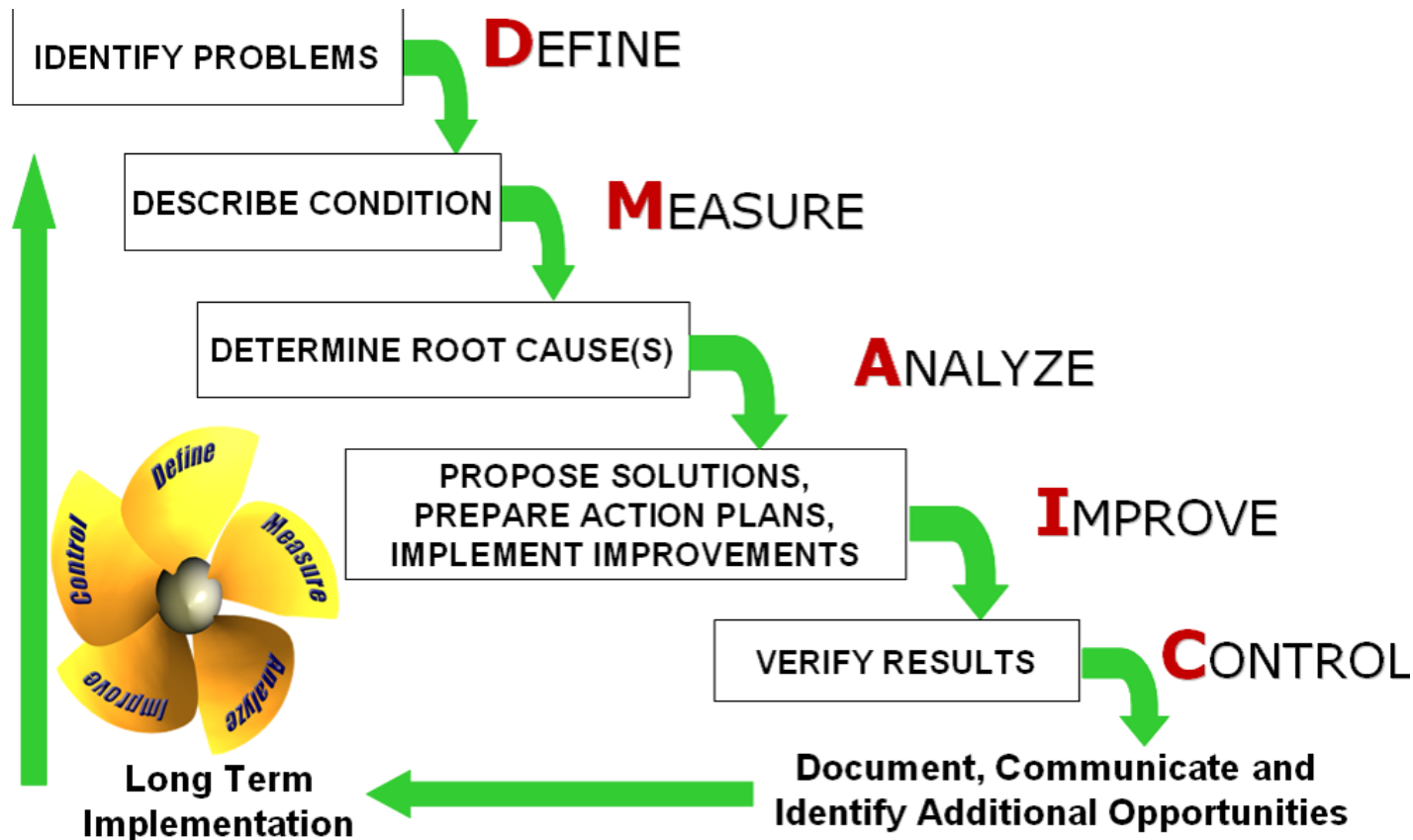
## Eliminating “waste or wasteful activities”



Waste of Motion impacts external & internal productivity  
How do you find “Waste” related to hidden human performance issues?

# Six Sigma

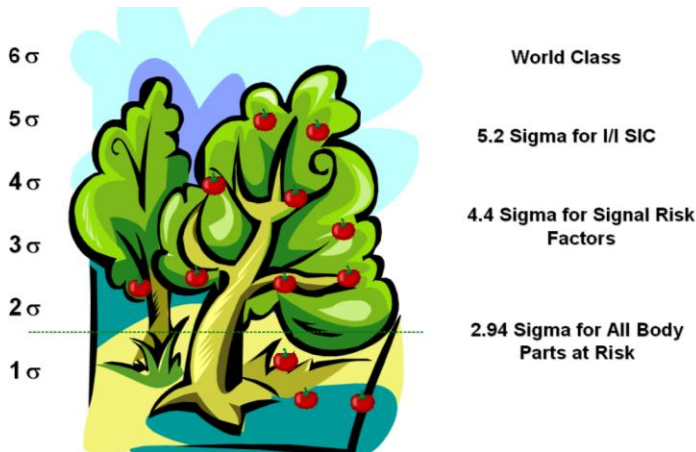
Uses a robust process known as DMAIC





# Where Do People Fit Into LSS?

- People are biggest source of quality, productivity, variation and cost.
- Minimizing NVA waste/overburden related to people, and creating consistent/ repeatable processes we can improve production, quality, reduce costs and improve health & safety.



**Are You Really World Class in Ergonomics & Human Performance?**

# Lean Ergonomic Six Sigma Tools

## Control, Sustain, & Scale Solutions

Best Practices – FORM

Training & Standard Work Instructions

Design Guidelines

Ergo DFM/DFA/DFLSS

Control Plan & Charts

## Define The Issues

Current Injury Data (injuries, costs, rates)

Employee Comments/Feedback

Production & Quality Issues

## Improve Process & Verify Results

Solution Impact Chart

Action Plan

Rapid Prototyping

Test & Evaluation

## Measure The Problem (Baseline)

Pareto Analysis of Injuries

B&W of Cycle Time Variation

Ergo Value Stream Map (Risk Map)

Task Analysis – VA, NVA

Link Analysis/Spaghetti Diagram

**Ergo Risk Assessment – REBAR**

Process Capability

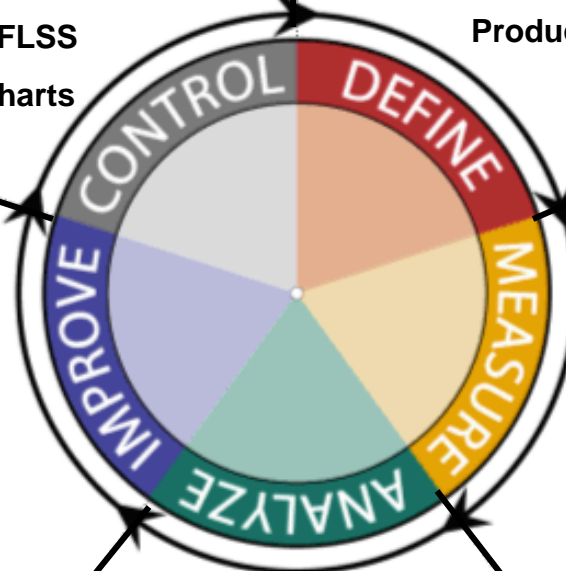
## Analyze Solutions

**Ergo Fishbone**

Brainstorm/Opportunity List

**Impact Analysis – PICK Chart, REBAR, PIPE**

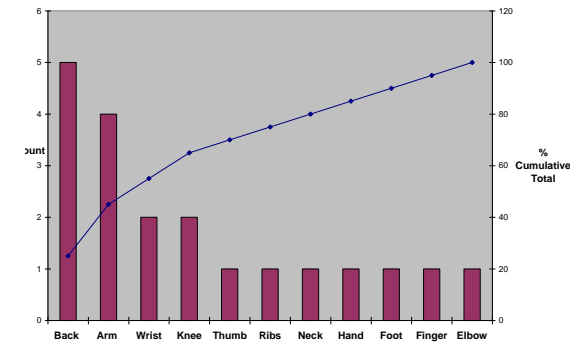
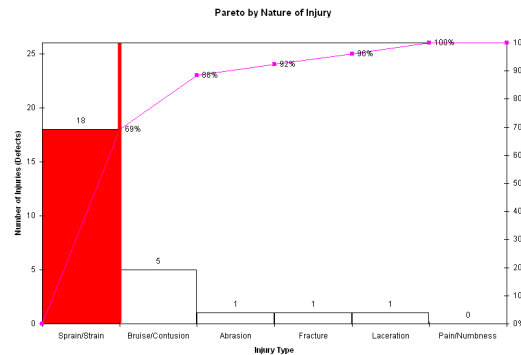
Solution Matrices



# Define & Measure Problem



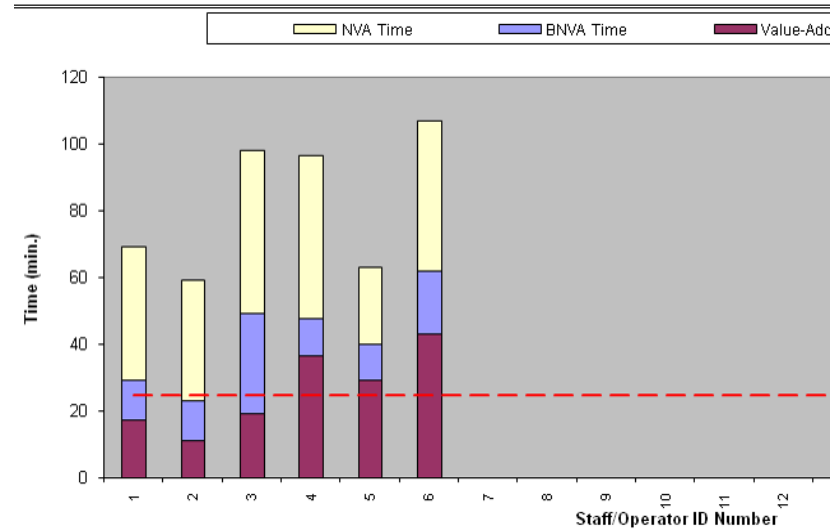
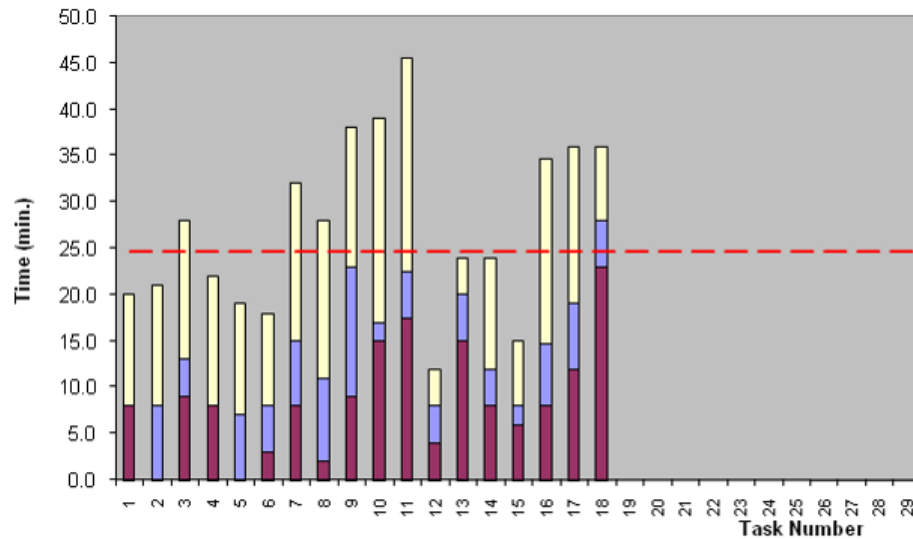
## Define



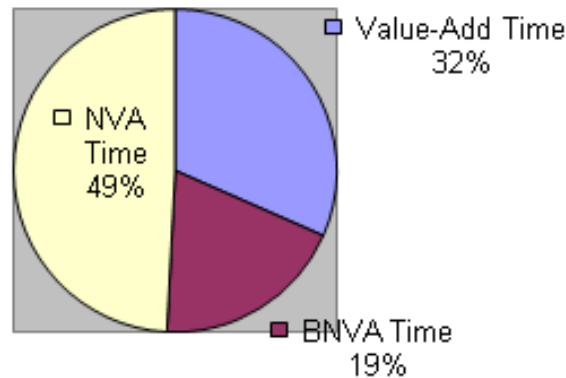
## Measure

| REBAR Scores                                   | Left Wrist | Right Wrist | Left Elbow | Right Elbow | Left Shoulder | Right Shoulder | Back | Neck | Legs |
|--|------------|-------------|------------|-------------|---------------|----------------|------|------|------|
| <b>P10 Preservation Technicians / Painters</b> |            |             |            |             |               |                |      |      |      |
| AB AL False Decking                            | 43 ▶       | 43 ▶        | 40 ▶       | 40 ▶        | 43 ▶          | 43 ▶           | 20   | 40 ▶ | 40 ▶ |
| Lube Oil Tank Prep                             | 53 ▶       | 53 ▶        | 53 ▶       | 53 ▶        | 57 ▶          | 57 ▶           | 20   | 47 ▶ | 27 ▶ |
| Tanks 5-78 2F & 1F – Grinding                  | 53 ▶       | 53 ▶        | 53 ▶       | 53 ▶        | 57 ▶          | 57 ▶           | 28 ▶ | 53 ▶ | 40 ▶ |
| Engine Room 1 – Prep for Paint                 | 53 ▶       | 53 ▶        | 53 ▶       | 53 ▶        | 50 ▶          | 50 ▶           | 36 ▶ | 47 ▶ | 40 ▶ |
| Engine Room 1 – Hot Work Rapid Response        | 30 ▶       | 30 ▶        | 23         | 27 ▶        | 20            | 33 ▶           | 22   | 40 ▶ | 27 ▶ |

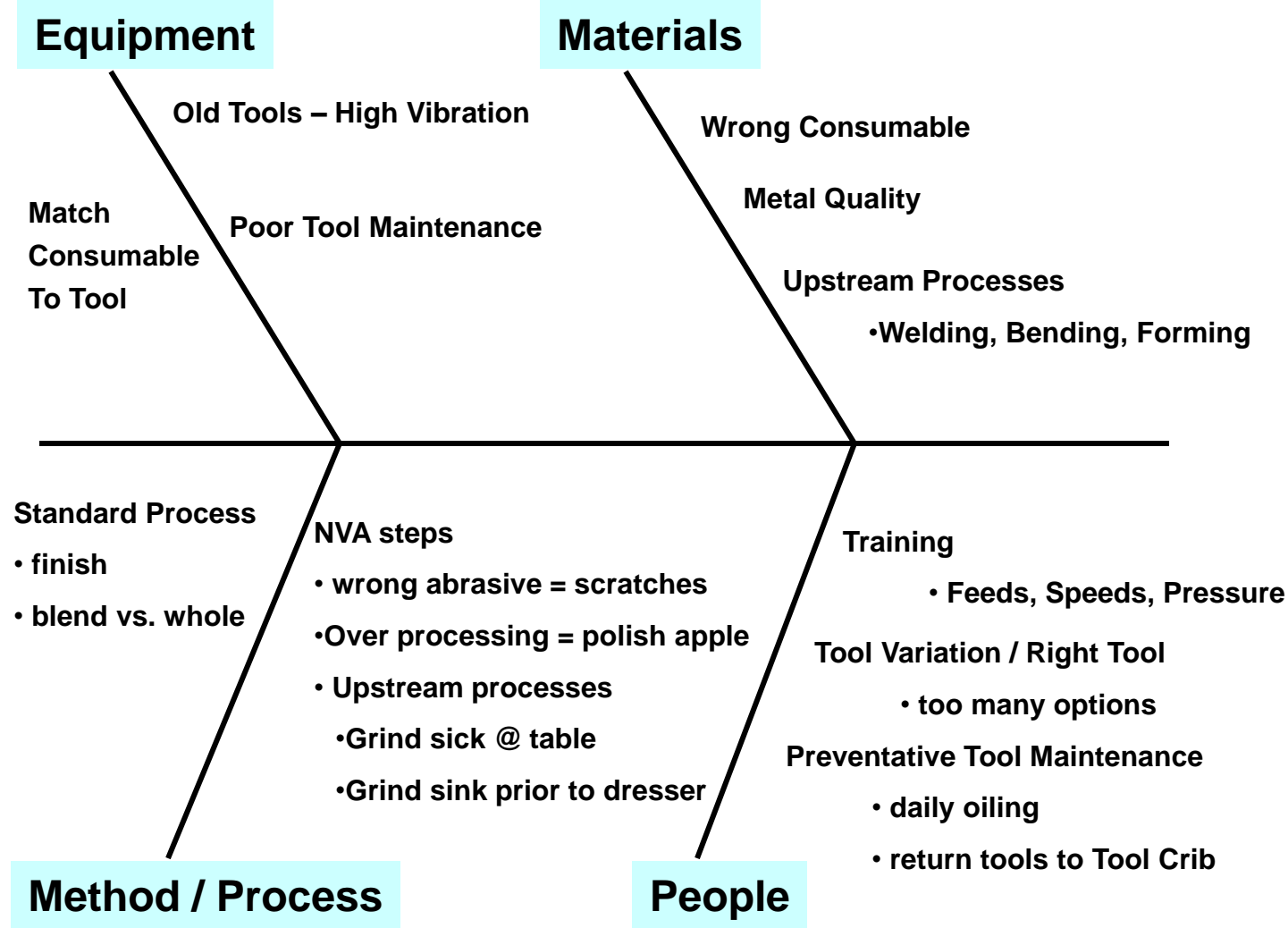
# Measure – Task Analysis VA vs. NVA



Legend for charts: NVA Time (yellow), BNVA Time (blue), Value-Add (dark red)



# Analysis - Fishbone Diagram



# Analysis - Impact Prioritization

Solutions prioritized based on lean metrics, ergo impact, cost, resources, operational efficiency

Improvements Impact on Lean Metrics

| # | Recommendation  | Improvements Impact on Lean Metrics |                         |                             |                        | Ergonomic Risk | Motion Impact (seconds) |
|---|---|-------------------------------------|-------------------------|-----------------------------|------------------------|----------------|-------------------------|
|   |   | 40% Floor Space Reduction           | 20% Increase Efficiency | 25% Reduction in Cycle Time | 50% Reduction in Scrap |                |                         |
| 1 | Quick Connectors Fixture beside folding fixture                       |                                     | ■                       | ■                           |                        | ■              | 3.96                    |
| 2 | Have inspection operator coil Flextome into fixture                   | ■                                   | ■                       | ■                           |                        | ■              | 0.72                    |
| 3 | In coil aside Flextome to next operation                              | ■                                   | ■                       | ■                           |                        | ■              | 1.8                     |
| 4 | Move joy stick controller to be within 9" of fixture on the left side |                                     | ●                       | ●                           |                        | ●              | 0.72                    |
| 5 | Mount air gun and use foot pedal to activate                          |                                     | ●                       | ●                           |                        | ●              | 3.72                    |

| Definitions:                               |   |
|--|---|
| <b>COST</b>                                |   |
| Low cost < \$500                           | ● |
| Moderate cost \$500 - \$3,000              | ● |
| High cost \$3,000+                         | ● |
| <b>DIFFICULTY TO IMPLEMENT</b>             |   |
| Easy to Implement - Quick or off the shelf | ■ |
| Moderate - Lean process                    | ■ |
| Difficult - VIP process/validation         | ■ |

| Solutions  | Impacts |      |           |            |           |                |
|--|---------|------|-----------|------------|-----------|----------------|
|  | Ergo    | Cost | Resources | Efficiency | Row Total | Weight Ranking |
| Weighting  | 0.4     | 0.3  | 0.15      | 0.15       | 1.0       |                |
| PEE  |         |      |           |            |           |                |
| Anti-vibratory Gloves                                | 1       | 3    | 4         | 0          | 3         | 1.9            |
| Grip Gloves  | 1       | 3    | 4         | 0          | 3         | 1.9            |
| Work Practice  |         |      |           |            |           |                |
| Keep Work Inside                                     | 1       |      |           |            |           |                |
| Administrative                                       |         |      |           |            |           |                |
| HAV Program  |         |      |           |            |           |                |
| Task Rotation  | 1       | 4    | 3         | 1          | 5         | 2.2            |
| Right Tool Right Job                                 | 1       | 4    | 3         | 2          | 6         | 2.35           |
| Tool Training  | 1       | 4    | 4         | 1          | 4         | 2.35           |
| Daily Tool Maintenance                               | 1       | 4    | 4         | 2          | 5         | 2.5            |
| Grand TO Spec / specific instructions on daily tasks | 1       | 4    | 4         | 2          | 5         | 2.5            |
| Behavior Based Training                              | 1       | 4    | 4         | 1          | 4         | 2.35           |
| Simple Equipment                                     |         |      |           |            |           |                |
| Swivels & quick disconnects                          | 1       | 3    | 4         | 1          | 5         | 2.05           |
| Hand Tools   |         |      |           |            |           |                |
| Ergo Tools   | 2       | 2    | 3         | 2          | 7         | 2.15           |
| Tool Maintenance - PM                                | 2       | 4    | 3         | 2          | 7         | 2.75           |
| Custom Equipment                                     |         |      |           |            |           |                |
| Grinding Carts/Tool Extensions                       | 3       | 3    | 2         | 3          | 11        | 2.85           |
| Double Grinding                                      | 3       | 2.5  | 2         | 3          | 9         | 2.7            |
| Mechanized Grinding                                  | 4       | 2    | 2         | 4          | 14        | 3.1            |
| Tool Monopod   | 3       | 2    | 2         | 2          | 11        | 2.4            |
| Tool Balancers                                       | 1       | 2    | 3         | 2          | 8         | 1.75           |
| Foot Pedal for Man Lift                              | 2       | 2    | 3         | 1          | 7         | 2.0            |
| Design/Process                                       |         |      |           |            |           |                |
| Upstream Processes                                   | 2       | 3    | 2         | 3          | 10        | 2.45           |
| Grinding Reduction Team                              | 2       | 3    | 2         | 3          | 10        | 2.45           |
| DFA/DFM, Lean Six Sigma                              | 2       | 3    | 2         | 3          | 10        | 2.45           |

Low = 1, Mod = 2, High Mod = 3, High = 4



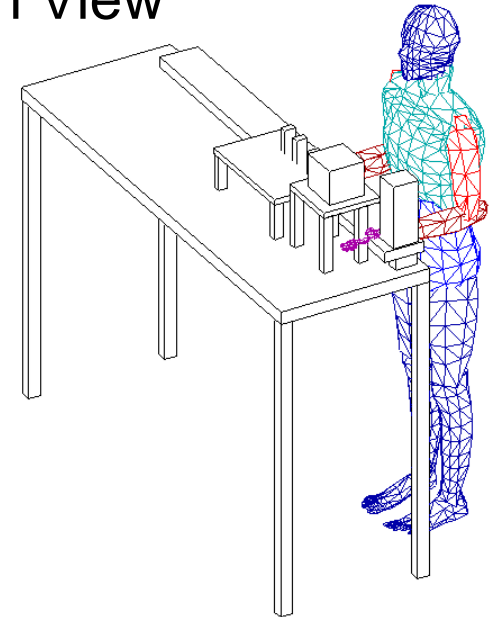
| Solutions                   | Impact Ranking |
|-----------------------------|----------------|
| Mechanized Grinding         | 3.1            |
| Grinding Carts/Tool Ext     | 2.85           |
| Tool Maintenance - PM       | 2.75           |
| Double Grinding             | 2.7            |
| Daily Tool Maintenance      | 2.5            |
| Grind To Spec               | 2.5            |
| DFA/DFM, Lean Six Sigma     | 2.45           |
| Grinding Reduction Team     | 2.45           |
| Upstream Processes          | 2.45           |
| Tool Monopod                | 2.4            |
| Behavior Based Training     | 2.35           |
| Right Tool Right Job        | 2.35           |
| Tool Training               | 2.35           |
| Task Rotation               | 2.2            |
| Ergo Tools                  | 2.15           |
| Swivels / quick disconnects | 2.05           |
| Foot Pedal for Man Lift     | 2              |
| Anti-vibratory Gloves       | 1.9            |
| Grip Gloves                 | 1.9            |
| Tool Balancers              | 1.75           |

# Improve

## Cell View



## Workstation View



# Verify & Control

Initial Ergonomic Risk Map Summary

| REBAR Scores                                   | Left Wrist | Right Wrist | Left Elbow | Right Elbow | Left Shoulder | Right Shoulder | Back     | Neck     | Legs |
|--|------------|-------------|------------|-------------|---------------|----------------|----------|----------|------|
| <b>P10 Preservation Technicians / Painters</b> |            |             |            |             |               |                |          |          |      |
| BOSN Store Room 1                              | High       | High        | High       | High        | High          | High           | Low      | Low      | Low  |
| Tanks 5-78 2F & 1F                             | High       | High        | High       | High        | High          | High           | Low      | High     | Low  |
| Engine Room 1                                  | High       | High        | High       | High        | High          | High           | Low      | Low      | Low  |
| Engine Room 1 – Hot Work Rapid Response        | Low        | Low         | Low        | Low         | Moderate      | Moderate       | Low      | Low      | Low  |
| Radio Transmitter 2-157-1C                     | High       | High        | High       | High        | Low           | Low            | Low      | Low      | Low  |
| Lube Oil Tank Prep                             | High       | High        | High       | High        | High          | High           | Moderate | Low      | Low  |
| <b>M40 Structural Grinders</b>                 |            |             |            |             |               |                |          |          |      |
| AL Shop Tanks                                  | High       | High        | High       | High        | High          | High           | Moderate | High     | Low  |
| Unit Prep                                      | High       | High        | Low        | Low         | Low           | Low            | Moderate | Low      | Low  |
| Panel Line                                     | High       | High        | Low        | Low         | Low           | Low            | Moderate | Low      | Low  |
| AB MSA   | High       | High        | Low        | Low         | Low           | Low            | Moderate | Low      | Low  |
| AB AL False Decking                            | Low        | Low         | Low        | Low         | Low           | Low            | Moderate | Low      | Low  |
| Exterior Remove Lifting Pads – Grinding        | High       | High        | Low        | Low         | Low           | Low            | Moderate | Moderate | Low  |
| Exterior Remove Lifting Pads – Gouging         | Low        | Low         | Low        | Low         | Low           | Low            | Moderate | Low      | Low  |
| Aft Stack Deck House                           | High       | High        | High       | High        | High          | High           | Moderate | Low      | Low  |
| Erection Butt / Break                          | High       | High        | Low        | Low         | Low           | Low            | Moderate | Low      | Low  |
| AB Stone Grinding – vertical                   | High       | High        | Low        | Low         | Low           | Low            | Moderate | Low      | Low  |
| AB Stone Grinding – horizontal                 | High       | High        | Low        | Low         | Low           | Low            | Moderate | Low      | Low  |

**Initial**

**82% high risk tasks**

**38% high risk body parts**

12 Month Follow Up Ergonomic Risk Map Summary

| REBAR Scores                                   | Left Wrist | Right Wrist | Left Elbow | Right Elbow | Left Shoulder | Right Shoulder | Back     | Neck     | Legs     |
|--|------------|-------------|------------|-------------|---------------|----------------|----------|----------|----------|
| <b>P10 Preservation Technicians / Painters</b> |            |             |            |             |               |                |          |          |          |
| Dry/Habitability Spaces                        | Low        | Low         | Low        | Low         | Low           | Low            | Low      | Low      | Low      |
| Tanks  | Low        | Low         | Low        | Low         | Low           | Low            | Low      | High     | Low      |
| Machinery Spaces                               | Low        | Low         | Low        | Low         | Low           | Low            | Low      | Low      | Low      |
| Engine Room 1 – Hot Work Rapid Response        | Low        | Low         | Low        | Low         | Moderate      | Moderate       | Low      | Low      | Low      |
| Electronic Spaces                              | Low        | Low         | Low        | Low         | Low           | Low            | Low      | Low      | Low      |
| Lube Oil Tanks                                 | Low        | Low         | Low        | Low         | Low           | Low            | Low      | Low      | Low      |
| <b>M40 Structural Grinders</b>                 |            |             |            |             |               |                |          |          |          |
| AL Shop Tanks                                  | Low        | Low         | Low        | Low         | Low           | Low            | Moderate | High     | Low      |
| Unit Prep                                      | Low        | Low         | Low        | Low         | Low           | Low            | Moderate | Low      | Moderate |
| Panel Line                                     | Low        | Low         | Low        | Low         | Low           | Low            | Moderate | Low      | Low      |
| AB MSA   | Low        | Low         | Low        | Low         | Low           | Low            | Moderate | Low      | Low      |
| AB AL False Decking                            | Low        | Low         | Low        | Low         | Low           | Low            | Moderate | Low      | Low      |
| Exterior Remove Lifting Pads – Grinding        | Low        | Low         | Low        | Low         | Low           | Low            | Moderate | Moderate | Low      |
| Exterior Remove Lifting Pads – Gouging         | Low        | Low         | Low        | Low         | Low           | Low            | Moderate | Low      | Low      |
| Aft Stack Deck House                           | High       | High        | High       | High        | High          | High           | Moderate | Low      | Low      |
| Erection Butt / Break                          | High       | High        | Low        | Low         | Low           | Low            | Moderate | Low      | Low      |
| AB Stone Grinding – vertical                   | Low        | Low         | Low        | Low         | Low           | Low            | Moderate | Low      | Low      |
| AB Stone Grinding – horizontal                 | Low        | Low         | Low        | Low         | Low           | Low            | Moderate | Low      | Low      |

**65% Reduction in Risk**

**40-60% Time Savings**

**Follow Up**

**35% high risk tasks**

**13% high risk body parts**

▼ Low ▶ Moderate ▲ High



# Summary

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- Understanding root cause of ergonomic issues is key in creating the long-term vision
- Linking ergonomic risk reduction to board room goals will ensure a long-term “pull”
- Integrating ergo into LSS is truly moving towards “Operational Human Excellence”
- Take time & effort - results are so worth it