# Package 'SixSigma'

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**Type** Package

**Title** Six Sigma Tools for Quality Control and Improvement

**Version** 0.9-4

**Encoding** UTF-8

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**Description** Functions and utilities to perform
Statistical Analyses in the Six Sigma way.
Through the DMAIC cycle (Define, Measure, Analyze, Improve, Control),
you can manage several Quality Management studies:
Gage R&R, Capability Analysis, Control Charts, Loss Function Analysis,
etc. Data frames used in the books ``Six Sigma with R'' (Springer, 2012)
and ``Quality Control with R'' (Springer, 2015)
are also included in the package.

**URL** http://www.sixsigmawithr.com

**License** GPL (>= 2)

**Depends** R (>= 2.14.0)

**Imports** grDevices, stats, graphics, qcc, lattice, ggplot2, reshape2,
nortest, e1071, scales, testthat, xtable

**LazyLoad** yes

**LazyData** yes

**RoxygenNote** 6.0.1

**NeedsCompilation** no

**Repository** CRAN

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## R topics documented:

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| climProfiles | *Compute profiles limits* |
|---|---|

---

## Description

Function to compute prototype profile and confidence bands for a set of profiles (Phase I)

## Usage

```
climProfiles(profiles, x = 1:nrow(profiles), smoothprof = FALSE,
  smoothlim = FALSE, alpha = 0.01)
```

## Arguments

| | |
|---|---|
| profiles | Matrix with profiles in columns |
| x | Vector for the independent variable |
| smoothprof | regularize profiles? [FALSE] |
| smoothlim | regularize confidence bands? [FALSE] |
| alpha | limit for control limits [0.01] |

## Value

a matrix with three profiles: prototype and confidence bands

## Author(s)

Javier M. Moguerza and Emilio L. Cano

## References

Cano, E.L. and Moguerza, J.M. and Prieto Corcoba, M. (2015) *Quality Control with R. An ISO Standards Approach*. Springer.

## Examples

```
wby.phase1 <- ss.data.wby[, 1:35]
wb.limits <- climProfiles(profiles = wby.phase1,
    x = ss.data.wbx,
    smoothprof = FALSE,
    smoothlim = FALSE)
    plotProfiles(profiles = wby.phase1,
                x = ss.data.wbx,
                cLimits = wb.limits)
```

---

| outProfiles | *Get out-of-control profiles* |
|---|---|

---

## Description

Returns a list with information about the out-of-control profiles given a set of profiles and some control limits

## Usage

```
outProfiles(profiles, x = 1:nrow(profiles), cLimits, tol = 0.5)
```

## Arguments

| | |
|---|---|
| `profiles` | Matrix of profiles |
| `x` | Vector with the independent variable |
| `cLimits` | Matrix with the prototype and confidence bands profiles |
| `tol` | Tolerance (%) |

## Value

a list with the following elements:

| | |
|---|---|
| `labOut` | labels of the out-of-control profiles |
| `idOut` | ids of the out-of-control profiles |
| `pOut` | proportion of times the profile values are out of the limits |

## References

Cano, E.L. and Moguerza, J.M. and Prieto Corcoba, M. (2015) *Quality Control with R. An ISO Standards Approach*. Springer.

## Examples

```
wby.phase1 <- ss.data.wby[, 1:35]
wb.limits <- climProfiles(profiles = wby.phase1,
    x = ss.data.wbx,
    smoothprof = TRUE,
    smoothlim = TRUE)
wby.phase2 <- ss.data.wby[, 36:50]
wb.out.phase2 <- outProfiles(profiles = wby.phase2,
    x = ss.data.wbx,
    cLimits = wb.limits,
    tol = 0.8)
wb.out.phase2
plotProfiles(wby.phase2,
    x = ss.data.wbx,
    cLimits = wb.limits,
    outControl = wb.out.phase2$idOut,
    onlyout = TRUE)
```

---

plotControlProfiles      *Profiles control plot*

---

## Description

Plots the proportion of times that each profile remains out of the confidence bands

## Usage

```
plotControlProfiles(pOut, tol = 0.5)
```

## Arguments

| | |
|---|---|
| pOut | identifiers of profiles out of control |
| tol | tolerance for the proportion of times the value of the profile is out of control |

## Value

There is only graphical output

## Author(s)

Javier M. Moguerza and Emilio L. Cano

## References

Cano, E.L. and Moguerza, J.M. and Prieto Corcoba, M. (2015) *Quality Control with R. An ISO Standards Approach*. Springer.

## Examples

```
wby.phase1 <- ss.data.wby[, 1:35]
wb.limits <- climProfiles(profiles = wby.phase1,
    x = ss.data.wbx,
    smoothprof = TRUE,
    smoothlim = TRUE)
wby.phase2 <- ss.data.wby[, 36:50]
wb.out.phase2 <- outProfiles(profiles = wby.phase2,
    x = ss.data.wbx,
    cLimits = wb.limits,
    tol = 0.8)
plotControlProfiles(wb.out.phase2$pOut, tol = 0.8)
```

---

| plotProfiles | *Plot Profiles* |
|---|---|

---

## Description

Plot profiles and optionally control limits

## Usage

```
plotProfiles(profiles, x = 1:nrow(profiles), cLimits = NULL,
  outControl = NULL, onlyout = FALSE)
```

**Arguments**

| | |
|---|---|
| `profiles` | matrix with profiles in columns |
| `x` | vector with the independent variable |
| `cLimits` | matrix with three profiles: prototype and confidence bands (limits) |
| `outControl` | identifiers of out-of-control profiles |
| `onlyout` | plot only out-of-control profiles? [FALSE] |

**Value**

Only graphical output with the profiles

**Author(s)**

Javier M. Moguerza and Emilio L. Cano

**References**

Cano, E.L. and Moguerza, J.M. and Prieto Corcoba, M. (2015) *Quality Control with R. An ISO Standards Approach*. Springer.

**Examples**

```
plotProfiles(profiles = ss.data.wby,
    x = ss.data.wbx)
```

---

|  |  |
|---|---|
| SixSigma | *Six Sigma Tools for Quality and Process Improvement* |

---

**Description**

Six Sigma Tools for Quality and Process Improvement

**Details**

This package contains functions and utilities to perform Statistical Analyses in the Six Sigma way. Through the DMAIC cycle (Define, Measure, Analyze, Improve, Control), you can manage several Quality Management studies: Gage R&R, Capability Analysis, Control Charts, Loss Function Analysis, etc. Data frames used in "Six Sigma with R" (Springer, 2012) are also included in the package. Use the package to perform Six Sigma Methodology tasks, throughout its breakthrough strategy: Define, Measure, Analyze, Improve, Control (DMAIC)
Define: Process Map (ss.pMap), Cause and effect Diagram (ss.ceDiag);
Measure: Gage R&R study (ss.rr); Capability Analysis (ss.study.ca); Loss Function Analysis (ss.lfa)
Analyze: Confidence Intervals (ss.ci)
Control: Moving Average Control Chart
Soon: further functions

## Note

The current version includes Loss Function Analysis, Gage R&R Study, confidence intervals, Process Map and Cause-and-Effect diagram. We plan to regularly upload updated versions, with new functions and improving those previously deployed. The subsequent versions will cover tools for the whole cycle:

- Define
- Measure
- Analyze
- Improve
- Control

## Author(s)

Emilio L. Cano, Javier M. Moguerza, Mariano Prieto Corcoba and Andrés Redchuk;

Maintainer: Emilio L. Cano <emilio.lopez@urjc.es>

## References

Allen, T. T. (2010) *Introduction to Engineering Statistics and Lean Six Sigma - Statistical Quality Control and Design of Experiments and Systems* (Second Edition ed.). London: Springer.

Box, G. (1991). Teaching engineers experimental design with a paper helicopter. Report 76, Center for Quality and Productivity Improvement. University of Wisconsin.

Cano, Emilio L., Moguerza, Javier M. and Redchuk, Andrés. 2012. *Six Sigma with R. Statistical Engineering for Process Improvement*, Use R!, vol. 36. Springer, New York. http://www.springer.com/statistics/book/978-1-4614-3651-5.

Cano, Emilio L., Moguerza, Javier M. and Prieto Corcoba, Andrés. 2015. *Quality Control with R. An ISO Standards approach*, Use R!, Springer, New York.

Chambers, J. M. (2008) *Software for data analysis. Programming with R* New York: Springer.

Montgomery, DC (2008) *Introduction to Statistical Quality Control* (Sixth Edition). New York: Wiley&Sons

Wikipedia, http://en.wikipedia.org/wiki/Six_Sigma

## See Also

ss.pMap, ss.rr, ss.ceDiag, ss.ci, ss.heli, ss.lfa

## Examples

```
example(ss.ci)
example(ss.study.ca)
example(ss.rr)
example(ss.lf)
example(ss.lfa)
example(ss.ceDiag)
```

```
example(ss.pMap)
example(ss.ca.yield)
example(ss.ca.z)
example(ss.ca.cp)
example(ss.ca.cpk)
example(ss.cc)
example(plotProfiles)
example(plotControlProfiles)
```

---

smoothProfiles            *Regularise set of profiles*

---

### Description

This function takes a set of profiles and regularise them by means of a SVM

### Usage

```
smoothProfiles(profiles, x = 1:nrow(profiles), svm.c = NULL,
    svm.eps = NULL, svm.gamma = NULL, parsvm.unique = TRUE)
```

### Arguments

| | |
|---|---|
| profiles | Matrix of y values, one column per profile |
| x | Vector of predictive variable values, common to all profiles |
| svm.c | SVM parameter (cost) |
| svm.eps | SVM parameter (epsilon) |
| svm.gamma | SVM parameter (gamma) |
| parsvm.unique | Same parameters for all profiles? (logical [TRUE]) |

### Value

Regularized profiles

### Note

The package e1071 is needed in order to be able to use this function. SVM Parameters can be vectors of the same lenght as number of profiles, or a single value for all of them

### Author(s)

Javier M. Moguerza and Emilio L. Cano

### References

Cano, E.L. and Moguerza, J.M. and Prieto Corcoba, M. (2015) *Quality Control with R. An ISO Standards Approach*. Springer.

## Examples

```
wby.smooth <- smoothProfiles(profiles = ss.data.wby,
    x = ss.data.wbx)
plotProfiles(profiles = wby.smooth,
    x = ss.data.wbx)
```

---

| ss.ca.yield | *Main calculations regarding The Voice of the Process in SixSigma: Yield, FTY, RTY, DPMO* |
|---|---|

---

## Description

Computes the Yield, First Time Yield, Rolled Throughput Yield and Defects per Million Opportunities of a process.

## Usage

```
ss.ca.yield(defects = 0, rework = 0, opportunities = 1)
```

## Arguments

| | |
|---|---|
| defects | A vector with the number of defects in each product/batch, ... |
| rework | A vector with the number of items/parts reworked |
| opportunities | A numeric value with the size or length of the product/batch |

## Details

The three arguments must have the same length.

## Value

| | |
|---|---|
| Yield | Number of good stuff / Total items |
| FTY | (Total - scrap - rework) / Total |
| RTY | prod(FTY) |
| DPMO | Defects per Million Opportunities |

## Author(s)

Emilio L. Cano

## References

Cano, Emilio L., Moguerza, Javier M. and Redchuk, Andres. 2012. *Six Sigma with R. Statistical Engineering for Process Improvement*, Use R!, vol. 36. Springer, New York. http://www.springer.com/statistics/book/978-1-4614-3651-5.

Gygi C, DeCarlo N, Williams B (2005) *Six sigma for dummies*. –For dummies, Wiley Pub.

## Examples

```
ss.ca.yield(c(3,5,12),c(1,2,4),1915)
```

---

| ss.ca.z | *Capability Indices* |
|---------|----------------------|

---

## Description

Compute the Capability Indices of a process, Z (Sigma Score), $C_p$ and $C_{pk}$.

## Usage

```
ss.ca.cp(x, LSL = NA, USL = NA, LT = FALSE, f.na.rm = TRUE,
  ci = FALSE, alpha = 0.05)
```

## Arguments

| | |
|---------|------------------------------------------------------------|
| x       | A vector with the data of the process performance          |
| LSL     | Lower Specification Limit                                   |
| USL     | Upper Specification Limit                                   |
| LT      | Long Term data (TRUE/FALSE). Not used for the moment        |
| f.na.rm | Remove NA data (TRUE/FALSE)                                 |
| ci      | If TRUE computes a Confidence Interval                      |
| alpha   | Type I error ($\alpha$) for the Confidence Interval         |

## Value

A numeric value for the index, or a vector with the limits of the Confidence Interval

## Author(s)

EL Cano

## References

Cano, Emilio L., Moguerza, Javier M. and Redchuk, Andres. 2012. *Six Sigma with R. Statistical Engineering for Process Improvement*, Use R!, vol. 36. Springer, New York. http://www.springer.com/statistics/book/978-1-4614-3651-5.

Montgomery, DC (2008) *Introduction to Statistical Quality Control* (Sixth Edition). New York: Wiley&Sons

## See Also

ss.study.ca

## Examples

```
ss.ca.cp(ss.data.ca$Volume,740, 760)
ss.ca.cpk(ss.data.ca$Volume,740, 760)
ss.ca.z(ss.data.ca$Volume,740,760)
```

---

ss.cc                    *Control Charts*

---

## Description

Plot control charts

## Usage

```
ss.cc(type, data, cdata, CTQ = names(data)[1], groups, climits, nsigmas = 3)
```

## Arguments

| | |
|---|---|
| type | Type of chart (see details) |
| data | data.frame with the process data. |
| cdata | Vector with the controlled process data to compute limits. |
| CTQ | Name of the column in the data.frame containing the CTQ. |
| groups | Name of the column in the data.frame containing the groups. |
| climits | Limits of the controlled process. It should contain three ordered values: lower limit, center line and upper limit. |
| nsigmas | Number of sigmas to compute the limits from the center line (default is 3) |

## Details

If control limits are provided, cdata is dismissed and a message is shown. If there are no control limits nor controlled data, the limits are computed using data.
Supported types of control charts:

- mrMoving Range

## Value

A plot with the control chart, and a list with the following elements:

| | |
|---|---|
| LCL | Lower Control Limit |
| CL | Center Line |
| UCL | Upper Control Limit |
| phase | II when cdata or climits are provided. I otherwise. |
| out | Out of control points |

## Note

We have created this function since the qAnalyst package has been removed from CRAN, and it was used in the "Six Sigma with R" book to plot moving average control charts.

## Author(s)

EL Cano

## References

Cano, Emilio L., Moguerza, Javier M. and Redchuk, Andres. 2012. *Six Sigma with R. Statistical Engineering for Process Improvement*, Use R!, vol. 36. Springer, New York. http://www.springer.com/statistics/book/978-1-4614-3651-5.

## See Also

ss.cc.constants

## Examples

```
ss.cc("mr", ss.data.pb1, CTQ = "pb.humidity")
testout <- ss.data.pb1
testout[31,] <- list(31,17)
ss.cc("mr", testout, CTQ = "pb.humidity")
```

---

| ss.cc.constants | *Functions to find out constants of the relative range distribution.* |
| --- | --- |

---

## Description

These functions compute the constants d2, d3 and c4 to get estimators of the standard deviation to set control limits.

## Usage

```
ss.cc.getd2(n = NA)
```

## Arguments

n               Sample size

## Value

A numeric value for the constant.

## Author(s)

EL Cano

## References

Cano, Emilio L., Moguerza, Javier M. and Redchuk, Andres. 2012. *Six Sigma with R. Statistical Engineering for Process Improvement*, Use R!, vol. 36. Springer, New York. http://www.springer.com/statistics/book/978-1-4614-3651-5.

## See Also

ss.cc

## Examples

```
ss.cc.getd2(20)
ss.cc.getd3(20)
ss.cc.getc4(20)
```

---

ss.ceDiag                    *Cause and Effect Diagram*

---

## Description

Represents a Cause and Effect Diagram by cause group.

## Usage

```
ss.ceDiag(effect, causes.gr, causes,
  main = "Six Sigma Cause-and-effect Diagram", sub, ss.col = c("#666666",
  "#BBBBBB", "#CCCCCC", "#DDDDDD", "#EEEEEE"))
```

## Arguments

| | |
|---|---|
| effect | A short character string that represents the effect we want to analyse. |
| causes.gr | A vector of characters that represents the causes groups. |
| causes | A vector with lists that represents the individual causes for each |
| main | Main title for the diagram |
| sub | Subtitle for the diagram (recommended the Six Sigma project name) |
| ss.col | A vector of colors for a personalized drawing. At least five colors, sorted by descendant intensity |

## Details

The default value for ss.col is c("#666666", "#BBBBBB", "#CCCCCC", "#DDDDDD", "#EEEEEE"), a grayscale style. You can pass any accepted colour string.

## Value

A drawing of the causes and effect with "fish-bone" shape

## Note

The cause and effect diagram is also known as "Ishikawa diagram", and has been widely used in Quality Management. It is one of the Seven Basic Tools of Quality.

## Author(s)

EL Cano

## References

Cano, Emilio L., Moguerza, Javier M. and Redchuk, Andres. 2012. *Six Sigma with R. Statistical Engineering for Process Improvement*, Use R!, vol. 36. Springer, New York. http://www.springer.com/statistics/book/978-1-4614-3651-5.

Wikipedia, http://en.wikipedia.org/wiki/Ishikawa_diagram

## See Also

ss.pMap

## Examples

```
effect <- "Flight Time"
causes.gr <- c("Operator", "Environment", "Tools", "Design",
  "Raw.Material", "Measure.Tool")
causes <- vector(mode = "list", length = length(causes.gr))
causes[1] <- list(c("operator #1", "operator #2", "operator #3"))
causes[2] <- list(c("height", "cleaning"))
causes[3] <- list(c("scissors", "tape"))
causes[4] <- list(c("rotor.length", "rotor.width2", "paperclip"))
causes[5] <- list(c("thickness", "marks"))
causes[6] <- list(c("calibrate", "model"))
ss.ceDiag(effect, causes.gr, causes, sub = "Paper Helicopter Project")
```

---

ss.ci                           *Confidence Interval for the mean*

---

## Description

Computes a confidence interval for the mean of the variable (parameter or feature of the process), and prints the data, a histogram with a density line, the result of the Shapiro-Wilks normality test and a quantile-quantile plot.

## Usage

```
ss.ci(x, sigma2 = NA, alpha = 0.05, data = NA, xname = "x",
  approx.z = FALSE, main = "Confidence Interval for the Mean", digits = 3,
  sub = "", ss.col = c("#666666", "#BBBBBB", "#CCCCCC", "#DDDDDD",
  "#EEEEEE"))
```

## Arguments

| | |
|---|---|
| x | A numeric vector with the variable data |
| sigma2 | The population variance, if known |
| alpha | The eqn\alpha error used to compute the $100 * (1 - alpha)\%$ confidence interval |
| data | The data frame containing the vector |
| xname | The name of the variable to be shown in the graph |
| approx.z | If TRUE it uses z statistic instead of t when sigma is unknown and sample size is greater than 30. The default is FALSE, change only if you want to compare with results obtained with the old-fashioned method mentioned in some books. |
| main | The main title for the graph |
| digits | Significant digits for output |
| sub | The subtitle for the graph (recommended: six sigma project name) |
| ss.col | A vector with colors |

## Details

When the population variance is known, or the size is greater than 30, it uses z statistic. Otherwise, it is uses t statistic.
If the sample size is lower than 30, a warning is displayed so as to verify normality.

## Value

The confidence Interval.
A graph with the figures, the Shapiro-Wilks test, and a histogram.

## Note

Thanks to the kind comments and suggestions from the anonymous reviewer of a tentative article.

## Author(s)

EL Cano

## References

Cano, Emilio L., Moguerza, Javier M. and Redchuk, Andres. 2012. *Six Sigma with R. Statistical Engineering for Process Improvement*, Use R!, vol. 36. Springer, New York. http://www.springer.com/statistics/book/978-1-4614-3651-5.

## See Also

[ss.data.rr](ss.data.rr)

## Examples

```
ss.ci(len, data=ss.data.strings, alpha = 0.05,
  sub = "Guitar Strings Test | String Length",
  xname = "Length")
```

---

ss.data.batteries          *Data for the batteries example*

---

## Description

This is a simulated data set of 18 measurements of the voltage of batteries using different voltmeters.

## Usage

```
data(ss.data.batteries)
```

## Format

A data frame with 18 observations on the following 4 variables.

voltmeter  a factor with levels 1 2

battery  a factor with levels 1 2 3

run  a factor with levels 1 2 3

voltage  a numeric vector

## Note

This data set is used in chapter 5 of the book "Six Sigma with R" (see References).

## Source

See references.

## References

Cano, Emilio L., Moguerza, Javier M. and Redchuk, Andrés. 2012. *Six Sigma with R. Statistical Engineering for Process Improvement*, Use R!, vol. 36. Springer, New York. [http://www.springer.com/statistics/book/978-1-4614-3651-5](http://www.springer.com/statistics/book/978-1-4614-3651-5).

## See Also

[ss.rr](ss.rr)

## Examples

```
data(ss.data.batteries)
summary(ss.data.batteries)
plot(voltage~voltmeter, data = ss.data.batteries)
```

---

ss.data.bills                    *Errors in bills data set*

---

### Description

This data set contains the number of errors detected in a set of bills and the name of the person in charge of the bill.

### Usage

```
data("ss.data.bills")
```

### Format

A data frame with 32 observations on the following 3 variables.

**nbill**  a numeric vector identifying a given bill

**clerk**  a character vector for the clerk responsible for the bill

**errors**  a character vector with the number of errors in the bill

### Details

This data set illustrates concepts in the book "Quality Control with R".

### Source

Table 6.1 in the reference below.

### References

Cano, E.L. and Moguerza, J.M. and Prieto Corcoba, M. (2015) *Quality Control with R. An ISO Standards Approach*. Springer.

### Examples

```
data(ss.data.bills)
str(ss.data.bills)
barplot(table(ss.data.bills$clerk),
    main = "number of invoices")
aggregate(errors ~ clerk, ss.data.bills, sum)
```

---

| ss.data.bolts | *Data for the bolts example* |

---

### Description

A data frame with 50 observations of the diameter of the bolts manufactured in a production line.

### Usage

```
data(ss.data.bolts)
```

### Format

A data frame with 50 observations on the following variable.

diameter  a numeric vector with the diameter of the bolts

### Note

This data set is used in chapter 4 of the book "Six Sigma with R" (see References).

### Source

See references.

### References

Cano, Emilio L., Moguerza, Javier M. and Redchuk, Andrés. 2012. *Six Sigma with R. Statistical Engineering for Process Improvement*, Use R!, vol. 36. Springer, New York. [http://www.springer.com/statistics/book/978-1-4614-3651-5](http://www.springer.com/statistics/book/978-1-4614-3651-5).

### See Also

ss.lfa

### Examples

```
data(ss.data.bolts)
summary(ss.data.bolts)
hist(ss.data.bolts$diameter)
```

---

ss.data.ca                    *Data for a filling process in a winery*

---

## Description

The only field of the data is the volume measured in 20 bottles.

## Usage

```
data(ss.data.ca)
```

## Format

A data frame with 20 observations on the following variable.

Volume  a numeric vector (volume in cl

## Note

This data set is used in chapter 7 of the book "Six Sigma with R" (see References).

## Source

See references.

## References

Cano, Emilio L., Moguerza, Javier M. and Redchuk, Andrés. 2012. *Six Sigma with R. Statistical Engineering for Process Improvement*, Use R!, vol. 36. Springer, New York. http://www.springer.com/statistics/book/978-1-4614-3651-5.

## See Also

ss.study.ca

## Examples

```
data(ss.data.ca)
summary(ss.data.ca)
hist(ss.data.ca$Volume)
```

---

ss.data.density               *Pellets density*

---

**Description**

This data set contains the density for 24 pellets.

**Usage**

```
data("ss.data.density")
```

**Format**

A vector with 24 items for the density of a set of pellets (*gr/cm*$^3$).

**Details**

This data set illustrates concepts in the book "Quality Control with R". Note that, in the book, the vector named pdensity is directly created and then used in the examples.

**Source**

Table 1.2 in the reference below.

**References**

Cano, E.L. and Moguerza, J.M. and Prieto Corcoba, M. (2015) *Quality Control with R. An ISO Standards Approach*. Springer.

**Examples**

```
data(ss.data.density)
str(ss.data.density)
library(qcc)
qcc(ss.data.density,
    type = "xbar.one")
```

---

ss.data.doe1         *Pizza dough example data*

---

### Description

Experimental data for the scores given to a set of pizza doughs.

### Usage

```
data(ss.data.doe1)
```

### Format

A data frame with 16 observations on the following 6 variables.

repl  Replication id

flour  Level of flour in the recipe (- +)

salt  Level of salt in the recipe (- +)

bakPow  Level of Baking Powder in the recipe (- +)

score  Scored assigned to the recipe

ord  Randomized order

### Note

This data set is used in chapter 11 of the book "Six Sigma with R" (see References).

### Source

See references.

### References

Cano, Emilio L., Moguerza, Javier M. and Redchuk, Andrés. 2012. *Six Sigma with R. Statistical Engineering for Process Improvement*, Use R!, vol. 36. Springer, New York. http://www.springer.com/statistics/book/978-1-4614-3651-5.

### Examples

```
data(ss.data.doe1)
summary(ss.data.doe1)
lattice::bwplot(score ~ flour | salt + bakPow ,
 data = ss.data.doe1,
 xlab = "Flour",
 strip = function(..., style) lattice::strip.default(..., strip.names=c(TRUE,TRUE)))
```

---

ss.data.doe2                    *Data for the pizza dough example (robust design)*

---

### Description

Experimental data for the scores given to a set of pizza doughs. Noise factors added for robust design.

### Usage

```
data(ss.data.doe2)
```

### Format

A data frame with 64 observations on the following 7 variables.

repl  Replication id

flour  Level of flour in the recipe (- +)

salt  Level of salt in the recipe (- +)

bakPow  Level of Baking Powder in the recipe (- +)

temp  Level of temperature in preparation (- +)

time  Level of time in preparation (- +)

score  Scored assigned to the recipe

### Note

This data set is used in chapter 11 of the book "Six Sigma with R" (see References).

### Source

See references.

### References

Cano, Emilio L., Moguerza, Javier M. and Redchuk, Andrés. 2012. *Six Sigma with R. Statistical Engineering for Process Improvement*, Use R!, vol. 36. Springer, New York. http://www.springer.com/statistics/book/978-1-4614-3651-5.

### Examples

```
data(ss.data.doe2)
summary(ss.data.doe2)
lattice::bwplot(score ~ temp | time, data = ss.data.doe2)
```

---

ss.data.pastries          *Pastries data*

---

### Description

A data frame with 18 observations of the amount of the CTQ compound in some pastries from a bakery. There are two runs for each combination of two factors (laboratory and batch).

### Usage

```
data(ss.data.pastries)
```

### Format

A data frame with 18 observations on the following 4 variables.

lab  laboratory: a factor with levels 1 2 3

batch  batch: a factor with levels 1 2 3

run  identifies the run: a factor with levels 1 2

comp  proportion of the compound in the pastry: a numeric vector

### Note

This data set is used in chapter 5 exercises of the book "Six Sigma with R" (see References).

### Source

See references.

### References

Cano, Emilio L., Moguerza, Javier M. and Redchuk, Andrés. 2012. *Six Sigma with R. Statistical Engineering for Process Improvement*, Use R!, vol. 36. Springer, New York. http://www.springer.com/statistics/book/978-1-4614-3651-5.

### Examples

```
data(ss.data.pastries)
summary(ss.data.pastries)
lattice::xyplot(comp ~ lab | batch, data = ss.data.pastries)
```

---

ss.data.pb1                      *Particle Boards Example - Individual Data*

---

### Description

Humidity of 30 raw material used to make particle boards for individual control chart.

### Usage

```
data(ss.data.pb1)
```

### Format

A data frame with 30 observations on the following 2 variables.

pb.group  Group id (distinct for each observation)

pb.humidity  Humidity of the particle board

### Note

This data set is used in chapter 12 of the book "Six Sigma with R" (see References).

### Source

See references.

### References

Cano, Emilio L., Moguerza, Javier M. and Redchuk, Andrés. 2012. *Six Sigma with R. Statistical Engineering for Process Improvement*, Use R!, vol. 36. Springer, New York. http://www.springer.com/statistics/book/978-1-4614-3651-5.

### Examples

```
data(ss.data.pb1)
summary(ss.data.pb1)
library(qcc)
pb.groups.one <- with(ss.data.pb1, qcc.groups(pb.humidity, pb.group))
pb.xbar.one <- qcc(pb.groups.one, type="xbar.one")
summary(pb.xbar.one)
plot(pb.xbar.one)
```

---

ss.data.pb2 *Particle Boards Example - by Groups*

---

## Description

Humidity of 20 groups of size 5 of raw materials to make particle boards. For the mean and range control chart.

## Usage

```
data(ss.data.pb2)
```

## Format

A data frame with 100 observations on the following 2 variables.

pb.group a numeric vector

pb.humidity a numeric vector

## Note

This data set is used in chapter 12 of the book "Six Sigma with R" (see References).

## Source

See references.

## References

Cano, Emilio L., Moguerza, Javier M. and Redchuk, Andrés. 2012. *Six Sigma with R. Statistical Engineering for Process Improvement*, Use R!, vol. 36. Springer, New York. http://www.springer.com/statistics/book/978-1-4614-3651-5.

## Examples

```
data(ss.data.pb2)
summary(ss.data.pb2)
if (require(qcc)){
  pb.groups.xbar <- with(ss.data.pb2, qcc.groups(pb.humidity, pb.group))
  pb.xbar <- qcc(pb.groups.xbar, type="xbar")
  summary(pb.xbar)
} else {
message("qcc package is needed to run this example")
}
```

---

ss.data.pb3                         *Particle Boards Example - Attribute data*

---

### Description

Counts of raw materials stockouts during 22 weekdays in a month.

### Usage

```
data(ss.data.pb3)
```

### Format

A data frame with 22 observations on the following 3 variables.

day  Day id

stockouts  Number of stockouts

orders  Number of orders

### Note

This data set is used in chapter 12 of the book "Six Sigma with R" (see References).

### Source

See references.

### References

Cano, Emilio L., Moguerza, Javier M. and Redchuk, Andrés. 2012. *Six Sigma with R. Statistical Engineering for Process Improvement*, Use R!, vol. 36. Springer, New York. http://www.springer.com/statistics/book/978-1-4614-3651-5.

### Examples

```
data(ss.data.pb3)
summary(ss.data.pb3)
if (require(qcc)){
with(ss.data.pb3,
plot(qcc(stockouts, orders, type ="p"))
)
} else {
message("qcc package is needed to run this example")
}
```

---

ss.data.pb4 *Data for Practicle Boards Example - number of defects*

---

### Description

Number of defects detected in an order of particle boards.

### Usage

```
data(ss.data.pb4)
```

### Format

A data frame with 80 observations on the following 2 variables.

order Order id

defects Number of defects

### Note

This data set is used in chapter 12 of the book "Six Sigma with R" (see References).

### Source

See references.

### References

Cano, Emilio L., Moguerza, Javier M. and Redchuk, Andrés. 2012. *Six Sigma with R. Statistical Engineering for Process Improvement*, Use R!, vol. 36. Springer, New York. [http://www.springer.com/statistics/book/978-1-4614-3651-5](http://www.springer.com/statistics/book/978-1-4614-3651-5).

### Examples

```
data(ss.data.pb4)
summary(ss.data.pb4)
```

---

ss.data.pc                    *Data set for the printer cartridge example*

---

### Description

This data set contains data from a simulated process of printer cartridge filling.

### Usage

```
data(ss.data.pc)
```

### Format

A data frame with 24 observations on the following 6 variables.

pc.col a factor with levels C B for the colour

pc.filler a factor with levels 1 2 3

pc.volume a numeric vector

pc.density a numeric vector

pc.batch a numeric vector

pc.op a factor with levels A B C D for the operator

### Note

This data set is used in chapter 8 of the book "Six Sigma with R" (see References).

### Source

See references.

### References

Cano, Emilio L., Moguerza, Javier M. and Redchuk, Andrés. 2012. *Six Sigma with R. Statistical Engineering for Process Improvement*, Use R!, vol. 36. Springer, New York. http://www.springer.com/statistics/book/978-1-4614-3651-5.

### Examples

```
data(ss.data.pc)
summary(ss.data.pc)
```

---

ss.data.pc.big            *Larger data set for the printer cartridges example*

---

#### Description

This data set contains data from a simulated process of printer cartridges filling with complete replications.

#### Usage

```
data(ss.data.pc.big)
```

#### Format

A data frame with 72 observations on the following 5 variables,

filler a factor with levels 1 2 3

batch a factor with levels 1 2 3 4

col a factor with levels B C

operator a factor with levels 1 2 3

volume a numeric vector

#### Note

This data set is used in chapter 8 of the book "Six Sigma with R" (see References).

#### Source

See references.

#### References

Cano, Emilio L., Moguerza, Javier M. and Redchuk, Andrés. 2012. *Six Sigma with R. Statistical Engineering for Process Improvement*, Use R!, vol. 36. Springer, New York. http://www.springer.com/statistics/book/978-1-4614-3651-5.

#### Examples

```
data(ss.data.pc.big)
summary(ss.data.pc.big)
```

---

ss.data.pc.r                  *Data set for the printer cartridge example, by region*

---

### Description

This data set contains data from a simulated process of printer cartridge filling. The dataframe contains defects by region of each type of cartridge.

### Usage

```
data(ss.data.pc.r)
```

### Format

A data frame with 5 observations on the following 4 variables.

pc.regions  a factor with levels region.1 region.2 region.3 region.4 region.5

pc.def.a  a numeric vector for defects type A

pc.def.b  a numeric vector for defects type B

pc.def  a numeric vector for total defects

### Note

This data set is used in chapter 8 of the book "Six Sigma with R" (see References).

### Source

See references.

### References

Cano, Emilio L., Moguerza, Javier M. and Redchuk, Andrés. 2012. *Six Sigma with R. Statistical Engineering for Process Improvement*, Use R!, vol. 36. Springer, New York. http://www.springer.com/statistics/book/978-1-4614-3651-5.

### Examples

```
data(ss.data.pc.r)
summary(ss.data.pc.r)
```

---

ss.data.rr *Gage R&R data*

---

### Description

Example data for Measure phase of the Six Sigma methodology.

### Usage

```
data(ss.data.rr)
```

### Format

A data frame with 27 observations on the following 5 variables.

prototype a factor with levels prot #1 prot #2 prot #3

operator a factor with levels op #1 op #2 op #3

run a factor with levels run #1 run #2 run #3

time1 a numeric vector

time2 a numeric vector

### Note

This data set is used in chapter 5 of the book "Six Sigma with R" (see References).

### Source

See references.

### References

Cano, Emilio L., Moguerza, Javier M. and Redchuk, Andrés. 2012. *Six Sigma with R. Statistical Engineering for Process Improvement*, Use R!, vol. 36. Springer, New York. http://www.springer.com/statistics/book/978-1-4614-3651-5.

### Examples

```
data(ss.data.rr)
summary(ss.data.rr)
```

ss.data.strings    *Data set for the Guitar Strings example*

### Description

This data set contains data from a simulated process of guitar strings production.

### Usage

```
data(ss.data.strings)
```

### Format

A data frame with 120 observations on the following 6 variables.

id  a numeric vector

type  a factor with levels A5 B2 D4 E1 E6 G3

res  a numeric vector for resistance

len  a numeric vector for length

sound  a numeric vector for

power  a numeric vector

### Note

This data set is used in chapter 10 of the book "Six Sigma with R" (see References).

### Source

See references.

### References

Cano, Emilio L., Moguerza, Javier M. and Redchuk, Andrés. 2012. *Six Sigma with R. Statistical Engineering for Process Improvement*, Use R!, vol. 36. Springer, New York. http://www.springer.com/statistics/book/978-1-4614-3651-5.

### Examples

```
data(ss.data.strings)
summary(ss.data.strings)
```

---

`ss.data.thickness` *Metal Plates Thickness*

---

### Description

This data set contains the thickness and additional data for 24 metal plates.

### Usage

```
data("ss.data.thickness")
```

### Format

A data frame with 24 observations on the following 5 variables.

**thickness**  a numeric vector with the thickness (*in*)

**day**  a factor with the day (two days)

**shift**  a factor with the shift (two shifts)

**dayshift**  a factor with the day-shift combination

**position**  a factor with the position of the thickness with respect to the nominal value of 0.75 *in*

### Details

This data set illustrates concepts in the book "Quality Control with R". Note that, in the book, the data set is named `plates` and it is created sequentially throughout the examples.

### Source

Table 5.1 in the reference below.

### References

Cano, E.L. and Moguerza, J.M. and Prieto Corcoba, M. (2015) *Quality Control with R. An ISO Standards Approach*. Springer.

### Examples

```
data(ss.data.thickness)
str(ss.data.thickness)
lattice::bwplot(thickness ~ shift | day,
    data = ss.data.thickness)
```

---

ss.data.thickness2            *Metal Plates thickness (extended)*

---

### Description

This data set contains the thickness and additional data for 84 metal plates.

### Usage

```
data("ss.data.thickness2")
```

### Format

A data frame with 84 observations on the following 5 variables.

**day**  a factor with the day (seven days)

**shift**  a factor with the shift (two shifts)

**thickness**  a numeric vector with the thickness (*in*)

**ushift**  a factor with the day-shift combination

**flaws**  an integer vector with the number of flaws on the surface of sampled plates

### Details

This data set illustrates concepts in the book "Quality Control with R".

### Source

Examples 8.1 and 9.9 in the reference below.

### References

Cano, E.L. and Moguerza, J.M. and Prieto Corcoba, M. (2015) *Quality Control with R. An ISO Standards Approach*. Springer.

### Examples

```
data(ss.data.thickness2)
str(ss.data.thickness2)
lattice::dotplot(thickness ~ shift | day,
    data = ss.data.thickness2,
    layout = c(7, 1))
```

---

## ss.data.wbx        *Woodboard location for profiles*

---

### Description

This data set contains the 500 locations at which the density of a 0.5*in*-thick engineered woodboard is measured, i.e., 0.001 *in* apart

### Usage

```
data("ss.data.wbx")
```

### Format

A vector with 500 items for the locations (*in*).

### Details

This data set illustrates concepts in the book "Quality Control with R". This data set should be used along with the `ss.data.wby` data set.

### Source

Example 10.1 in the reference below. It is a variation of the one introduced by Walker (2002).

### References

Cano, E.L. and Moguerza, J.M. and Prieto Corcoba, M. (2015) *Quality Control with R. An ISO Standards Approach*. Springer.

Walker, E. amd Wright, W (2002) Comparing curves with additive models. *J. Qual. Technol.* **34**(1), 118–129

### See Also

`ss.data.wby`

### Examples

```
data(ss.data.wbx)
data(ss.data.wby)
plotProfiles(profiles = ss.data.wby,
    x = ss.data.wbx)
```

ss.data.wby                    *Woodboard profiles*

### Description

This data set contains 50 profiles corresponding to the density measurements of 50 0.5*in*-thick engineered woodboard, measured in 500 locations.

### Usage

```
data("ss.data.wby")
```

### Format

A matrix with 500 rows (locations) and 50 columns (woodboard).

### Details

This data set illustrates concepts in the book "Quality Control with R". This data set should be used along with the ss.data.wbx data set.

### Source

Example 10.1 in the reference below. It is a variation of the one introduced by Walker (2002).

### References

Cano, E.L. and Moguerza, J.M. and Prieto Corcoba, M. (2015) *Quality Control with R. An ISO Standards Approach.* Springer.

Walker, E. amd Wright, W (2002) Comparing curves with additive models. *J. Qual. Technol.* **34**(1), 118–129

### See Also

ss.data.wbx

### Examples

```
data(ss.data.wbx)
data(ss.data.wby)
plotProfiles(profiles = ss.data.wby,
    x = ss.data.wbx)
```

---

ss.heli                    *Creates a pdf file with the design of the Paper Helicopter*

---

### Description

The pdf file contains a template with lines and indications to build the paper helicopter described in many SixSigma publications.

### Usage

```
ss.heli()
```

### Details

The pdf file must be printed in A4 paper, without adjusting size to paper.

### Value

No value is returned. A pdf file is saved in the working directory

### Note

See the `vignette("HelicopterInstructions")` to see assembling instructions.

### Author(s)

EL Cano

### References

George Box. Teaching engineers experimental design with a paper helicopter. *Quality Engineering*, 4(3):453–459, 1992.

Cano, Emilio L., Moguerza, Javier M. and Redchuk, Andres. 2012. *Six Sigma with R. Statistical Engineering for Process Improvement*, Use R!, vol. 36. Springer, New York. [http://www.springer.com/statistics/book/978-1-4614-3651-5](http://www.springer.com/statistics/book/978-1-4614-3651-5).

### Examples

```
ss.heli()
vignette("HelicopterInstructions")
```

---

ss.lf                          *Evaluates the Loss Function for a process.*

---

### Description

The quality loss function is one of the tools of the Six Sigma methodology. The function assigns a cost to an observed value, that is larger as far as it is from the target.

### Usage

```
ss.lf(lfa.Y1, lfa.Delta, lfa.Y0, lfa.L0)
```

### Arguments

| | |
|---|---|
| lfa.Y1 | The observed value of the CTQ (critical to quality) characteristic that will be evaluated. |
| lfa.Delta | The tolerance for the CTQ. |
| lfa.Y0 | The target for the CTQ. |
| lfa.L0 | The cost of poor quality when the characteristic is $Y_0 + \Delta$. |

### Value

| | |
|---|---|
| ss.lf | A number with the evaluated function at $Y_1$ |

### Author(s)

EL Cano

### References

Taguchi G, Chowdhury S,Wu Y (2005) *Taguchi's quality engineering handbook*. John Wiley

Cano, Emilio L., Moguerza, Javier M. and Redchuk, Andres. 2012. *Six Sigma with R. Statistical Engineering for Process Improvement*, Use R!, vol. 36. Springer, New York. [http://www.springer.com/statistics/book/978-1-4614-3651-5](http://www.springer.com/statistics/book/978-1-4614-3651-5).

### See Also

[ss.lfa](ss.lfa)

### Examples

```
#Example bolts: evaluate LF at 10.5 if Target=10, Tolerance=0.5, L_0=0.001
ss.lf(10.5, 0.5, 10, 0.001)
```

ss.lfa *Loss Function Analysis*

### Description

This function performs a Quality Loss Function Analysis, based in the Taguchi Loss Function for "Nominal-the-Best" characteristics.

### Usage

```
ss.lfa(lfa.data, lfa.ctq, lfa.Delta, lfa.Y0, lfa.L0, lfa.size = NA,
  lfa.output = "both", lfa.sub = "Six Sigma Project")
```

### Arguments

| | |
|---|---|
| lfa.data | Data frame with the sample to get the average loss. |
| lfa.ctq | Name of the field in the data frame containing the data. |
| lfa.Delta | Tolerance of the process. |
| lfa.Y0 | Target of the process (see note). |
| lfa.L0 | Cost of poor quality at tolerance limit. |
| lfa.size | Size of the production, batch, etc. to calculate the total loss in a group (span, batch, period, ...) |
| lfa.output | Type of output (see details). |
| lfa.sub | Subtitle for the graphic output. |

### Details

lfa.output can take the values "text", "plot" or "both".

### Value

| | |
|---|---|
| lfa.k | Constant k for the loss function |
| lfa,lf | Expression with the loss function |
| lfa.MSD | Mean Squared Differences from the target |
| lfa.avLoss | Average Loss per unit of the process |
| lfa.Loss | Total Loss of the process (if a size is provided) |

### Note

For smaller-the-better characteristics, the target should be zero (lfa.Y0 = 0). For larger-the-better characteristics, the target should be infinity (lfa.Y0 = Inf).

### Author(s)

EL Cano

## References

Taguchi G, Chowdhury S,Wu Y (2005) *Taguchi's quality engineering handbook.* John Wiley

Cano, Emilio L., Moguerza, Javier M. and Redchuk, Andres. 2012. *Six Sigma with R. Statistical Engineering for Process Improvement*, Use R!, vol. 36. Springer, New York. http://www.springer.com/statistics/book/978-1-4614-3651-5.

## See Also

ss.lf, ss.data.bolts.

## Examples

```
ss.lfa(ss.data.bolts, "diameter", 0.5, 10, 0.001,
lfa.sub = "10 mm. Bolts Project",
lfa.size = 100000, lfa.output = "both")
```

---

ss.pMap                     *Process Map*

---

## Description

This function takes information about the process we want to represent and draw the Process Map, with its X's, x's, Y's and y's in each step of the process

## Usage

```
ss.pMap(steps, inputs.overall, outputs.overall, input.output, x.parameters,
  y.features, main = "Six Sigma Process Map", sub, ss.col = c("#666666",
  "#BBBBBB", "#CCCCCC", "#DDDDDD", "#EEEEEE"))
```

## Arguments

| | |
|---|---|
| steps | A vector of characters with the name of the 'n' steps |
| inputs.overall | A vector of characters with the name of the overall inputs |
| outputs.overall | A vector of characters with the name of the overall outputs |
| input.output | A vector of lists with the names of the inputs of the $i - th$ step, that will be the outputs of the $(i - 1) - th$ step |
| x.parameters | A vector of lists with a list of the x parameters of the process. The parameter is a vector with two values: the name and the type (view details) |
| y.features | A vector of lists with a list of the y features of the step. The feature is a vector with two values: the name and the type (view details) |
| main | The main title for the Process Map |

| sub | Subtitle for the diagram (recommended the Six Sigma project name) |
|---|---|
| ss.col | A vector of colours for a custom drawing. At least five colours, sorted by descendant intensity (see details) |

## Details

The type of the x parameters and y features can be: C(controllable), N(noise), Cr(Critical), P(Procedure). The default value for ss.col is c("#666666", "#BBBBBB", "#CCCCCC", "#DDDDDD", "#EEEEEE"), a grayscale style. You can pass any accepted color string.

## Value

A graphic representation of the Map Process.

## Note

The process map is the starting point for a Six Sigma Project, and it is very important to find out who the x's and y'x are.

## Author(s)

EL Cano

## References

[http://en.wikipedia.org/wiki/Business_Process_Mapping](http://en.wikipedia.org/wiki/Business_Process_Mapping)

Cano, Emilio L., Moguerza, Javier M. and Redchuk, Andres. 2012. *Six Sigma with R. Statistical Engineering for Process Improvement*, Use R!, vol. 36. Springer, New York. [http://www.springer.com/statistics/book/978-1-4614-3651-5](http://www.springer.com/statistics/book/978-1-4614-3651-5).

## See Also

[ss.ceDiag](ss.ceDiag)

## Examples

```
inputs.overall<-c("operators", "tools", "raw material", "facilities")
outputs.overall<-c("helicopter")
steps<-c("INSPECTION", "ASSEMBLY", "TEST", "LABELING")
#Inputs of process "i" are inputs of process "i+1"
input.output<-vector(mode="list",length=length(steps))
input.output[1]<-list(c("sheets", "..."))
input.output[2]<-list(c("sheets"))
input.output[3]<-list(c("helicopter"))
input.output[4]<-list(c("helicopter"))

#Parameters of each process
```

```
x.parameters<-vector(mode="list",length=length(steps))
x.parameters[1]<-list(c(list(c("width", "NC")),list(c("operator", "C")),
list(c("Measure pattern", "P")), list(c("discard", "P"))))
x.parameters[2]<-list(c(list(c("operator", "C")),list(c("cut", "P")),
list(c("fix", "P")), list(c("rotor.width", "C")),list(c("rotor.length",
"C")), list(c("paperclip", "C")), list(c("tape", "C"))))
x.parameters[3]<-list(c(list(c("operator", "C")),list(c("throw", "P")),
list(c("discard", "P")), list(c("environment", "N"))))
x.parameters[4]<-list(c(list(c("operator", "C")),list(c("label", "P"))))
x.parameters

#Features of each process
y.features<-vector(mode="list",length=length(steps))
y.features[1]<-list(c(list(c("ok", "Cr"))))
y.features[2]<-list(c(list(c("weight", "Cr"))))
y.features[3]<-list(c(list(c("time", "Cr"))))
y.features[4]<-list(c(list(c("label", "Cr"))))
y.features

ss.pMap(steps, inputs.overall, outputs.overall,
        input.output, x.parameters, y.features,
        sub="Paper Helicopter Project")
```

---

ss.rr                          *Gage R & R (Measurement System Assessment)*

---

### Description

Performs Gage R&R analysis for the assessment of the measurement system of a process. Related to the Measure phase of the DMAIC strategy of Six Sigma.

### Usage

```
ss.rr(var, part, appr, lsl = NA, usl = NA, sigma = 6, data,
  main = "Six Sigma Gage R&R Study", sub = "", alphaLim = 0.05,
  errorTerm = "interaction", digits = 4)
```

### Arguments

| | |
|---|---|
| var | Measured variable |
| part | Factor for parts |
| appr | Factor for appraisers (operators, machines, ...) |
| lsl | Numeric value of lower specification limit used with USL to calculate Study Variation as %Tolerance |
| usl | Numeric value of upper specification limit used with LSL to calculate Study Variation as %Tolerance |
| sigma | Numeric value for number of std deviations to use in calculating Study Variation |

| data | Data frame containing the variables |
| --- | --- |
| main | Main title for the graphic output |
| sub | Subtitle for the graphic output (recommended the name of the project) |
| alphaLim | Limit to take into account interaction |
| errorTerm | Which term of the model should be used as error term (for the model with interation) |
| digits | Number of decimal digits for output |

## Details

Performs an R&R study for the measured variable, taking into account part and appraiser factors. It outputs the sources of Variability, and six graphs: bar chart with the sources of Variability, plots by appraiser, part and interaction and x-bar and R control charts.

## Value

Analysis of Variance Table/s. Variance composition and %Study Var. Graphics.

| anovaTable | The ANOVA table of the model |
| --- | --- |
| anovaRed | The ANOVA table of the reduced model (without interaction, only if interaction not significant) |
| varComp | A matrix with the contribution of each component to the total variation |
| studyVar | A matrix with the contribution to the study variation |
| ncat | Number of distinct categories |

## Note

The F test for the main effects in the ANOVA table is usually made taken the operator/appraisal interaction as the error term (repeated measures model), thereby computing F as $MS\_factor/MS\_interaction$, e.g. in appendix A of AIAG MSA manual, in Montgomery (2009) and by statistical software such as Minitab. However, in the example provided in page 127 of the AIAG MSA Manual, the F test is performed as $MS\_factor/MS\_equipment$, i.e., repeatability. Thus, since version 0.9-3 of the SixSigma package, a new argument errorTerm controls which term should be used as error Term, one of "interaction", "repeatability".

Argument alphaLim is used as upper limit to use the full model, i.e., with interaction. Above this value for the interaction effect, the ANOVA table without the interaction effect is also obtained, and the variance components are computed pooling the interaction term with the repeatibility.

## Author(s)

EL Cano with contributions by Kevin C Limburg

## References

Automotive Industry Action Group. (2010). Measurement Systems Analysis (Fourth Edition). AIAG.

Cano, Emilio L., Moguerza, Javier M. and Redchuk, Andres. 2012. *Six Sigma with R. Statistical Engineering for Process Improvement*, Use R!, vol. 36. Springer, New York. http://www.springer.com/statistics/book/978-1-4614-3651-5.

Montgomery, D. C. (2009). Introduction to Statistical Quality Control (Sixth Edition ed.). New York: Wiley & Sons, Inc.

## See Also

ss.data.rr

## Examples

```
ss.rr(time1, prototype, operator, data = ss.data.rr,
sub = "Six Sigma Paper Helicopter Project",
alphaLim = 0.05,
errorTerm = "interaction",
lsl = 0.7,
usl = 1.8)
```

---

| ss.study.ca | *Graphs and figures for a Capability Study* |
|---|---|

---

## Description

Plots a Histogram with density lines about the data of a process. Check normality with qqplot and normality tests. Shows the Specification Limits and the Capability Indices.

## Usage

```
ss.study.ca(xST, xLT = NA, LSL = NA, USL = NA, Target = NA,
  alpha = 0.05, f.na.rm = TRUE, f.main = "Six Sigma Capability Analysis Study",
  f.sub = "")
```

## Arguments

| | |
|---|---|
| xST | Short Term process performance data |
| xLT | Long Term process performance data |
| LSL | Lower Specification Limit of the process |
| USL | Upper Specification Limit of the process |
| Target | Target of the process |
| alpha | Type I error for the Confidence Interval |

| | |
|---|---|
| `f.na.rm` | If TRUE NA data will be removed |
| `f.main` | Main Title for the graphic output |
| `f.sub` | Subtitle for the graphic output |

## Value

Figures and plot for Capability Analysis

## Author(s)

EL Cano

## References

Cano, Emilio L., Moguerza, Javier M. and Redchuk, Andres. 2012. *Six Sigma with R. Statistical Engineering for Process Improvement*, Use R!, vol. 36. Springer, New York. http://www.springer.com/statistics/book/978-1-4614-3651-5.

Montgomery, DC (2008) *Introduction to Statistical Quality Control* (Sixth Edition). New York: Wiley&Sons

## See Also

ss.ca.cp

## Examples

```
ss.study.ca(ss.data.ca$Volume, rnorm(40, 753, 3),
LSL = 740, USL = 760, T = 750, alpha = 0.05,
  f.sub = "Winery Project")
```

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