

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> <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 One-Day Course on
Info-Gap Theory and Its Applications

29 January 2016
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 is a brief introduction to 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 two components. *Lectures* present new material and *exercises* help the participants to master this material.

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, national 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 system design, risk analysis, reliability assessment and policy selection.

Website with lecture notes and exercise problem.

Course Outline

MORNING

08:15–09:15 *Lecture 1. Water infrastructure planning.*¹

- Analysis and Design of Water Storage and Processing.²
- Redundancy in Water Infrastructure.³

09:30–10:30 *Lecture 2. Water infrastructure planning, continued.*⁴

- Pipeline Replacement Planning.

10:45–11:45 *Lecture 3. Safety factors and info-gap robustness.*⁵

LUNCH 11:45–12:45

AFTERNOON

12:45–13:45 *Lecture 4. Info-gap forecasting and estimation.*⁶

14:00–15:00 *Lecture 5. Retrospective overview of info-gap theory.*⁷

- Examples of severe info-gaps.
- Ignorance, probability, and info-gaps.⁸

15:15–16:30 *Exercises. Pipeline replacement.*⁹

*Waste water system design.*¹⁰

*Transportation network.*¹¹

¹**ebmud2016Lec001.pdf**, sections 1, 2, pp.3–84.

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.

³Yakov Ben-Haim, 2010, *Info-Gap Economics: An Operational Introduction*, Palgrave, section 4.1.

⁴**ebmud2016Lec001.pdf**, section 3, pp.85–121.

⁵**ebmud2016Lec004.pdf**.

⁶**ebmud2016Lec003.pdf**, sections 1–2, pp.3–47.

⁷**ebmud2016Lec002.pdf**, sections 1–4, pp.3–64.

⁸Yakov Ben-Haim, *Info-Gap Decision Theory*, 2nd ed., 2006, sections 2.2 and 2.3.

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

¹⁰Problem Set on Robustness and Opportuneness (ps2-02.tex) #57.

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

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.
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5. Yakov Ben-Haim, 2012, Doing Our Best: Optimization and the Management of Risk, *Risk Analysis*, to appear.
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7. Yakov Ben-Haim, 2011, Interpreting null results from measurements with uncertain correlations: An info-gap approach, *Risk Analysis*, vol.31 (1), pp.78–85.
8. 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.
9. Michael Smithson and Yakov Ben-Haim, 2015, Reasoned decision making without math? Adaptability and robustness in response to surprise, *Risk Analysis*, vol.35, #10, pp.1911–1918.
10. Yakov Ben-Haim, 2015, Dealing with uncertainty in strategic decision-making, *Parameters*, the US Army War College Quarterly, 45(3) Autumn 2015.
11. References, background material, links. <http://info-gap.com>