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# Lean Six Sigma Module 1 Revision Answers

## 1. Sample Sizes

1. What sample size is required to estimate the mean queue time to within +/-0.1m? Standard deviation = 3.4m.

$$n = \left(\frac{2s}{\Delta}\right)^2$$

$$n = \left(\frac{2 \times 3.4}{0.1}\right)^2 = 4624$$

2. What is the sample size for mortgage processing times given a standard deviation of 23 minutes and a requirement to be accurate to +/- 5 minutes.

$$n = \left(\frac{2s}{\Delta}\right)^2$$

$$n = \left(\frac{2 \times 23}{5}\right)^2 = 85$$

3. What is the sample size required to establish if people prefer TV3 to TV1? We want the answer to be accurate to +/-3%. Assume that, historically, the two stations have been equally popular.

$$n = \left(\frac{2}{\Delta}\right)^2 p(1-p)$$

$$n = \left(\frac{2}{0.03}\right)^2 0.5(1-0.5) = 1111$$

4. What is the sample size required to estimate the number of people who prefer branch banking to online banking to an accuracy of +/- 5%? This has historically been 10%.

$$n = \left(\frac{2}{\Delta}\right)^2 p(1-p)$$

$$n = \left(\frac{2}{0.05}\right)^2 0.1(1-0.1) = 144$$

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## 2. Baseline calculations

Baseline the following situations to find the sigma level and DPMO (assume a long term drift of 1.5 sigma when converting short term sigma to long term sigma and vice versa):

1. A process has 7 steps with the following first time yields in the long term:

   70%, 85%, 90%, 99%, 80%, 95%, 95%

   $$Y_{RT} = 0.70 \times 0.85 \times 0.90 \times 0.99 \times 0.80 \times 0.95 \times 0.95 = 0.383 \ (or\ 38.3\%)$$

   $$DPU = 1 - 0.383$$

   $$DPMO = \frac{DPU \times 1000000}{opportunites\ for\ a\ defect} = \frac{0.617 \times 1000000}{7} = 88143$$

   $$From\ DPMO\ tables\!: \ Sigma\ Level\ (Z_{ST}) = \ 2.85$$

   Note: This is the simple method. Another method would be to use Normalised Average Yield in the estimation of the probability of a defect (advanced subject).

2. Long term unacceptable lead times for resolving transaction disputes = 959 out of 1000 analysed. There are 5 process steps.

   $$DPU = \frac{959}{1000} = 0.959$$

   $$DPMO = \frac{DPU \times 1000000}{opportunites\ for\ a\ defect} = \frac{0.959 \times 1000000}{5} = 191800$$

   $$From\ DPMO\ tables\!: \ Sigma\ Level\ (Z_{ST}) = \ 2.37$$

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3. The office temperature has a mean of 20.2 degrees and a standard deviation of 1.5 degrees measured over 365 days (normal distribution). The specification range is 20 degrees +/- 2.7 degrees.

$$Z_{(upper)} = \frac{22.7 - 20.2}{1.5} = 1.66\dot{6}$$

$$Z_{(lower)} = \frac{20.2 - 17.3}{1.5} = 1.93\dot{3}$$

$From\ Standard\ Normal\ Distribution\ tables:$

$p_{(upper)} = 0.0475$

$p_{(lower)} = 0.0268$

$p_{(total)} = 0.0475 + 0.0268 = 0.0743$

$Reverse\ look\ up\ in\ Standard\ Normal\ Distribution\ tables:$

$Z = 1.44\ (as\ this\ is\ long\ term\ data\ this\ is\ Z_{LT})$

$As\ the\ Sigma\ Level = \ Z_{ST}\ then\ we\ need\ to\ add\ the\ shift\ of\ 1.5\ sigma:$

$Z_{ST} = 1.44 + 1.5 = 2.95$

4. A 12 stage process creates an average of 12 defects for every 150 items processed over a period of 2 years.

$$DPU = \frac{12}{150} = 0.08$$

$$DPMO = \frac{DPU \times 1000000}{opportunites\ for\ a\ defect} = \frac{0.08 \times 1000000}{12} = 6667$$

$From\ DPMO\ tables:\ Sigma\ Level\ (Z_{ST}) = \ 3.97$

5. A process measured over a year has a DPU of 0.11. The following is a description of the process scope:

    1. Inspect incoming documents
    2. Enter customer details in the database
    3. Update customer credit rating
    4. Check for errors
    5. Call customer with response

$There\ are\ 3\ opportunities\ for\ a\ defect: Steps\ 2{,}3\ and\ 5$

$$DPMO = \frac{DPU \times 1000000}{opportunites\ for\ a\ defect} = \frac{0.11 \times 1000000}{3} = 36667$$

$From\ DPMO\ tables:\ Sigma\ Level\ (Z_{ST}) =\ 3.29$

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