George Mason University
School of Information Technology and Engineering
Department of Systems Engineering and Operations Research

OR 651 – Military Operations Research: Cost Analysis
Spring, 2008

Abstract: Cost Analysis is a sub-discipline of Operations Research. While drawing on other disciplines (e.g., Managerial Accounting, Econometrics, Systems Analysis, etc.), Cost Analysis uses the basic tools of Operations Research to solve a specific class of public sector problems. Cost Analysis is an inquiry to assist decision-makers in choosing preferred future courses of action by evaluating selected alternatives on the basis of their costs, benefits, and risks. Cost Analysis is different from Cost Estimating in that projecting future courses of action usually requires mathematical modeling, hence the link to Operations Research and Economic Analysis. This course introduces the basic concepts of Cost Analysis.

This class will follow a lecture format, but there will be a different lecturer each week. An important topic in Cost Analysis is scheduled for each lecture. We draw on the experiences of experts from the cost analysis research and practitioner communities; hence, this course provides a unique introduction to the topic. This course is particularly useful for students of Operations Research, Public Policy, Information and Software Systems Engineering, and Systems Engineering.

Course Coordinators:

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Time: Thursday, 16:15–18:55

Location: Institute for Defense Analyses

Prerequisites: STAT 344 (or equivalent) – Probability and Statistics for Engineers
OR 541, OR 542 (or equivalent) – Introduction to Operations Research

Textbooks: Course Pack (available at the book store)

Optional texts: Quade, E.S., *Analysis for Public Decisions*, 3rd Edition. Englewood Cliffs: Prentice-Hall, 1989.

Fisher, G.H., *Cost Considerations In Systems Analysis*. New York: American Elsevier, 1971.

Proposed Topical Outline and Lecturers:

January 24 **Cost Analysis Overview and Statistics Review**
Rm. 1313 D. McNicol, Institute for Defense Analyses, and
Timothy Anderson, George Mason University

Presents a concise definition of cost analysis, its history and evolution to the present time. Cost analysis is differentiated from related disciplines, including operations research, systems analysis and cost-effectiveness analysis. Each ensuing lecture topic will be described along with the contribution of the topic to cost analysis. Those taking the course for graduate credit will be advised of testing, grading and required class projects. A short review of the statistics needed for the course will be given.

January 31 **Cost Effectiveness Analysis**
Rm. 1313 D. Levine, Institute for Defense Analyses

First postulated by RAND Corporation analysts in the 1950s, cost effectiveness analysis has been accepted as the principle analytical methodology for making resource allocation decisions in the government. In the Department of Defense (DoD), it is applied to choices among weapons systems, support concepts, training methods, and many other military outputs. This lecture will highlight the methodology: a clear statement of the objective(s), a broadly based search for alternatives for meeting the objective, and the quantitative analysis of the costs and effectiveness of each alternative. Preference is indicated for the alternative with minimum cost for achieving a desired level of effectiveness (or maximizing effectiveness among equal cost alternatives).

February 7 **Economics in Cost Analysis**
Rm. 1313 S. Horowitz, Institute for Defense Analyses

Presents the economic underpinnings of cost analysis. In particular, the cost function will be derived from the underlying production function relating input and output quantities. In addition, the rationale for discounting future costs and benefits will be given. Finally, various criteria will be compared for choosing among alternative investment projects: cost-benefit ratio, internal rate of return, and discounted present value.

February 14 **Estimating Relationships - I: Factors and Simple Models**
Rm. 1313 P. Lurie, Institute for Defense Analyses

Introduces simple factor models and linear regression analysis as tools for establishing cost estimating relationships (CERs). Topics to be covered include measures of model fit, graphical goodness-of-fit diagnostics, significant tests, confidence intervals, and cost prediction. The lecture will use a real-world example of an aircraft airframe cost model to help illustrate the methodologies covered.

February 21 **Cost Data**
Rm. 1313 J. Cloos, Institute for Defense Analyses

Emphasizes the requirement and importance of accurate, consistent and relevant data for use in cost estimating and analysis. The discussion will focus on various dimensions of cost data and how such data should be presented for analytical purposes. The overall cost data process will be described, to include identifying data requirements, assessing potential sources, and selecting methods for collecting and adjusting data. Specific areas to be covered include definitions of costs and cost structures (e.g., Work Breakdown Structures), major sources of cost data, both contractor (e.g., Cost Performance Reports) and government (e.g., Future Years Defense Program), consistent measurement in dollar terms (e.g., normalization), and the implications of time value of money on costs and investments (e.g., net present value).

February 28 **Estimating Relationships - II: Complex Models**
Rm. 1313 P. Lurie, Institute for Defense Analyses

This lecture is a continuation of the lecture on "Simple Models." The lecture will introduce more realistic non-linear models that are often used to model cost relationships in practice. The same aircraft airframe example used in the earlier lecture will be used again to guide the students through model estimation, diagnostics, testing, and prediction. Also to be covered are methods of cost risk analysis, which allow the analyst to supplement point estimates of cost with more informative distribution on cost.

March 6 **Force Costing**
Rm. 1313 L. Roark, Institute for Defense Analyses

Introduces the concepts of force and infrastructure costing. An example will be used to demonstrate how the tools and techniques taught in earlier sessions can be used to create a cost estimate for a change in force structure of a defined force. Infrastructure categories will be defined and their relationship to forces will be discussed. Important questions the analysts must consider will be identified along with possible approaches to overcome inherent shortcomings of available analytical tools and methods. A brief history of force costing and trends for the future will be presented.

March 13 **Spring Break**

March 20 **Midterm Examination**
Rm. 1313

March 27 **Cost Progress Curves**
Rm. 1313 T. Anderson, George Mason University

The public generally understands the notion of the learning curve. This lecture presents the theory and history of the development of the related cost progress curve in common use by cost analysts. The fitting of curve parameters is illustrated using empirical data. Application of the curve is illustrated using an example. Extensions of the cost progress curve are described.

April 3 **Production Rate Effects**
Rm. 1301 S. Balut, Institute for Defense Analyses

The relationships between direct and indirect costs, and fixed and variable costs will be discussed, along with related implications for possible error in forecasts of the costs in future periods. A method for separating fixed and variable costs will be presented. Two methods for forecasting future costs will be described, both of which take into account the component of cost that is fixed, thereby avoiding this source of error in estimates.

April 10 **Schedule Estimating**
Rm. 1313 B. Harmon, Institute for Defense Analyses

As proposed defense system acquisition programs approach major decision points, the reasonableness of planned acquisition schedules must be assessed by DoD representatives. Research into this problem had included the development of databases and methods of assessing the reasonableness of proposed acquisition schedules for tactical aircraft, tactical missiles, and unmanned space systems. The cornerstone of the methods consists of time estimating relationships (TER's). TER's are analogous to CER's, where the dependent variable is a time interval instead of cost. This lecture will focus on both the development of the methods and their application, illustrated using examples.

April 17 **Life-Cycle Costing**
Rm. 1313 J.R. Nelson, Institute for Defense Analyses

Life-cycle cost estimating relationships and procedures will be presented in the context of the DoD acquisition process. A hypothetical fighter aircraft will be used to illustrate the methodology. The phases of the life-cycle (development, production, operating and support) will be described, and the components of costs for each element of the fighter aircraft (airframe, engine, and avionics) will be addressed for these phases. Constant, then-year and discounted life-cycle cost funding streams will be discussed.

April 24 **Software Costing**
Rm. 1313 T. Frazier, Institute for Defense Analyses

Describes the background and history of software cost estimating. The discussion will focus on software metrics used today; software cost estimation methods; software cost models; and the predictive accuracy of current models. Finally, the lecture will deal with the impact of new software engineering practices and tools on software cost estimating.

May 1 **Project Presentations**
Rm. 1313 T. Anderson, George Mason University

Final Examination **Thursday, May 8, 16:15–18:55**
Rm. 1301 T. Anderson, George Mason University

Performance Evaluation:

Homework Assignments	10%
Midterm Examination	25%
Final Examination	25%
Project in Cost Analysis	30%
Participation in discussions	10%