SIE 464-564 Cost Estimation
Mon & Wed 3:00 PM – 4:15 PM
Harvill Building 404
Ricardo Valerdi
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Office hours: Mondays and Wednesday 1:45-2:45 PM in Old Engineering room 225 or by appointment

TA: Alex Lee, alee5@email.arizona.edu
Office hours: Tuesdays and Thursdays 2 PM – 3 PM in Old Engineering room 260

This course focuses on principles of cost modeling, measurement systems, and forecasting with specific emphasis on parametric models. Approaches from the fields of hardware, software and systems engineering are applied to a variety of contexts (risk assessment, judgment & decision making, performance measurement, process improvement, adoption of new tools in organizations, etc.). Material is divided into five major sections: cost estimation fundamentals, parametric model development and calibration, advanced engineering economics principles, measurement systems, and behavioral economics/forecasting.

Course Description
Each section will include analysis of theoretical principles that have motivated the state of the practice as well as a review of applicable methodologies. Where appropriate, case studies will be used for more detailed exploration of critical issues and examples from Sabermetrics (using baseball data) will be introduced to enhance discussions. Selectively, guest speakers will be invited to share their perspectives on the development, use, and evaluation of cost models and complementary approaches. Students are encouraged to leverage their interests into individual projects that involve developing and validating their own cost model.

Rationale
The objective of this course is to provide future technical leaders the necessary tools and evaluation techniques to reason about the economic impact of their decisions for the technologies and products they develop.

Technical leadership requires an understanding of three areas, including but not limited to: technology, economic factors, and human decision making. This course assumes a background in some area of technology that can be analyzed from a cost perspective. This course will explore the more challenging – and often overlooked – domain of cost estimation and incorporate methodologies from established engineering disciplines to explore the impact of: continuous process improvement, economies of scale, present value, risk and decision analysis, etc. This will be done in the context of new challenges in complex engineering systems and new approaches introduced by process maturity models, evolutionary development, and systems architecting and engineering.
Learning objectives [measurable outcome]
1. Build awareness of phenomena that influence cost of engineering systems across a variety of contexts [homework]
2. Understand the practical application of cost modeling and its role in government and industry [homework, final project]
3. Use cost models to develop cost estimates [homework, midterm]
4. Learn the financial vocabulary and effective methods for communicating with non-technical audiences [homework, midterm]
5. Employ data-driven decision making to make economic choices between design alternatives [final project]
6. Understand the methods used to develop and validate cost models and associated limitations [homework]
7. Identify enterprise-wide cost issues involving strategy, knowledge, policy, process, etc. [homework, final project]
8. Communicate technical results in clear and concise writing style [final project]
9. Develop an appreciation for the controversial issues in the area of cost estimation [homework]
10. Develop a cost model [final project]

Required Course Texts

Optional Course Text
Boehm, B. W., et al, Software Cost Estimation with COCOMO II, Prentice-Hall, 2000. (Note: I will provide the necessary chapters for those who do not want to purchase the book)

Class Schedule

<table>
<thead>
<tr>
<th>Lecture</th>
<th>Homework due &amp; Readings</th>
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</thead>
<tbody>
<tr>
<td><strong>.Topic 1 (Jan 18) – Intro and course overview</strong></td>
<td><strong>Required</strong></td>
</tr>
<tr>
<td>• Syllabus review</td>
<td>Boehm, B. W. et al, Software Cost Estimation with COCOMO II, 2000 (Chapter 1).</td>
</tr>
<tr>
<td>• Cost estimation activity</td>
<td><strong>Optional</strong></td>
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<tr>
<td>• History of parametrics</td>
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<tr>
<td>• Cost estimation theories</td>
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<tr>
<td>• Life-cycle cost &amp; total ownership cost</td>
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<tr>
<td>• DMAIC project</td>
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| **Topic 2 (Jan 23, 25) – Cost Estimation Approaches** | **HW#1**: Cost estimation in the news, 7 wonders of the modern world & COCOMO Intro (due Jan 27) |
| *Basic concepts of software development* | **Required** |
| (parametric, activity-based, analogy, expert based, etc.) | |
The estimation process (NASA example)
- Software cost estimation with COCOMO II and commercial models
- Tool demo: online COCOMO II

Optional
- Hihn, J., Griesel, A., Bruno, K., Fouser, T., Tausworthe, R., Mental Models of Software Forecasting, NASA JPL.

Topic 3 (Jan 30, Feb 1) – Sizing and Work Breakdown Structures
- The Sizing Problem
- Function points
- Work Breakdown Structures
- Measurement, metrics and associated terminology
- 10 deadly sins of cost estimation
- Evaluating software models

HW#2: Cost estimation with COCOMO II, comparison of cost estimation approaches, DMAIC (due Feb 3)

Required

Optional

Topic 4 (Feb 6, 8) – Advanced Cost Modeling Concepts
- Systems engineering cost estimation (COSYSMO)
- Data collection, statistical data analysis, and calibration (M&Ms)
- Bayesian approximations of historical data and expert opinion
- Threats to validity
- Model integration
- Bayesian Belief Networks
- Final project brainstorming

HW#3: Sizing and WBS (due Feb 10)

Required

Optional
- Ross, M., Software Size Growth and Uncertainty

Topic 5 (Feb 13, 15) - Economic Principles
- Diseconomies of scale
- Cognitive decision making
- Reuse
- Productivity
- Cost risk analysis
- Trade studies
- Value articulation
- Earned value/project staffing profiles
- Leading indicators vs. lagging indicators
- Learning curves
- Real options

HW#4: Cost analysis fundamentals (due Feb 17)

Required

Optional

Topic 6 (Feb 20, 22) Modeling Data
- Descriptive vs. Inferential statistics
- Regression analysis (using baseball data)
- IBM Watson Analytics

Topic 7 (Feb 27, Mar 1) - Measurement Systems
- Measurement frameworks
- Goal Question Metric
- Capability maturity

HW#5: Application of economic principles, regression (due Mar 3)

Required
### Topic 8 (March 6, 8) – Enablers and barriers to adoption of process improvement
- Technology acceptance model
- Adoption of innovations
- ROI of process improvement
- Cost model adoption process
- Barriers for process improvement
- Stakeholder negotiations
- Cost estimation and negotiation

**Required**
- Rico, D. F., ROI of Technology Readiness Assessments Using Real Options: An Analysis of GAO Data from 62 U.S. DoD Programs
- Mah, M., Marriage of Estimation & Negotiation, STQE

**Optional**

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### Topic 9 (March 20, 22) – Risk Estimation & Project Management
- Cost estimation heuristics
- Cost risk (probabilistic)
- Cost risk (knowledge-based)
- Portfolio risk management
- Cost estimation guidance
- Descriptive and inferential statistics
- Earned Value Management Systems
- Detailed case studies

**HW#6: Cost Risk Analysis (due March 24)**

**Required**
- Valerdi, R., Systems Engineering and Program Management Strategies, draft Chapter 5.

**Optional**

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### Topic 10 (March 27, 29) – Decision Analysis, Value-based engineering, Psychometrics, Project Dynamics
- Value-based engineering
- Psychometrics & measurement scales
- Data validity & reliability
- Examples from baseball
- Software project dynamics

**HW#7: Organizational aspects of cost estimation (due March 31)**

**Required**

**Optional**
Topic 11 (April 3, 5) – Human Side of Estimation

- Heuristics and biases
- Cost model estimation errors and limitations of approaches
- Optimism in estimation
- Calibrating optimism
- Effect of estimates on project performance

HW#8: Midterm question (due Apr 5)

Required

Optional
Valerdi, Yang, *Optimism in Schedule Estimation*

Midterm (April 10, 12)

Topic 12 (April 17, 19) – Forecasting

- Prediction markets
- Weather prediction
- Earthquake prediction
- Extrapolation
- Bayesian inference


Topic 13 (April 24, 26) – Sabermetrics

- Moneyball
- Sandlot statistics
- Simpson’s paradox
- Ballpark effects
- Playoff predictions

DMAIC report due

Course Overview (May 1, 3)

Final paper due

Basis of grade (SIE 464)

<table>
<thead>
<tr>
<th>Component</th>
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<td>10%</td>
<td>Based on in-class participation (or out of class contributions from distance students) and quality of assignments</td>
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<td>5-6 pages</td>
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Homework assignments
There are eight homework assignments worth a total of 16% of your grade. Assignments must be 2-3 pages in length (single spaced) and must be submitted (via course drop box on D2L) on the date indicated in the syllabus.

Final Project
The final project should be summarized in a report between 5 and 10 pages long (plus or minus 20%; clarity of understanding and evidence of independent thinking are much more important than length) single spaced 12-point font. Projects should be a result of individual effort only. Students are expected to develop their own cost model and are encouraged to select a technical area that interests them. Proposals for final projects, which is a homework assignment, will serve as an opportunity to negotiate the topic and scope of the final paper.

Midterm Exam
An exam will be administered approximately two-thirds through the semester to assess progress on learning objectives. Rather than testing memorization, the focus will be on the application of concepts from the first half of the class. Questions for the midterm will be a combination of questions generated from student inputs and instructor-generated questions.