UNIVERSITEIT VAN AMSTERDAM

IBIS UvA

Lean Six Sigma
Trial Exam

Green Belt

Name of the Green Belt:

.....

Please check you are taking the correct exam.

This is an open-book exam. You are allowed to use books and notes.
You are **not** allowed to use a calculator, telephone, tablet or computer.
Please circle your answer.

Calculation of points
Score = 10(#correct – 10) / 30
The score will be rounded to halves, with the exception of 5.5.
The exam consists of 40 questions.

1

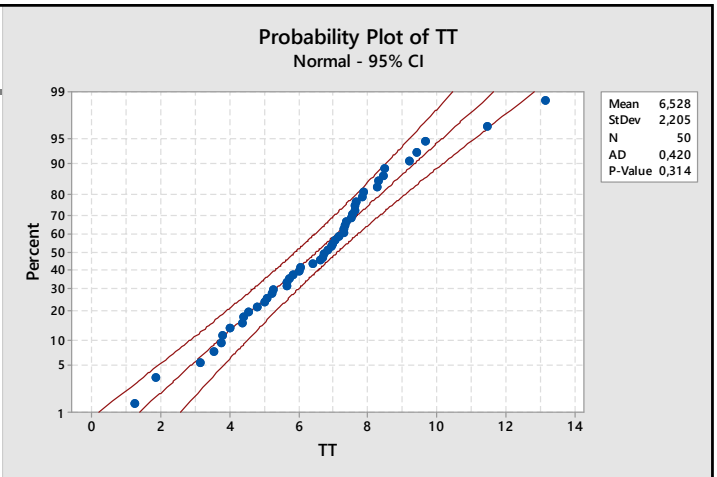
DMAIC 7: Improve process control

The Green Belt (GB) implements new standard operating procedures. To make sure these procedures are followed, she organizes weekly coaching sessions. In a coaching session, the team leaders check whether the team members follow procedures. If not, then the team leader helps team members to do so. If necessary, the operating procedures are further improved.

According to Juran, this is an example of…

a) …visual management.
b) …quality improvement, where management continuously improves the process.
c) …quality control, where management checks and facilitates personnel.
d) …a control chart with an out-of-control-action-plan (OCAP).

2

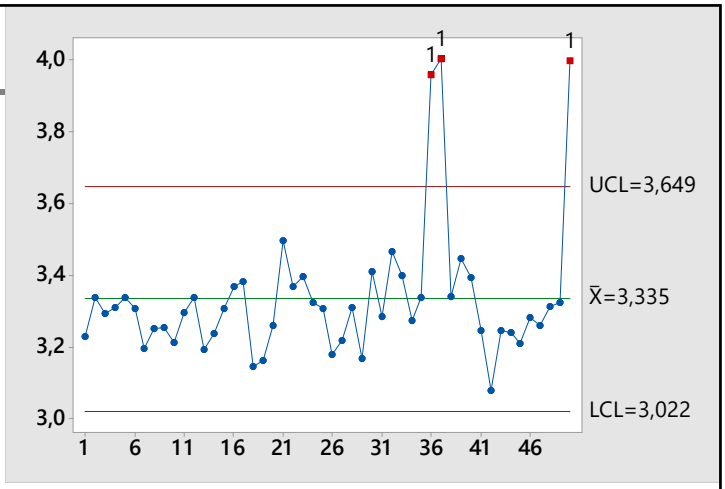


CTQ: Total time (TT) needed to process a request.

Which is true?

a) The p-value is high, which shows that there is no relation between TT and Percent.
b) Before continuing the analysis, an outlier should be removed.
c) The CTQ follows a normal distribution.
d) 1 out of 50 cases do not meet the requirements.

3

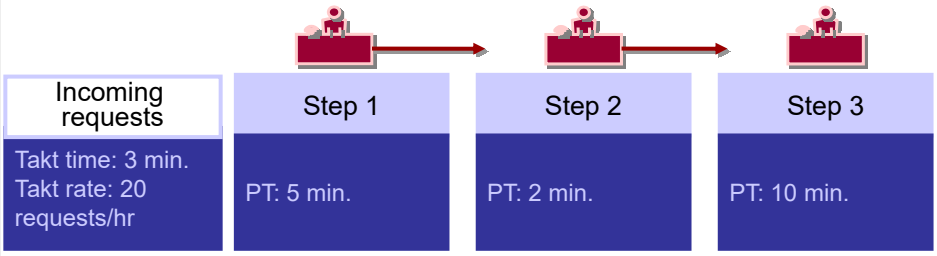


In DMAIC 3, the GB creates the control chart above.

What is the logical next step?

a) The process is not in control, proceed to DMAIC's control phase.
b) Find out what caused the outliers.
c) Split the dataset in two, and make a separate control chart for each part.
d) Determine the customer specification limits (LSL and USL).

4



Requests are processed in three steps. The processing time (PT) for each process step is indicated above. There is negligible variation in work volume and PTs.

How many employees are needed to sufficiently staff this process (assume that employees are dedicated to a process step)?

a) 3.
b) 7.
c) 10.
d) 17.

5

How did we arrive at ‘Six Sigma’ as a name for the improvement programme?

a) Because all processes are allowed to deviate 6σ from the mean at most.
b) The method originated from statistics.
c) It is a symbolic name that represents the pursuit of virtually zero defects.
d) It was the official name of the 6th reorganisation at Motorola.

6

In a warehouse, a GB wants to measure both the daily work volume and the employees’ picking times of products.

She has a database in which she can find the work volumes (categorized by product type) per day, and she is going to measure the employees’ picking times by means of time sheets.

What type of variables is the GB dealing with?

a) Work volume is categorical, and picking time is categorical.
b) Work volume is categorical, and picking time is numerical.
c) Work volume is numerical, and picking time is categorical.
d) Work volume is numerical, and picking time is numerical.

7

A GB performed a regression to study the potential effect of X on her CTQ Y.

Regression Analysis: CTQ versus X

The regression equation is

CTQ = 0.65 + 0.70 X

S = 1.40 R-Sq = 34.8% R-Sq(adj) = 32.5 %

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	1	29.1469	29.1469	14.9743	0.001
Error	28	54.5010	1.9465		
Total	29	83.6478			

Given the analysis above, which statement is true?

a) X explains the majority of the variation in Y.
b) X does not have a significant effect on Y.
c) The predicted value for Y is 2.05 when X=2.
d) The p-value is too low for reliable conclusions.

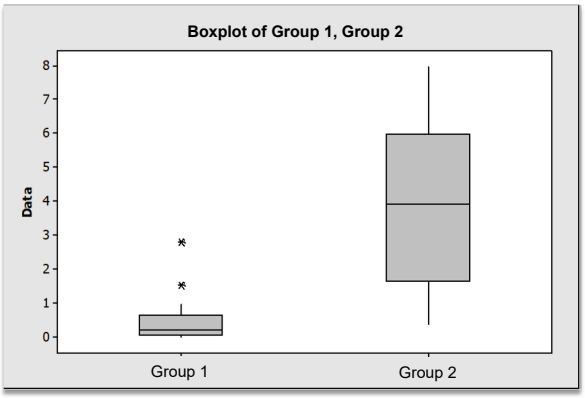
8

A GB investigates a process in a call center, where requests for information are processed. Company policy prescribes that waiting time before a customer is connected to an operator, should always be below 10 minutes. There is only one CTQ: *Waiting time* (per call).

What could be the strategic focal point(s) of this project?

a) Customer satisfaction and operational costs.
b) Quality, efficiency and operational costs.
c) Quality of service.
d) Personnel costs.

9



What statement is **not** true given the information in the boxplot?

a) The distribution of Group 1 is relatively skewed.
b) The graph enables us to read the averages of both groups separately.
c) The dispersion in Group 2 is higher.
d) Roughly half of the values in Group 2 is higher than 3.9.

10

Two-Sample T-Test and CI: Group 1, Group 2

```
Two-sample T for Group 1 vs Group 2

         N   Mean  StDev  SE Mean
Group 1  8  11.94   1.53     0.54
Group 2  8  14.28   1.12     0.40

Difference = mu (Group 1) - mu (Group 2)
Estimate for difference:  -2.34302
95% CI for difference:
(-3.77999, -0.90605)
T-Test of difference = 0 (vs not =):
T-Value = -3.50  P-Value = 0.004  DF = 14
Both use Pooled StDev = 1.3400
```

Test for Equal Variances: Group 1, Group 2

```
95% Bonferroni confidence intervals for standard
deviations

         N     Lower    StDev    Upper
Group 1  8  0.955548  1.52738  3.49844
Group 2  8  0.701728  1.12167  2.56916

F-Test (normal distribution)
Test statistic = 1.85, p-value = 0.434

Levene's Test (any continuous distribution)
Test statistic = 0.53, p-value = 0.477
```

What conclusion can be drawn from the two analyses above?

a) The averages differ significantly, but the standard deviations do not.
b) The standard deviations differ significantly, but the averages do not.
c) Both the averages and the standard deviations differ significantly.
d) Neither the averages and the standard deviations differ significantly.

11

DMAIC 4 is called “Identify potential influence factors”. Which of these tools is probably not useful here?

a) Failure Mode & Effect Analysis (FMEA).
b) Control charts.
c) Control plan.
d) Ishikawa or fishbone diagram.

12

The number of calls that arrives at a call center each day has a normal distribution with an average of 500 and a standard deviation of 25.

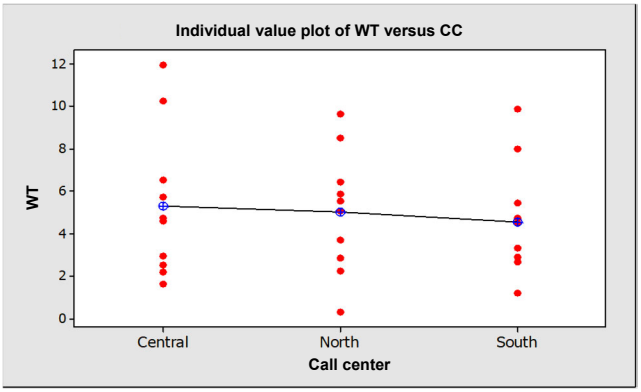
A GB records the number of incoming calls for 1000 consecutive days

What is true about the data that the GB collected?

a) In roughly 95% of days, the number of calls is between 475 and 575.
b) The standard deviation is roughly equal to the median.
c) In roughly 68% of days, the number of calls is between $495\ (= 500 - \sqrt{25})$ and $505\ (= 500 + \sqrt{25})$.
d) In roughly 50% of days, the number of calls is below 500.

13

A company has three call centers. To find influence factors for waiting time (WT), the GB considers the *individual value plot*.



If the GB wants to generate more ideas for possible influence factors, what would be a good next step?

a) Autopsies and BOB vs. WOW.
b) Find out the reason for the large differences between call centers.
c) Perform an ANOVA to find out whether the differences are significant.
d) Perform a test for equal variances.

14

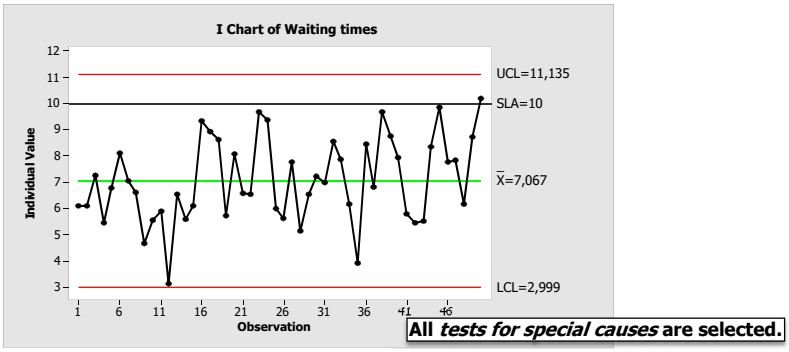
During the first Lean Six Sigma team meeting, a team member does not show up. You run into him in the hallways the next day, and ask him where he was the day before.
He tells you that he will also be absent the next meeting, because he thinks Lean Six Sigma is a worthless method.

What is the appropriate response?

a) Explain to him that Lean Six Sigma is a good method, and stress what the financial benefits are.
b) Invite him for a personal meeting, and politely ask something like “A worthless method, you say?” and listen.
c) Shout at him and tell him he is being disloyal.
d) Accept his resignation and try to find somebody to replace him on the team.

15

After the improvement phase, the call center's line manager monitors the waiting time using a control chart. Suppose the 50th call had a waiting time of 10.2 minutes, as shown in the control chart below.



What should the line manager do after the 50th call?

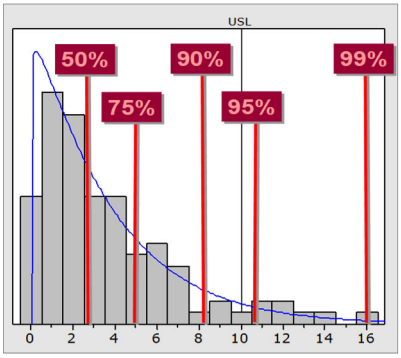
a) Do not do anything yet, as there is no signal that indicates a change in the process.
b) Study why the 50th call had an unusually long waiting time.
c) Study what caused the rising trend in waiting times.
d) Temporarily increase the number of operators.

16

What is the difference between control limits (UCL and LCL in the control chart) and customer specifications (USL and LSL)?

a) It is practically the same.
b) Customer specifications are used to detect special causes of variation. With control limits you indicate how small the variation of the process should be.
c) Control limits are used to detect customer specifications.
d) Control limits indicate the bandwidth within a process varies. Customer specifications indicate what is acceptable to the customer.

17



Lead times:
50% less than 2.6 days
75% less than 5.1 days
90% less than 8.3 days
95% less than 10.6 days
99% less than 16.0 days

The above histogram indicates that 50% of lead times are less than 2.6 days, 75% is less than 5.1 days, etc. Using which technique in Minitab can these percentages be determined?

a) Descriptive statistics (*Basic Statistics* > *Display Descriptive statistics*).
b) Capability-analysis (*Quality tools* > *Capability analysis*).
c) Empirical CDF (*Graph* > *Empirical CDF*).
d) Normal Distribution (*Calc* > *Probability distributions* > *Normal*).

18

```
Descriptive Statistics: CTQ

Variable   N  N*    Mean  SE Mean  StDev  Minimum      Q1  Median      Q3  Maximum
CTQ       30   0  12.099    0.193  1.055    9.754  11.212  11.885  13.116   14.056
```

Which statement is true?

a) The standard deviation is 1.06 and 75% of the data is less than 13.1.
b) All measurements are smaller than 14.1 and the median is 12.1.
c) The data set has 30 measurements, and 25% of the data is greater than 11.2.
d) The standard deviation is 0.193 and 50% of the data is greater than 11.9.

19

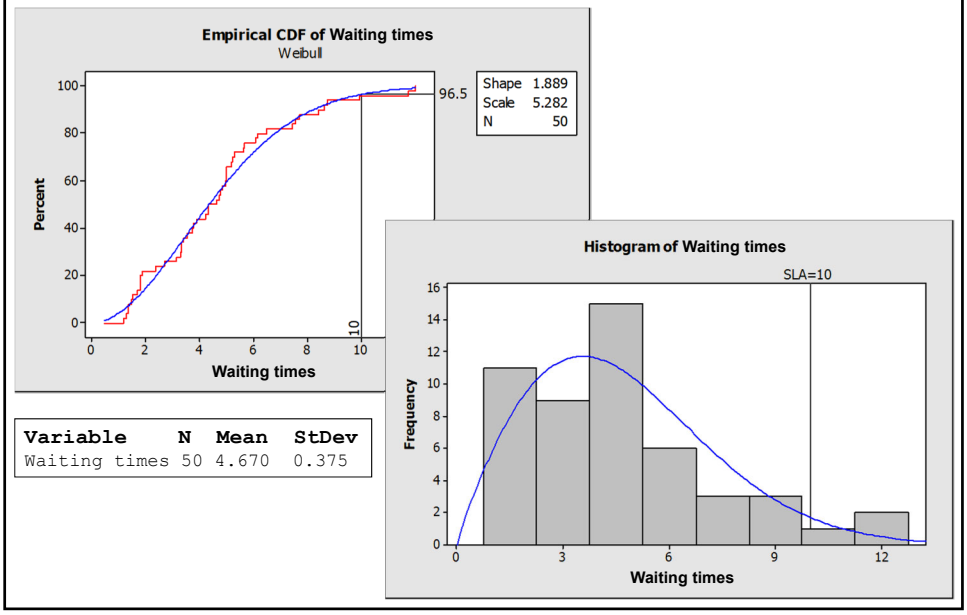
A GB performs a process performance analysis of the CTQ: waiting time. She wants customer waiting time to be shorter than the 10-minute service level agreement (SLA). She has data on the waiting times of 50 selected calls from the past year.

The analysis is on the **next slide**.

What can the GB conclude from the analysis?

a) The process performance can not be determined because the data does not follow normal distribution.
b) About 96.5% of waiting times are longer than 10 minutes.
c) In the past year, approximately 3.5% of the waiting times did not meet the SLA.
d) The default deviation of waiting times is approximately 1.89.

19 – output



Variable	N	Mean	StDev
Waiting times	50	4.670	0.375

20

One-way ANOVA: Waiting time versus Callcenter

Source	DF	SS	MS	F	P
Callcenter	2	2.85	1.42	0.16	0.855
Error	27	243.42	9.02		
Total	29	246.27			

S = 3.003 R-Sq = 1.16% R-Sq(adj) = 0.00%

Level	N	Mean	StDev	Individual 95% CIs For Mean
Central	10	5.288	3.460	(----------*----------)
North	10	4.993	2.848	(----------*----------)
South	10	4.539	2.639	(----------*----------)

3.6 4.8 6.0 7.2

The GB has performed an ANOVA with CTQ *Waiting time* and factor *Callcenter*.

What conclusion can the GB draw from this analysis of variance (ANOVA)?

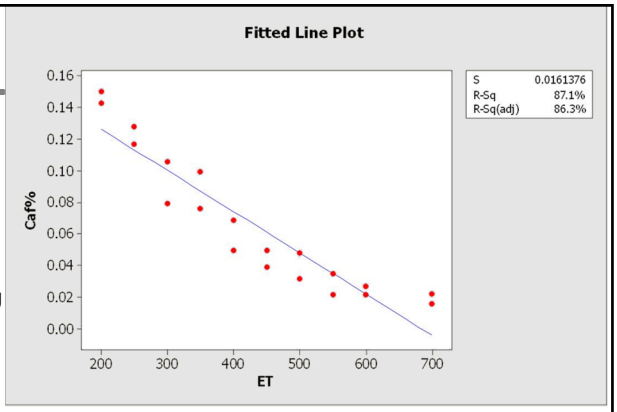
a) There are significant differences in average waiting time between call centers.
b) Call center has an effect on waiting time, but only a very small effect.
c) Call Center has no significant effect on waiting time.
d) South can serve as a benchmark, because it has the shortest waiting times.

21

When producing caffeine-free coffee, the extraction time (*ET*) is the most important factor of influence.

To investigate the effect of *ET* on the caffeine percentage (CTQ), the GB performs an experiment, varying the *ET* from 200 to 700 minutes.

The results of the experiment are analyzed using regression analysis.



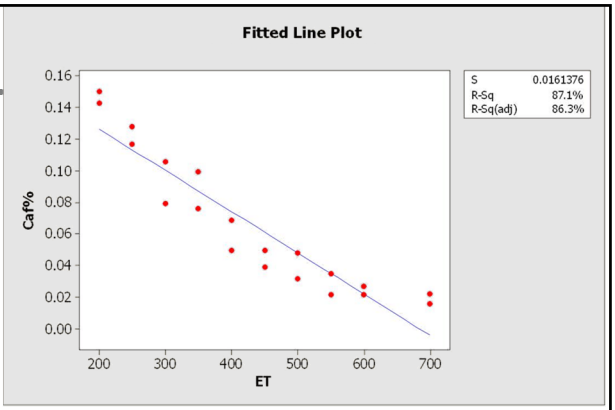
Analysis of Variance

Source	DF	SS	MS	F	P
Regression	1	0.0315351	0.0315351	121.09	0.000
Error	18	0.0046876	0.0002604		
Total	19	0.0362227			

In this case, how can the GB make sure her analysis is reliable?

a) By looking at the corresponding patterns and normality of the residuals.
b) By removing outliers.
c) Due to the high R-Sq, more than 87.1%.
d) By counting the dots (observations), there must be more than 30.

22



Assume that the analysis is correct.

Based on the fitted line plot on the **previous slide**, which is shown above as well. What would be an acceptable extraction time (ET) to meet the USL of 0.1%?

a) ET = 200 min.
b) ET = 300 min.
c) ET = 350 min.
d) ET = 430 min.

23

The regression analysis of *Caf%* versus ET (**two slides back**) states:

Analysis of Variance					
Source	DF	SS	MS	F	P
Regression	1	0.0315351	0.0315351	121.09	0.000
Error	18	0.0046876	0.0002604		
Total	19	0.0362227			

What does this mean?

a) It means that the slope of the regression line significantly differs from zero (i.e., the regression line is not horizontal).
b) It means that *Caf%* is significant.
c) It means that the *ET* determines almost 100% of *Caf%*.
d) It means that the dataset is not large enough to prove that there is a relationship between *Caf%* and *ET*.

24

Suppose that a GB worries about possible irregularities in the data set during the analysis phase in DMAIC (*Analyze),* and thus wants to screen the data on *outliers*.

What is the best way to identify outliers in a dataset?

a) Regression
b) The empirical CDF (cumulative distribution function).
c) The probability plot.
d) ANOVA.

Reduce lead time of mortgage offers
*Questions **25** to **40** relate to this case.*

A bank handles requests for mortgages. If the request is accepted, an offer will be sent. Otherwise, a rejection letter will be drawn up.

- On average, 40 requests each day go through the process. In the first phase, they are processed by 4 coordinators, who check the applications for completeness, and request further information from the Kadaster.
- Next, the coordinators send the request to one of the 3 reviewers. They assess whether the applicant meets the requirements for a loan, and they determine the interest rate.
- Applications for the larger loans (25% of applications) are then sent to an internal advisor who assesses the risk and decides on approval or rejection of the loan.
- Eventually 10% of applications are rejected. In that case, the secretary will write a rejection letter. For approved applications (90%), the secretary makes an offer and sends it to the applicant.

The company loses customers due to the long turnaround of the process. If applicants do not receive an offer within a few days, they give it up and try it at another bank. This results in a bad conversion rate (= the percentage of bids accepted by the applicants).

25

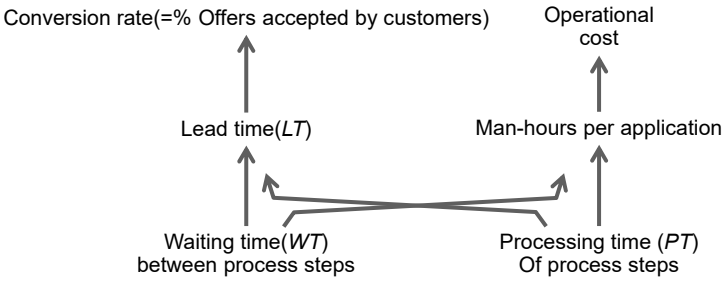
As a start of the project the GB makes a stakeholder analysis, which shows the stake and influence of people concerning the project, and a SIPOC, which shows the main steps of the process.

In the next step the GB wants to form a team.

Who should be included in your team?

a) Yellow belts.
b) User.
c) Champion.
d) Supplier.

26



Is the above CTQ flowdown acceptable?

a) Yes, the flowdown is acceptable.
b) No, waiting time (*WT*) should not be connected to man-hours per application.
c) No, processing time (*PT*) should not be connected to man-hours per application.
d) No, conversion rate should be replaced by quality and efficiency.

27

What is a practical and effective way to measure *PT* and *WT*?

a) *Travelsheet*: Follow a sample of requests through the process, where employees place time stamps when they begin or end a task.
b) *Day-in-the-life-of* (multi-moment recording): Follow a number of employees during a day. Every 15 minutes. They indicate on a form what task they are doing.
c) *Time study*: Ask an employee to complete the first process step for 10 requests and measure the processing times with a stopwatch. Same for the second process step, and so forth.
d) *Process Study*: Measure what times an application reaches the first process step, then the second step, and so forth.

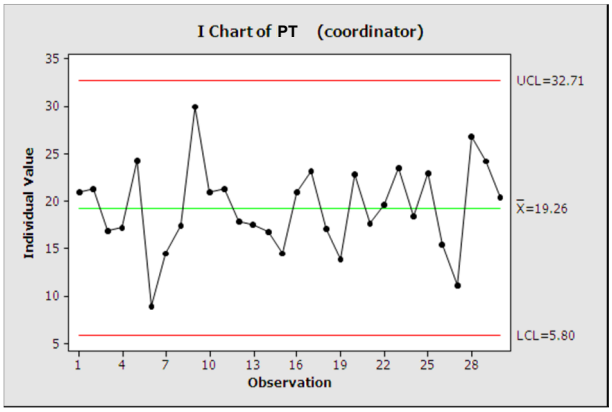
28

DMAIC 2: Validate the measuring procedures
The GB wants to validate the measurement plan that it has designed to determine the *WT* and *PT*.

Which of these techniques is **not** relevant for validating the measurement plan.

a) Brainstorming session to identify validity issues.
b) A test measurement.
c) Check the face validity of the results afterwards.
d) Control chart.

29



Based on 30 measurements, the GB makes a control chart for the coordinator *PT* (see above). What is a correct conclusion?

a) The processing times of the coordinators are acceptable.
b) The coordinator's *PT* is not in statistical control.
c) There is no evidence of trends or outliers (the *PT* is stable).
d) All coordinators' *PT* remains within the standards as agreed in the *SLA* (*Service Level Agreement*).

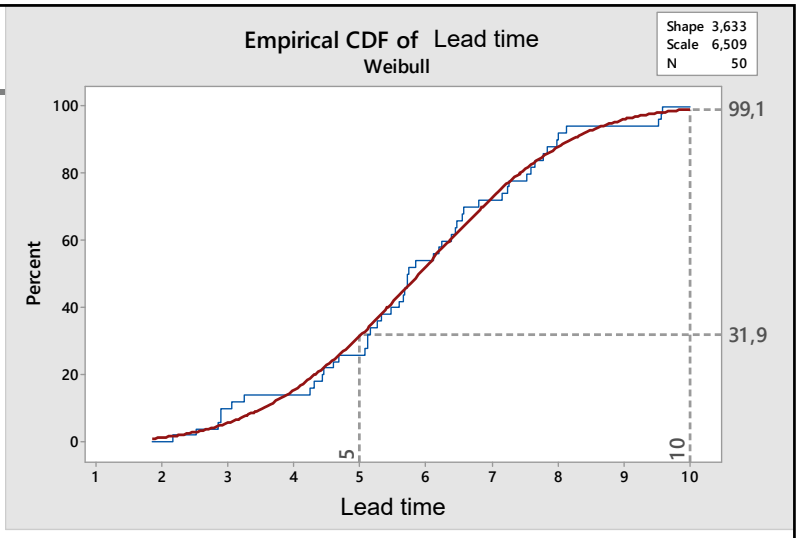
30

The GB wants to determine whether the *WT* has a normal, lognormal or Weibull distribution, or maybe another distribution.

What is the best technique to investigate the distribution of data?

a) Empirical CDF (cumulative distribution function).
b) Histogram.
c) Control chart.
d) Probability plot.

31



What can be concluded from the graph above?

a) About 1% is in the process for more than 10 days.
b) About 32% have a lead time of 5 days.
c) The data is not on a straight line: this distribution does not fit well.
d) The lead time has no linear effect on the CTQ.

32

DMAIC 4: Identify possible influencing factors.
With the aim of reducing the CTQ (*Leadtime*) to a more acceptable level, the GB is considering an FMEA with employees in the process.

Is it helpful to do an FMEA in this project?

a) No, because the project goals are not about risks.
b) No: An FMEA is used to identify faults (possible defects) in products.
c) Yes, assuming that some of the long lead times are caused by errors and mistakes.
d) Yes, because it helps to identify the bottleneck in the process.

33

DMAIC 4: Identify possible influencing factors.
The GB organizes a brainstorm session with the employees from the process. The purpose of the meeting is to identify causes of long lead times and to think of possible solutions.

What is the main role of the employees in this brainstorming session?

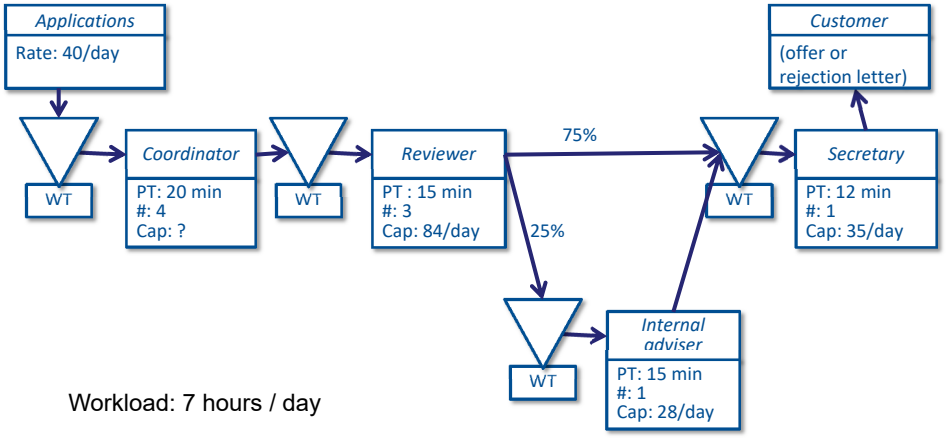
a) The employees vote on the value of improvement ideas, and the ideas with the most votes are implemented.
b) Employees suggest a large number of potential causes and solutions.
c) Employees judge whether the influence factors indicated by the GB are correct.
d) The employees are discussing some promising solutions.

34

Based on the measurements, the GB creates a Value Stream Map (**next slide**).

How are the processing times (*PT*) per process step determined in the Value Stream Map?

a) As the average of the measurements.
b) As the median of the measurements.
c) As the average of the measurements plus twice the standard deviation.
d) As the maximum of measurements.



Workload: 7 hours / day

35

What is the capacity of the coordinators?

a) 3 requests / day.
b) 21 requests / day.
c) 24 requests / day.
d) 84 requests / day.

36

What process step has undercapacity?

a) None of the process steps have undercapacity.
b) The internal advisory process step.
c) The secretary's process step.
d) Both the internal adviser's step and the secretary's step.

37

```
Two-sample T for Approval (offer) vs Rejection

           N    Mean  StDev  SE Mean
Offer      6   8.754  0.820     0.33
Rejection  6  12.063  0.846     0.35

Difference = mu (Offer) - mu (Rejection)
Estimate for difference:  -3.309
95% CI for difference:  (-4.396; -2.221)
T-Test of difference = 0 (vs not =):
T-Value = -6.88  P-Value = 0.000  DF = 9
```

The GB is doing a small study. For six approved applications, she measures how much time (*WT*) it costs the secretary to prepare the offer. In addition, she also measures for six rejected applications how long it takes to write the rejection letter.

Assuming that the assumptions for this test are satisfied, what can the GB conclude from the analysis?

a) The processing time for making an offer is significantly shorter than the time to write a rejection letter.
b) The number of measurements in the study is too small to make reliable conclusions.
c) The averages and variations differ significantly between the two groups.
d) A conclusion is not yet possible, because the GB should have used ANOVA.

38

The GB wants to determine the relationship between the waiting time *WT* in the queue for the coordinators, and the workload *WL* (the number of applications submitted per day).
On 21 different days, she registers the number of applications submitted. In addition, she keeps track of how long a randomly chosen application stays in the queue for the coordinator.
See the regression analysis on the **next slide**.

Is this a good fit?

a) Yes, there is no evidence of a bad fit.
b) No, there are too many points off the regression (fitted) line.
c) No, the relationship is not significant.
d) No, there are outliers to be removed from the data.

Regression Analysis: WT versus WL

```
The regression equation is
WT (hours) = - 10.35 + 0.2392 WL (requests)

S = 0.481152   R-Sq = 96.5%   R-Sq(adj) = 96.3%

Analysis of Variance

Source       DF       SS       MS       F      P
Regression    1  121.771  121.771  525.99  0.000
Error        19    4.399    0.232
Total        20  126.170
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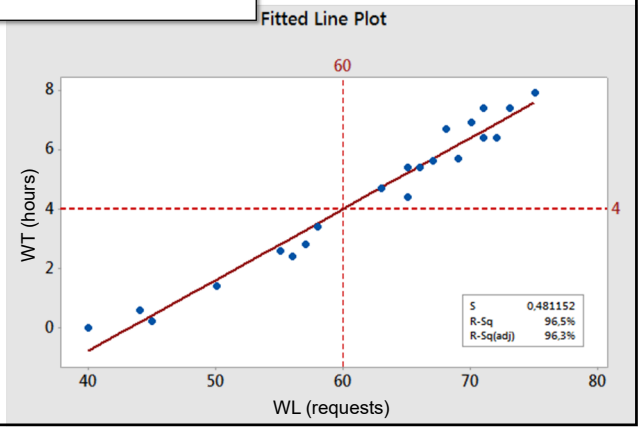

39

Is the workload (*WL*) an important influence factor for the waiting time (*WT*) for the coordinators?

a) Yes, the small p-value indicates that this is an important influence factor.
b) Yes, the high R^2 indicates that this is an important influence factor.
c) No, the small p value indicates that this is not an important influence factor.
d) No, the high R^2 indicates that most of the variation can not be explained by this influence factor.

40

Suppose the workload is equal to 60 requests per day, that is, *WL* = 60. What can you say about the waiting time *WT* (in hours) in the queue for the coordinator?

a) In that case, 95% of all requests will be less than 4 hours in the queue for the coordinators.
b) Then the *WT* is up to 4 hours.
c) Then the *WT* is on average of 4 hours.
d) Then the *WT* is exactly 4 hours.

This is the end of the exam

Please check:

- Did you answer all questions?
- Have you filled in your name on the front sheet?

If you are finished before XX:XX hours then you may quietly leave the examination room and hand in your exam to one of the examiners.

If you are finished after XX:XX hours then you should wait until the examiners collected all exams at YY:YY hours.

IBIS UvA

Answers

Question	Answer	Question	Answer	Question	Answer	Question	Answer
1	C	11	C	21	A	31	A
2	C	12	D	22	D	32	C
3	B	13	A	23	A	33	B
4	B	14	B	24	C	34	A
5	C	15	A	25	C	35	D
6	D	16	D	26	B	36	C
7	C	17	C	27	A	37	A
8	C	18	A	28	D	38	A
9	B	19	C	29	C	39	B
10	A	20	C	30	D	40	C