Package ‘SixSigma’

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Type Package

Title Six Sigma Tools for Quality Control and Improvement

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BugReports https://github.com/emilopezcano/SixSigma/issues/

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'' [ISBN 978-1-4614-3652-2]
and ``Quality Control with R'' [ISBN 978-3-319-24046-6],
are also included in the package.

URL https://www.sixsigmawithr.com/,
http://emilopezcano.github.io/SixSigma/,
https://github.com/emilopezcano/SixSigma/

License GPL (>= 2)

Depends R (>= 3.5.0)

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

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Suggests covr

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Contents

`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)
```

---

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 arguments defects and rework 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. https://link.springer.com/book/10.1007/978-1-4614-3652-2.

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)

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

ss.ca.z(x, LSL = NA, USL = NA, LT = FALSE, f.na.rm = TRUE)
```

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 (α) 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. https://link.springer.com/book/10.1007/978-1-4614-3652-2.

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. https://link.springer.com/book/10.1007/978-1-4614-3652-2.

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)

ss.cc.getd3(n = NA)

ss.cc.getc4(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. https://link.springer.com/book/10.1007/978-1-4614-3652-2.

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", "#FFFFFF", "#000000",
    "#000000")
)
```

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", "#FFFFFF", "#000000", "#000000"), 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. https://link.springer.com/book/10.1007/978-1-4614-3652-2.

Wikipedia, https://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", "#FFFFFF", "#000000",
    "#000000")
)
```

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. https://link.springer.com/book/10.1007/978-1-4614-3652-2.

See Also

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. https://link.springer.com/book/10.1007/978-1-4614-3652-2.

See Also

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. https://link.springer.com/book/10.1007/978-1-4614-3652-2.

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. https://link.springer.com/book/10.1007/978-1-4614-3652-2.

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)
summary(ss.data.density)
```

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. https://link.springer.com/book/10.1007/978-1-4614-3652-2.

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. https://link.springer.com/book/10.1007/978-1-4614-3652-2.

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. https://link.springer.com/book/10.1007/978-1-4614-3652-2.

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. https://link.springer.com/book/10.1007/978-1-4614-3652-2.

Examples

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

`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. https://link.springer.com/book/10.1007/978-1-4614-3652-2.

Examples

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

`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. https://link.springer.com/book/10.1007/978-1-4614-3652-2.

Examples

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

`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. https://link.springer.com/book/10.1007/978-1-4614-3652-2.

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. https://link.springer.com/book/10.1007/978-1-4614-3652-2.

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. https://link.springer.com/book/10.1007/978-1-4614-3652-2.

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. https://link.springer.com/book/10.1007/978-1-4614-3652-2.

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. https://link.springer.com/book/10.1007/978-1-4614-3652-2.

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. https://link.springer.com/book/10.1007/978-1-4614-3652-2.

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. https://link.springer.com/book/10.1007/978-1-4614-3652-2.

Examples

```
## Not run:
## ss.heli()
vignette("HelicopterInstructions")

## End(Not run)
```

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. https://link.springer.com/book/10.1007/978-1-4614-3652-2.

See Also

`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. https://link.springer.com/book/10.1007/978-1-4614-3652-2.

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", "#FFFFFF", "#000000",
    "#000000")
)
```

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", "#FFFFFF", "#000000", "#000000") 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

https://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. https://link.springer.com/book/10.1007/978-1-4614-3652-2.

See Also

`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,
  tolerance = usl - lsl,
  data,
  main = "Six Sigma Gage R&R Study",
  sub = "",
  alphaLim = 0.05,
  errorTerm = "interaction",
  digits = 4,
  method = "crossed",
  print_plot = TRUE,
  signifstars = FALSE
)
```

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
tolerance	Numeric value for the tolerance
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
method	Character to specify the type of analysis to perform, "crossed" (default) or "nested"
print_plot	if TRUE (default) the plots are printed. Change to FALSE to avoid printing plots.
signifstars	if FALSE (default) the significance stars are ommitted. Change to TRUE to allow printing stars.

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.

`Tolerance` can be calculaten from usl and lsl values or specified by hand.

The type of analysis to perform can be specified with the parameter method, `"crossed"` or `"nested"`. Be sure to select the correct one and to have the data prepare for such type of analysis. If you don't know wich one is for you check it before. It is really important to perform the correct one. Otherwise results have no sense.

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. https://link.springer.com/book/10.1007/978-1-4614-3652-2.

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,
method = "crossed")
```

---

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 = "",
 f.colours = c("#4682B4", "#d1d1e0", "#000000", "#A2CD5A", "#D1EEEE", "#FFFFFF",
    "#000000", "#000000")
)
```

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
f.colours	Vector of colours fot the graphic output

Value

Figures and plot for Capability Analysis

Note

The argument `f.colours` takes a vector of colours for the graphical outputs. The order of the elements are, first the colour for histogram bars, then Density ST lines, Density LT lines, Target, and Specification limits. It can be partially specified.

Author(s)

Main author: Emilio L. Cano. Contributions by Manu Alfaro.

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. https://link.springer.com/book/10.1007/978-1-4614-3652-2.

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")

 ss.study.ca(ss.data.ca$Volume, rnorm(40, 753, 3),
LSL = 740, USL = 760, T = 750, alpha = 0.05,
  f.sub = "Winery Project",
  f.colours = c("#990000", "#007700", "#002299"))
```

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