

Dr. Yakov Ben-Haim

Professor
Yitzhak Moda'i Chair in
Technology and Economics



Technion

Israel Institute of Technology
Faculty of Mechanical Engineering
Haifa 32000 Israel

<http://info-gap.com> Blog: <http://decisions-and-info-gaps.blogspot.com> <http://www.technion.ac.il/yakov>
Tel: +972-4-829-3262, +972-50-750-1402 Fax: +972-4-829-5711
yakov@technion.ac.il

A 4 Day Course on
Info-Gap Theory and Its Applications

4–7 September 2012
East Bay Municipal Utility District
Oakland, CA

Course Rationale

Scientists, engineers, policy planners and analysts use measurements and science-based models to design systems, evaluate reliability, and make plans and policies. However, models may be simpler than reality, causal factors may be unknown, measurements may err or be incomplete, and systems may change over time in unknown ways. Probability is useful for modeling and managing some of these uncertainties. However some uncertainties are *info-gaps*: disparities between what *is known* and what *needs to be known* in order to make good decisions. For instance, we sometimes do not know the correct probability distribution or all of the relevant physical mechanisms such as non-linearities or time dependencies. This course studies info-gap theory for modeling and managing uncertainties in planning, design and decision problems. The course emphasizes the added value of an info-gap analysis as well as its limitations, and the integration of info-gap theory with probabilistic analysis.

Course Structure

This course has three components. *Lectures* present new material and *exercises* help the participants to master this material. The first two days are devoted to lectures and exercises. The last two days are devoted to *mini-projects* that are formulated and implemented by the participants, in small groups. This facilitates the internalization of the concepts and methods learned, their integration with other methods familiar to the participants, and their application to problems of interest.

The Instructor

Yakov Ben-Haim initiated and developed info-gap decision theory for modeling and managing severe uncertainty. Info-gap theory is applied in engineering, biological conservation, economics, project management, climate change management, homeland security, medicine, and other areas. He has been a visiting scholar in Australia, Austria, Canada, England, France, Germany, Italy, Japan, Korea, Netherlands, Norway, and the US. He has lectured at universities, medical and technological research institutions and central banks around the world. He has published more than 90 articles and 5 books. He is a professor of mechanical engineering and holds the Yitzhak Moda'i Chair in Technology and Economics at the Technion—Israel Institute of Technology.

The Participants

Engineers and analysts involved in risk analysis, reliability assessment and policy selection.

Selected Sources

1. Yakov Ben-Haim, 2006, *Info-gap Decision Theory: Decisions Under Severe Uncertainty*, 2nd edition, Academic Press, London.
2. Yakov Ben-Haim, 2010, *Info-Gap Economics: An Operational Introduction*, Palgrave.
3. Yakov Ben-Haim, 2005, Info-gap Decision Theory For Engineering Design. Or: Why ‘Good’ is Preferable to ‘Best’, appearing as chapter 11 in *Engineering Design Reliability Handbook*, Edited by Efstratios Nikolaidis, Dan M.Ghiocel and Surendra Singhal, CRC Press, Boca Raton.
4. Keith W. Hipel and Yakov Ben-Haim, 1999, Decision making in an uncertain world: Information-gap modelling in water resources management, *IEEE Trans., Systems, Man and Cybernetics, Part C: Applications and Reviews*, 29: 506–517.
5. Yakov Ben-Haim, 2012, Doing Our Best: Optimization and the Management of Risk, *Risk Analysis*, to appear.
6. Yakov Ben-Haim, 2012, Why risk analysis is difficult, and some thoughts on how to proceed, *Risk Analysis*, to appear.
7. Yakov Ben-Haim, 2009, Info-gap forecasting and the advantage of sub-optimal models, *European Journal of Operational Research*, 197: 203–213.
8. Yakov Ben-Haim, Interpreting null results from measurements with uncertain correlations: An info-gap approach, *Risk Analysis*, vol.31 (1), pp.78–85.
9. Tania Mirer and Yakov Ben-Haim, 2010, Reliability Assessment of Explosive Material Based on Penalty Tests: An Info-Gap Approach, Proceedings of the Institution of Mechanical Engineers, Part O, *Journal of Risk and Reliability*, vol. 224(4), pp.346–355.
10. Yakov Ben-Haim, Clifford C. Dacso, Jonathon Carrasco and Nithin Rajan, 2009, Heterogeneous Uncertainties in Cholesterol Management, *International Journal of Approximate Reasoning*, 50: 1046–1065.
11. Lior Davidovitch and Yakov Ben-Haim, 2008, Is your profiling strategy robust? *Law, Probability and Risk*, 10: 59–76.
12. Lior Davidovitch and Yakov Ben-Haim, 2010, Robust satisficing voting: Why are uncertain voters biased towards sincerity? *Public Choice*, vol.145, Issue 1, pp.265–280.
13. Barry Schwartz, Yakov Ben-Haim, and Cliff Dacso, 2011, What Makes a Good Decision? Robust Satisficing as a Normative Standard of Rational Behaviour, *The Journal for the Theory of Social Behaviour*, 41(2): 209–227.
14. Yoshihiro Kanno and Yakov Ben-Haim, 2011, Redundancy and Robustness, Or, When is Redundancy Redundant? *ASCE Journal of Structural Engineering*, 137(9): 935–945.
15. References, background material, links. <http://info-gap.com>
16. Decisions and Info-Gaps: A Blog. <http://decisions-and-info-gaps.blogspot.co.il>

Brief Outline

Day 1 Tuesday 4 September 2012

MORNING

08:30–09:20 *Lecture 1. Water infrastructure planning.*

09:30–10:20 *Lecture 2. Water infrastructure planning, continued.*

10:20–10:40 Coffee break.

10:40–11:30 *Lecture 3. Water infrastructure planning, continued. (Info-gap overview.)*

LUNCH 11:30–13:00

AFTERNOON

13:00–13:50 *Exercise. Sewage system design.*

14:00–14:50 *Exercise. Pipeline replacement.*

14:50–15:10 Coffee break.

15:10–16:00 *Exercise. Project cost management.*

EVENING

19:00–20:00 *Public lecture: Model-Based Planning for an Uncertain Future:
An Info-Gap Approach*

Day 2 Wednesday 5 September 2012

MORNING

08:30–09:20 *Lecture 4. Optimizer's Curse: An Info-Gap Response.*

09:30–10:20 *Lecture 5. Info-Gap Statistics.*

10:20–10:40 Coffee break.

10:40–11:30 *Lecture 6. Forecasting.*

LUNCH 11:30–13:00

AFTERNOON

13:00–13:50 *Exercise. Transportation network.*

14:00–14:50 *Exercise: Robustness and opportuneness of failure probability.*

14:50–15:10 Coffee break.

15:10–16:00 *Exercise. In-house or out-source?*

Day 3 Thursday 6 September 2012

MORNING

08:30–11:30 *Brain-storm and initiate mini-projects.*

LUNCH 11:30–13:00

AFTERNOON

13:00–16:00 *Guided independent work on mini-projects.*

Day 4 Friday 7 September 2012

MORNING

08:30–10:00 *Guided independent work on mini-projects.*

10:00–11:30 *Preliminary reports on mini-projects.*

LUNCH 11:30–13:00

AFTERNOON

13:00–16:00 *Guided independent work on mini-projects.*

Detailed Outline

Day 1 Tuesday 4 September 2012

MORNING

08:30–09:20 *Lecture 1. Water infrastructure planning.*¹

- Analysis and Design of Water Storage and Processing.²

09:30–10:20 *Lecture 2. Water infrastructure planning, continued.*³

- Redundancy in Water Infrastructure.⁴

10:20–10:40 Coffee break.

10:40–11:30 *Lecture 3. Water infrastructure planning, continued.*⁵ (*Info-gap overview.*)⁶

- Pipeline Replacement Planning.
- Overview of info-gap uncertainty (time permitting):
 - Examples of severe info-gaps.
 - Ignorance, probability, and info-gaps.⁷

LUNCH 11:30–13:00

AFTERNOON

13:00–13:50 *Exercise. Sewage system design.*⁸

14:00–14:50 *Exercise. Pipeline replacement.*⁹

14:50–15:10 Coffee break.

15:10–16:00 *Exercise. Project cost management.*¹⁰

EVENING

19:00–20:00 *Public lecture: Model-Based Planning for an Uncertain Future:
An Info-Gap Approach*¹¹

¹**ebmud2012Lec03.pdf**, section 1.

²Keith W. Hipel and Yakov Ben-Haim, 1999, Decision making in an uncertain world: Information-gap modelling in water resources management, IEEE Trans., *Systems, Man and Cybernetics*, Part C: *Applications and Reviews*, 29: 506–517.

³**ebmud2012Lec03.pdf**, sections 2, 3.

⁴Yakov Ben-Haim, 2010, *Info-Gap Economics: An Operational Introduction*, Palgrave, section 4.1.

⁵**ebmud2012Lec03.pdf**, section 4.

⁶**ebmud2012Lec01.pdf**, sections 1–3, pp.3–46.

⁷Yakov Ben-Haim, *Info-Gap Decision Theory*, 2nd ed., 2006, (henceforth “*IGDT*”), sections 2.2 and 2.3.

⁸Problem Set on Robustness and Opportuneness (ps2-02.tex) #57.

⁹Problem Set on Robustness and Opportuneness (ps2-02.tex) #58.

¹⁰Problem Set on Info-Gap Risks in Project Management (p-mgt-hw02.tex), #1, c, d.

¹¹San Francisco Section of the American Society of Civil Engineers, East Bay Municipal Utility District, Oakland California. oakland-asce2012-01.pdf

Day 2 Wednesday 5 September 2012

MORNING

08:30–09:20 *Lecture 4. Optimizer’s Curse: An Info-Gap Response.*¹²

- Why best-model optimization is not a good bet if the best model is highly uncertain.¹³

10:40–11:30 *Lecture 5. Info-Gap Statistics.*¹⁴

- Embedding a statistical test in an info-gap robustness analysis.
- Distributional uncertainty.
- Statistical test of the mean with distributional uncertainty.¹⁵
- Test of false nulls with uncertain sampling distribution.¹⁶

10:20–10:40 Coffee break.

10:40–11:30 *Lecture 6. Estimation and Forecasting.*¹⁷

- Use regression to predict with preliminary data from an unstable process.¹⁸

LUNCH 11:30–13:00

AFTERNOON

13:00–13:50 *Exercise. Transportation network.*¹⁹

14:00–14:50 *Exercise. Robustness and opportuneness of failure probability.*²⁰

14:50–15:10 Coffee break.

15:10–16:00 *Exercise. In-house or out-source?*²¹

Day 3 Thursday 6 September 2012

MORNING

08:30–09:30 *Brainstorming on mini-projects.*

09:30–11:30 *Guided independent work on mini-projects.*

LUNCH 11:30–13:00

AFTERNOON

13:00–16:00 *Guided independent work on mini-projects.*

Day 4 Friday 7 September 2012

MORNING

08:30–10:00 *Guided independent work on mini-projects.*

10:00–11:30 *Preliminary reports on mini-projects.*

LUNCH 11:30–13:00

13:00–16:00 *Guided independent work on mini-projects.*

¹²**ebmud2012Lec04.pdf**, sections 1.1, 1.2.1, 2.1–2.3.

¹³(1) Lecture Notes on the Optimizer’s Curse (optimizers-curse03.tex). (2) *IGDT*, section 11.4.

¹⁴**ebmud2012Lec05.pdf**, sections 1.1–1.3.

¹⁵Tanya Mirer and Yakov Ben-Haim, 2010, Reliability Assessment of Explosive Material Based on Penalty Tests: An Info-Gap Approach, working paper.

¹⁶(1) Yakov Ben-Haim, 2010, Interpreting Null Results from Measurements with Uncertain Correlations: An Info-Gap Approach, working paper. (2) L.J. Moffitt and Yakov Ben-Haim, 2010, Robustness Analysis of Expert Dispute About Incubation Time, working paper.

¹⁷**ebmud2012Lec06.pdf**, sections 1, 2.1.

¹⁸*IGE*, sections 6.1, 6.2.

¹⁹Problem Set on Info-Gap Risks in Project Management (p-mgt-hw02.tex), #11.

²⁰Problem Set on Robustness and Opportuneness (ps2-02.tex) #46.

²¹Problem Set on Info-Gap Risks in Project Management (p-mgt-hw02.tex), #12.