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## 2WH03: Modeling C

- Statistical Modeling and Consulting -

dr. J.J.M. Rijkema  
Eindhoven University of Technology,  
dept. Mathematics & Computer Science  
P.O.Box 513, 5600 MB Eindhoven, NL  
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# Outline

- Mathematical Modeling
- Statistical Modeling
- Engineering Problem Solving
- Statistical Consulting
- TU/e-Expertise
- References.....

**dr. J.J.M. (Koo) Rijkema**  
TU/e-Mathematics & Computer Science  
Chair Probability & Statistics  
Room HG 10.24  
Tel.: 040-2473170 (040-2472753)  
E-mail [jj.m.rijckema@tue.nl](mailto:jj.m.rijckema@tue.nl)

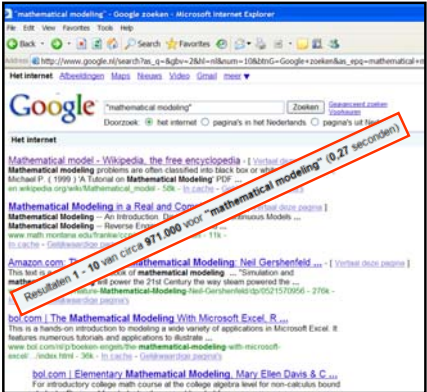


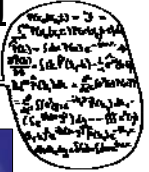
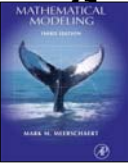
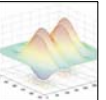
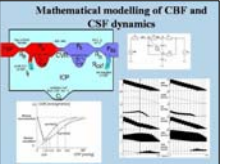
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# Mathematical Modeling

- What is **Mathematical** Modeling ?

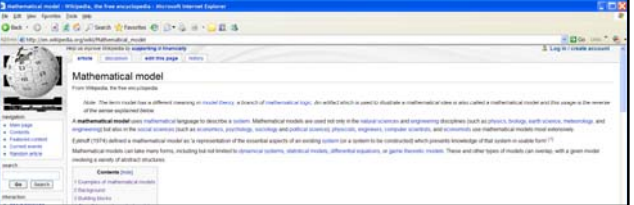


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- What is **Mathematical** Modeling ?



[http://en.wikipedia.org/wiki/Mathematical\\_modeling](http://en.wikipedia.org/wiki/Mathematical_modeling)

A **mathematical** model is:  
'a representation of the essential aspects of an existing system (or a system to be constructed) which presents knowledge of that system in usable form'. Eykhooff (1974)

Mathematical models can take many forms, including but not limited to dynamical systems, **statistical** models, differential equations, or game theoretic models.

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Resources on **Mathematical Modeling**

Materials

- AVM of (1-4)3d Scotland (1)
- Astudeerleslag (2)
- Book (64)
- Congressverz (7)
- Proefschrift (3)
- Rapport of HOCs (4)

Localie

- HEI library (6-65) (7)
- Natuurwet. Magazijn (10)
- Uoorkunde (2)
- Centrale Bibliotheek (15)
- Digitale Bibliotheek (11)
- Biotechnisch (8)
- Natuurkunde (4)
- Wiskunde & Informatica (29)

Publicatiejaar

- 2008 (16)
- 2008-2009 (17)
- 1998-1999 (22)
- 1990-1999 (15)
- 1900-11/01 (16)

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What is **Mathematical Modeling** ?

The student learns to solve a practical problem related to the three application areas Physics, Communication Technology and Business Applications.

This means that the student is able to:

- analyse the problem,
- translate it to a mathematical problem,
- carry out a mathematical analysis,
- convert an algorithm into a computer program,
- translate the results to the original problem.

Further, the student is able:

- to write a clear report in LaTeX
- to give a presentation of the results, by using slides and PowerPoint.
- to find literature in library.

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Projects **Mathematical Modeling** 2009-2010:

Projecten

De projecten zijn onderverdeeld in drie stromen: Techniek, Digitale communicatie en Bedrijfsvoering. Klik op een project voor meer informatie.

Het is de bedoeling dat elk groepje zijn voorkeur (en voor bepaalde projecten aangeeft op het aanmeldformulier).

**Techniek**

- t1: mistechniek
- t2: ...
- ... verwarming
- ... etsen

**Digitale communicatie**

- d1: woordscrabble
- d2: afstanden visualiseren
- d3: stofzuiger
- d4: webnieuws

**Bedrijfsvoering**

- b1: griep epidemie
- b2: rotondes
- b3: ijspakketten
- b4: appels
- b5: vliegtarieven

Tijdschema

31-8-2010  
2e college M...  
van het ...

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Project allocation **Mathematical Modeling** 2008-2009:

Toewijzing van projecten

Hieronder zien jullie welk project aan welke groep is toegewezen. Informatie over de diverse begeleiders en opdrachtgevers staat onderaan deze pagina. De opdrachtgevers worden ook bij de diverse projecten vermeld.

Project	Begeleider	Studenten	Bijbeh...
d4: webnieuws	Johan van Leeuwen	Christine van Vredendaal	...
t4: centrale veranaming	Jan Ten Thije	Book...	Christine van Vredendaal
d3: stofzuiger	...	Laura Sprenkels	Sander Verkerk
...	...	Britt Mathysen	Christian Vlegels
...	...	...	Richard Both
...	...	...	Richard Both
...	...	...	Richard Both
b2: rotondes	Roel Braekers	Dorien Vander Cappellen	Luuk van de Sande
...	...	Thomas Schuermans	Frank Wessels
b1: griep epidemie	Luc Habets	Luuk van de Sande	Gouss Bollen
...	...	Frank Wessels	Tom Slenders

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# Statistical Modeling

- What is **Statistical** Modeling ?

Introduction to Statistical Modeling

Statistical modeling is a set of mathematical equations which describe the behavior of an object of study in terms of random variables and their associated probability distributions.

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- What is **Statistical** Modeling ?

Statistical model

A **statistical model** is a set of mathematical equations which describe the behavior of an object of study in terms of random variables and their associated probability distributions. The random variables are called **random variables** and their associated probability distributions are called **probability distributions**.

Statistical modeling is a set of mathematical equations which describe the behavior of an object of study in terms of random variables and their associated probability distributions.

Statistical inference enables us to make statements about which element(s) of this set are likely to be the true one.

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- Resources on **Statistical** Modeling

Pagina 1 / 1 (12 items)

Materiaalsoort	Locatie	Publicatiejaar
Boek (9)	Bibi /Library IE&IS (4)	2006- (3)
Proefschrift (1)	Bibliotheek Magazijn (2)	2000-2005 (3)
Rapport of Rede (1)	Digitale Bibliotheek (2)	1990-1999 (4)
	Elektrotechniek (1)	1980-1989 (4)
	Wiskunde & Informatica (6)	1900-1979 (1)

Journal on Statistical Modeling

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- Example: On-line Paper Quality Prediction

Variable Reduction: PCA  
Time Series Modelling  
Multivariate Control

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• Example: Analyzing Small Sample Data

Development of Rank-Based Procedures

- Null distributions linear rank statistics
- Power calculations linear rank statistics
- Control limits of rank-based control charts
- Some ARL-out-of-control calculations of rank-based control charts

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• Example: Modeling Easter Scheldt Water Level Data

- Consequence of dredging
- Consequence of closing the storm surge barrier
- Nature reserve as compensate for second Maasvlakte

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• Example: Leak Detection of Vacuum Coffee

Monitoring Infrequent Failures of High-volume Production Processes

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## Engineering Problem Solving

How can statistics help ??

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• What is Engineering Problem Solving ?

The diagram shows a cycle of steps: Goal, Define, Measure, Compare, Analyze, Improve, Monitor, and Reliability. A cartoon character 'the trouble Shooter' is also present.

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The circular diagram lists steps: Control, Define, Measure, Analyze, Improve. A list of steps is provided: 1. Explore, 2. Measure, 3. Characterize, 4. Model, 5. Improve, 6. Monitor, 7. Compare, 8. Reliability.

<http://www.itl.nist.gov/div898/handbook>

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• Example:

Statlab Laboratories  
P.O. Box 513  
5600 MB Eindhoven

Subject: your assignment.

Dear Sir/Madam,

We believe that the **performance of our nitride etching process can be improved** and we would like you to investigate whether this is the case. In case there is a possibility for improvement, we will consider asking you for help in a **follow-up project to find optimal settings of the factors. But at this time we are merely interested in finding out which external factors influence the process.**

We would like to welcome you to our factory as soon as possible. We have already informed our process engineer, Ms. Miep Dobbelsteen, about your arrival. She can give you the exact details concerning the etching process and she can assist you in carrying out your experiments.

We hope for a successful collaboration!

Yours sincerely,

A. Select  
Managing director of Statlab Laboratories

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• Process Model:

The diagram shows a central box labeled 'Etching Process'. Arrows point into it from 'Controlled Inputs (Factors)' on the left and 'Uncontrolled Inputs (Co-Factors)' from above. An arrow points out to 'Outputs (Responses)' on the right.

**Research Questions:**  
Which external factors influence the process ?  
Find optimal settings for these factors !

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**Research Approach:**

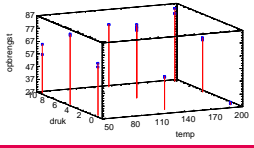
Research question:

Statlab Laboratoria  
P.O. Box 513  
5600 MB Eindhoven  
Subject your assignment:  
Dear Sir/Madam,  
We believe that the performance of our nitro-blasting process can be improved and we would like you to investigate whether this is the case. In case there is a possibility for improvement, we will consider asking you for help in a follow-up project to find optimal settings of the factors. But at first time we are merely interested in finding out which external factors influence the process.  
We would like to welcome you to our factory as soon as possible. We have already informed our process engineer, Mr. Miep Dijkshoorn, about your arrival. She can give you the exact details concerning the etching process and she can assist you in carrying out your experiments.  
We hope for a successful collaboration!  
Yours sincerely,  
A. Savel  
Managing director of Statlab Laboratoria

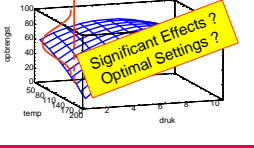
Experiment:



Results:



Empirical Model:  $Y = g(x_A, x_B) + \varepsilon$

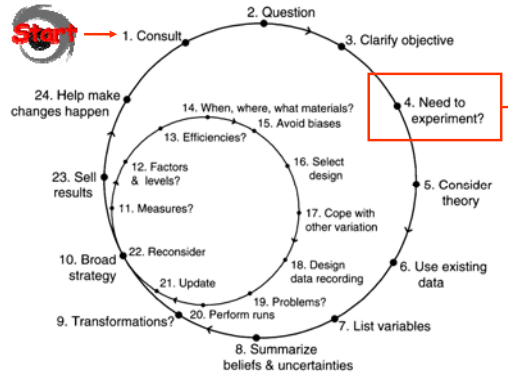


1. Explore  
2. Measure  
3. Characterize  
4. Model  
5. Improve  
6. Monitor  
7. Compare  
8. Reliability

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**General Approach:**



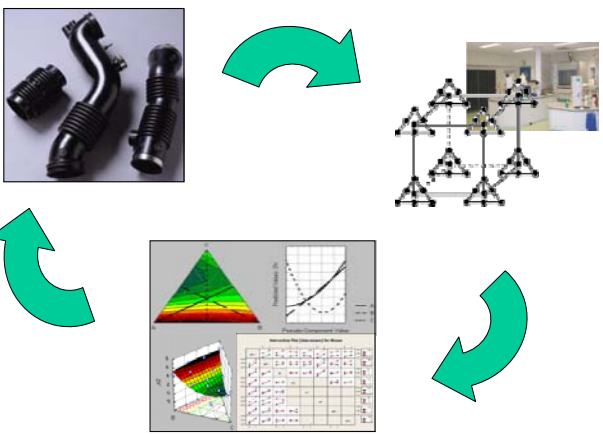
1. Consult  
2. Question  
3. Clarify objective  
4. Need to experiment?  
5. Consider theory  
6. Use existing data  
7. List variables  
8. Summarize beliefs & uncertainties  
9. Transformations?  
10. Broad strategy  
11. Measures?  
12. Factors & levels?  
13. Efficiencies?  
14. When, where, what materials?  
15. Avoid biases  
16. Select design  
17. Cope with other variation  
18. Design data recording  
19. Problems?  
20. Perform runs  
21. Update  
22. Reconsider  
23. Sell results  
24. Help make changes happen

Source: G.K. Robinson, Practical Strategies for Experimenting

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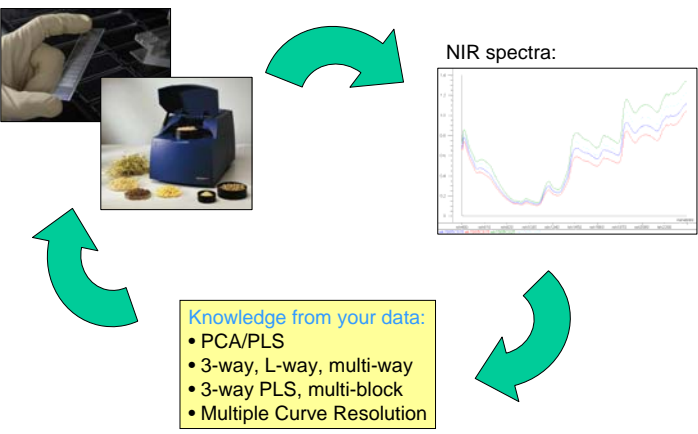
**Example: Prototyping of Small Series of Products**



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**Example: Analyzing Spectral Information**



NIR spectra:

Knowledge from your data:

- PCA/PLS
- 3-way, L-way, multi-way
- 3-way PLS, multi-block
- Multiple Curve Resolution

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Resources on **Engineering Problem Solving**

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## Statistical Consulting

What is **Statistical Consulting** ?

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What is **Statistical Consulting** ?

**Statistical Consulting:**  
The interaction between statisticians and scientists with the **primary purpose** to help the field of application (and possibly as a spin-off: ideas for new research in statistics)

Jim Boen & Doug Zahn

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What is **Statistical Consulting** ?

[http://en.wikipedia.org/wiki/Statistical\\_consultant](http://en.wikipedia.org/wiki/Statistical_consultant)

**Statistical Consulting:**  
The interaction between statisticians and scientists with the **primary purpose** to help the field of application (and possibly as a **spin-off**: ideas for new research in statistics)

Jim Boen & Doug Zahn

A **statistical consultant** provides statistical and research advice and guidance to clients in business, medicine, psychology, law, industry.

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- What is **Statistical Consulting** ?



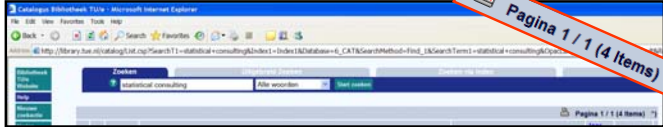
Running a small business

- Client Satisfaction
- Challenges
- Rewards:
  - Growth & Development
  - Contributions to Science
  - Satisfying Relationships
  - Challenging Problems
  - Client's Gratitude
  - A Good Future

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- Resources on **Statistical Consulting**





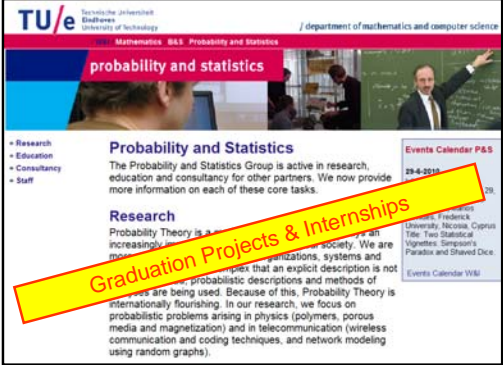
<http://www.amstat.org/sections/cnsl/>

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## TU/e-Expertise

- Probability & Statistics Group:



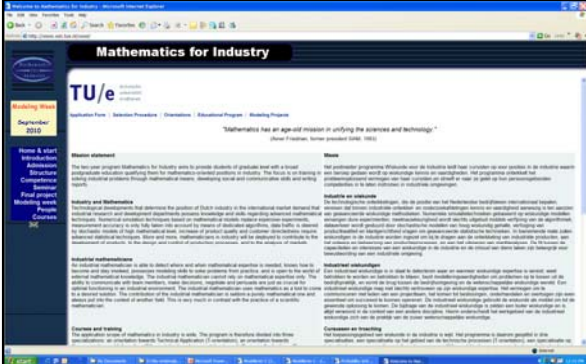
Graduation Projects & Internships

<http://www.win.tue.nl/bs/ps.html>

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- Designers Program: Mathematics for Industry



Graduation Projects & Internships

<http://www.win.tue.nl/oww/>

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• Internal Statistical Consultancy:

**The CEE/e Initiative**  
 Within the CEE/e-initiative for Continuing Engineering Education a number of more advanced short courses on Applied Statistics and Data Analysis will be organized within the CEE/e initiative for Continuing Engineering Education.

- Design of Experiments
- Multivariate Data Analysis with SPSS
- Advanced ANOVA with SPSS
- Categorical Data Analysis with SPSS
- General Linear Models with SPSS
- Structural Equation Modeling with AMOS

<http://www.win.tue.nl/cee>

**Statistical Consultancy Service: SCS/e**  
 We have initiated a Statistical Consultancy Service, SCS/e, in which we offer specific advise to PhD-students and staff members from the TU/e.

**Partnership in Research Projects**  
 We are open for co-operation and partnership in research projects, needing advanced or non-standard methods of statistical modeling or data analysis.

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• External Industrial Mathematical Consultancy:

<http://www.lime.tue.nl>

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- **Mathematical Modeling:**
  - Basmadjin, D.; *The Art of Modeling in Science and Engineering with Mathematica*
  - Cumberbatch, E. et al.; *Mathematical Modeling – Case Studies from Industry*
  - Dym, C.L.; *Principles of Mathematical Modeling*
  - Meerschaert, M.M.; *Mathematical Modeling*
  - Shier, D.R.; *Applied Mathematical Modeling, a Multidisciplinary Approach* (e-book ©)
  - Svobodny, T.; *Mathematical Modeling for Industry and Engineering*
  - Tung, K.K.; *Topics in Mathematical Modeling*
- **Statistical Modeling:**
  - Congdon, P.; *Bayesian Statistical Modelling*
  - Freund, R.J.; *Regression Analysis – Statistical Modeling of a Response Variable*
  - Kaplan, D.T.; *Introduction to Statistical Modeling*
  - Krzanowsky, W.J.; *An Introduction to Statistical Modelling*
  - Statistical Modeling, an International Journal
- **Statistical Consulting:**
  - Boen, J.R. et al.; *The Human Side of Statistical Consulting*
  - Cabrera, J. et al.; *Statistical Consulting*
  - Derr, J.; *Statistical Consultancy, a guide to effective communication*
  - Hand, D.J. et al.; *The Statistical Consultant in Action*

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- **Engineering Problem Solving:**
  - Brockman, J.B.; *Introduction to Engineering: Modeling and Problem Solving*
  - Chatfield, C.; *Problem Solving – a Statistician's Guide*
  - Czitrom, V.; *Statistical Case Studies for Industrial Process Improvement*
  - *Engineering Statistics Handbook*: <http://www.itl.nist.gov/div698/handbook>
  - Peck, R. et al.; *Statistical Cases Studies – a Collaboration between Academe and Industry*
  - Robinson, G.K.; *Practical Strategies for Experimenting*
  - Wang, J.X.; *Engineering Robust Designs with Six Sigma*

Suggestions for Improvements of this presentation 4WH03 are welcomed:

[j.j.m.rijpkema@tue.nl](mailto:j.j.m.rijpkema@tue.nl)

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