Six Sigma Metrics

Six Sigma Measures

-Defects per unit

-Defects per million opportunities

-Cycle time

-Rolled throughput yield

Six Sigma Measures

Defects Per Unit /

Defects Per Million Opportunities

Defects Per Unit

- DPU or defects per unit is simply
  - a ratio of the number of defects to the number of units produced

    or

  - the total number of defects found in a sample divided by sample size.
- To calculate, we simply divide the total number of defects by the number of units.

Example Mortgage Applications

- You are processing Mortgage applications and this month your organization process 75 of the applications.
- In this application, 12 errors or defects were found.
- We would divide the number of defects 12 by the number of units 75, **there are 0.16 or 16% defects per unit.**
- We multiply the decimal by 100 to find the percentage.

Defects Per Unit

12/75=.16

.16*100=16%

- So when we multiply 0.16 by 100
- we find that about 16% of the mortgages had an error.
- But we need to remember that a single mortgage application could have multiple errors!

Defects Per Unit

12/75=.16

.16*100=16%

- Let's say we're making automobiles and this month we've produced a 1,000 new cars.
- Automobiles are complex machines and many things can go wrong.
- We found 9,000 defects on our automobiles.
- When we divide the number of units produced, 1,000 into the number of defects 9,000, we get 9 defects per unit.
- Some units may have more defects and some may have non at all, but the average number is 9.

Defects Per Unit

9,000/1000=9 Defects Per Unit

Defects per million Opportunities

- Defects per million opportunities for this measure, we want to convert our defects or errors to see how many there would be out of a million opportunities.
- First, we should define opportunities.
- **Every possible <u>defect</u> in a product or <u>error</u> in a service represents an opportunity.**

- So from our mortgage application example, let's say there are 30 different field that needs to be properly field out in the application.
- We multiply the number fields or places where an error could occur by the number of mortgages process.
- 30 times 75 equals 2250 opportunities for error in our 75 units.

DPMO - Mortgages

Defects Per Million Opportunities

– 30*75=2250 opportunities.

- To calculate DPMO, we first divide the defects by the opportunities, then we multiply this number by 1 million.

- Defects Per Million Opportunities
  - 30*75=2,250 opportunities.
- Formula for DPMO
  - (Defects/Opportunities)*1,000,000
  - (12/2,250)*1,000,000
  - (0.005333)*1,000,000=5,333.333DPMO
- Shortcut
  - (DPU/Opportunities per unit)*1,000,000
  - (0.16/30)*1,000,000
  - 0.005333*1,000,000 = 5,333.333DPMO

Example

- Every possible defect in a product or error in a service represents an opportunity.
- So from our mortgage application example, let's say there are 30 different field that needs to be properly field out in the application.

DPMO - Automobiles

Defects Per Million Opportunities

– 500 opportunities per vehicle

– 1,000 vehicles

– 500*1,000-500,000

DPMO - Automobiles

- Defects Per Million Opportunities
  - 500 opportunities per vehicle
  - 1,000 vehicles
  - 500*1,000-500,000
  - (Defects/Opportunities)*1,000,000
  - 9,000/500,000=0.018
  - 0.018*1,000,000=18,000 DPMO
- Shortcut
  - (DPU/Opportunities per unit)*1,000,000
  - (9/500)*1,000,000
  - 0.018*1,000,000 = 18,000 DPMO

Difference

DPU/DPMO

- Defects Per Unit
  - Defects/Units
- Defects Per Million Opportunities
  - Opportunities per unit * units
  - (Defects/Opportunities)*1,000,000
  - OR
  - (DPU/Opportunities per unit)*1,000,000

Six Sigma Measures - 2

Cycle Time / Rolled Throughput Yield

Cycle Time

- It is often confused with processing time and lead time, but they are very different things.
- Process time is how much time it takes to actually perform all of the steps in a process.
- It does not include time when the product is waiting to be processed or is being transported or delayed for some reason.
- Process time is the time of the actual work.
- **Cycle time is typically defined as the time required to complete one cycle of an operation.**

Cycle Time

- Definition
  - Process Time
    - Process time is the sum of the processing times for all of the steps in a process
  - Cycle Time
    - Time to complete one cycle of an operation.

- Cycle time is the time from the beginning to the end of a process including waiting time and other delays.
- That is, it's the time it takes an individual product to travel from the beginning to the end of the process.
- Consider the process time for product might be two minutes.
- However, any individual product may spend a significant amount of time waiting between steps in a process.

- How much time is greatly influenced by batch sizes and work in process inventory.
- The larger your batch sizes, the more work in process inventory you will have.
- For example, if you're processing batches of 100 pieces.
- Typically, you will be processing one piece through a process that, while the other 99 wait.

- One way to test cycle time is to put an identifying mark on the part at the beginning of the process, and see how long it takes to come out the other end of the process.
- It's not unusual for cycle time to be 10 to 20 times is much as process time.

Lead Time

- Lead time is the time between a customer order and the delivery of that order.
- It includes cycle time, it may also have delays after the order is placed and before the work begins.

Cycle Time

- Why is it important?
  - Customer service
  - Waste Elimination
  - WIP Reduction

Customer Service

- Often, in our improvement efforts we can reduce cycle time.
- The most immediate benefit of reducing cycle time is to better serve our customers.
- This improvements are often related to the current state process maps that we discussed earlier.
- We can analyze these process maps and remove waste from the process.

Waste Elimination

- Reducing waste can mean in part reducing the wait time between operations and reducing batch sizes.
- If we can reduce wait times, cycle time will improve and because product will spend less time waiting.

WIP Reduction

- If we can reduce batch size, we can reduce work in process inventory (WIP), which will also reduce cycle times.
- It's important to note that all those things, waste elimination, working process, reduction in cycle time go together.
- They're part of the the lean system. You can pick and choose the parts that you like.

Roll throughput yield

- Roll throughput yield is the probability that a process with more than one step will produce an error or a defect free unit.
- This also applies when multiple components are used to create a single product.

First Pass Yield (FPY)

- Before we can calculate roll throughput yield, we need to calculate first pass yield for each operation or each component.
- First pass yield is actually just a compliment of our defects per unit calculation.
- Remember to get defects per unit, we divided the number of defects by the number of units.
- Let's take an example, say we're producing 50 units, and we find 3 defects.

- We divide 3 by 50, and we get a DPU of 0.06.
- We can get the compliment of our DPU calculation by subtracting it from 1.
- In this case, the answer is 0.94.
- We can interpret this to mean that we have 94% good quality.

It also means that for any individual part there is a 0.94 probability that it will be defect free.
This is our first pass yield.

First Pass Yield (FPY)

- Component #1.
- Defects/units
- 3/50=0.06 (dpu)
- Complement = 1.0-dpu
- 1.0-.06=.94

- Now let's add some more components to our assembly.
- We now have four components in our assembly.
- The first pass yield for these components is **0.94, 0.96, 0.98 and 0.96**.
- Again, that is also the probability that a component will be defect free.
- It would seem that these numbers do not look too bad.

First Pass Yield (FPY)

- Component #1: 3/50=0.06 (dpu), 1.0-0.06=.94
- Component #2: 2/50=0.04 (dpu), 1.0-0.04=.96
- Component #3: 1/50=0.02 (dpu), 1.0-0.02=.98
- Component #4: 2/50=0.04 (dpu), 1.0-0.04=.96

- But we want to know how many of our assembles will be defect free.
- Our assembly could have a defect occurring from any one these components.
- According to the multiplication rule of probability, we can find the probability of multiple events happening at the same time by multiplying the individual probabilities.

Rolled Throughout Yield

- So, if we multiply the first pass yield or probability of good parts for each component together, we can get the probability that the assembly will be defect free.
- This is rolled through put yield.
  - To find the probability of two or more independent events occurring at the same time, you multiply the individual probabilities.
  - 0.94*0.96*0.98*0.96=0.85

- Imagine how this works in complex products like a computer, or an automobile transmission.
- The more components or steps in the process, the more opportunities for failure.

Your Turn

- Calculate: DPU, FPY, RTY
  - Component #1:
    - 200 units, 6 defects
  - Component #2:
    - 200 units, 1 defect
  - Component #3:
    - 200 units, 3 defects

- Calculate: DPU, FPY, RTY
  - Component #1:
    - 6/200=0.03 (dpu), 1-0.03=0.97 (FPY)
  - Component #2:
    - 1/200=0.005 (dpu), 1-0.005=0.995 (FPY)
  - Component #3:
    - 3/200=0.015 (dpu), 1-0.015=0.985 (FPY)

  - 0.97*0.995*0.985=0.95 (RTY)

Conclusion

Six Sigma Measures

-Defects per unit

-Defects per million opportunities

-Cycle time

-Rolled throughput yield