

| VSM Terms, Calculations & Units of Measure (UOM) |                                                                                                                                                                                                                                                                                                                                                                                                                                              | 1                                                                                                                                                                               |
|--------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Available Working Time (AWT)                     | <ul style="list-style-type: none"> <li>The time a process is available to conduct work.</li> <li>AWT excludes time when work isn't occurring such as time for breaks, meetings, lunch, preventative maintenance (PM), estimates of unplanned downtime, change overs, etc.</li> </ul>                                                                                                                                                         | <p><math>AWT = \text{Shift duration} - (\text{breaks, meals, meetings, PM} \dots)</math></p> <p>UOM: year, month, day, hour, minutes, seconds...</p>                            |
| Throughput (Tput)                                | <ul style="list-style-type: none"> <li>The average number of good parts or transactions completed over a period of time.</li> <li>Typically measured as average over at least several days.</li> </ul>                                                                                                                                                                                                                                       | <p><math>T_{put} = \frac{\# \text{ good items}}{\text{period of time}}</math></p> <p>UOM examples: parts per day, transactions per hour, etc.</p>                               |
| Lead time (LT)                                   | <ul style="list-style-type: none"> <li>The total elapsed time to produce one defect free product or transaction.</li> <li>Alternative way to state it: the time difference between when a part or transaction enters and leaves a process.</li> </ul>                                                                                                                                                                                        | <p><i>LT calculated using Little's Law</i></p> <p>UOM: year, month, day, hour, minutes, seconds...</p>                                                                          |
| Customer Demand Rate (CDR)                       | <ul style="list-style-type: none"> <li>The number of parts or transactions that the customer desires over a period of time (usually a day, week, or month).</li> <li>For example, a purchase order quantity or a yearly forecast.</li> <li>The CDR is needed in order to calculate Takt time (TT); broken down into the same units to be used for TT. For example, a yearly forecast broken down into a weekly or daily quantity.</li> </ul> | <p><math>CDR = \frac{\# \text{ items required}}{\text{in a time period}}</math></p> <p>UOM examples: 500 parts per month, forecast of 50 prototype designs per year, etc.</p>   |
| Takt time (TT)                                   | <ul style="list-style-type: none"> <li>The pace at which an operation should complete products or transactions in order to meet customer demand during the Available Working Time.</li> <li>Available working time during a period divided by the number of products or transactions required during that same period.</li> </ul>                                                                                                            | <p><math>TT = \frac{AWT}{CDR}</math></p> <p>UOM example: time per item</p> <p><math>\frac{\text{minutes/day}}{\text{parts/day}} = \frac{\text{minutes}}{\text{part}}</math></p> |

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| VSM Terms, Calculations & Units of Measure (UOM), cont'd |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 2                                                                                                              |
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| Cycle time (CT)                                          | <ul style="list-style-type: none"> <li>The fastest repeatable time between part or transaction completions using the current processes and resources.</li> <li>Shows what a process is capable of, typically measured through "clocking" the processing time and determining the fastest repeatable (sustainable) time.</li> <li>Combines with AWT to determine capacity: if we know how much time we have, and how much time we need per part, we can figure out how many parts we can make during that time.</li> </ul>                                                                        | <p><math>CT = \frac{\text{time}}{\text{item}}</math></p> <p>UOM : time per item</p>                            |
| Work In Progress (WIP)                                   | <ul style="list-style-type: none"> <li>Includes items waiting to be worked on and items actively being worked on.</li> <li>WIP includes all inventory in the production system, i.e., within the workflow scope.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                      | <p><math>WIP = \# \text{ items}</math></p>                                                                     |
| Little's Law                                             | <ul style="list-style-type: none"> <li>Formula for estimating Lead Time from WIP and either Throughput or Cycle time.</li> <li>Typically, we are working with Averages although minimums and maximums may also be helpful.</li> <li>UOM calculation example using Throughput (Tput):<br/> <math display="block">\frac{\# \text{ WIP parts}}{\frac{\# \text{ good parts}}{\text{hours}}} = \text{hours}</math> </li> <li>UOM calculation example using Cycle time (CT):<br/> <math display="block">\# \text{ WIP parts} \times \frac{\text{hours}}{\text{part}} = \text{hours}</math> </li> </ul> | <p><math>LT = \frac{WIP}{T_{put}}</math></p> <p>or</p> <p><math>LT = WIP \times CT</math></p> <p>UOM: time</p> |
| Process Cycle Efficiency (PCE)                           | <ul style="list-style-type: none"> <li>The percentage of time that WIP is being transformed by VA activities. In other words, the percentage of lead time that is value added.</li> <li>No units since it's a ratio, usually reported as a percentage and it's understood the context is time.</li> </ul>                                                                                                                                                                                                                                                                                        | <p><math>PCE = \frac{VA \text{ time}}{LT}</math></p>                                                           |

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| VSM Calculation Examples                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 3 |
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| <b>Example of Takt Time &amp; Cycle Time</b> | <p>Working time per day = 450 mins (7.5 hrs)</p> <p>Avg. daily quantity required = 55 units</p> <p>Avg. daily defect free quantity that we can produce = 48 units</p> <p>Takt time = <math>\frac{450 \text{ minutes}}{55 \text{ units}} = 8.2 \text{ mins}^*</math></p> <p>Cycle time = <math>\frac{450 \text{ minutes}}{48 \text{ units}} = 9.4 \text{ mins}^*</math></p> <p>* technically, "minutes/unit" but it's typical to just state these terms in "time"</p> |   |
| <b>Example of Little's Law</b>               | <p>Total average WIP for all steps of a process = 100 items</p> <p>Cycle Time = 9.4 minutes/item</p> <p>Avg. Lead Time = 100 items x 9.4 min./item = 940 minutes<br/>or<br/>940 min. x 1 hr/60 min = 15 hours, 40 minutes</p>                                                                                                                                                                                                                                        |   |

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| Definitions of Value                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 4 |
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| <p>Customer value adding (CVA)</p> <ul style="list-style-type: none"> <li>• Activities that are required, from the customer's point of view, to provide the desired products and services</li> <li>• What the customer is willing to pay for</li> </ul> <p>Non-value adding (NVA)</p> <ul style="list-style-type: none"> <li>• There exists a feasible future state in which the desired products and services can be provided without these activities</li> </ul> <p>Business value adding (BVA)</p> <ul style="list-style-type: none"> <li>• Activities that are not CVA, but cannot feasibly be eliminated under current constraints</li> </ul> |   |

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