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Joint Undergraduate-Graduate Course on

Info-Gap Risks in Project Management

096131

Syllabus. Projects are temporary and unique. Project managers face gaps in their knowledge, and models of processes are incomplete or flawed. Information-gaps are the essence of project risks. Integration of project planning, execution and modification, time- and cost-planning and control, quality management, risk assessment and response and other components of successful project management all face info-gap risks arising from the temporary dynamics and uniqueness of projects.

This course emphasizes quantitative modelling and management of project risks resulting from info-gaps. We develop decision paradigms for probabilistic and info-gap uncertainty, and study the trade-offs between robustness, bare survival and windfall success. We consider probabilistic risk assessment and its combination with info-gap methods. We develop tools to support value judgments in project management and to make decisions with multiple criteria. In short, we view the management of info-gap risks in projects as a particular type of strategic decision under severe uncertainty.

Audience. Project managers, systems analysts, systems engineers.

Prerequisite. This course is based on concepts and methods drawn from the analysis of systems: project management, operational research, or economics. The mathematical background required for the course includes integral and differential calculus, basic matrix algebra, fundamental probability. The required course is "Project planning and management" (095140).

Weekly hours. 3 hours of lecture, including discussion of homework.

Grading. Course grade based upon:
Midterm exam, required, 50%.
Homework, required, 7%
Final project, required, 43%. Guidelines are presented below.

Homework. Homework sets are distributed each week, and discussed in the exercise session. Students must hand in solutions to 7 homework sets. Each adequate homework set credits the student with 1 grade point, up to a maximum of 7 points.

Time and place of lectures: Wednesdays, 16:30–18:30, Blumfield 151.

Office hours: Mondays 14:00–15:00, Wednesdays 10:00–11:00, or by appointment.

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Outline of Lectures

Lecture 1. **Risk, uncertainty and info-gaps.** An info-gap is the disparity between what the manager *does know* and what *needs to be known* in order to make a responsible decision. We discuss probabilistic and info-gap concepts of uncertainty and risk, illustrated with riddles and paradoxes of decision under uncertainty. We review the PMBOK 9-point taxonomy of knowledge areas in project management (integration, scope, time, cost, quality, human resources, communications, risk and procurement). In this and following lectures we discuss info-gaps and probabilistic risks in these knowledge areas which arise in projects. We present examples of quantitative models for managing these uncertainties.

Lecture 2. **Task-duration uncertainty.** We begin our study of the 1st and 3rd PMBOK knowledge areas: integration and time management. Task scheduling is a central requirement in project integration, but task durations are often highly uncertain. We discuss the info-gap modelling and management of task-duration info-gaps. We study the relation between the classical concept of the critical path and the info-gap concept of uncertainty-critical paths. We address both the risks and the opportunities from these uncertainties.

Lecture 3. **Task-duration uncertainty:** robustness and opportuneness. Time buffering: distribution of buffer times among project tasks as a tool for dealing with uncertain duration. We discuss the relation between Goldratt's theory of constraints and info-gap methods.

Lecture 4. **Task-duration uncertainty:** strategies for enhancing robustness.

Lecture 5. **Task-duration uncertainty:** PERT and beta distribution methods. Central limit theorem and total project duration. Info-gap analysis of uncertainty in probabilistic models.

Lecture 6. **Task-duration uncertainty:** modelling and managing task-scheduling risks in projects with dynamic requirements; queueing applications.

Lecture 7. **Statistical data and info-gaps:** incorporating statistical data into an info-gap analysis of risk. Means, variance-covariance matrix, and ellipsoidal info-gap models of uncertainty.

Lecture 8. **Project cost management.** We discuss modelling and managing info-gap and probabilistic risks associated with cost over-runs.

Lecture 9. **Project cost management,** continued. We discuss a military project-budgeting problem.

Lecture 10. **Project valuation:** Value at risk (VaR) methods are a standard tool for investment valuation. However, for highly novel projects we often are uncertain about the probability distribution of the project value. We use info-gap theory to study VaR methods with uncertain pdf's.

Lecture 11. **Project quality management.** In this and the following lecture we discuss decisions regarding the quality of a new product during development, stressing risk analysis of the uncertain future market for the product.

Lecture 12. **Project quality management,** continued.

Lecture 13. **Value of information.** The project manager facing serious info-gaps must ask: what new knowledge should be sought? The answer depends on assessing the value of information with respect to project goals. This assessment is exploited to optimize information-gathering. We use the info-gap robustness premium to evaluate the demand value of information.

Lecture 14. **Value judgments.** Project plans must be robust to the info-gaps facing the manager, and more robustness is better than less. But how safe is safe enough? How much robustness to info-gaps is needed? How good is our project plan? In previous lectures we studied the quantitative trade-off between robustness and project performance. We now consider the qualitative calibration of this robustness. The basic tool is analogical reasoning.

Books

The main text is:

Ben-Haim, Yakov, 2006, *Info-Gap Decision Theory: Decisions Under Severe Uncertainty,* 2nd edition, Academic Press.

Supplementary material includes:

1. Haimes, Yacov Y., 1998, *Risk Modeling, Assessment, and Management,* John Wiley.

2. Kerzner, Harold, 2001, *Project Management: A Systems Approach to Planning, Scheduling, and Controlling,* 7th ed., John Wiley, New York.

3. Project Management Institute, 2000, *A Guide to the Project Management Body of Knowledge,* (PMBOK Guide), Project Management Institute, Upper Darby, PA.

4. Shtub, Avraham, Jonathan F. Bard and Shlomo Globerson, 1994, *Project Management: Engineering, Technology, and Implementation,* Prentice-Hall, Englewood Cliffs, NJ.

Project Guidelines

1. The student's report is devoted to the info-gap analysis of some aspect of a project. The report will contain the following elements:

   (a) **Statement of the problem,** typically the modelling and management of info-gaps in one or more of the PMBOK areas of knowledge.

   (b) **Mathematical model** of the project and problem area. The project may be specific or generic.

   (c) Formulation of **failure criteria.**

   (d) Formulation of the **uncertainty model** with info-gap (and possibly probabilistic) components.

   (e) Derivation of the **robustness function** (and possibly also the opportuneness function). Use of the derived function to resolve the formulated problem.

2. The project will be submitted in two stages.

   (a) Stage 1: Project **definition and outline** of items 1a–1d above. A printed outline of about 1 page length is due by about the 8th week of the semester.

   (b) Stage 2: **Final report.** Printed, with text not exceeding 10 pages (not counting tables or graphs). Due by the end of the exam period.

3. Each student must submit his own project. **No team submissions.**

4. **Expected depth and complexity:** more than the typical homework problem; much less than a realistic full scale analysis.

5. **Advice and suggestions** can be obtained by consulting with the instructor.

6. **Grading.** The project makes up 43% of the final course grade. The project grade will be one of four:

   - 100 (excellent): innovative and comprehensive application, different in substance from examples discussed in the lectures and homeworks.
   - 85 (good): Solid comprehensive analysis basically similar or analogous to examples discussed in the lecture.
   - 70 (pass): Correct analysis but neither comprehensive nor innovative.
   - 40 (fail): Anything else.