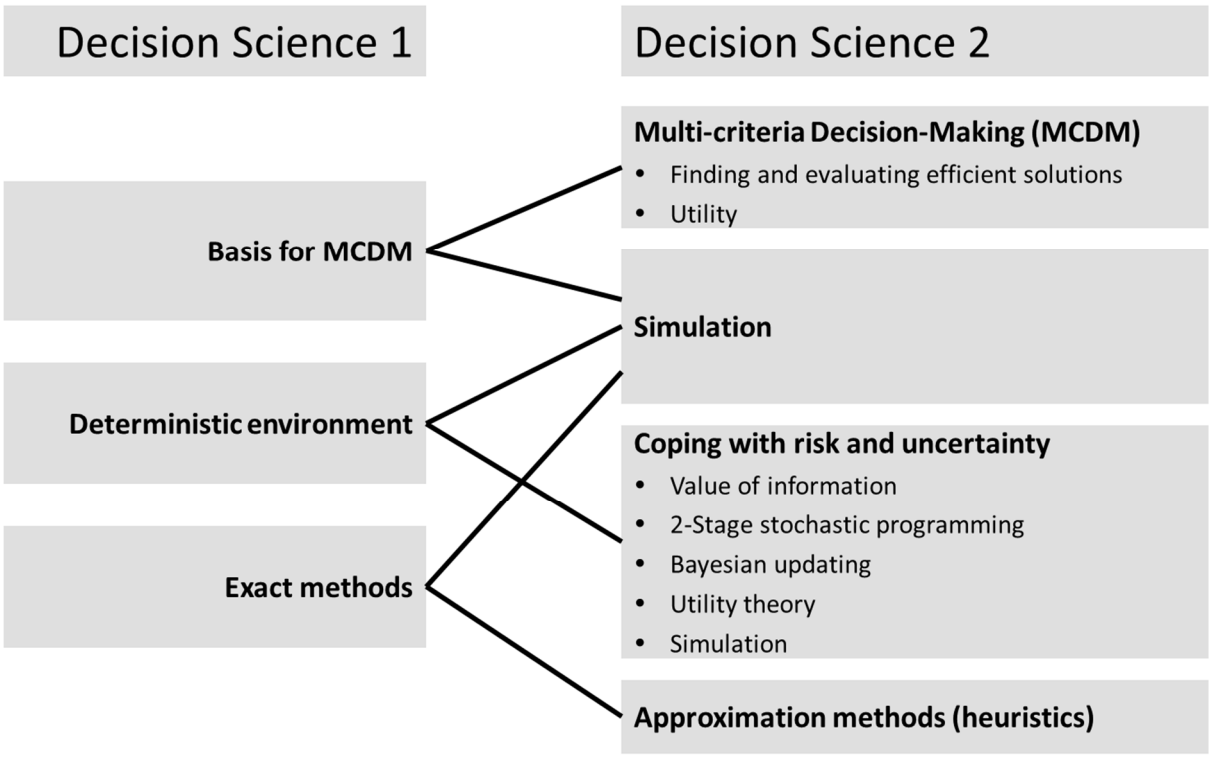
Decision Science 2

Course code	ORL-30306
Participating chair groups	Operations Research and Logistics Business Economics Information Technology
Period	5
Contact Person	Joke van Lemmen (ORL)
Lecturers Examiners	Frits Claassen (ORL) René Haijema (ORL) Mark Kramer (INF) Joke van Lemmen (ORL) Monique Mourits (BEC)
Language of instruction	English
Assumed prerequisite knowledge	Decision Science 1 (ORL-20306)
Secretariat	Leeuwenborch building, k6.033 tel: 0317-484154 office.orl@wur.nl

Profile of the course

Decision Science deals with quantitative methods and techniques to support decision processes. The course Decision Science 1 (ORL20306) provides a solid base for formulating and solving Linear Programming models, (Mixed) Integer Linear Programming models, an introduction to Multi-criteria Decision Making, and Dynamic Programming. Decision Science 2 broadens and deepens the knowledge and skills acquired in Decision Science 1 and presents important topics that were not presented in Decision Science 1.



The topics in Decision Science 2 can be classified into four groups:

1. *Multi-criteria decision making*

Ways of dealing with problems that have several, mostly conflicting, objectives. In that case the decision making process focusses on finding and evaluating efficient solutions. This topic also comprises utility, in order to incorporate the personal judgements of the decision maker about uncertainties and outcome-values.

2. *Simulation*

Many systems are so complex that you cannot optimise them in a straightforward, analytical way. Simulation increases the understanding of such a system by building a model of reality, and analysing its behaviour.

3. Coping with risk and uncertainty

Decision Science 1 focused on deterministic problems. However, in practice often risk and uncertainty occur. Decision Science 2 offers various techniques to cope with these.

4. Approximation methods (heuristics)

In many cases problems are too big or too complex to find an optimal solution in a reasonable amount of time. In those cases we can use approximation methods (heuristics) that find relatively good solutions in a relatively short amount of time.

In Decision Science 2 three different chair groups participate:

- Operations Research and Logistics (ORL)
- Business Economics (BEC).
- Information technology (INF).

The methods and techniques will be demonstrated with examples from e.g. the milk chain, production planning, pest control, investment problems. These are collected in the connecting theme.

Learning outcomes:
After this course students are expected to be able to:

- Analyse an MCDM situation using multi-objective programming and compromise programming.
- Apply the provided approximation methods to solve a small-scale problem.
- Analyse a decision situation where risk and uncertainty occurs, using value of information, simulation, Bayesian updating, and utility theory.
- For a provided situation construct a simulation model in professional software.
- Analyse the outcome of a simulation model.
- Judge which decision making tool is appropriate in a given decision situation.

Learning materials and resources

- Claassen, G.D.H. et al., *Decision Science; Theory and applications*. ISBN 978-90-8686-001-2 (also used in Decision Science 1).
- Multiple Criteria Analysis for Agricultural Decisions, Edited by: Carlos Romero and Tahir Rehman, ISBN: 9780444503435. Chapter 4 (Multiobjective programming) and Chapter 5 (Compromise programming). 2003. Pdf-files of both chapters are available via http://www.sciencedirect.com/science/bookseries/09265589/11. (after logging in via library.wur.nl).
- Reader on the connecting theme (Milk chain), which will be handed out.
- Reader Decision Science 2, part ORL, which will be handed out
- Hardaker et al., Coping with risk in agriculture: applied decision analysis, 3rd edition, 2015. ISBN: 978-1-78064-240-6, CABI publishing. Chapter 1-7. Full text free available via http://library.wur.nl/WebQuery/clc/1733370.
- Additional learning materials are provided via Blackboard.

Educational activities

- *Tutorial sessions*. Theory is presented in tutorial sessions. Small-scale examples are given. Main goal is to support and stimulate students in acquiring knowledge, insight and understanding. Students make exercises and can receive feedback. Difficult aspects are explained plenary.
- *Computer practicals*. Exercises are made using professional software. These practicals have a significant added value in acquiring insight and understanding. In line with the learning outcomes the practicals are compulsory. Due to both a limited capacity of computer labs and the restricted availability of teaching assistance, it is necessary to enrol for the course via AIR, and to enrol for the practical groups in Blackboard.
- *Self study*. The total number of contact hours comprises only a part of the 6 credits. Experience has taught that keeping up with the subjects and studying during the lecture period is much more effective and efficient than a great study effort shortly before the exam.

Assessment strategy

	Learning outcomes\where assessed?	Practical Simulation	Exam
1	Analyse an MCDM situation using multi-objective programming and compromise programming.		x
2	Apply the provided approximation methods to solve a small-scale problem.		x
3	Analyse a decision situation where risk and uncertainty occurs, using value of information, simulation, Bayesian updating, and utility theory.		x
4	For a provided situation construct a simulation model in professional software.	x	x
5	Analyse the outcome of a simulation model.	x	x
6	Judge which decision making tool is appropriate in a given decision situation.		x
	Contribution to final mark:		100%

During the practicals about discrete-event simulation you learn how to prepare models in Enterprise Dynamics. This is compulsory subject matter. As one of the tests you have to prepare a model, perform some experiments, and prepare a report. You cannot pass the exam without having fulfilled this obligation to the satisfaction of the assessors (René Haijema and Mark Kramer). The model (mod file), the results in Excel, and the report should be submitted by the Assignments of Blackboard no later than Tuesday May 1st. The other deadlines after the initial deadline are two weeks before each re-exam. After the third deadline no model or report can be submitted.

Submitting identical (or otherwise copied) work for model or report of the discrete-event simulation assignment is considered as plagiarism. Models created by ED contain a sort of fingerprint, which is different for independently created models, but which does not change significantly during editing operations on an existing model. Examples will be shown during the Simulation practical. In consultation with the examination board we have arranged the following procedure for dealing with cases of plagiarism in the discrete-event simulation assignment. If the assessors detect strong similarities in two models or reports, both students involved will be invited for an interview with the assessors in order to find out which work is original. A student who copied the model or report will be requested to hand in a completely new, original model and report. Moreover 1 point (on a scale of 10) will be subtracted from the mark of the Simulation-part of his or her written exam, and the names of both students involved will be reported to the examination board.

The exam is a written exam that consists of open questions and multiple-choice questions, and has to be passed (i.e. score at least 5.5). Examiners for the written exam: Frits Claassen, René Haijema, Mark Kramer, Joke van Lemmen, and Monique Mourits.

The following rules apply:

- Only the use of a non-programmable calculator is allowed. The use of the reader, book, written notes, etcetera is not allowed.
- The written exam consists of three parts: Decision Analysis, Simulation, ORL (Multi-Criteria Decision Making, Value of Information, Stochastic LP, Heuristics) that have equal weight in the final assessment.
- The exam can only be passed if for every separate part of it (Decision Analysis, Simulation, ORL) at least 40% of the points is attained.
- A student who does not pass the exam has to resit the exam for all three parts.

Important: The contents of this course may be updated yearly, which means that the contents of the exam may also change yearly.

Principal themes of the course

Multi-Criteria Decision Making

Many optimisation problems have more than one objective, and in many situations these objectives are (at least partly) conflicting. The latter can e.g. be the case when a decision maker seeks a solution that maximises profit and minimises environmental impact in a situation where cheap production methods produce more pollution than expensive production methods. In such context the concept of efficient solution is very important. An efficient solution has the property that it's not possible to improve the value of one objective without harming another objective. In our example efficient solutions are those for which a decrease of cost can only be obtained by accepting an increase of environmental impact. Chapter 4 of Romero addresses the issue of (finding) efficient solutions.

Another important concept is that of ideal point, i.e. the (hypothetical) solution in which all objective functions reach their optimum at the same time. Chapter 5 of Romero presents ways to quantify the distance between a current solution and the ideal point, and addresses interpretation issues.

Simulation

Up to now we have focussed on optimisation methods to model and solve decision problems and find the optimal solution. But many systems are so complex that you cannot optimise them in a straightforward way. Then the best you may do is to evaluate multiple solutions and select the best one. The evaluation of a complex system can be done relatively easily by simulation. A simulation model mimics the systems behaviour and thus generates insight and a better understanding on how to improve the (control of the) system. In Decision Science 2 you will learn the basics of discrete event simulation:

- to model relevant processes and in particular to select probability distributions to model uncertainty,
- to analyse output variables using statistical techniques,
- to verify and validate simulation models,
- to implement a model in simulation modelling software (Enterprise dynamics),
- to use computer simulation to evaluate alternative scenarios, and
- to report on the outcome of a simulation study.

Uncertainty in data, value of information, decision analysis

Many decision makers have to deal with risk and uncertainty. The impact of uncertainty is quantified by calculating the value of (perfect) information, i.e. quantifying how much extra profit could be made if uncertainty could be eliminated. This is an upper bound for the price of advice. Also it is explained how risk needs to be accounted for within the decision making process. Students will become familiar with the concept of rational choice and the theoretical principles of probability and risk preferences as well as methods to include risk within evaluations of decision alternatives.

Approximation methods (heuristics)

In many cases problems are too big or too complex to find an optimal solution in a reasonable amount of time. Often it's not even possible to find a feasible solution in reasonable time. In those situations we can either use simulation or approximation methods to analyse the problem. Approximation methods (heuristics) try to find relatively good solutions in a relatively short amount of time. They do not give the guarantee that the optimal solution will be found, but we can hope that they provide us with a satisfying outcome.

Approximation methods can be classified in several ways, e.g. by distinguishing common sense heuristics, metaheuristics, and heuristics based on mathematical programming. In this course heuristics of different types are presented.

Connecting theme

The techniques that are taught in Decision Science 2 have a wide application area. We have chosen to use a connecting theme for demonstrating the coherence and the applicability of the topics. This connecting theme is the milk chain. Various aspects of the milk chain shall be highlighted at many moments during the course. On Blackboard a reader 'Connecting theme' will be published, which contains a set of exercises based on decision problems in the milk chain.

Overview of the programme (schedule can be found on last page)
JL: Joke van Lemmen; FC: Frits Claassen; RH: René Haijema; MK: Mark Kramer; MM: Monique Mourits

Multi-Criteria Decision Making (JL)
Multi-Criteria Decision Making 1, Romero Chapter 4
Multi-Criteria Decision Making 2, Romero Chapter 4/5
Multi-Criteria Decision Making 3, Romero Chapter 5
Multi-Criteria Decision Making 4 (practical), Romero Chapter 4+5

Heuristics (JL, FC)
Heuristics 1 (JL), Claassen (2007), Sections 10.1 – 10.5
Heuristics 2 (JL), Claassen (2007), Sections 10.6 – 10.8
Heuristics 3 (JL) (practical), Handout
Heuristics 4 (FC), Handout
Heuristics 5 (FC), Handout

Value of information and 2-stage Stochastic Programming (FC)
Handout

Simulation (tutorials RH, practicals RH & MK)
Simulation tutorial 1, Introduction: what is discrete event simulation?
Simulation practical P1, Introduction to ED software
Simulation tutorial 2, Verification and random numbers: (How) does DES work?
Simulation practical P2, Simulation experiments for multi-criteria analysis
Simulation tutorial 3, Observation period and output analysis
Simulation practical P3, Controlling the product flow
Simulation tutorial 4, Validating your model and Experimenting
Simulation practical P4, Supply chain modelling: information flows for ordering products

Simulation tutorial 5, (Supply chain) modelling and reporting
Simulation practical P5, Milk supply chain (assignment)
Simulation practical P6, Milk supply chain (assignment)

Decision Analysis (MM)
Decision analysis 1; Introduction - Hardaker, Chapter 1 & 2
Decision analysis 2; Measuring uncertainty - Hardaker, Chapter 3 and 4
Decision analysis 3 (practical); Decision analysis by decision trees - Blackboard
Decision analysis 4; Measuring preferences - Hardaker, Chapter 5
Decision analysis 5; Decision analysis with known preferences - Hardaker, Chapter 6
Decision analysis 6; Decision analysis with unknown preferences - Hardaker, Chapter 7
Decision analysis 7; Decision analysis with multiple objectives - Handout
Decision analysis 8 (practical); Decision analysis by stochastic programming -Blackboard

Students are expected to know (from previous courses on Quantitative methods, Mathematics or Statistics) how to compute statistical measures (like the mean, standard deviation and variance, covariance, coefficient of correlation, 95% confidence interval of a set of data, confidence interval for the mean of a set of data), and to have knowledge of basic probability theory (computing a probability or mean of a given probability density function or (probability) distribution function) and in particular of the following probability distributions: Normal, (negative) Exponential, Binomial, Poisson.

Course Schedule Decision Science 2, 2018

	week 29 19-23 March	week 30 26-30 March	week 31 2-6 April	week 32 9-13 April	week 33 16-20 April	week 34 23-27 April
Monday (t/i) Group 1:8^{30}–10^{15} Group 2:10^{30}–12^{15}	MCDM 1 (JL)	Heuristics 1 (JL)		Value of Info (FC)	DA1 (MM)	DA5 (MM)
Tuesday (t/i) Group 1:8^{30}–10^{15} Group 2:10^{30}–12^{15}	MCDM 2 (JL)	Heuristics 2 (JL)	Heuristics 4 (FC)	2-stage Stoch Progr (FC)	DA2 (MM)	DA6 (MM)
Wednesday (t/i) Group 1:8^{30}–10^{15} Group 2:10^{30}–12^{15}	MCDM 3 (JL)	SimC2 (RH)	Heuristics 5 (FC)	2-stage Stoch. Progr. (FC)	DA3 (MM)	DA7 (MM)
Thursday (t/i) Group 1:8^{30}–10^{15} Group 2:10^{30}–12^{15}	SimC1 (RH)	SimP2 (RH, MK)	SimC3 (RH)	SimC4 (RH)	SimC5 (RH)	Group 1: 8^{30}–10^{15} Group 2: 10^{30}–12^{15} SimP6 (RH, MK)
Thursday (pti) Group 2:8^{30}–10^{15} Group 1:10^{30}–12^{15}	MCDM 4 (JL)	Heuristics 3 (practical, JL)		Value of Info + 2-stage Stoch. Progr. (practical, FC)	DA4 (practical, MM)	Group 2: 8^{30}–10^{15} Group 1: 10^{30}–12^{15} DA8 (MM) practical
Friday (t/i) Group 1:8^{30}–10^{15} Group 2:10^{30}–12^{15}	SimP1 (RH, MK)		SimP3 (RH, MK)	SimP4 (RH, MK)	SimP5 (RH, MK)	

RH: René Haijema; MK: Mark Kramer; MM: Monique Mourits; FC: Frits Claassen; JL: Joke van Lemmen

On most Thursdays both groups have classes from 8^{30} – 12^{15}!
Shaded cells indicate computer practical.
Room numbers can be found in MyPortal.
Question hour: to be announced via Blackboard.
Exam dates and locations can be found in MyPortal.