Reference:C:\MathCad\Units Rev D.xmcd

Monte Carlo Simulation of Project TIC - An Example

$np := 50000$ Choose a number of times to run the simulation "np"

$i := 0, 1 .. np \qquad x_i := \frac{i}{np}$ Set up an index simply to plot each Project TIC for each random simulation

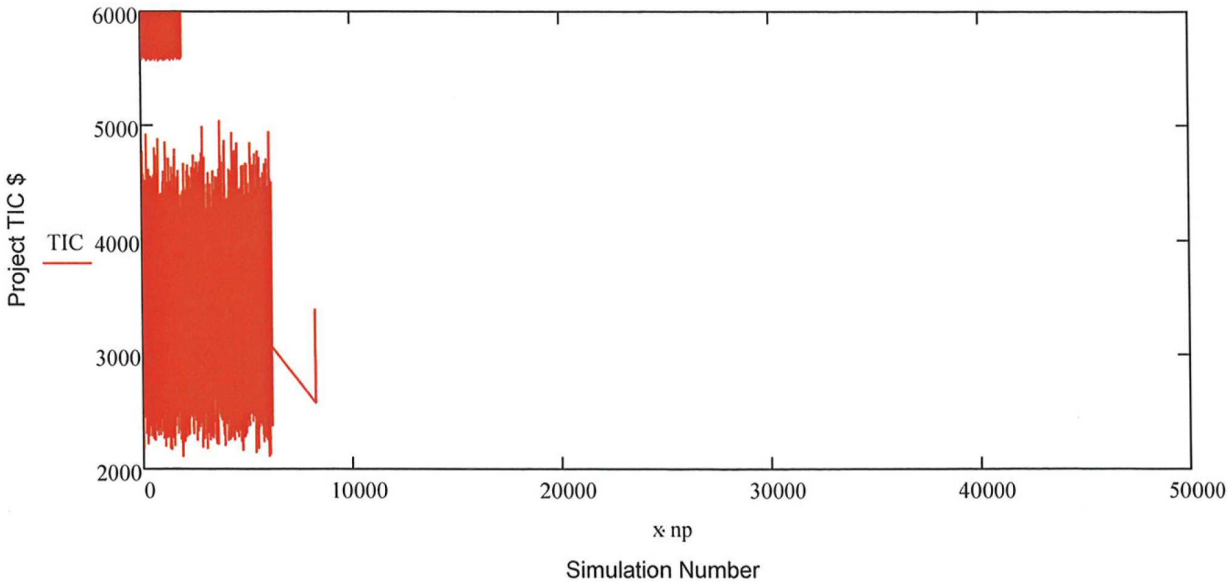
Fictitious example project consists of:
A length of the project not yet fully defined but between 1200m & 1800m "Lr"
An application rate that can vary depending on conditions when applied 3% to 5% "Rr"
Price of the application can vary by $47 to $53 due to market influence "Pr"
A fixed set-up/demobilise cost of $ 800 applies.
Supplier discounts this set up cost based on length "Lr" and on a contract discount rate between 20% & 40% "Cr"

A uniform distribution of variation of each the input parameters to the Total Installed Cost "TIC" estimate can be generated.

Each of the variables is a vector with each "np" elements being a random value in the appropriate range.

$L_r := runif(np, 1200, 1800) \qquad C_r := runif(np, 0.2, 0.4) \qquad R_r := runif\left(np, \frac{3}{100}, \frac{5}{100}\right) \qquad P_r := runif(np, 47, 53)$

$TIC := \overrightarrow{\left[L_r \cdot R_r \cdot P_r + \left(800 - L_r \cdot C_r\right)\right]}$ Set up the Project TIC cost equation. It is calculated element by element



Graph Project TIC (each simulation) vs Simulation Number

Need to now analyse the above simulation record statistically. Choose a number of bars for the frequency histogram "nb". This will allow a plot of the frequency at which particular Project TIC costs occur breaking the range into the number of histogram bars chosen.

Note: MathCad has a bug - if you choose too many histogram bars later use of the linear interpolation function "linterp" may fail as the upper end of the commulative probability distribution curve created below will not have values sorted in increasing order. Just reduce the number of bars if this occurs.

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$nb := 75$ "nb" is number of histogram bar intervals

Take some usual statistics. The standard deviation 15% and 85% in a normal distribution is distorted if Project TIC is skewed or an unusual shape.

$\max(TIC) = 5045.999$

$x_{mean} := \text{mean}(TIC) = 3348.488$ $\quad \text{Stdev}(TIC) = 542.858$ $\quad x_{med} := \text{median}(TIC) = 3316.526$

$\min(TIC) = 2080.367$

Create the Project TIC frequency histogram "plot" $\quad plot := \text{histogram}(nb, TIC)$

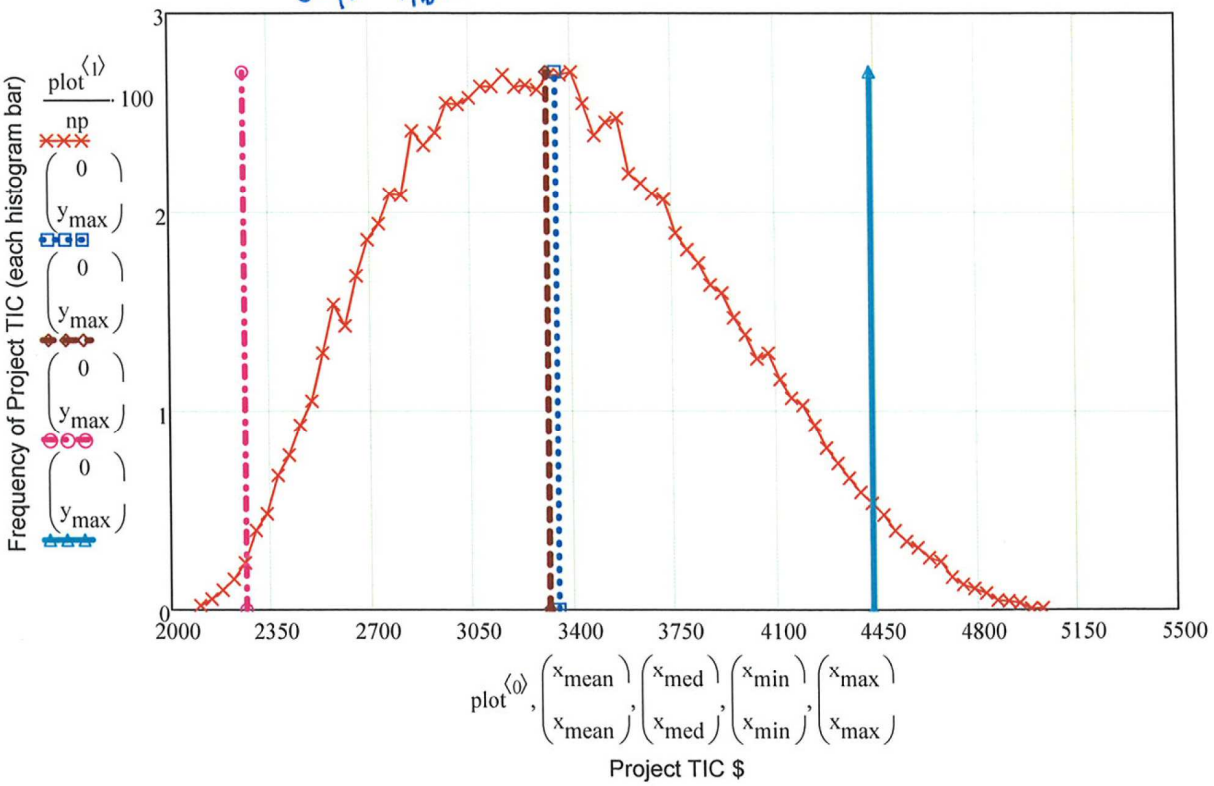
To create a good plot find the maximum result "ymax" $\quad y_{max} := \max\left(\frac{plot^{\langle 1 \rangle}}{np} \cdot 100\right) = 2.704$

Plot the usual normal distribution standard deviation

$x_{min} := x_{mean} - 2\,\text{Stdev}(TIC) = 2262.772$ 85% 1%×2

$x_{max} := x_{mean} + 2\,\text{Stdev}(TIC) = 4434.204$ 85% 1%×2

$\frac{2\,\text{Stdev}(TIC)}{x_{mean}} \cdot 100 = 32.424$



Project TIC Frequecy Distribution Histogram

Check the area under the frequency distribution histogram is actually 100% $\quad \sum_{n=0}^{nb-1} \left[\frac{(plot^{\langle 1 \rangle})_n}{np} \cdot 100\right] = 100.000$

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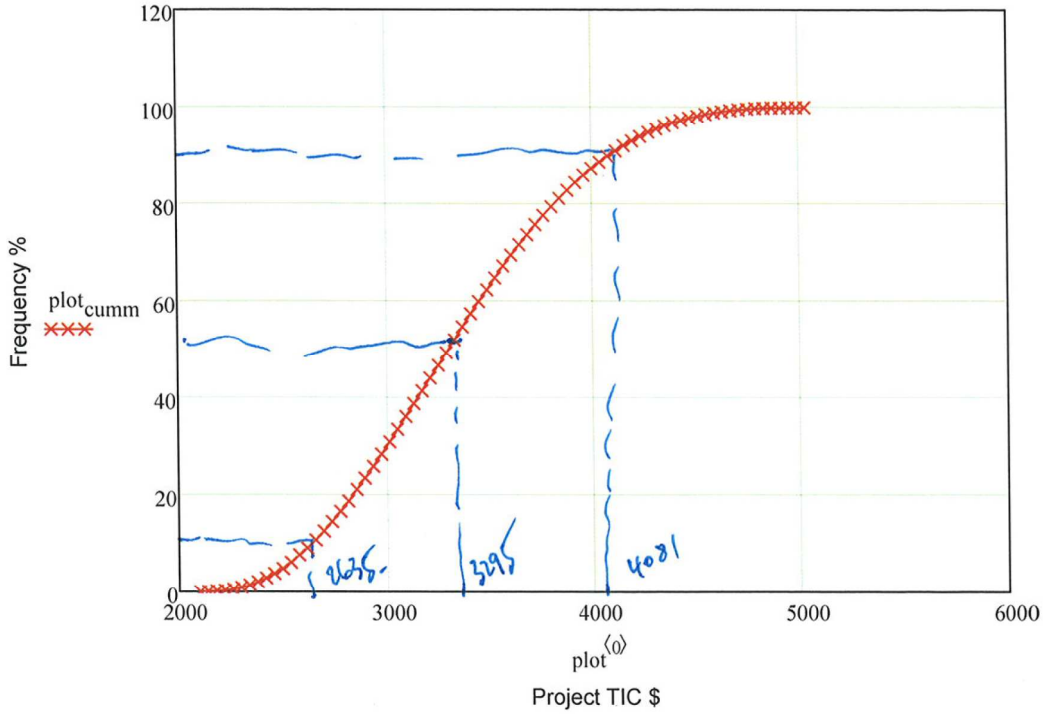
Determine the cummulative sum of the Project TIC frequencies "$plot_{cumm}$". Should be an "S" curve from 0% to 100%

First establish an index over the histogram bars "ib",
The simply add from first bar to each individual bar in turn.

$ib := 0 .. nb - 1$

$$plot_{cumm_{ib}} := \sum_{n=0}^{ib} \left[\frac{\left(plot^{\langle 1 \rangle}\right)_n}{np} \cdot 100 \right]$$



Project TIC $

Cummulative Frequency % (vs) Project TIC

From this plot can interpret the values for P50, being 50% of frequencies each side of value,
P10 being the lower bound of confidence required, and P90 the upper bound of confidence required.

$$x_{50} := linterp\left(plot_{cumm}, plot^{\langle 0 \rangle}, 50\right) = 3295.423$$

$$x_{10} := linterp\left(plot_{cumm}, plot^{\langle 0 \rangle}, 10\right) = 2635.414$$

$$x_{90} := linterp\left(plot_{cumm}, plot^{\langle 0 \rangle}, 90\right) = 4081.255$$

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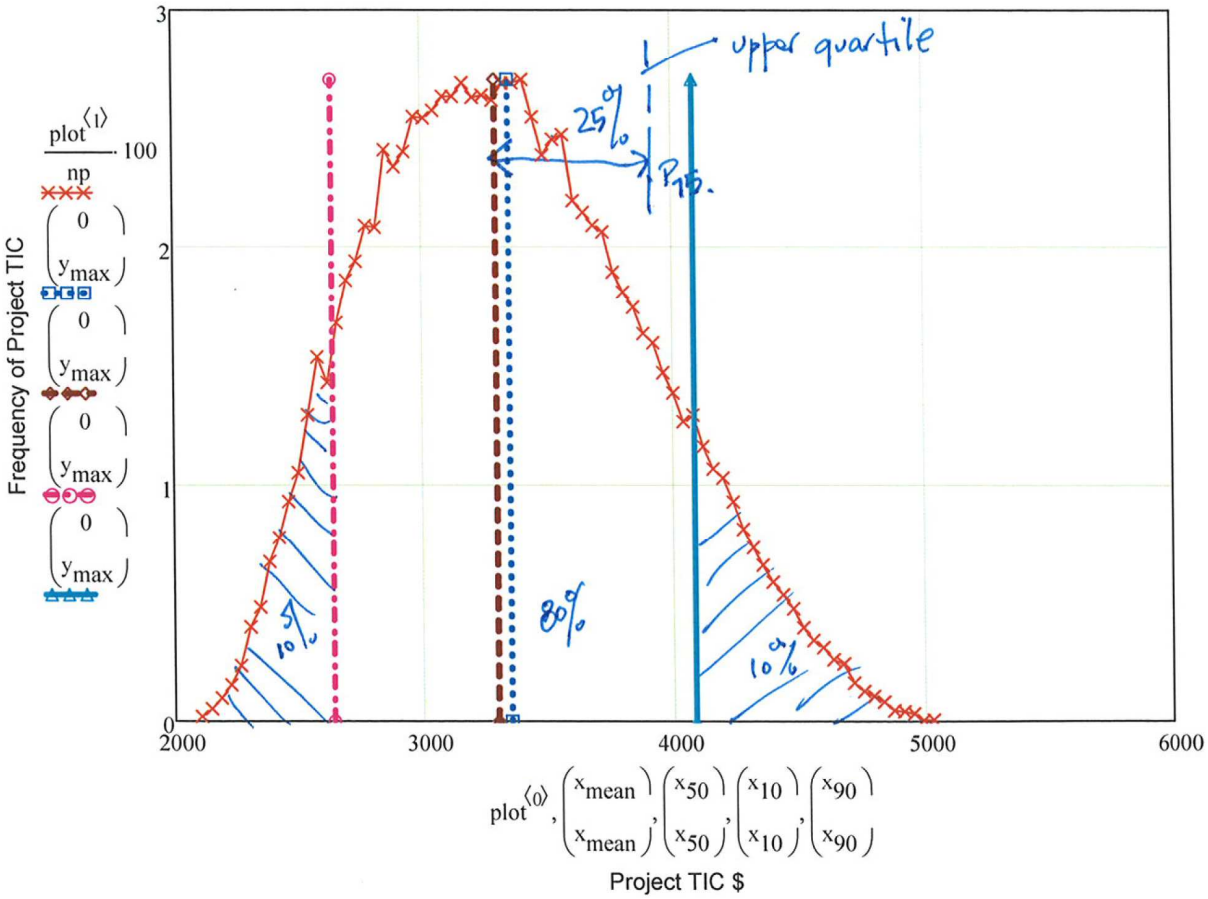
Finally the % of Project TIC variance that each of the P10 & P90 values from the P50 value can be found.

$$\frac{x_{10} - x_{50}}{x_{50}} \cdot 100 = -20.028$$ ✓

$$\frac{x_{90} - x_{50}}{x_{50}} \cdot 100 = 23.846$$ ✓

Project TIC is $ 3295, -20%, +24%
Suitable for Define - Class 2 -+30%



Frequency of Project TIC (vs) Project TIC