Six Sigma

Process Baselines

Process Baseline

Most organizations find it useful to have a way to evaluate the capacity of products, services, and processes. This step provides them with an idea of where they are on the Six Sigma map, where to focus improvement projects, as well as point out areas where data is available or needs to be collected in the future. It is important to note that there may be different approaches used to apply these concepts because each situation is different.

There are three types of analysis that can be done to estimate capability; product benchmarking, process baselining, and capability analysis. With product benchmarking, metrics are calculated for products and services to compare them to each other and to the best in class. With process baselining, we develop metrics to compare key processes and identify improvement areas. Capability analysis is done at the CT level and is usually the focus of a Black Belt's Six Sigma improvement project. The ultimate goal is to compare things with a common metric, the Sigma value.

Product benchmarking can be done at both the macro and micro level. The focus of macro-level product benchmarking is to obtain an overall Sigma value for selected products. Micro-level product benchmarking is used to evaluate the capability of several products or services (deliverables) for a functional area using more detailed data, such as the number of opportunities for defect.

For process baselining, we focus on key processes that have leverage, such as processes which run across many products. Existing data must be gathered on key processes to determine metrics. At this point, we are not interested in organizing a big data collection. We are simply interested in estimating the current situation. If there is no existing data, this is an opportunity for a Six Sigma project.

For key processes, process maps will help identify data collection points for a particular process. At each step of the process, it is important to determine the CTs that are being measured. Data that is available for these CTs will enable us to determine the process baseline for particular processes. At this point, it is usually discrete data that is used for process baselining, since it is more available in most organizations. Calculating metrics will help identify improvement opportunities for Six Sigma projects. Eventually, when there is continuous data available for these CTs, we will be able to roll temp up to obtain an overall Sigma capability for the organization.

Some of the key performance metrics that are associated with a process baseline are Sigma value, CPU, DPMO, and PPM.

Key Questions

- **What is a “process baseline” and how is it different from a product benchmark?**
- **What is the connection between a process baseline and a process map?**
- **What is the connection between a process baseline, CTs and defect opportunities?**
- **What are the key performance metrics associated with a process baseline?**
- **How should a process baseline be established?**
- **How can a process baseline be improved?**

Key Questions

A process baseline is a first step estimation of the capability of our key processes so that we can evaluate them and identify improvement projects. Product benchmarking is based on similar tools, however, we benchmark our products and services, comparing them to each other and to the best in class.

For key processes, a process map will allow for the identification of available data at different collection points to be used for baselining. By the same token, it will also indicate where data needs to be collected.

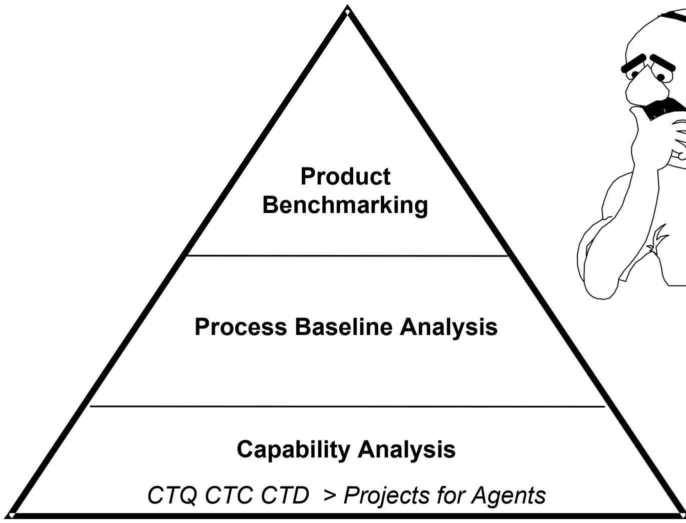
After identifying data collection points for a particular process, it is important to determine for each point how many CTs are currently measured. Each CT that is being measured and reported is an active opportunity for defect. At this step, data that is currently available for these CTXs will enable us to determine the process baseline for that particular process. Eventually, we could flow these metrics up throughout the organization to obtain overall Sigma values.

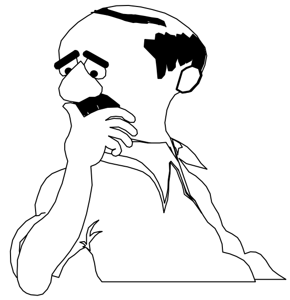
Some of the key performance metrics that are associated with a process baseline are Sigma level, DPU, DPMO, and PPM.

A process baseline should be established by first identifying the functional area's key processes. Data collection points in the process are identified and metrics are calculated with the available data. Usually discrete data is available for process baselining.

A process baseline can be improved once areas for improvement or areas for data collection have been determined. Identified CTs are assigned to Black Belts to be characterized and optimized in Six Sigma projects.

Where Are We on the Six Sigma Journey?





Where Are We on the Six Sigma Journey?

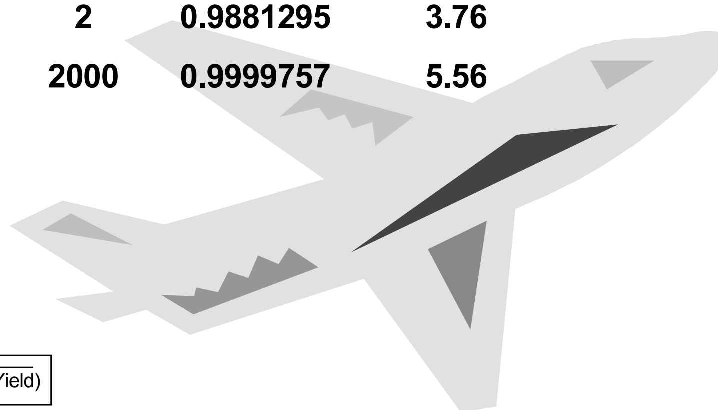
A Champion said to a Master Black Belt: "I am trying to figure out where my function is on the Sigma journey, but I don't know where to start." The Master Black Belt replied: "Well, remember, in order to determine how we are doing, we need data to analyze. We can only evaluate and improve what we are measuring. There are three different types of analysis: product benchmarking, process baselining, and capability analysis. Product benchmarking and process baselining both use similar tools, however, their perspective is different. Capability analysis is done at the individual CT level and is the focus of a Black Belt's Six Sigma project."

Product benchmarking and process baselining provide us with a method to estimate the quality levels of our products and processes. With product benchmarking, products, or services, our deliverables are compared to each other using a Sigma value. With process baselining, we are comparing our processes. Different metrics are used, usually Defects per Unit (DPU), drive plant-wide improvement, whereas Defects per Million Opportunities (DPMO) allows product comparisons to be made since it considers complexity. Sigma level metrics facilitate benchmarking within and across companies.

Product benchmarking will allow us to determine how we compare with world-class performance at both macro and micro levels. Depending on the situation, it may be done by corporate groups or actual business units for external and internal customers. Ultimately, some top level benchmarks for Bombardier will consist of overall Sigma values for different products or services for different groups. Some examples of these groups include: the Global Express, the Learjet 45, and the Dash 8 for the aerospace groups; different Ski-doo or Sea-doo models for the motorized consumer products group.

Macro Level Product Benchmarking

Product	Yield	m	Ynorm	Sigma
1	0.9694	345	0.9999098	5.25
2	0.9804	120	0.9998351	5.09
3	0.9660	23	0.9984972	4.47
4	0.9764	2	0.9881295	3.76
5	0.9526	2000	0.9999757	5.56



1_02_05_004

m: complexity factor
Ynorm: normalized yield ($\sqrt[m]{Yield}$)

Define

Process Baselines

5

Macro Level Product Benchmarking

During an initial meeting on Six Sigma, a Champion asked a Master Black Belt to help her determine where the Manufacturing division is on the Six Sigma journey. The Master Black Belt said: "We want to know the capability of our products so that we can compare them to world-class. It is important to remember that we need to start somewhere. Macro-level product benchmarking will enable us to start estimating capability. This may only take two days because we will focus our efforts by looking at discrete data at final test or inspection steps. Let's start with an example."

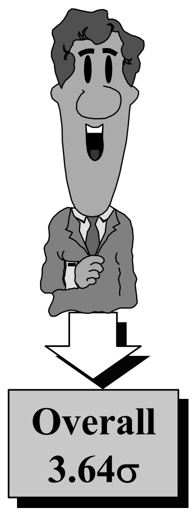
"Suppose we have five products. We could start looking at the yield of each one at final inspection because this data is generally available. We would also need to account for the different complexity levels of these products. This is the complexity factor (m), which could be several things, such as the number of lines items on the bill of materials; the number of actual process operations for the product; the number of CTQs that are assessed throughout the process. The complexity factor enables us to normalize the yield (Ynorm). This is an estimate of the average yield for each of the "complexity units." For example, if m = number of operations for product 1, and m = 345, then Ynorm represents the estimated yield at each of the 345 operations. This figure, Ynorm, enables us to calculate our Sigma metric. Since discrete data is long-term by nature, we add 1.5 Sigma to account for shift and drift of long-term data to obtain short-term capability (ZB)."

"So what do we do with this information? Well, we place these Sigmas on a chart, as in our example, and we determine where to focus our efforts. Our example shows that product number 4 has a lower capability than the others, so this is where we should begin process baselining."

Benchmarking Engineering Drawings

$$DPU = \frac{\text{Total \# of defects}}{\text{Total \# of units}}$$

$$DPMO = \frac{\text{DPU X 1,000,000.}}{\text{Total opportunities for error in one unit}}$$



Line	Date	Contract	Description	D	U	OP	TOP	DPU	DPO	DPMO	Shift	Z.B
1	02-93	910019		2	1	659	659	2	0.0030	3,035	1.50	4.24
2	05-93	910062		8	1	544	544	8	0.0147	14,706	1.50	3.68
3	05-93	910063		5	1	544	544	5	0.0092	9,191	1.50	3.86
4	07-93	910069		5	1	659	659	5	0.0076	7,587	1.50	3.93
.	.	.		.	.	.	.	.	.	.	.	.
.	.	.		.	.	.	.	.	.	.	.	.
.	.	.		.	.	.	.	.	.	.	.	.
.	.	.		.	.	.	.	.	.	.	.	.
.	.	.		.	.	.	.	.	.	.	.	.
.	.	.		.	.	.	.	.	.	.	.	.
.	.	.		.	.	.	.	.	.	.	.	.
.	.	.		.	.	.	.	.	.	.	.	.
60	12-93	930044		0	1	481	481	0	0.0000	0	1.50	6.00
61	12-93	930051		13	1	420	420	13	0.0310	30,952	1.50	3.37
62	12-93	930052		2	1	420	420	2	0.0048	4,762	1.50	4.09
63	12-93	930058		2	1	481	481	2	0.0042	4,158	1.50	4.14
			Grand Total	**532**			**32,526**		**0.0164**	**16,356**	**1.50**	**3.64**

1_02_05_005

Process Baselines

Define

6

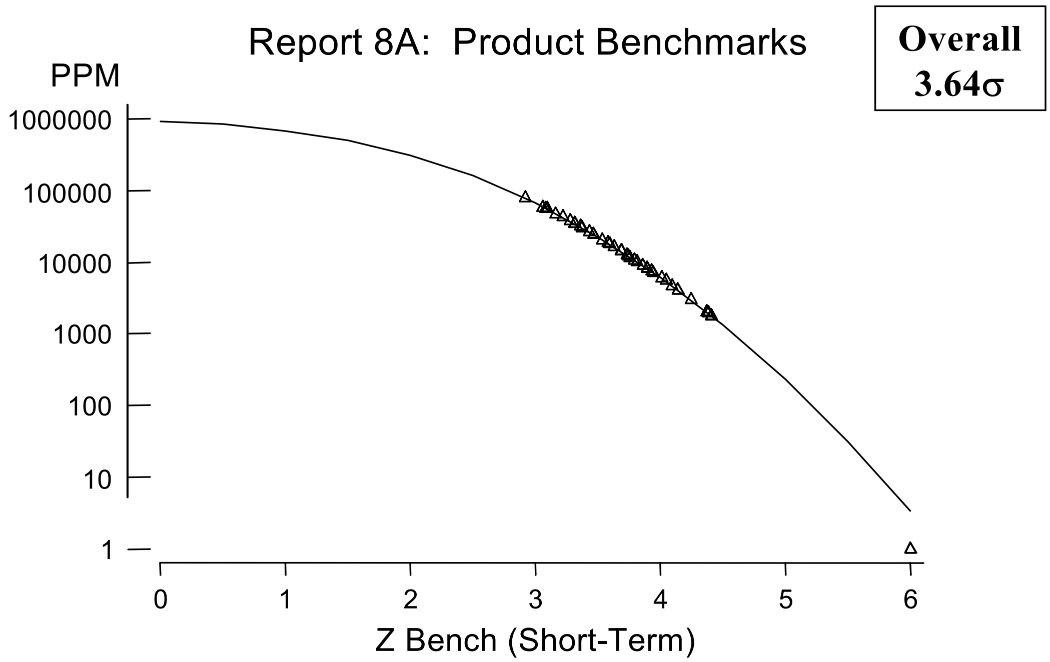
Benchmarking Engineering Drawings

A Champion in an Engineering department asked a Master Black Belt to help him benchmark engineering drawings in his functional area. He is interested in determining where the engineering function is positioned on the organization's Six Sigma journey. At the micro-level, he wants to determine Sigmas for different engineering drawings for different contracts so his group can focus their improvement efforts.

The Master Black Belt said: "Remember, in order to do micro-level product benchmarking, we need data measuring the quality of the main deliverables of the function – engineering drawings. Since there is no data available, we need to organize a data collection." The Champion replied, "But I do not want my staff to think that I am looking over their shoulders because they are doing a great job! I just want us to discover where we can improve our process so that we are working to our best potential." The Master Black Belt replied: "This is a very important point. We will definitely have to ensure that our staff understands why we are doing this and we will need to work together on this data collection. We can get a Six Sigma team in Engineering to gather data for a sample of drawings for different contracts."

The team gathered data on 63 drawings. They determined the number of opportunities for defect on each drawing and then counted the number of defects on the selected drawings. With these figures, they are now able to determine different metrics, such as defects per unit, defects per million opportunities, and the Sigma capability (which is represented by Z.Benchmark). With this information, they are now able to estimate Sigma values for the drawings for each contract. This information can then be flowed up in order to determine the overall Sigma metric.

Product Report in Minitab for Engineering Drawings



Process Baselines

Define

7

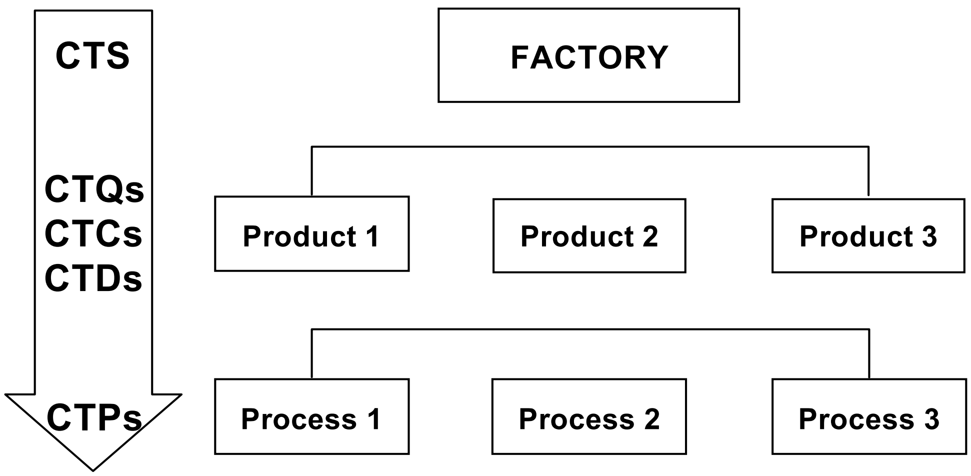
Product Report in Minitab for Engineering Drawings

A Champion and Master Black Belt were reviewing the results of micro-level benchmarking on engineering drawings. The Champion asked: "There seems to be a lot of detailed calculation that is required for this type of analysis! Is there a computer tool available to facilitate this?" The Master Black Belt replied: "Actually, the Six Sigma product report function in Minitab software can be used for this. Let's look at the graph on the screen. This graph is the result of this type of calculation, based on a sample of 63 engineering drawings."

The Champion asked: "So what is this graph telling us?" The Master Black Belt replied: "Well, we are looking at metrics to evaluate how we are doing. By plotting PPM (DPMO) versus Z.Benchmark, we can see the relationship between the two measurements. For example, increasing Z.Benchmark may result in an exponential decrease of PPM. In our case, the majority of the drawings are between 3σ and 4.5σ, and we calculated that the overall Sigma level for the engineering drawings is 3.64σ. This means that as we increase our Sigma value, our defect rate will decrease rapidly. This graph is a good tool to visualize our current situation."

The Champion exclaimed: "Well, I was expecting us to be much better than that. We will need to find projects and select Black Belts in order to improve the quality!" The Master Black Belt replied: "We first have to discover why we are at this level and where we should focus our improvement efforts. So, we will begin by identifying our key processes and baselining them."

What Is Process Baselining?



Process Baselines

Define

8

What Is Process Baselining?

Process baselining is done in order to create a quick basis of comparison. Depending on the situation, it could take from a couple of hours to a few days. When an organization is beginning a Six Sigma initiative, process baselining should be done with data that is available and easy to use, which is usually discrete data. Once we baseline our processes, we can flow these metrics down in order to focus improvement efforts. Ultimately, after the completion of a good number of Black Belt projects, continuous or discrete data for specific CTQs, CTCs, or CTDs may be available to flow up to create an overall Sigma value for quality, cost, and delivery characteristics separately for the functional area. In fact, this is the vision that we should work towards.

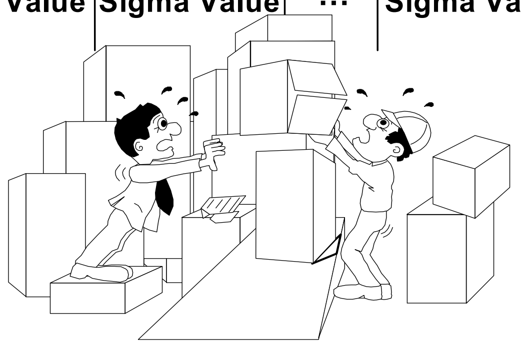
Process baselining is also an organizational step. It allows us to determine where data is available and where there are gaps. At this point, we are not interested in organizing a thorough data collection to create data because these gaps could represent future projects for Black Belts.

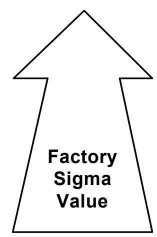
Process baselining tends to be focused on the vital few processes in a functional area. Vital few processes are key processes that have leverage, such as processes that run across many products. After identifying key processes, we determine which ones have existing data. We can map key processes to determine data collection points. At this point, we look at the data that is available at each of the data collection points in the process.

After identifying which key processes need the most improvement, we need to determine the CTQ characteristics (or Cost, or Delivery) for customer requirements. Process capability analysis can be done to determine the level of quality of these characteristics.

Identifying Key Processes

	Product 1	Product 2	…	Product m	
Process 1					Sigma Value
Process 2					Sigma Value
…					…
Process n					Sigma Value
	Sigma Value	Sigma Value	…	Sigma Value	Sigma Value





Define

Process Baselines

9

Identifying Key Processes

A business unit Director wants to know where the factory is along the Six Sigma journey. He asked the question of a Master Black Belt who explained that, at the beginning of the journey, when there are not many projects competed, we do a baseline of the key processes in the factory. The baseline provides an overall approximation of the factory capability, and allows us to focus efforts on the most important processes of our factory.

The Director then asked: "We must have hundreds of processes, how can we identify the key ones?"

The Master Black Belt replied: "If we create a matrix showing products along the columns and processes along the rows, then we can checkmark what process is used for each product. Once we complete the matrix, we count along the rows the processes used for more products, thus identifying our key processes: This matrix can also be used to identify product benchmarks along the column, and process baselines along the rows. Our overall Sigma value for the factory would be in the right lower corner. It is important to note, however, that there will probably not be many Sigma values at this point."

The Master Black Belt continued his explanation while check-marking the key processes for which data is available.

Baselining Manufacturing Processes

PROCESS	OPP	QTY	DEF	TOP	DPU	DPMO	SIGMA
PLATE	35	1889	86	4234	0.046	20311.76	3.55
ALODINE	205	28003	386	28003	0.014	13784.24	3.70
ANODIZE	45	4726	65	4777	0.014	13606.866	3.71
PAINT	200	3136	135	9405	0.043	14354.067	3.69
MARK	978	44158	263	168469	0.006	1561.118	4.46
PEEN	12	1371	5	1435	0.004	3484.321	4.20
BOND	19	355	3	786	0.008	3816.794	4.17
BORE	232	2105	30	24467	0.014	1226.141	4.53
GRIND	52	3540	17	17468	0.005	973.208	4.60
DRILL	2035	9692	206	192967	0.021	1067.540	4.57
MILL	3362	18486	314	603009	0.017	520.722	4.78
DEBURR	14044	38550	518	2180064	0.013	237.608	4.99
CLEAN	316	20120	19	110290	0.001	172.273	5.08
MACH	6361	30120	178	1186261	0.006	150.051	5.12
MASK	620	1356	15	21989	0.011	682.159	4.70
LASER	1447	6534	18	735818	0.003	24.463	5.56
PUNCH	125	610	12	21356	0.020	561.903	4.76

1_02_05_009

Process Baselines

Baselining Manufacturing Processes

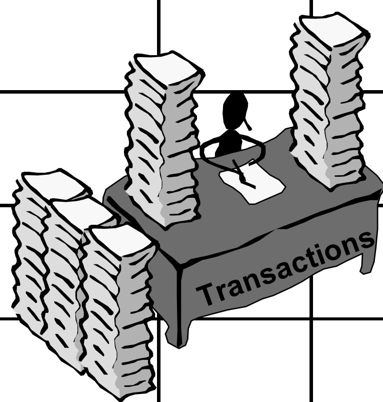
After identifying key processes in his manufacturing area, a Champion wanted to know what his Six Sigma team should do next. A Master Black Belt said: "Well, the next step is to identify where data is available for these key processes. The quality department should have inspection data that we can use to baseline our processes."

After the data has been collected, the Champion and Master Black Belt reviewed the tables of data that the team had found on 17 processes. The Champion asked: "So, where does this data come from?" The Master Black Belt replied, "This information comes from discrete data. Let's look at one of the lines in this table. For example, take the drilling process. There is data measuring the diameter of the holes on parts. Even though the holes were measured by Quality Black Belts at inspection, the data was recorded as pass/fail data. However, note that different parts have different numbers of holes. Parts that have more holes will have more opportunities for defect. The team took a batch of data that had been collected over a few weeks, and identified that there were a total number of 192,967 opportunities for defect (holes) on 9,692 parts. Out of these opportunities, 206 holes did not conform to standard – so, there are 206 defects. This results in a level of 2% defects per unit and 1,068 defects per million opportunities. This corresponds to a short-term Sigma value of 4.57.

This table will also allow us to identify the processes that need to be improved. For example, the plating, alodine, anodize, and painting processes should be the first processes on which we focus our improvement efforts through Six Sigma projects.

Baselining Transactional Processes

	Completeness	Accuracy	Legibility	
Execution Section				Sigma Value
Closing Section				Sigma Value
Modification Section				Sigma Value
Inspection Section				Sigma Value
	Sigma Value	Sigma Value	Sigma Value	Sigma Value



Define

Process Baselines

11

Baselining Transactional Processes

A Champion in manufacturing asked a Master Black Belt: "How can I determine how well my function is doing. In other words, where are we on the Six Sigma journey?" The Master Black Belt replied: "Well, the first thing we could do is define the functional area we wish to assess, then define the key processes in the function." She replied: "Well, I want to see where I can improve the processes in my Quality function, specifically, the documentation process."

"The next step," stated the Master Black Belt, "is to determine what the deliverables and requirements are for this process." She replied: "We must deliver documents that contain information on who has done what, when, and how for Transport Canada in order to obtain the Certificate of Airworthiness. Due to the importance of these documents, we need to ensure that they are completely accurate, so they are verified 100%. The deliverables are: the Production Order - Work Station; the movement production order, the movement or assembly book, the modification notice production order, the modification notice, the Serial Numbers Control sheet, and the FTP cell sheet."

The Master Black Belt said: "Okay, now remember, for transactional processes there is not usually a lot of data available and we need discrete data for metric calculation. One way a team could do this is to create a matrix and then write down all of the data fields for each document along with possible defect types, such as accuracy, completeness and legibility. After this is done, data will have to be collected to determine defects per each unit. We will have to involve the function in this process to obtain accurate data. Then we could determine the metric for the CTQ characteristics. This process baselining would provide us with insight as to where to begin our improvement efforts."

Lessons Learned

- Product benchmarking and process baselining are a first step in determining where an organization is on the Six Sigma journey.
- The approach to apply these concepts may differ depending on the situation.
- Product benchmarking and process baselining use similar tools, but their perspective is different.
- Product benchmarking compares products and services to each other, as well as to world-class.
- Process baselining evaluates and compares key processes to each other.
- Product benchmarking can be done at macro and micro levels.
- Macro-level product benchmarking is a quick estimation that should be completed in a short time period using available data.
- For macro-level benchmarking, organizations usually use yield at final inspection or test to determine Sigma capability.
- Micro-level benchmarking is a more detailed analysis usually done on several deliverables in a functional area.
- Organizations usually use the following metrics: DPU, DPMO and Sigma capability.
- The Six Sigma product report in Minitab is a good tool for micro-level product benchmarking and process baselining.
- The same tools for macro and micro-level product benchmarking can be used for process baselining, however the focus is on the processes.
- Process baselining is a quick estimation that should also be completed in a short time period.
- At this point, it is usually discrete data that is used for process baselining since it is more available in most organizations.
- Process baselining is usually accomplished by the following steps: first, identify key process; second, map these processes; third, identify existing data collection points; and fourth, use this data to develop metrics.
- Low process capability will enable us to identify opportunities for Six Sigma improvement projects.
- If no data is available, as may be the case in transactional areas, Six Sigma data collection projects must be organized.