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Six Sigma with R
Six Sigma Software
R Advantages
R Packages for SixSigma
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Six Sigma Quality Using R

Tools and Training

Emilio Lopez, Andres Redchuk and Javier M. Moguerza

Department of Statistics and Operations Research
Rey Juan Carlos University (Madrid)

The University of Warwick, August 2011

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The Basics

Quality

The Basics

Quality

Classical approach

The Key Characteristic of a product/service/process must be inside the specification limits

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The Key Characteristic approximate the target, with as less variation as possible.

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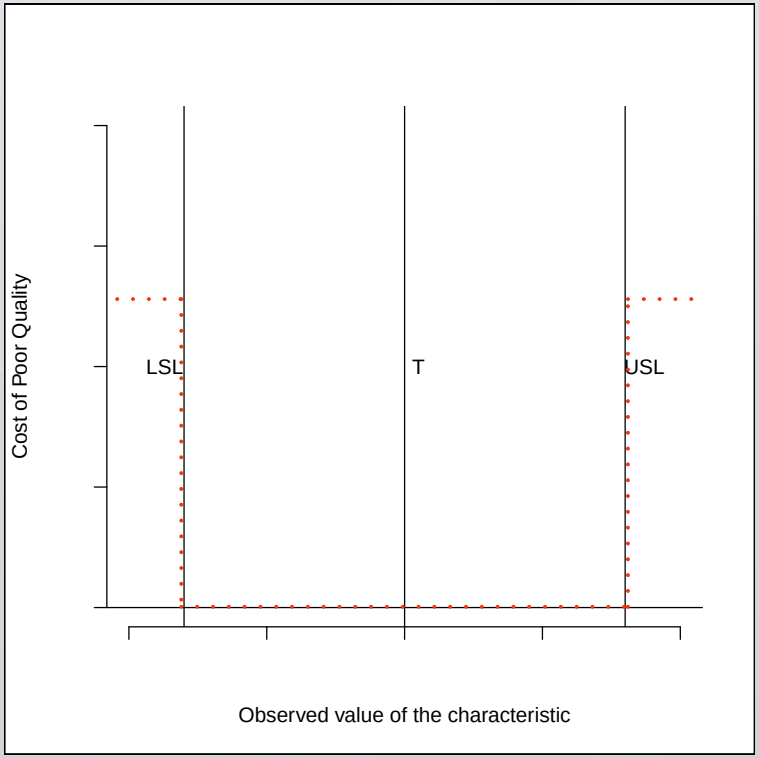

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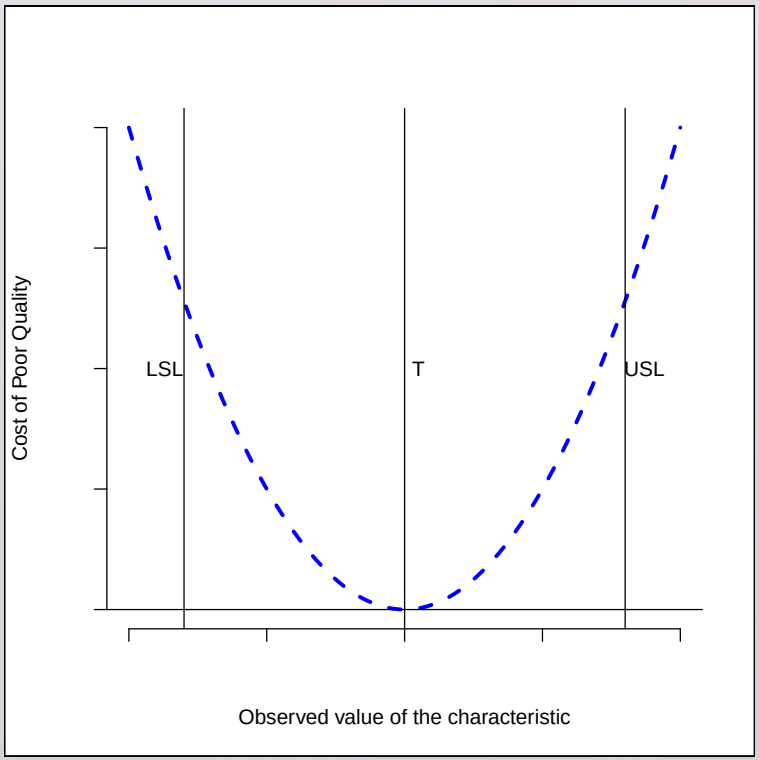

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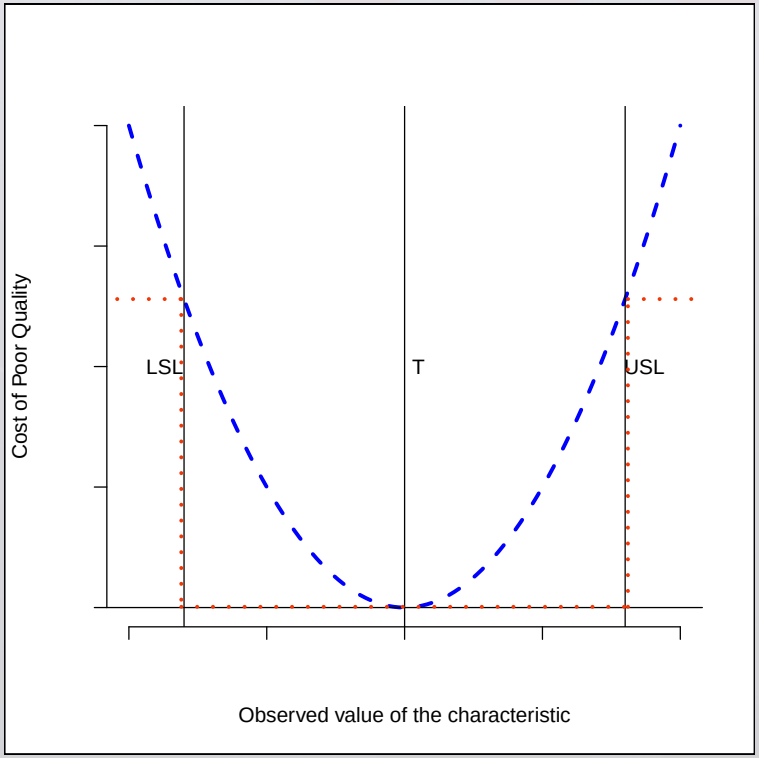

The Basics

Example

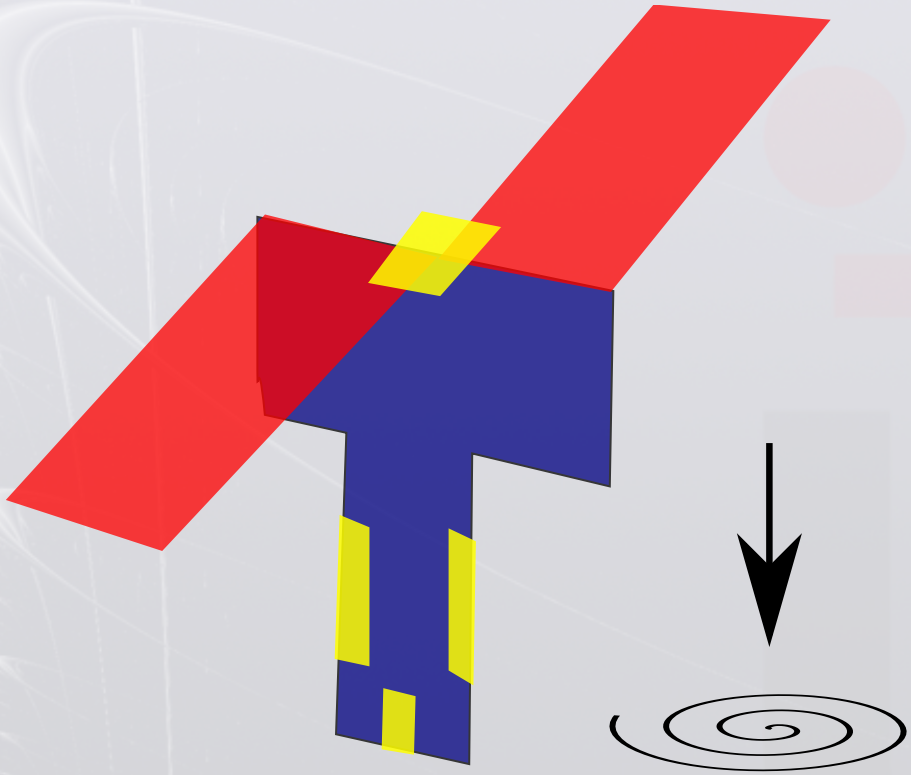

Figure: Paper Helicopter Design

Box [1992]

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DMAIC Strategy

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The Basics

DMAIC Strategy

Define

State problem, objectives, prioritize, and launch project

The Basics

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Define

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Measure

Understand the Process, validate data accuracy, determine process capability

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Determine solutions to achieve the objective, and implement.

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Understand the Process, validate data accuracy, determine process capability

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Determine the relationship between the Y's and the X's and look for causes.

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Determine solutions to achieve the objective, and implement.

Control

Process control, monitoring and auto-controlling methods

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Roles in Six Sigma

Description

In Six Sigma, everyone in the organization has a role in the project. Six Sigma methodology uses an intuitive categorization of these roles.

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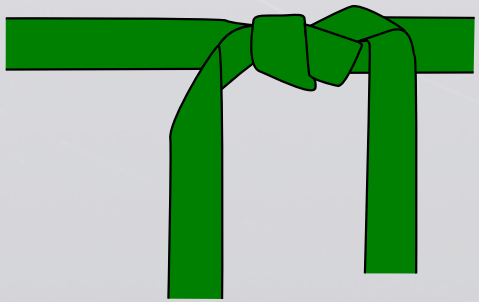

Roles for Six Sigma

Diagram

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Tools

For Every DMAIC Phase

Any Statistical, planning or management tool

Tools

For Every DMAIC Phase

Any Statistical, planning or management tool

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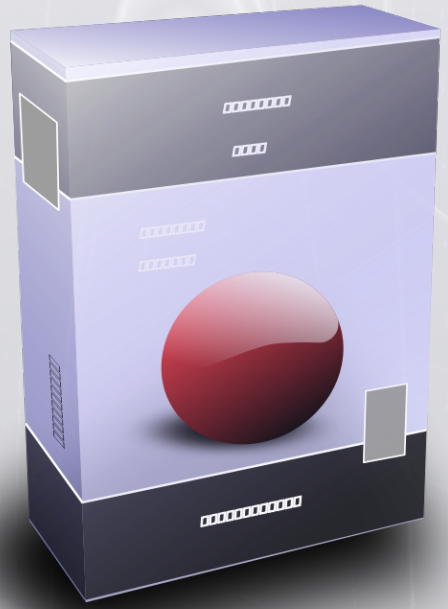
Commercial Software

State-of-the-art



Commercial Software

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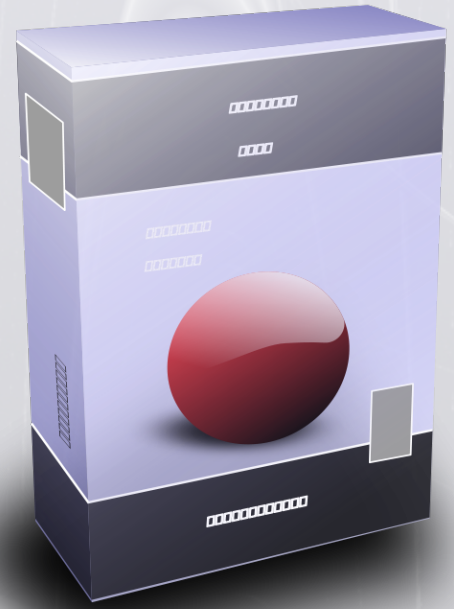

Programs

- Minitab
- SPSS
- StatGraphics
- JMP & SAS
- Any statistical software, or even spreadsheets

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Commercial Software

Trends

Commercial Software

Trends

Internet

- Software as a Service
- Web Applications
- Everywhere
- Every display

Commercial Software

Trends

Internet

- Software as a Service
- Web Applications
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Open Technologies

- Linux
- OpenOffice
- R
- ...

R Advantages

Customization + Innovation = Competitiveness

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R Advantages

Customization + Innovation = Competitiveness

Customization

A company can develop a package that fits its inner procedures and methods.

R Advantages

Customization + Innovation = Competitiveness

Customization

A company can develop a package that fits its inner procedures and methods.

Innovation

A company can develop and deploy an innovative method from its R&D department, or from the result of other published researches.

Other Authors

Packages

qcc 2.01 (Scrucca [2004])

Shewhart quality control charts for continuous, attribute and count data [...]

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IQCC 0.5 (Recchia et al. [2010])

Builds statistical control charts with exact limits for univariate and multivariate cases.

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IQCC 0.5 (Recchia et al. [2010])

Builds statistical control charts with exact limits for univariate and multivariate cases.

qualityTools 1.47 (Roth [2011])

This is a package for teaching statistical methods in the field of Quality Science [...] The focus is on teaching [...]

SixSigma package

Focused in SixSigma Practitioners

Version History

1. 0.2.0 March 2011
2. 0.2.1 April 2011
3. 0.3.0 July 2011 (current)

Data

`ss.data.rr`
`ss.data.ca`

Functions

`ss.pMap`
`ss.ceDiag`
`ss.rr`
`ss.ci`
`ss.study.ca`
`ss.ca.yield`
`ss.ca.z`
`ss.ca.cp`
`ss.ca.cpk`
`ss.heli`

Helicopter

Training Stuff

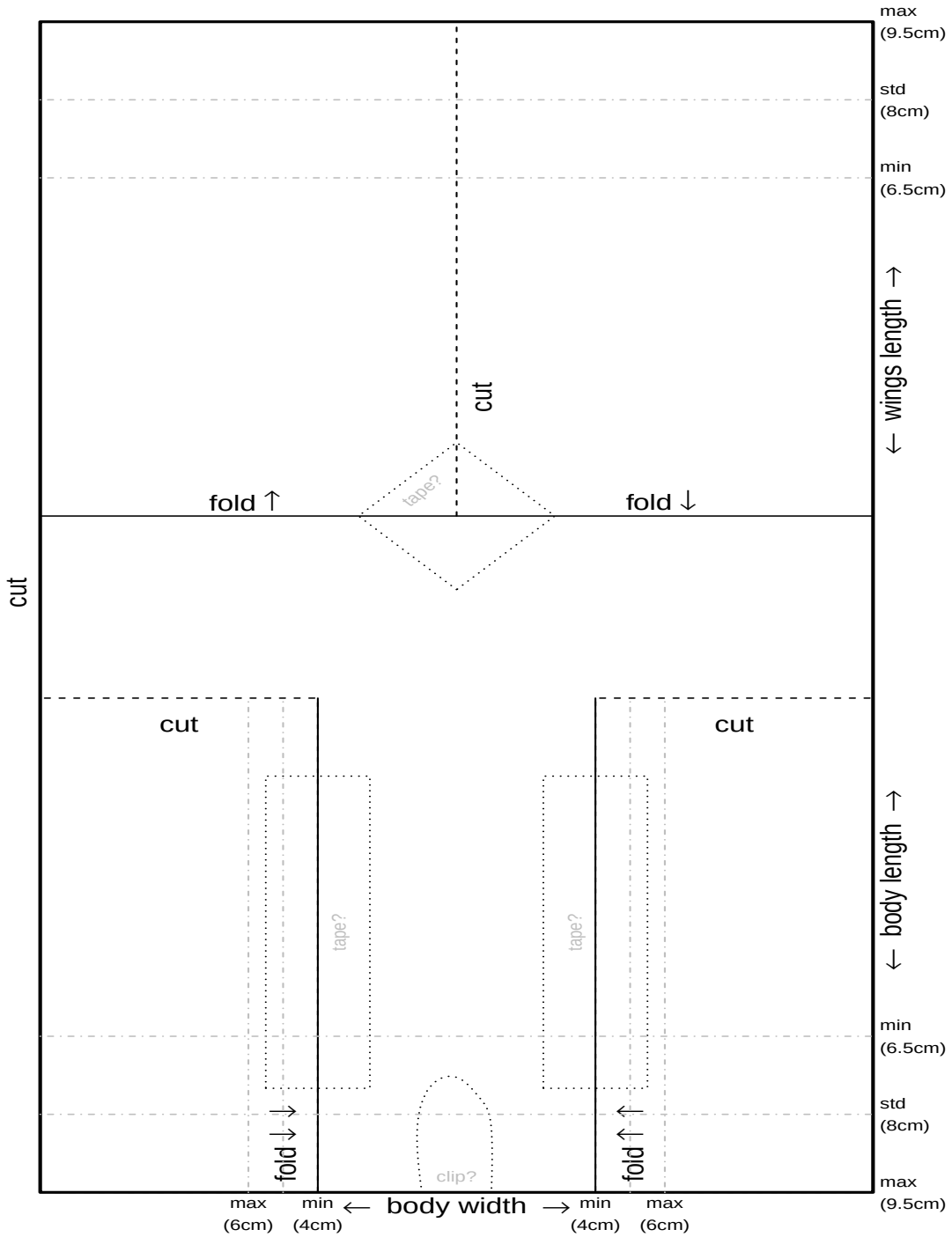
Template in pdf format to build paper helicopter prototypes (Box [1992])

```
> ss.heli()

null device
          1

> #vignette("HelicopterInstructions") for instructions
```

Six Sigma with R | Paper Helicopter template



Diagrams

SixSigma Package

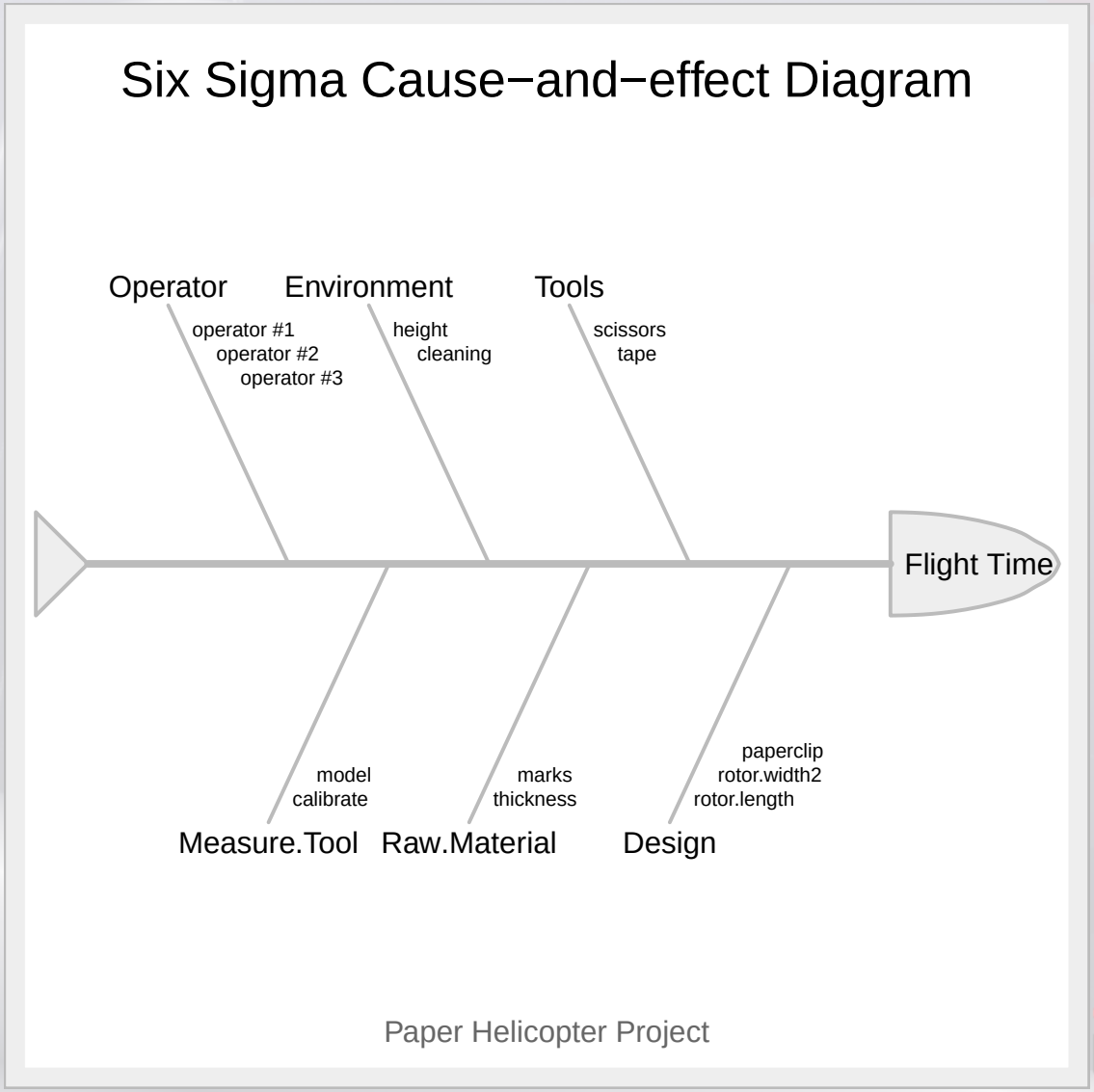
Cause-and-effect Diagram

```
> example(ss.ceDiag)

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

Cause-and-Effect Diagram

SixSigma Package



Diagrams

SixSigma Package

Process Map

```
> example(ss.pMap)
ss.pMp> inputs.overall<-c("operators", "tools", "raw material", "fac
ss.pMp> outputs.overall<-c("helicopter")
ss.pMp> procs<-c("INSPECTION", "ASSEMBLY", "TEST", "LABELING")
ss.pMp> input.output<-vector(mode="list",length=length(procs))
ss.pMp> input.output[1]<-list(c("sheets", "..."))
. . .
ss.pMp> x.parameters<-vector(mode="list",length=length(procs))
ss.pMp> x.parameters[1]<-list(c(list(c("width", "NC")),list(c("opera
ss.pMp+ list(c("Measure pattern", "P")), list(c("discard", "P"))))
. . .
ss.pMp> y.features<-vector(mode="list",length=length(procs))
ss.pMp> y.features[1]<-list(c(list(c("ok", "Cr"))))
. . .
ss.pMp> ss.pMap(procs, inputs.overall, outputs.overall,
ss.pMp+         input.output, x.parameters, y.features,
ss.pMp+         sub="Paper Helicopter Project")
```

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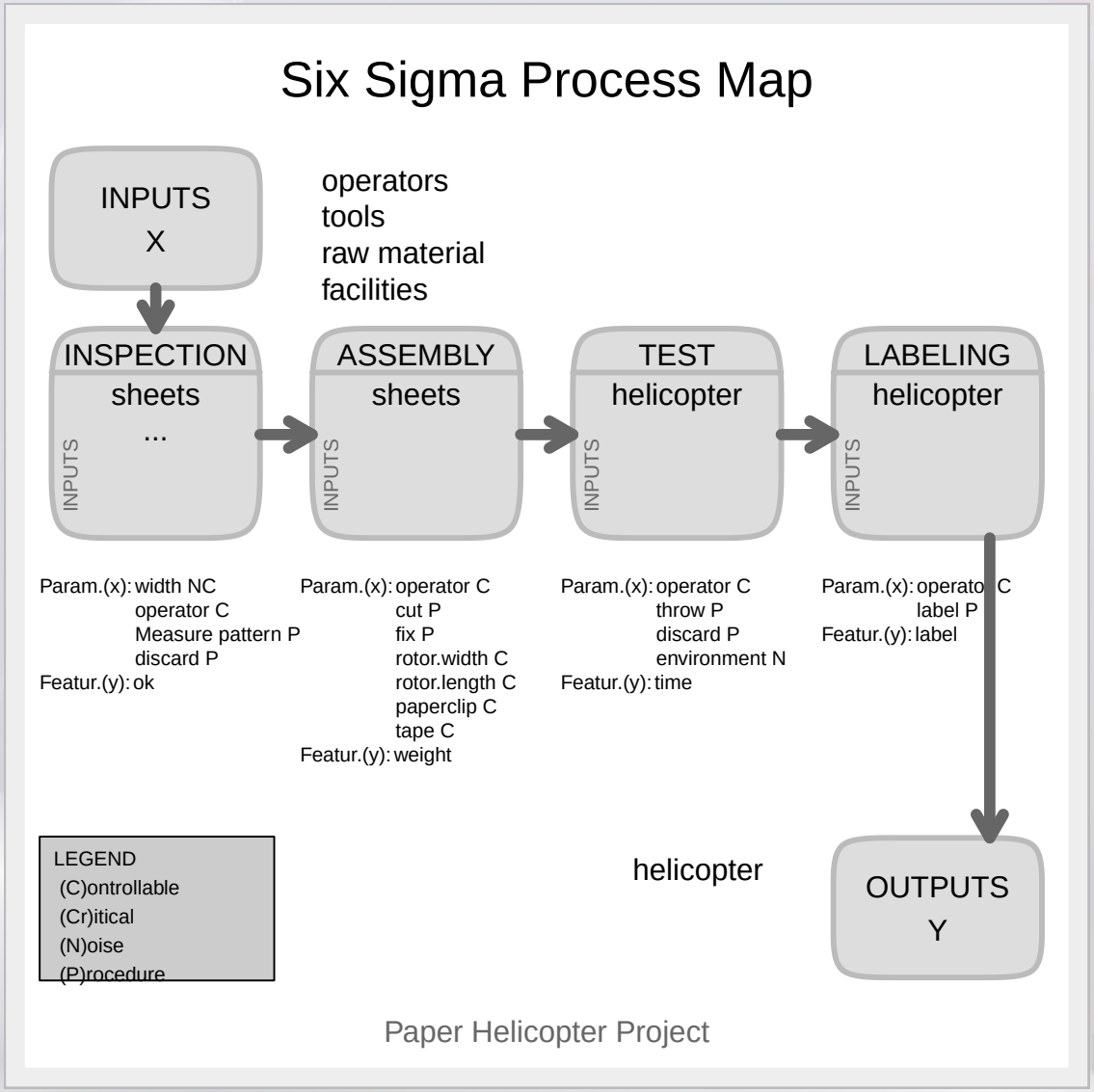
Process Map Diagram

SixSigma Package



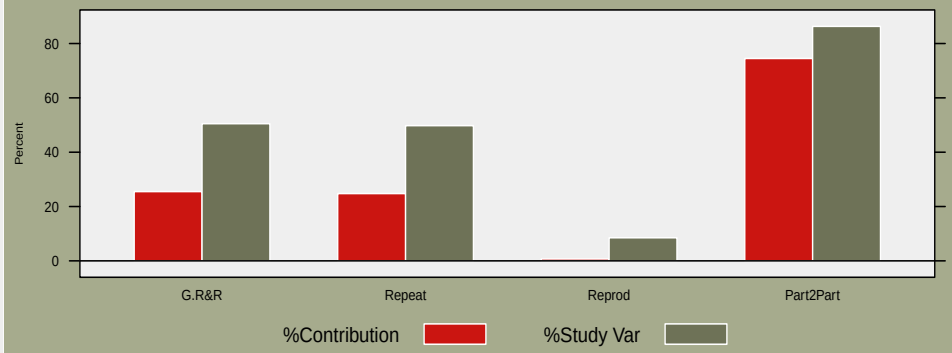
Gage R&R Study

Measurement System Analysis

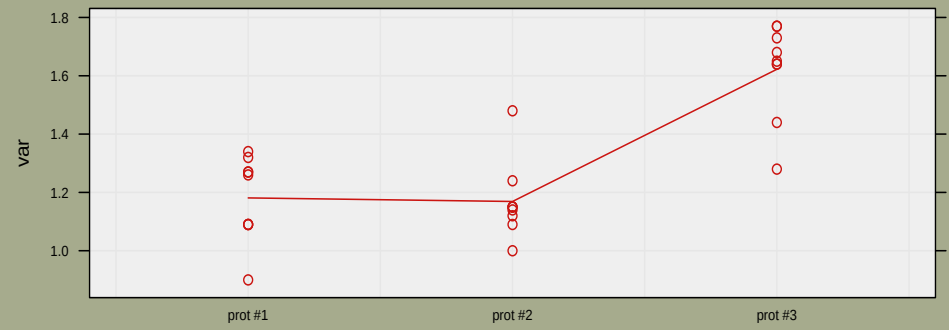
```
> #... Some theme instructions
> ss.rr(time1, prototype, operator,
+                 data=ss.data.rr, sub="Helicopter Project")
Analysis of Variance Table

Response: var
              Df  Sum Sq Mean Sq F value    Pr(>F)
part           2 1.20072 0.60036 28.0396 2.952e-06
appr           2 0.05294 0.02647  1.2363    0.3140
part:appr      4 0.08339 0.02085  0.9737    0.4462
Repeatability 18 0.38540 0.02141
                      VarComp %Contrib
Total Gage R&R      0.0220358    25.50
  Repeatability     0.0214111    24.77
  Reproducibility   0.0006247     0.72
    appr            0.0006247     0.72
    part:appr       0.0000000     0.00
Part-To-Part        0.0643901    74.50
Total Variation     0.0864259   100.00
. . .
```

Six Sigma Gage R&R Study

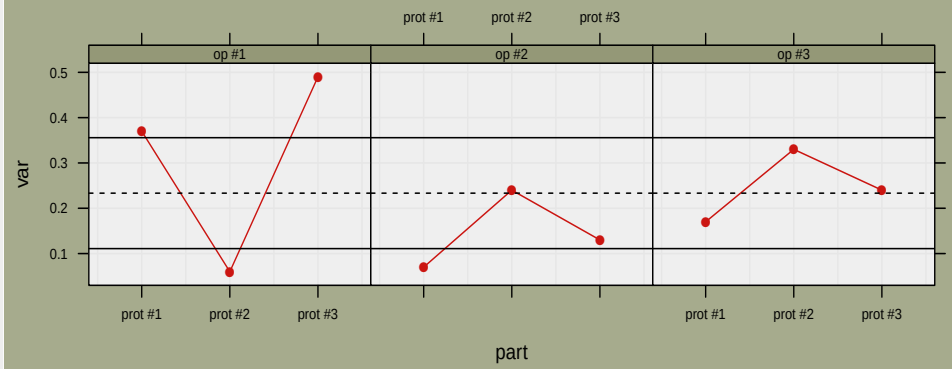
Components of Variation



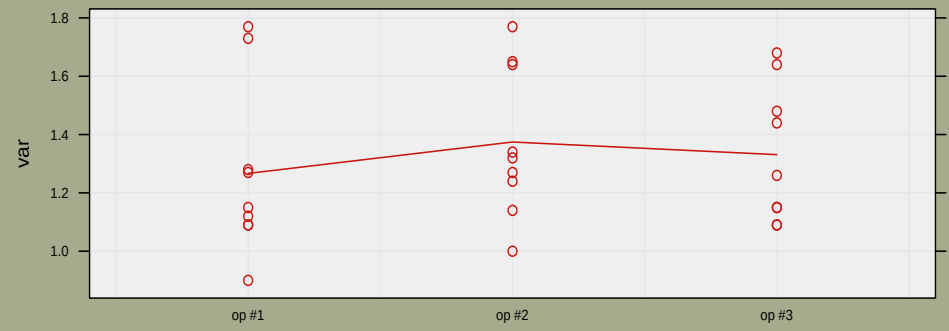
Var by Part



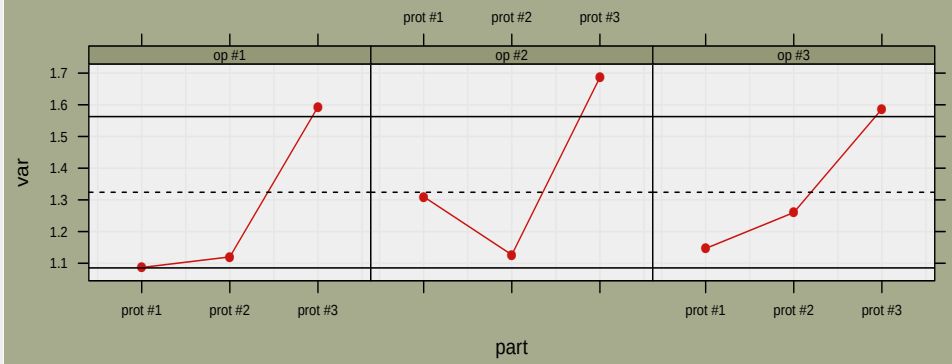
R Chart by appraiser



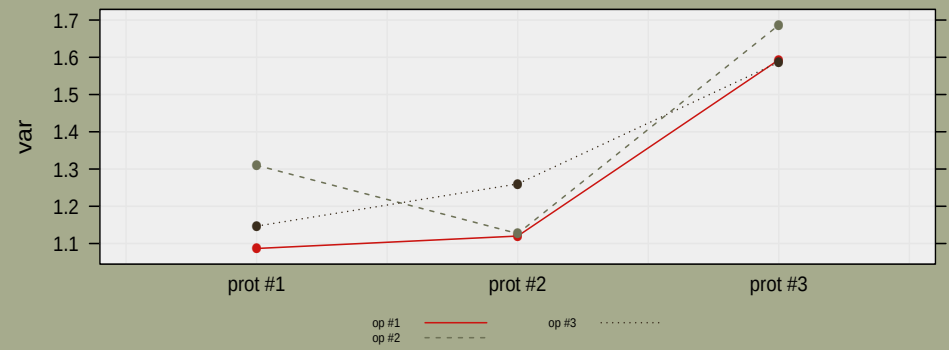
Var by appraiser



x̄ Chart by appraiser



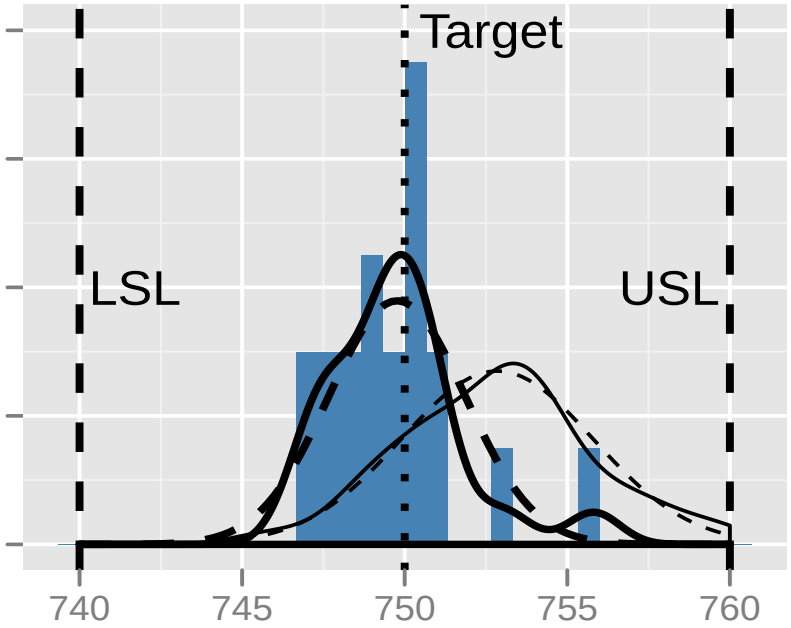
Part*appraiser Interaction



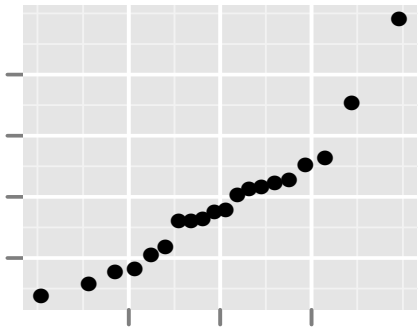
Capability Analysis

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

      Yield       FTY       RTY DPU     DPMO
1 0.9895561 0.9859008 0.9859563  20 10443.86

> ss.ca.cpk(ss.data.ca$Volume, 740, 760)

[1] 1.546513

> ss.study.ca(ss.data.ca$Volume, rnorm(40, 753, 3), LSL = 740,
+     USL = 760, T = 750, alpha = 0.5, f.sub = "Winery Project")
```

Six Sigma Capability Analysis Study



Check Normality



Shapiro−Wilk Test
p−value: 0.07506

Lilliefors (K−S) Test
p−value: 0.2291

Normality accepted when p−value > 0.05

Density Lines Legend

- Density ST
- Theoretical Dens. ST
- Density LT
- Theoretical Density LT

Specifications

LSL: 740
Target: 750
USL: 760

Process

Short Term	Long Term
Mean: 749.7625	**Mean:** 752.8443
SD: 2.1042	**SD:** 2.9577
n: 20	**n:** 40
Z_s: 3.14	**Z_s:** 2.42
	DPMO:

Indices

Short Term	Long Term
C_p: 1.5841	**P_p:** 1.1270
CI: [1.1,2.1]	**CI:** [0.9,1.4]
C_{pk}: 1.5465	**P_{pk}:** 0.8065
CI: [1.1,2.1]	**CI:** [0.9,1.4]

Winery Project

Universidad Rey Juan Carlos

Further Development

On the Way

- Functions for a wide range of tools along all the DMAIC phases.

Further Development

On the Way

- Functions for a wide range of tools along all the DMAIC phases.
- Improved graphics

Further Development

On the Way

- Functions for a wide range of tools along all the DMAIC phases.
- Improved graphics
- Tackle Further methodologies (DFSS, Lean, . . .)

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- Tackle Further methodologies (DFSS, Lean, . . .)
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- Bayesian perspective

Further Development

On the Way

- Functions for a wide range of tools along all the DMAIC phases.
- Improved graphics
- Tackle Further methodologies (DFSS, Lean, . . .)
- Non-normal / Non-linear methods
- Bayesian perspective
- Maybe a GUI

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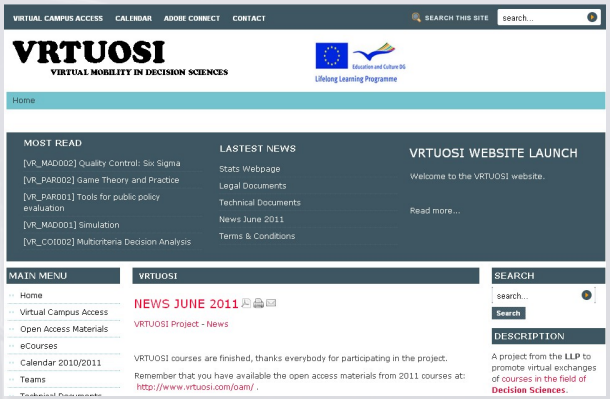
VRTUOSI project

European Lifelong Learning Programme



- www.vrtuosi.com

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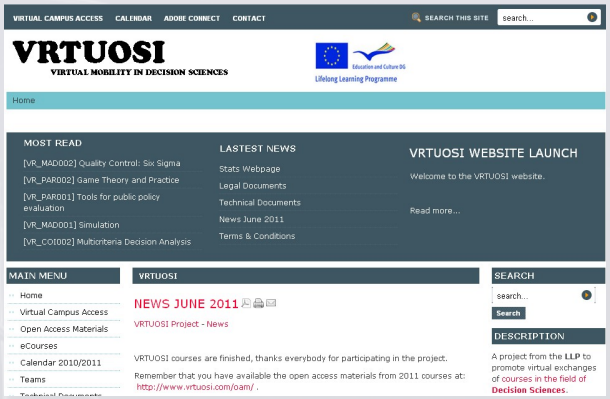
European Lifelong Learning Programme



- www.vrtuosi.com
- Code Project: LLP 502869-LLP-1-2009-ES-ERASMUS-EVC

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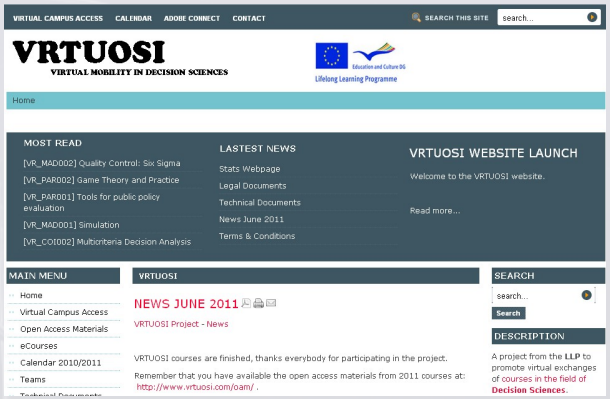
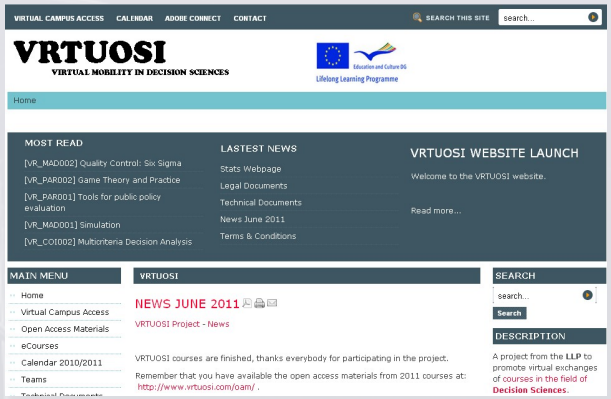


- www.vrtuosi.com
- Code Project: LLP 502869-LLP-1-2009-ES-ERASMUS-EVC
- One of the Courses: Quality Control: Six Sigma

VRTUOSI project

European Lifelong Learning Programme



- www.vrtuosi.com
- Code Project: LLP 502869-LLP-1-2009-ES-ERASMUS-EVC
- One of the Courses: Quality Control: Six Sigma
- Developed and carried out through the Six Sigma methodology.

VRTUOSI

VIRTUAL MOBILITY IN DECISION SCIENCES

Education and Culture DG
Lifelong Learning Programme

MOST READ

- [VR_MAD002] Quality Control: Six Sigma
- [VR_PAR002] Game Theory and Practice
- [VR_PAR001] Tools for public policy evaluation
- [VR_MAD001] Simulation
- [VR_COI002] Multicriteria Decision Analysis

LASTEST NEWS

- Stats Webpage
- Legal Documents
- Technical Documents
- News June 2011
- Terms & Conditions

VRTUOSI WEBSITE LAUNCH

Welcome to the VRTUOSI website.

Read more...

MAIN MENU

- Home
- Virtual Campus Access
- Open Access Materials
- eCourses
- Calendar 2010/2011
- Teams
- Technical Documents

VRTUOSI

NEWS JUNE 2011

VRTUOSI Project - News

VRTUOSI courses are finished, thanks everybody for participating in the project.

Remember that you have available the open access materials from 2011 courses at: http://www.vrtuosi.com/oam/ .

SEARCH

search...

Search

DESCRIPTION

A project from the **LLP** to promote virtual exchanges of courses in the field of **Decision Sciences**.

Master On Line

Master in Decision Systems Engineering

- Rey Juan Carlos University (www.urjc.es)

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- Six Sigma Quality subject. R used in most of the subjects.

Book

Springer Use R! Series

Book

Springer Use R! Series

Features

- Title: Six Sigma with R
- Due 2012
- 350 pages approx.
- Wide background scope
- Examples, a Case Study and practices

Further Projects

Platform

Further Projects

Platform

Open Platform for Quality Methodologies

- Improving the European Factory (link)
- FP7 PPP Funding Scheme
- Looking for Partners

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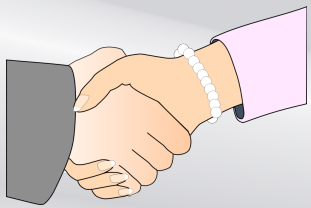
Other Projects

We are available for other projects that need partners in this area



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  - Publications in preparation
  - Six Sigma platform?

References

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Discussion

Thanks for your attention !

Any question?

emilio.lopez@urjc.es