THESIS

AN EXPERIMENTAL INVESTIGATION
OF THE IMPACT OF RISK ON
SOFTWARE PROJECT MANAGEMENT

by

Kimberly Sue Russ

September, 1995

Thesis Advisor: Tarek Abdel-Hamid
Co-Advisor: Kishore Sengupta

Approved for public release; distribution is unlimited.
### ABSTRACT (maximum 200 words)

The ability to develop information systems within cost and schedule is a difficult task for the DoD. The Systems Dynamics Model of Software Project Management is an interactive, computer simulation which allows for the investigation of decision making in a software development environment.

In this thesis the author investigates the impact of risk on dynamic decision making in software project management. Graduate students participate as project managers making management decisions pertaining to total staff acquisition, its allocation to development versus quality assurance, and cost and schedule adjustments. Data analyses reveal that risk does significantly impact decision making and in turn project performance in terms of final cost and duration.

### SUBJECT TERMS
- Risk, Software Project Development, Software Project Management,
  Software Project Staffing, Decision Making.
Approved for public release; distribution is unlimited.

AN EXPERIMENTAL INVESTIGATION OF THE IMPACT OF RISK ON SOFTWARE PROJECT MANAGEMENT

Kimberly Sue Russ
Lieutenant, United States Navy
B.S., United States Naval Academy, 1987

Submitted in partial fulfillment
of the requirements for the degree of

MASTER OF SCIENCE IN INFORMATION TECHNOLOGY
MANAGEMENT

from the

NAVAL POSTGRADUATE SCHOOL
September 1995

Author:

Kimberly Sue Russ

Approved by:

Tarek Abdel-Hamid, Thesis Advisor
Kishore Sengupta, Co-Advisor
Reuben Harris, Chairman
Department of Systems Management

iii
ABSTRACT

The ability to develop information systems within cost and schedule is a difficult task for the DoD. The Systems Dynamics Model of Software Project Management is an interactive, computer simulation which allows for the investigation of decision making in a software development environment.

In this thesis the author investigates the impact of risk on dynamic decision making in software project management. Graduate students participate as project managers making management decisions pertaining to total staff acquisition, its allocation to development versus quality assurance, and cost and schedule adjustments. Data analyses reveal that risk does significantly impact decision making and in turn project performance in terms of final cost and duration.
# TABLE OF CONTENTS

I. INTRODUCTION ............................................. 1  
   A. BACKGROUND ........................................... 1  
   B. PURPOSE OF RESEARCH ................................. 2  
   C. SCOPE OF RESEARCH .................................. 2  
   D. LIMITATIONS .......................................... 2  
   E. THESIS ORGANIZATION ................................ 3  

II. PREPARING THE GAME INTERFACE ......................... 5  
   A. EXPERIMENTAL DESIGN ................................. 5  
   B. THE THREE GROUPS .................................... 5  
   C. THE SOFTWARE ......................................... 6  
   D. THE DOCUMENTATION .................................. 8  
   E. TRIAL EXPERIMENT .................................... 9  
   F. FINAL PREPARATIONS .................................. 9  

III. CONDUCTING THE EXPERIMENT ............................. 11  
   A. TASKS AND PROJECT CHARACTERISTICS ................ 11  
   B. THE EXPERIMENTAL SUBJECTS ......................... 11  
   C. DEPENDENT MEASURES .................................. 12  

IV. EXPERIMENTAL RESULTS AND ANALYSES .................... 13  
   A. MODEL OF ANALYSIS .................................... 13  
   B. PERFORMANCE DATA .................................... 13  
   C. PROCESS DATA ......................................... 14  
      1. Total Staff ....................................... 15  
      2. Quality Assurance ................................. 16  
      3. Cost Estimates .................................... 17  
      4. Schedule Estimates ............................... 18  
   D. QUESTIONNAIRE AND DEMOGRAPHIC DATA ................ 19  

V. CONCLUSIONS ............................................. 21  
   A. FINDINGS AND IMPLICATIONS ............................ 21
<table>
<thead>
<tr>
<th>APPENDIX</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>FURTHER RESEARCH</td>
<td>22</td>
</tr>
<tr>
<td>A.</td>
<td>PROJECT CUMULATIVE REPORT SPECIFICATION</td>
<td>23</td>
</tr>
<tr>
<td>B.</td>
<td>STAFF LOSS REPORT SPECIFICATION</td>
<td>25</td>
</tr>
<tr>
<td>C.</td>
<td>PLANNED LOSS REPORT SPECIFICATION</td>
<td>29</td>
</tr>
<tr>
<td>D.</td>
<td>PLANNED LOSS OUTPUT</td>
<td>33</td>
</tr>
<tr>
<td>E.</td>
<td>DESCRIPTION OF THE SIMULATION INTERFACE</td>
<td>35</td>
</tr>
<tr>
<td>F.</td>
<td>STAFF LOSS OUTPUT</td>
<td>41</td>
</tr>
<tr>
<td>G.</td>
<td>PROGRESS REPORT SPECIFICATION</td>
<td>43</td>
</tr>
<tr>
<td>H.</td>
<td>BATCH CONTROL FILE (PROJECTA)</td>
<td>45</td>
</tr>
<tr>
<td>I.</td>
<td>BATCH CONTROL FILE (PROJECTB)</td>
<td>51</td>
</tr>
<tr>
<td>J.</td>
<td>PROJECT DYNEX FILE</td>
<td>57</td>
</tr>
<tr>
<td>K.</td>
<td>UNCERTAINTY GROUP INSTRUCTION SET (A1)</td>
<td>63</td>
</tr>
<tr>
<td>L.</td>
<td>RISK GROUP INSTRUCTION SET (A2)</td>
<td>67</td>
</tr>
<tr>
<td>M.</td>
<td>CERTAINTY GROUP INSTRUCTION SET (B1)</td>
<td>71</td>
</tr>
<tr>
<td>N.</td>
<td>PRACTICE EXPERIMENT INSTRUCTION SET</td>
<td>75</td>
</tr>
<tr>
<td>O.</td>
<td>GRAPH.S.DRS FILES</td>
<td>79</td>
</tr>
<tr>
<td>P.</td>
<td>RANDOMIZATION WORKSHEET</td>
<td>81</td>
</tr>
</tbody>
</table>

viii
I. INTRODUCTION

A. BACKGROUND

Developing and maintaining software that is acceptable to the end user continues to challenge the Department of Defense (DoD). The DoD currently spends about $9 billion each year on general purpose automated data processing equipment, software, and related services [Ref. 1]. With increasingly constrained budgets, improved management can lead to significant cost savings.

The General Accounting Office (GAO) reported that cost overruns and schedule slippages plague DoD systems [Ref. 2]. Surveys of experienced project managers identify personnel shortfalls, unrealistic schedules and budgets, and a continuing stream of requirement changes as serious sources of risk on software projects. Postmortems of software project disasters reveal that their problems would have been avoided or strongly reduced with an explicit early concern for identifying and resolving high-risk elements. [Ref. 3] New concepts from behavioral decision theory have sparked research into human decision making.

Behavioral decision theory concludes that people make choices using only a few sources of information processed with simple rules of thumb. Morecroft modeled the idea that only a few information flows actually penetrate to the heart of the decision function, passing through several cognitive and organizational filters, where they influence the choices and actions of the individual. The influence of behavioral decision theory on system dynamics can be seen in the development of microworlds or models that represent organizations as decision making/information processing systems involving many players, with multiple (often conflicting) goals and limited processing capability. [Ref. 4]

The Systems Dynamics Model (SDM) of Software Project Management models the dynamic nature of software project development [Ref. 5]. This simulation-based model has been used to conduct micro-empirical research on dynamic decisions made by software project managers [Ref. 6-11].
B. PURPOSE OF RESEARCH

The purpose of this thesis is to design and conduct an experimental investigation into the effects of risk on software project management. The SDM of Software Project Management will be used to study in a controlled environment, how project managers handle risk factors, how perceived risk affects decision making, and in turn project outcome in terms of final cost and schedule.

C. SCOPE OF RESEARCH

The scope of this research includes the experimental design, development of software to support the design, preparation of documentation and instruction sets for the participants, tailoring of the gaming interface to include risk factors, providing additional report capabilities, execution, and performance assessment of the allocation of resources by differing group project managers. Care was taken in the preparation of additional report capabilities and smoothing of the instruction sets in an effort to prevent introducing external biases. This research was conducted in a single project environment.

D. LIMITATIONS

Forty-one graduate students at the Naval Postgraduate School participated in the experiment as surrogates for software project managers. These students were in their seventh quarter of a masters program in Information Technology Management. They have completed significant course work and posses several years of practical managerial experience. These students also participated in a similar experimental investigation on the effect of goals on dynamic decision making as part of a software engineering course requirement.
E. THESIS ORGANIZATION

Chapter II is a detailed description of the experimental design and the methodology used. The design includes preparing the gaming interface, the software, the documentation, conducting the practice experiment, and making final preparations.

Chapter III describes conducting and organizing the experiment, including the dependent measures to be used. Chapter IV is the data analyses and experimental results. Specifically this chapter contains descriptive statistics from the three groups and discusses the findings. Chapter V contains the conclusions and recommendations for further study.
II. PREPARING THE GAME INTERFACE

A. EXPERIMENTAL DESIGN

The Systems Dynamics Model of Software Development is a role playing computer based simulation game that mimics the programming phase of a real software development project. The participants assume the role of software project manager and make resource allocation decisions to complete the project on time and within schedule. The software project manager makes staff allocation decisions including the total number of staff and the percent of staff allocated to quality assurance. The project managers also provide their estimates of cost and schedule throughout the project at each of the 40 day intervals.

The project begins with a core team of four. These software professionals provide the continuity between the requirements/design phase and the programming phase. The project managers initially receive estimates of the size of the system in delivered source instructions, cost of the programming phase in person days, and duration of the programming phase in days. Every two month interval, 40 working days, the model generates status information on the projects' progress. At the end of the period and after reviewing these reports and graphs, the project manager is able to make adjustments to the staffing level and its allocation.

The research question is to determine the effects of risk in terms of staff turnover on software project management. The 41 students were randomly assigned to three groups [Ref. 12]. The randomization worksheet is contained in Appendix P. All three groups interacted with projA.dnx. The source code is available in Appendix J. The three groups were the uncertainty group, the risk group, and the certainty group.

B. THE THREE GROUPS

The software program managers of the uncertainty group (A1) did not receive any probability information about staff turnover. The risk group (A2) managers were told that historically the turnover rate averages to 1.5 people lost every reporting period. The
certainty group (B1) managers were notified in advance about personnel intending to leave the project during the next 40 day period. The number of staff lost due to turnover experienced in a period was determined in advance and designed into the simulation at the onset. The project was created using data collected from an actual NASA development effort.

C. THE SOFTWARE

The students for this experiment had participated in an experimental investigation of the impact of goals on software project development six months earlier. First, part of the feedback from that experiment included a request to capture cumulative information on project status from several periods and make it available to the project manager. To incorporate this change, a new report, the Project Cumulative Report, was created. It is a report specification file that captures the values of variables in different periods and displays them to the user. This file is written in Dynamo Plus and is displayed in Appendix A.

Two other new dynamo report specification (.drs) files are contained in Appendices B and C. These files are the staff loss notices for the project. These files were created to display staff turnover information to the project managers of the three groups. The project managers for the uncertainty and risk groups used the project A batch control file while the managers for the certainty group used the project B batch control file.

During execution of the batch control files, the Staff Loss Report Specification and the Planned Loss Report Specification programs are called and allow for the information contained in them to be displayed. A sample of the report shown to the managers of the certainty group is contained in Appendix D. This report flashes on the screen and notifies the project manager of personnel leaving within the next 40 days. For the participants of the uncertainty and risk groups the report differs in that it flashes on the screen the total number of personnel lost in the previous period. This staff loss notice is displayed in Appendix F.
<table>
<thead>
<tr>
<th>Time</th>
<th>0</th>
<th>40</th>
<th>80</th>
<th>120</th>
<th>160</th>
<th>200</th>
<th>240</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loss</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Time</td>
<td>280</td>
<td>320</td>
<td>360</td>
<td>400</td>
<td>440</td>
<td>480</td>
<td>520</td>
</tr>
<tr>
<td>Loss</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>3</td>
<td>0</td>
</tr>
</tbody>
</table>

**Figure 2-1 Number of Staff Losses Per 40 Day Time Period**

Figure 2-1 displays the number of people lost due to turnover in each of the 40 day periods throughout the project. For example at time 120, project managers of the certainty group would receive a staff loss notice telling them that 2 people intend to leave the project within the next 40 days. The same is not true for managers in the risk and uncertainty groups. However during time 160 these two groups would be notified that the project lost two people due to turnover.

A menu capability for accessing multiple reports and graphs was developed in an earlier research effort along with a detailed description of module interaction for the simulation [Ref. 13]. The Project Staffing Report was modified to provide additional information for this project. Two output variables were created to report the total staff at the beginning of the period and the total staff hired in the period. This information was provided to the project manager to clarify what staffing changes had occurred. The report includes the total staff size, the percent of workforce experienced as of a particular day in the programming phase, and is displayed in Appendix E.

Another dynamo report specification was developed for this experiment. A progress.drs file was created to flash the current period prior to any loss notices being displayed. This progress report specification is contained in Appendix G. The report specifications for the graphs were also changed. These changes are summarized in Appendix O. Coding was added to the batch control files to allow these reports to be displayed to the user. These batch control files are contained in Appendices H and I. Having completed the software, the documentation was developed to provide the details of the experiment to the users.
D. THE DOCUMENTATION

A written description of the simulation interface, the menu, the reports, and the graphs available to the project managers is contained in Appendix E. The menu allows the project manager to select the report or graph to be viewed. These can be viewed repeatedly. An option at the bottom of the menu allows the user to proceed with the simulation.

The first report is the Project Status Report. This report shows the initial estimates for the project, updated estimates entered by the project manager, and reported progress on the project. This information is also contained in the Project Cumulative Report. This report aggregates the information from the start of the project to the current period. When the percent DSI reaches 100, the simulation is complete.

The Staffing Report provides the current total staff size and the allocation of staff between programming and quality assurance. The report reflects any changes in the staffing level hired or lost and provides the program manager with the percent of workforce that is experienced. A trained staff member is twice as productive as a new hire. A Defect Report details the total defects detected and the defect density for the current period and for the last 40 days.

Additional documentation was provided. Each project manager received an instruction set, Appendices K-M. The group instruction sets were different. Duplicate information includes the rules of the game, instructions for starting the system, and initial project estimates.

Project managers were told that for modest additions to staffing, the average hiring delay is 40 days. Requests for a large number of additional staff will cause longer delays and these new hires must be trained and assimilated. The assimilation period is typically 80 days. Project managers were also given information about the possibility of losing people due to turnover. Lastly, they were given a goal to minimize both cost and schedule.
E. TRIAL EXPERIMENT

The purpose of the trial experiment was to find problems with either the software or the documentation. Two people participated in the trial experiment. These were the same people designated as lab attendants in the actual experiment. This was an opportunity to gain feedback on the experiments' design. Neither student experienced any difficulty in the trial run.

F. FINAL PREPARATIONS

Two labs were reserved for conducting the experiment. Each student received an envelope containing a description of the simulation interface, an instruction set, a seating chart, and a disk. The disk contained the files for running the experiment.

All copies of the documentation and the files were made corresponding to the random assignment of personnel into the three groups conducted earlier. The randomization worksheet is contained in Appendix P. The terminals in the labs were checked prior to assigning personnel. Signs were posted on the labs during the experiment to prevent other students from entering. The remaining task was to assemble the envelope contents.
III. CONDUCTING THE EXPERIMENT

A. TASKS AND PROJECT CHARACTERISTICS

The students for the experiment received a 40 minute briefing on the documentation for the experiment and a review of the terminology present in the reports. They proceeded to the labs to conduct a practice experiment. Each student was given a folder containing a description of the simulation interface, an instruction set, a seating chart, and a disk. The students were instructed that their level of effort on the simulation would be reflected in their class participation grade.

The practice instruction set is displayed in Appendix N. Seating charts were developed and were the same for both the practice and the actual experiment. The goal for the practice experiment was for the students to familiarize themselves with the simulation environment. The initial estimates for the practice project remained constant and no personnel turnovers occurred.

The instruction set for the practice experiment was similar to that of the other instruction sets except that it lacked any information on the project risk, that of losing people due to turnover. The students conducted the practice experiment in 30 minutes. Each student had the opportunity to make staffing allocation decisions, review reports and graphs, and ask questions. The lab attendants received a 15 minute briefing to ensure questions asked were answered consistently. The designer frequently moved between the labs during the practice experiment.

B. THE EXPERIMENTAL SUBJECTS

Project managers for this experiment were graduate students in their seventh quarter of an eight quarter program in Information Technology Management at the Naval Postgraduate School. They have taken courses in software engineering, participated in a similar experiment six months earlier, and have practical managerial experience. These students participated in the actual experiment two days after conducting the practice experiment.
Before proceeding to the labs to conduct the actual experiment, the students received a ten minute briefing on project risk. Mentioned were the primary sources of risk including personnel shortfalls, unrealistic cost/schedule, and changing requirements.

In the actual experiment, the project is originally underestimated. The project grows from the original estimate of 42,000 DSI to 64,000 DSI. Students are briefed that the simulation ends when the reported percent DSI complete reaches 100.

C. DEPENDENT MEASURES

At project completion ten performance variables are captured. These variables are dependent upon the decisions made by the project manager throughout the experiment. An explanation of these performance variables can be found in Appendix Q. Three of these performance variables are final cost, final cumulative time, and final errors remaining undetected. These variables are compared to determine differing or similar project outcomes between the three groups; uncertainty, risk, and certainty.

Final cost is measured in person days and final cumulative time is measured in days. Final errors remaining undetected is a measure used to determine the quality of the software. These three performance variables are compared as part of the data analysis in Chapter IV.
IV. EXPERIMENTAL RESULTS AND ANALYSES

A. MODEL OF ANALYSIS

Several sets of data were captured during the simulation. These data include performance data, a measure of project outcome; process data, a measure of decisions made over time; and demographic data. The demographic data was obtained through the use of a questionnaire. A questionnaire was completed by each student and a sample is contained in Appendix R.

The analysis of the data was conducted using the Statistical Analysis System (SAS) software, Procedure Means, and the Procedure General Linear Models (GLM). The GLM Procedure was used for multivariate analyses. The Correlation Procedure was used to determine correlation between independent and dependent variables.

B. PERFORMANCE DATA

Final cost, final schedule, and final errors are the three dependent measures used to evaluate performance differences among the three groups. Figure 4-1 shows means

<table>
<thead>
<tr>
<th>Group</th>
<th>FNCOST, Mean and (Stnd Dev)</th>
<th>FNSKED, Mean and (Stnd Dev)</th>
<th>FNERR, Mean and (Stnd Dev)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uncertainty (A1)</td>
<td>3333.66 (733.04)</td>
<td>339.15 (54.9)</td>
<td>13414.73 (10470.29)</td>
</tr>
<tr>
<td>Risk (A2)</td>
<td>2941.76 (523.73)</td>
<td>310.21 (43.54)</td>
<td>14654.44 (9912.12)</td>
</tr>
<tr>
<td>Certainty (B1)</td>
<td>2667.01 (425.91)</td>
<td>274.64 (47.49)</td>
<td>11559.47 (8144.78)</td>
</tr>
</tbody>
</table>

Figure 4-1 Performance Means and Standard Deviations for the Groups and standard deviations for the three groups for the three variables mentioned. The certainty group had the lowest final cost, final schedule, and errors remaining.
The subjects of the certainty group were given advance notice of staff losses to occur during the next 40 day period. The group with the most risk, the uncertainty group, had the highest mean final cost and schedule. The risk group participants, given the probability of staff losses to occur during the next 40 day period, had the next highest final cost and schedule. The results indicate that the information received by the groups pertaining to staff turnover significantly influenced project outcome in terms of final cost and schedule.

The GLM Procedure was used for comparison of the groups' performance to determine if there were significant differences between the groups. For final cost, the GLM yielded a p value of 0.0187. This rejects the null hypothesis of no differences between the groups in terms of final cost. This result indicates that for final cost there were significant differences between the three experimental groups.

For final schedule the GLM produced a p value of 0.0066. Again, the null hypothesis is rejected and this result indicates that there were significant differences between the three groups in terms of schedule. The GLM Procedure for final errors revealed a p value of 0.7182. The null hypothesis is accepted that there was no significant difference between the three groups in terms of final errors.

C. PROCESS DATA

The subjects made four decisions in each period. At each 40 day interval the project managers selected their total staff, percentage of staff allocated to quality assurance, and estimates of the projects' final cost and schedule. The process data was analyzed to compare group means at each 40 day interval. In graphing the group means for the process data obtained, the last interval used is day 200. This is the last period in which all participants were still making decisions and had not completed the project. An analysis using the SAS GLM procedure was conducted to first determine if there was a period effect, second to determine any time effect between the different risk groups, and thirdly to determine if there was significant difference between subjects of the three groups.
Figure 4-2 Mean Total Staff Requested by Group

1. Total Staff

Figure 4-2 is a graph of the group means for the total staff requested by each group at each 40 day interval. The graph reveals that for total staff the uncertainty group and the risk group made similar decisions. These project managers received notice of a staff turnover after it had occurred. The first staff loss occurred at day 40.

The decisions made by the project managers of the certainty group are different. These project managers were notified at day 40 that three people intended to leave during the next 40 day period due to turnover. It can be seen that the certainty group staff decisions’ increase and decrease earlier than the other groups.

The analysis for a period effect yielded a p value of 0.0001. This allows the null hypothesis of no period effect to be rejected. There is a period effect. The test for interaction between the groups yielded a p value of 0.0001. Again, the null hypothesis of no interaction is rejected. The test for between subject effects yielded a p value of 0.1925. The null hypothesis is accepted that the subjects’ decisions toward staffing are not significantly different.
Figure 4-3 Percent of Requested Staff Allocated to QA by Group

2. Quality Assurance

Above is Figure 4-3, the percent of staff allocated to quality assurance by group. This graph depicts that there is a period effect. Both the uncertainty group and the risk group had their percent staff allocated to quality assurance decline while the certainty group had an initial increase in staff assigned to quality assurance. This can be explained by a shift in personnel from quality assurance to programming as staff turnovers occurred.

The test for a period effect yielded a p value of 0.0001. The null hypothesis of no period effect is rejected. The test for interaction between groups yielded a p value of 0.0078. The null hypothesis of no interaction is rejected. For the between subjects effects test, the p value was 0.7630. The null hypothesis of no significant difference between subjects is accepted.
Figure 4-4 Estimates of Project Final Cost by Group

3. Cost Estimates

The project mean cost estimates by group are shown in Figure 4-4. All three groups had cost estimates that continually increased. This can be explained by the growth in project size from its initial estimate of 42,000 DSI to 64,000 DSI. Again the graph shows that there is a period effect.

The test for a period effect revealed a p value of 0.0001 indicating that there is a period effect and the null hypothesis is rejected. The test for interaction yielded a p value of 0.1751. The null hypothesis of no interaction is accepted. For the between subjects effects the p value was 0.1219. The null hypothesis of no between subjects effect is accepted.
Figure 4-5 Estimates of Project Final Schedule by Group

4. Schedule Estimates

Figure 4-5 represents the project final schedule estimates by group. The graph depicts a period effect. All three groups also had increasing estimates for the final schedule. Again, this can be explained by the fact that the project increased in size from the initial estimates.

With a p value of 0.0001, the null hypothesis of no period effect is rejected. The test for interaction revealed a p value of 0.0857. The null hypothesis of no interaction is accepted. The test for between subjects effects yielded a p value of 0.0848. The null hypothesis of no between subjects effect is accepted.
D. QUESTIONNAIRE AND DEMOGRAPHIC DATA

At project completion each participant filled out a questionnaire. The final section of the questionnaire was dedicated to demographics. The demographic data format can be found in Appendix S and sample data for all the subjects is in Appendix T.

<table>
<thead>
<tr>
<th>Group</th>
<th>AGE</th>
<th>CHRSWK</th>
<th>WKEXP</th>
<th>EDAGO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uncertainty</td>
<td>34.9</td>
<td>28.1</td>
<td>14.3</td>
<td>13.3</td>
</tr>
<tr>
<td>Risk</td>
<td>34.5</td>
<td>15.8</td>
<td>12.6</td>
<td>10.8</td>
</tr>
<tr>
<td>Certainty</td>
<td>32.8</td>
<td>20.6</td>
<td>10.8</td>
<td>9.4</td>
</tr>
</tbody>
</table>

Figure 4-6 Group Mean Demographics

Figure 4-6 represents the sample profile by group. CHRSWK represents the number of hours spent on the computer per week, WKEXP represents the years of work experience, and EDAGO is the number of years since the subject completed undergraduate education. The uncertainty group subjects have the highest mean age, have more work experience, and spend the most hours per week on the computer. The risk group subjects spend the least amount of time on the computer per week. The certainty group subjects are the youngest with the least amount of work experience and have most recently completed their undergraduate education.
V. CONCLUSIONS

A. FINDINGS AND IMPLICATIONS

The results of this experimental investigation into the effects of risk on dynamic decision making in a software project environment reveal that the presence of risk significantly impacts project outcome. The uncertainty group, the group receiving the least information about staff turnover, had a higher final cost and schedule at project completion. The risk group had the next highest final cost and schedule. The certainty group, which were informed about staff departures prior to their occurrence, performed better than the other two groups.

The analysis of the process data which was concerned with the mean performance of the groups over time, revealed that the groups perform significantly different. This is especially visible in the graphical depictions of total staffing and quality assurance allocation decisions.

The certainty group once informed that a staff loss was to occur, padded the staffing level in anticipation of the loss while the other two groups responded with additional hires immediately following the loss. This perceived risk had an impact on their decision making. In addition the risk group subjects shifted their staffing resources from quality assurance to programming following the initial loss of personnel.

This research effort provides empirical findings that support the assessment and management of risk as significant factors in achieving successful project outcome. The greater the risk the greater the cost and schedule overrun. Additionally, this research effort seeks to provide impetus toward investigation of other human behavioral decision making characteristics found in the software project development domain.
B. FURTHER RESEARCH

One area with potential for further research is to investigate the impact of risk on team decision making. This experiment could be repeated with teams managing the project rather than single individuals. This would provide insight into team management of risk and the communication required. It is likely that the groups would identify and deal with risk differently. Finally, this research could be duplicated in a multi-project environment.
APPENDIX A: PROJECT CUMULATIVE REPORT SPECIFICATION

report
time = maxtime,
FORMAT="5<"" 
">>> >> >> >> >> >> >> >> >> >> >> PROJECT CUMULATIVE REPORT
<< << << << << << << << << << << << << << << << << << <"; 

Format="5<,43<",
"UPDATED ESTIMATES","REPORTED PROGRESS";

Format="5<,13<,20<,26<,31<,43<,49<,58<,72>,",
"TIME","SIZE","COST","DUR","TIMREM","%DSI","TOT DSI","PD EXP'D","PROD";

FOR TIME = 40 TO MAXTIME BY 40 DO
Format="2<,,17<,22<,30<,40<,49<,59<,72>,",
PICTURE="ZZZ,ZZ9V"
TIME,PJBSZT,JBSZMD,STCHDT,TIMERM,PRCMPL,CMDSI,CUMMD,RPPROD 
END

"PRESS <ENTER> TO RETURN TO THE MENU"
APPENDIX B: STAFF LOSS REPORT SPECIFICATION

; ; ; ; ; ;
report

time=maxtime,

if maxtime<41 then
FORMAT="15 < 
" "************************************************************************cej", 
FORMAT="15 <,67 <" 
"**" **
FORMAT="15 <,28 <,67 <" 
"**", "Press <ENTER> to continue. ", 
FORMAT="15 <,67 <" 
"**" **
FORMAT="15 < " 
"************************************************************************cej", 
end

if maxtime >41 then
if maxtime <81 then
FORMAT="15 < " 
"************************************************************************cej", 
FORMAT="15 <,67 <" 
"**" **
FORMAT="15 <,28 <,67 <" 
"**", "!! STAFF LOSS NOTICE  !!", 
FORMAT="15 <,67 <" 
"**" **
FORMAT="15 <,29 <,42 <,48 <,67 <", PICTURE="Z,ZZ9V" 
"**", "[Current TIME =",TM,"DAYS]", 
FORMAT="15 <,67 <" 
"**" **
FORMAT="15 <,21 <,67 <" 
"**", "During the last 40 day Period, the project", 
FORMAT="15 <,21 <,22 <,28 <,67 <" 
"**", "lost", WFLOSA, "people due to turnover.", 
FORMAT="15 <,67 <" 
"**", **

25
FORMAT="15<,67<"
"*","*","

FORMAT="15<,28<,67<"
"*","Press <ENTER> to continue. ","*",
FORMAT="15<,67<"
"*","

FORMAT="15<"
"*"="*
end
end

if maxtime>81 then
if maxtime<121 then
FORMAT="15<"
"*"="*
FORMAT="15<,67<"
"*","
FORMAT="15<,28<,67<"
"*","Press <ENTER> to continue. ","*
FORMAT="15<,67<"
"*","
FORMAT="15<"
"*"="*
end
end

if maxtime >121 then
if maxtime<401 then
FORMAT="15<"
"*"="*
FORMAT="15<,67<"
"*","
FORMAT="15<,28<,67<"
"*","!! STAFF LOSS NOTICE  !! ","*
FORMAT="15<,67<"
"*","
FORMAT="15<,29<,42<,48<,67<",PICTURE="Z,ZZ9V"
"*","Current TIME =",TM,"DAYS"","*
FORMAT="15<,67<"
"*","
FORMAT="15<,21<,67<"
"*","During the last 40 day Period, the project","*
FORMAT="15<,21<,22<,28<,67<"
"*", "lost", WFLOSA, "people due to turnover.", "*",
FORMAT = "15 < ,67 < 
"*", "*", 
FORMAT = "15 < ,67 < 
"*", "*", 
FORMAT = "15 < ,28 < ,67 < 
"*", "Press < ENTER > to continue.", "*",
FORMAT = "15 < ,67 < 
"*", "*", 
FORMAT = "15 < 
"**********************************************************************
end
end

if maxtime > 401 then
if maxtime < 441 then

FORMAT = "15 < 
"**********************************************************************
FORMAT = "15 < ,67 < 
"*", "*", 
FORMAT = "15 < ,28 < ,67 < 
"*", "Press < ENTER > to continue.", "*",
FORMAT = "15 < ,67 < 
"*", "*", 
FORMAT = "15 < 
"**********************************************************************
end
end

if maxtime > 441 then
FORMAT = "15 < 
"**********************************************************************
FORMAT = "15 < ,67 < 
"*", "*", 
FORMAT = "15 < ,28 < ,67 < 
"*", "!! STAFF LOSS NOTICE !!", "*",
FORMAT = "15 < ,67 < 
"*", "*", 
FORMAT = "15 < ,29 < ,42 < ,48 < ,67 < ", PICTURE = "Z,ZZ9V" 
"*", "Current TIME =", TM, "DAYS", "*",
FORMAT = "15 < ,67 < 
"*", "*", 

27
FORMAT = "15<,21<,67<"
"**", "During the last 40 day Period, the project",**;
FORMAT = "15<,21<,22<,28<,67<"
"**", "lost" ,WFLOSA,"people due to turnover.",**;
FORMAT = "15<,67<"
"**", "**",
FORMAT = "15<,67<"
"**", "**",  
FORMAT = "15<,28<,67<"
"**", "Press <ENTER> to continue.",**;
FORMAT = "15<,67<"
"**", "**",  
FORMAT = "15<"
"**********
end

if maxtime > 481 then
FORMAT = "15<"
"**********
end

FORMAT = "15<,67<"
"**", "**",  
FORMAT = "15<,28<,67<"
"**", "Press <ENTER> to continue.",**;
FORMAT = "15<,67<"
"**", "**",  
FORMAT = "15<"
"**********
end
APPENDIX C: PLANNED LOSS REPORT SPECIFICATION

report
time=maxtime,

if maxtime < 41 then
  FORMAT="15 <"
  "****************************************************";
  FORMAT="15 ,67 <"
  "*", "*
  FORMAT="15 ,28 <,67 <"
  "**, "!! STAFF LOSS NOTICE !!", "**
  FORMAT="15 <,67 <"
  "**, "*
  FORMAT="15 <,29 <,42 <,48 <,67 <",PICTURE="Z,ZZ9V"
  "**, [Current TIME = "TM,"DAYS]", "**
  FORMAT="15 <,67 <"
  "**, "*
  FORMAT="15 <,21 <,41 <,47 <,67 <"
  "**, "We received notice from",WFLOS,"people that", "**
  FORMAT="15 <,21 <,67 <"
  "**, "they intend to leave the project", "**
  FORMAT="15 <,21 <,67 <"
  "**, "within the next 40 days.", "**
  FORMAT="15 <,67 <"
  "**, "*
  FORMAT="15 <,67 <"
  "**, "*
  FORMAT="15 <,67 <"
  "**, "*
  FORMAT="15 <,28 <,67 <"
  "**, "Press <ENTER> to continue.", "**
  FORMAT="15 <,67 <"
  "**, "*
  FORMAT="15 <"
  "****************************************************"
end

if maxtime > 41 then
if maxtime < 81 then
if maxtime > 81 then
if maxtime < 361 then
FORMATE="15<"

FORMAT="15<,67<"

","=";"end"

FORMAT="15<,28<,67<"
","=";"!! STAFF LOSS NOTICE !!","=";

FORMAT="15<,67<"

","=";"end"

FORMAT="15<,28<,67<"

","=";"We received notice from",WFLOSB,"people that","=";

FORMAT="15<,21<,41<,47<,67<"
","=";"they intend to leave the project","=";

FORMAT="15<,21<,67<"

","=";"within the next 40 days.","=";

FORMAT="15<,67<"

","=";"end"

FORMAT="15<,67<"

","=";"end"

FORMAT="15<,28<,67<"

","=";"Press <ENTER> to continue.","=";

FORMAT="15<,67<"

","=";"end"
if maxtime > 361 then
if maxtime < 401 then
FORMAT = "15<"
"*************************************************************
FORMAT = "15<,67<"
"* * *
FORMAT = "15<,28<,67<"
"* *, Press <ENTER> to continue. *, *
FORMAT = "15<,67<"
"* * *
FORMAT = "15<"
"*************************************************************
end
end

if maxtime > 401 then
if maxtime < 441 then
FORMAT = "15<"
"*************************************************************
FORMAT = "15<,67<"
"* * *
FORMAT = "15<,28<,67<"
"* *, !! STAFF LOSS NOTICE !! *, *
FORMAT = "15<,67<"
"* * *
FORMAT = "15<,29<,42<,48<,67<", PICTURE = "Z,ZZ9V"
"* *, [Current TIME = "TM,"DAYSJ", *
FORMAT = "15<,67<"
"* * *
FORMAT = "15<,21<,41<,47<,67<"
"* *, "We received notice from", WFLOSB, "people that", *
FORMAT = "15<,21<,67<"
"* *, "they intend to leave the project", *
FORMAT = "15<,21<,67<"
"* *, "within the next 40 days. ", *
FORMAT = "15<,67<"
"* * *
FORMAT = "15<,67<"
"* * *
FORMAT = "15<,28<,67<"
"**", "Press <ENTER> to continue. **";
FORMAT = "15 <,67 <"
"**", "**",
FORMAT = "15 <"
""********************
end
end

if maxtime > 441 then
FORMAT = "15 <"
""********************
FORMAT = "15 <,67 <"
"**", "**",
FORMAT = "15 <,28 <,67 <"
"**", "Press <ENTER> to continue. **",
FORMAT = "15 <,67 <"
"**", "**",
FORMAT = "15 <"
""********************
end
APPENDIX D: PLANNED LOSS OUTPUT

*************************************************************************
*
*    !! STAFF LOSS NOTICE !!
*  *
*  [Current TIME = 120 DAYS]
*  *
*    We received notice from 2 people that
*    they intend to leave the project
*    within the next 40 days.
*  *
*    Press <ENTER> to continue.
*  *
*************************************************************************
APPENDIX E: DESCRIPTION OF THE SIMULATION INTERFACE

REPORTS AND GRAPHS MENU:

After every 40-day simulation period, you will immediately get the Reports and Graphs Menu shown below. All of the reports and graphs concerning your project's progress are available from this menu. You may select any of them by pressing their corresponding number.

<table>
<thead>
<tr>
<th>REPORTS:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>PROJECT SIZE &amp; STATUS REPORT</td>
</tr>
<tr>
<td>2</td>
<td>STAFFING REPORT</td>
</tr>
<tr>
<td>3</td>
<td>DEFECT REPORT</td>
</tr>
<tr>
<td>4</td>
<td>CUMULATIVE REPORT</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>GRAPHS:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>PROJECT SIZE &amp; STATUS GRAPH</td>
</tr>
<tr>
<td>6</td>
<td>STAFFING GRAPH</td>
</tr>
<tr>
<td>7</td>
<td>DEFECT GRAPH</td>
</tr>
</tbody>
</table>

PRESS P TO PROCEED TO ENTER DECISIONS FOR THE NEXT 40 DAYS

After viewing the pertinent information (you may view any report or graph more than once), use the "P" selection to proceed to enter your decisions for the next 40 day simulation period.
Report 1 (PROJECT STATUS REPORT)  A sample report is pictured below:

```

PROJECT STATUS REPORT

AT TIME = 120 DAYS

INITIAL ESTIMATES: (These will not change throughout the project)
- System Size: 20,000 DSI
- Programming Cost: 1,400 Person Days
- Programming Phase Duration (start-end): 350 Days

UPDATED ESTIMATES
- New Est of System Size due to Changes in Requirements: 20,000 DSI
- Your Last Est of Programming Phase Cost: 1,567 Person Days
- Your Last Est of Prog Phase Duration (start-end): 353 Days
- Time Remaining: 153 Days

REPORTED PROGRESS
- % DSI Reported Complete: 63.33 Percent
- Total DSI Reported Complete to Date: 12,665 DSI
- Total Person Days Expended to Date: 817 Person Days
- Reported Productivity: 16 DSI/Person Day

PRESS <ENTER> TO RETURN TO THE MENU
```

This report contains Project Status information as of a particular day in the programming phase. The report is divided into 3 sections. The top section shows the INITIAL ESTIMATES provided to your customer. This information will not change throughout the project.

The middle portion is the UPDATED ESTIMATES section. The Updated Est of System Size can change (increase or decrease) to reflect the addition or deletion of requirements. The entries of Your Last Est of Programming Phase Cost and Your Last Est of Prog Phase Duration (start-end) would reflect any change in cost and duration that you feel you need to make. The Time Remaining is equal to your current estimate of total duration minus current time.

The bottom section is the REPORTED PROGRESS section. Remember that this is "reported" information and is not guaranteed to be totally accurate, especially early in the phase. Reported Productivity is simply calculated as Total DSI Reported Complete to Date divided by Total Person Days Expended to Date.

Your Task is complete when the % DSI Reported Complete is 100%.
Report 2 (STAFFING LEVEL REPORT)  A sample report is pictured below:

<table>
<thead>
<tr>
<th>STAFFING REPORT</th>
<th>AT TIME = 160 DAYS</th>
</tr>
</thead>
<tbody>
<tr>
<td>STAFFING ADDITIONS/LOSSES LAST 40 DAY PERIOD ONLY</td>
<td></td>
</tr>
<tr>
<td>Total Staff At Beginning of Period</td>
<td>7.21 People</td>
</tr>
<tr>
<td>Total Staff Hired this Period</td>
<td>2.49 People</td>
</tr>
<tr>
<td>Total Staff Lost this Period</td>
<td>2.00 People</td>
</tr>
<tr>
<td>Current Total Staff Size</td>
<td>7.69 People</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>STAFF ALLOCATION</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Staff Allocated to Programming</td>
<td>6.92 People</td>
</tr>
<tr>
<td>Staff Allocated to QA</td>
<td>.77 People</td>
</tr>
<tr>
<td>Current Total Staff Size</td>
<td>7.69 People</td>
</tr>
</tbody>
</table>

| Percent of Workforce that is Experienced | 43 Percent |

PRESS <ENTER> TO RETURN TO THE MENU

This report contains staffing information as of a particular day in the programming phase. The Current Total Staff Size consists of your total staff allocated to both programming activities and QA activities. It is the sum of Staff Allocated to Programming and Staff Allocated to QA.

The Percent of Workforce that is Experienced is also shown on this report. This is the number of experienced people (i.e. already trained/assimilated) divided by the total staff size (which is the sum of experienced and new staff). As mentioned above, once new people are hired, they go through an assimilation/training period. This is the time needed to train a new employee in the mechanics of the project and bring him/her up to speed. A new employee (i.e. one that is being trained) is only half as productive as an experienced employee.
Report 3 (DEFECT REPORT)  A sample report is pictured below:

<table>
<thead>
<tr>
<th>DEFECT REPORT</th>
<th>200</th>
</tr>
</thead>
<tbody>
<tr>
<td>CUMULATIVE STATUS FROM START OF PROJECT TO CURRENT DAY =&gt;</td>
<td></td>
</tr>
<tr>
<td>TOTAL Person Days Expended to Date</td>
<td>817 Person Days</td>
</tr>
<tr>
<td>Programming Person Days Expended to Date</td>
<td>735 Person Days</td>
</tr>
<tr>
<td>QA Person Days Expended to Date</td>
<td>82 Person Days</td>
</tr>
<tr>
<td>TOTAL Defects Detected</td>
<td>137 Defects</td>
</tr>
<tr>
<td>TOTAL KDSI Completed</td>
<td>12.67 KDSI</td>
</tr>
<tr>
<td>Defect Density</td>
<td>10.9 Defects/KDSI</td>
</tr>
</tbody>
</table>

| STATISTICS FOR THE LAST 40 DAY PERIOD ONLY |
| QA Person Days Expended Last 40 Days | 18 Person Days |
| Defects Detected Last 40 Days | 38 Defects |
| Defect Density Observed Last 40 Days | 11.6 Defects/KDSI |

PRESS <ENTER> TO RETURN TO THE MENU

This report recaps the TOTAL Person Days Expended to Date and provides a breakdown of the number of person days expended on both the QA and programming activities.

In the top section, this report gives cumulative defect data (i.e. from start of programming phase to current time). The bottom section shows data for the last 40 day period only.

Historically, the Defect Density (i.e. number of defects detected during programming divided by the number of KDSI developed) has ranged from 5-20 Defects/KDSI.

Comparing the aggregate data and the data for the last period can indicate trends.
This report contains Cumulative Project Status information from the start of the project to the current period. The report is divided into 2 sections.

The left portion is the **UPDATED ESTIMATES** section. It reflects cumulative changes in the following project estimates:

- **SIZE**  New Estimate of System Size due to changes in Requirements (DSI)
- **COST**  Your Last Est of Programming Phase Cost (Person Days)
- **DUR**  Your Last Est of Prog Phase Duration (start-end) (Days)
- **TIMREM**  Time Remaining (Days)

The right portion is the **REPORTED PROGRESS** section. Remember that this is "reported" information and is not guaranteed to be totally accurate, especially early in the phase. It reflects cumulative changes in the following project estimates:

- **%DSI**  %DSI Reported Complete (Percent)
- **TOT DSI**  Total DSI Reported Complete to Date (DSI)
- **PD EXP'D**  Total Person Days Expended to Date (Person Days)
- **PROD**  Reported Productivity (DSI/Person Day)

Your Task is complete when the % DSI is 100%.
Graph 5 (PROJECT STATUS GRAPH)

This graph shows how the total staff level and the estimates of system size and programming cost are changing over time.

Graph 6 (STAFFING GRAPH)

This graph shows how the level of the total staff, programming staff, and QA staff is changing over time.

Graph 7 (DEFECT GRAPH)

This graph shows how "QA person days expended per period" and the "number of defects detected per period" are changing over time.
APPENDIX F: STAFF LOSS OUTPUT

******************************************************************************
*                                                                     *
*                    ! ! STAFF LOSS NOTICE   !!                             *
*                                                                     *
*                    Current TIME = 160 DAYS                             *
*                                                                     *
*                    During the last 40 day Period, the project          *
*                    lost 2 people due to turnover.                     *
*                                                                     *
*                    Press <ENTER> to continue.                         *
*                                                                    *
******************************************************************************
APPENDIX G: PROGRESS REPORT SPECIFICATION

; ; ; ;
; report
; time=maxtime,
; FORMAT="15<"
; "*******************************************************************"
; FORMAT="15<,67<"
; "*"; "*";
; FORMAT="15<,21<,67<"
; "*", "The model has simulated a 40 day period.", "*";
; FORMAT="15<,67<"
; "*"; "*";
; FORMAT="15<,29<,42<,48<,67<", PICTURE="Z,ZZ9V"
; "*", "[Current TIME =", TM, "DAYS]", "*";
; FORMAT="15<,67<"
; "*"; "*";
; FORMAT="15<,28<,67<"
; "*", "Press <ENTER> to continue.", "*";
; FORMAT="15<,67<"
; "*"; "*";
; FORMAT="15<"
; "*******************************************************************";
APPENDIX H: BATCH CONTROL FILE (PROJECTA)

@echo off
rem PROJA initially underestimated project
cls
rem init.exe requires 3 parameters i.e. [project,group,ins.set]
init A 1 1
graphics
bat /n /p /s
ram
smlt PROJA -go = -prs = -ls -ns -plm 16
rep PROJA.RSL PROCESS.DRS -outf PROCESS.OUT -t >NUL
rep PROJA.RSL PROCESS.DRS -outf PROCESSS.OUT -t >NUL

-top dynex PROJA -in PROJA.STT -sc -ls -plm 16
smlt PROJA -gm = -ns -plm 16

    copy process.out process.old >NUL
    rep PROJA.RSL PROCESS.DRS -outf PROCESS.OUT -t >NUL
    rep PROJA.RSL PROCESS.DRS -outf PROCESSS.OUT >NUL
    rep PROJA.RSL INTERVAL.DRS -outf INTERVAL.OUT -t >NUL
    process

    call -topl
    rep PROJA.RSL PERFORM.DRS -outf PERFORM.OUT -t >NUL
    perform
    rem finish
    exit

-topl cls

-PROGREP **** VIEW PROGRESS *****************************
timestamp
    rep PROJA PROGRESS.DRS -outf PROGRESS.OUT -t -sc -ls -plm 16
    inkey
    capture R5 >NUL
cls
    color \1F

-STAFLoss **** VIEW STAFFING LOSS REPORT ********************
timestamp
    rep PROJA STAFLoss.DRS -outf STAFLoss.OUT -t -sc -ls -plm 16
    inkey
    capture R6 >NUL
cls
    color \1F

-menu
    color \1F
cls
    begtype
REPEATS AND GRAPHS MENU

\1EREPORTS: \1F
\1E 1 \1F PROJECT SIZE & STATUS \1EREPORT\1F
\1E 2 \1F STAFFING \1EREPORT\1F
\1E 3 \1F DEFECT \1EREPORT\1F
\1E 4 \1F CUMULATIVE \1EREPORT\1F

\1BGRAPHS: \1F
\1B 5 \1F PROJECT SIZE & STATUS \1BGRAPH\1F
\1B 6 \1F STAFFING \1BGRAPH\1F
\1B 7 \1F DEFECT \1BGRAPH\1F

PRESS \1D P \1F TO \1DPROCEED\1F TO ENTER DECISIONS FOR THE NEXT 40 DAYS

Choose an option: (Do NOT hit <ENTER> after selection!!) ;
end

-lstkey1 inkey %2 ; type %2;
  if %2 = 1 goto -STATREP
  if %2 = 2 goto -STAFREP
  if %2 = 3 goto -DEFREP
  if %2 = 4 goto -CUMREP
  if %2 = 5 goto -STATPLOT
  if %2 = 6 goto -STAFPLOT
  if %2 = 7 goto -DEFPLOT
  if %2 = P goto -proceed
  if %2 = KEY011 return
  beep goto -menu

-STATREP **** VIEW PROJECT STATUS REPORT ***********************
timestamp
  rep PROJA STATUS.DRS -outf STATUS.OUT -t -sc -ls -plm 16
  inkey
  capture R1 >NULL
  cls
  color \1F

46
goto -menu

-STAFREP  **** VIEW STAFFING REPORT ********************
timestamp
rep PROJA STAFFING.DRS -outf STAFFING.OUT -t -sc -ls -plm 16
inkey
capture R2 >NUL
cls
color \1F
goto -menu

-DEFREP  **** VIEW DEFECT REPORT ********************
timestamp
rep PROJA DEF.DRS -outf DEF.OUT -t -sc -ls -plm 16
inkey
capture R3 >NUL
cls
color \1F
goto -menu

-CUMREP  **** VIEW PROJECT CUMULATIVE REPORT ****************
timestamp
rep PROJA CUM.DRS -outf CUM.OUT -t -sc -ls -plm 16
inkey
capture R4 >NUL
cls
color \1F
goto -menu

-STATPLOT  **** VIEW PROJECT STATUS PLOT ****
timestamp
cls
color \1F
begtype

**********************************************************************

* PROJECT STATUS VARIABLES

THE FOLLOWING PROJECT STATUS VARIABLES WILL BE PLOTTED:
TOTAL STAFF . . . . . . TOTAL STAFF LEVEL
EST SYSTEM SIZE . . . . . CURRENT ESTIMATE OF SYSTEM SIZE (KDSI)
EST PROGRAMMING COST . . CURRENT ESTIMATE OF PROGRAMMING COST (Person Days)

\1A AFTER VIEWING PLOT PRESS <ESC> TO RETURN TO THE MENU  \1F

\1A PRESS <ENTER> TO VIEW PLOT  \1F

end
  inkey
cls
rep PROJA STATPLOT.DRS
capture G5 >NUL
color \1F
cls
goto -menu

-STATPLOT **** VIEW GRAPHIC STAFFING PLOT ****
timestmp
cls
color \1F
begtype

****************************
*  
\1A STAFFING VARIABLES  \1F
****************************

THE FOLLOWING STAFFING VARIABLES WILL BE PLOTTED:

TOTAL STAFF . . . . . . TOTAL STAFF LEVEL
QA STAFF . . . . . . NUMBER OF PERSONS ALLOCATED TO QA
PROG STAFF . . . . . . NUMBER OF PERSONS DOING PROGRAMMING
AFTER VIEWING PLOT PRESS <ESC> TO CONTINUE

PRESS <ENTER> TO VIEW PLOT

end
inkey
cls
rep PROJA STAFFPLOT.DRS
capture G6 >NUL
color \1F
cls
goto -menu

-DEFPLOT **** VIEW DEFECT PLOT ****
timestamp
cls
color \1F
begtype

DEFECT VARIABLES

THE FOLLOWING DEFECT VARIABLES WILL BE PLOTTED:

QA PERSON DAYS PER PERIOD . . . . QA PERSON DAYS EXPENDED PER PERIOD
DEFECTS DETECTED PER PERIOD . . . . DEFECTS DETECTED PER PERIOD

AFTER VIEWING PLOT PRESS <ESC> TO RETURN TO THE MENU

PRESS <ENTER> TO VIEW PLOT
END
  inkey
  cls
  rep PROJA DEFPLLOT.DRS
  capture G7 >NUL
  color \1F
  cls
  goto -menu

-proceed  **** PROCEED WITH NEXT SIMULATION ***********************
  cls
  color \1F
  begtype

******************************************************************************
*                  Press <ENTER> to continue                          *
******************************************************************************

end
  goto -top

-on.error-
  if %R > 82 if %R < 90 type !! Floating Point Error !! |goto -Calc.
  cls beep type Unexpected batch file error %R in line %L |exit
APPENDIX I: BATCH CONTROL FILE (PROJECTB)

@echo off
rem PROJA initially underestimated project

cls
rem init.exe requires 3 parameters i.e. [project,group,ins.set]
init B 1 1
graphics
bat /n /p /s
ram
smlt PROJA -go = -prs = -ls -ns -plm 16
rep PROJA.RSL PROCESS.DRS -outf PROCESS.OUT -t >NUL
rep PROJA.RSL PROCESS.DRS -outf PROCESSS.OUT -t >NUL

-top dynex PROJA -in PROJA.STT -sc -ls -plm 16
smlt PROJA -gm = -ns -plm 16

  copy process.out process.old >NUL
  rep PROJA.RSL PROCESS.DRS -outf PROCESS.OUT -t >NUL
  rep PROJA.RSL PROCESS.DRS -outf PROCESSS.OUT >NUL
  rep PROJA.RSL INTERVAL.DRS -outf INTERVAL.OUT -t >NUL

  process
  call -top1
  rep PROJA.RSL PERFORM.DRS -outf PERFORM.OUT -t >NUL
  perform
  rem finish
  exit

-top1 cls

-PROGREP **** VIEW PROGRESS
************************************************************
timestamp
    rep PROJA PROGRESS.DRS -outf PROGRESS.OUT -t -sc -ls
-plm 16
inkey
capture R5 >NUL
cls
color \1F

-STAFLOSS **** VIEW STAFFING LOSS REPORT
*****************************
timestamp
    rep PROJA PLANLOSS.DRS -outf PLANLOSS.OUT -t -sc -ls
-plm 16
inkey
capture R6 >NUL
cls
color \1F

-menu
color \1F
cls
begtype

REPORTS AND GRAPHS MENU

\1EREPORTS:\1F
  \1E 1 \1F PROJECT SIZE & STATUS \1EREPORT\1F
  \1E 2 \1F STAFFING \1EREPORT\1F
  \1E 3 \1F DEFECT \1EREPORT\1F

\1BGRAPHS:\1F
  \1E 4 \1F CUMULATIVE \1EREPORT\1F
  \1F
  \1B 5 \1F PROJECT SIZE & STATUS \1BGRAPH\1F
  \1B 6 \1F STAFFING \1BGRAPH\1F
  \1B 7 \1F DEFECT \1BGRAPH\1F

PRESS\1D P \1F TO \1DPROCEED\1F TO ENTER DECISIONS FOR THE NEXT 40 DAYS

Choose an option: (Do NOT hit <ENTER> after selection!!) ;
end

-1stkey1 inkey %2 | type %2;
  if %2 = 1 goto -STATREP
  if %2 = 2 goto -STAFREP
  if %2 = 3 goto -DEFREP
  if %2 = 4 goto -CUMREP
  if %2 = 5 goto -STATPLOT
  if %2 = 6 goto -STAFPLOT
  if %2 = 7 goto -DEFPLOT
  if %2 = P goto -proceed
  if %2 = KEY011 return
  beep goto -menu
-STATREP **** VIEW PROJECT STATUS REPORT *********************
timestamp
rep PROJA STATUS.DRS -outf STATUS.OUT -t -sc -ls -plm 16
inkey
capture R1 >NUL
cls
color \1F
goto -menu

-STATREP **** VIEW STAFFING REPORT *********************
timestamp
rep PROJA STAFFING.DRS -outf STAFFING.OUT -t -sc -ls -plm 16
inkey
capture R2 >NUL
cls
color \1F
goto -menu

-DEFREP **** VIEW DEFECT REPORT *********************
timestamp
rep PROJA DEF.DRS -outf DEF.OUT -t -sc -ls -plm 16
inkey
capture R3 >NUL
cls
color \1F
goto -menu

-CUMREP **** VIEW PROJECT CUMULATIVE REPORT *********************
timestamp
rep PROJA CUM.DRS -outf CUM.OUT -t -sc -ls -plm 16
inkey
capture R4 >NUL
cls
color \1F
goto -menu

-STATPLOT **** VIEW PROJECT STATUS PLOT ****
timestamp
cls
color \1F

53
begtype

*---------------------------------------------------------------*
\1A PROJECT STATUS VARIABLES                                   \1F
*---------------------------------------------------------------*

THE FOLLOWING PROJECT STATUS VARIABLES WILL BE PLOTTED:

TOTAL STAFF. . . . . . TOTAL STAFF LEVEL
EST SYSTEM SIZE. . . . CURRENT ESTIMATE OF SYSTEM SIZE (KDSI)
EST PROGRAMMING COST . . CURRENT ESTIMATE OF PROGRAMMING COST (Person Days)

\1A AFTER VIEWING PLOT PRESS <ESC> TO RETURN TO THE MENU \1F

\1A PRESS <ENTER> TO VIEW PLOT \1F

end
inkey
cls
rep PROJA STATPLOT.DRS
capture G5 >NUL
color \1F
cls
goto -menu

-STAFFPLOT **** VIEW GRAPHIC STAFFING PLOT ****
timestamp
cls
color \1F
begtype

*---------------------------------------------------------------*
\1A STAFFING VARIABLES                                       \1F
*---------------------------------------------------------------*

THE FOLLOWING STAFFING VARIABLES WILL BE PLOTTED:

54
TOTAL STAFF . . . . . . TOTAL STAFF LEVEL
QA STAFF. . . . . . . NUMBER OF PERSONS ALLOCATED TO QA
PROG STAFF. . . . . . . NUMBER OF PERSONS DOING PROGRAMMING

\1A AFTER VIEWING PLOT PRESS <ESC> TO CONTINUE \1F

\1A PRESS <ENTER> TO VIEW PLOT \1F

e nd
  inkey
cls
rep PROJA STAFFPLOT.DRS
capture G6 >NUL
color \1F
cls
goto -menu

-DEFPLOT **** VIEW DEFECT PLOT ****
timestamp
cls
color \1F
begtype

********************************************************************
* \1A DEFECT VARIABLES \1F
********************************************************************

THE FOLLOWING DEFECT VARIABLES WILL BE PLOTTED:

QA PERSON DAYS PER PERIOD . . . QA PERSON DAYS EXPENDED PER PERIOD
DEFECTS DETECTED PER PERIOD . . . DEFECTS DETECTED PER PERIOD

\1A AFTER VIEWING PLOT PRESS <ESC> TO RETURN TO THE MENU \1F
\1A PRESS <ENTER> TO VIEW PLOT \1F

END

inkey
cls
rep PROJA DEFPLOT.DRS
capture G7 >NUL
color \1F
cls
goto -menu

-proceed **** PROCEED WITH NEXT SIMULATION *******************
cls
color \1F
begtype

***************************************************************************
* Press <ENTER> to continue  *
***************************************************************************

end
goto -top

-on.error-
if %R > 82 if %R < 90 type !! Floating Point Error !! |goto -Calc.
Cls beep type Unexpected batch file error %R in line %L |exit
APPENDIX J: PROJECT DYNEX FILE

if #tm<.1 then
display clear

**********************************************************************
!!! Important Points to Remember !!!
**********************************************************************

- You are not allowed to discuss this exercise with anyone other than the lab attendant. Please refrain from discussing this with members in the other class until they have completed the exercise.

- The system will show you the size of the initial core team of software developers who have just completed the requirements/design specifications. You will then be asked for your desired staffing level for the programming phase. Then, the system will run through the first simulation time period (40 working days) and allow you to view various reports and graphs. You will then be allowed to update your estimates for project cost and duration and change your staffing levels.

- Record your decision for each interval on the documentation sheet provided before proceeding to the next interval.

THE LAB ATTENDANT MUST VERIFY YOUR FINAL RESULTS!

- GOOD LUCK! Press <ENTER> to continue.
dend
choice 1
cend 1/1

display clear
INITIAL ESTIMATES FOR THIS PROJECT:

System Size 42000. DSI
Cost of Programming Phase #TOTMD1 Person Days
Duration of Programming Phase #TDEV Days

The initial core team of software developers who have just completed the requirements and design specifications is #WFS1 people.

Your task is to take over as manager of the programming phase. At this point, you need to make 2 decisions:

1. The total staff level for the programming phase.
2. The percent of this staff to allocate to Quality Assurance.

FIRST DECISION: The total staff level

Enter your total requested staff level and press <ENTER>.
dendq
dq WFS1=0.5<
display clear

SECOND DECISION:

NEW TOOL's estimate for the percent of the total staff to allocate to QA is #FRMPQA percent. Remember, NEW TOOL has not yet been calibrated to your environment. Thus, this estimate is merely illustrative. It may or may not be appropriate for your unique project.

1) Enter a different desired percentage (a number from 0 - 100) and press <ENTER>.

OR

2) Press <ENTER> to allocate #FRMPQA percent of your staff to QA.
dendq
dq FRMPQA=0<100
display clear

Your total requested staffing level = #WFS1
people. The percent to be devoted to QA activities = #FRMPQA percent.
(This means that you are devoting #WFS1 * #FRMPQA / 100 = #WFS1*FRMPQA/100 people to QA)

***************************************************************************
*                           !! IMPORTANT !!                             *
*                        *                                                 *
*                 This is your final opportunity to check and          *
*        change the values for this period.                           *
*                         *                                                 *
*                 Press 1 then <ENTER> to change these values.        *
*                         *                                                 *
*                 If all values are correct, record them on          *
*        the documentation sheet provided then                      *
*                         *                                                 *
*                 Press 2 then <ENTER> to continue.                   *
*                         *                                                 *
***************************************************************************
dend
choice 2
display
Your total requested staffing level = dendq
dq WFS1=0.5<
display
The percent allocated to QA = dendq
dq FRMPQA=0<100
cend
cend
else
choice 1
cend 1/1
display clear
***************************************************************************
* Make Your Desired Changes To The Variables                        *
*                                           and press <ENTER>         *
*                        OR                                              *
*                 Press <ENTER> to keep the displayed value           *
***************************************************************************

Your updated estimate for project cost (person days) =
dendq
dq TOTMD1=0<
Your updated estimate for project duration (days) = \( d_{\text{PROJDR}} \)
\( d_{\text{PROJDR}} = 0 \leq < \)

Your total requested staffing level = \( d_{\text{WFS1}} \)
\( d_{\text{WFS1}} = 0.5 \leq < \)

The percent to allocate to QA (a number from 0 - 100) = \( d_{\text{FRMPQA}} \)
\( d_{\text{FRMPQA}} = 0 \leq 100 \leq < \)

Your updated estimate for project cost = \( #\text{TOTMD1} \) person days
Your updated estimate for project duration = \( #\text{PROJDR} \) days
Your total requested staffing level = \( #\text{WFS1} \) people
The percent to be devoted to QA activities = \( #\text{FRMPQA} \) percent
(This means that you are devoting \( #\text{WFS1} \times \#\text{FRMPQA} / 100 = \#\text{WFS1} \times \text{FRMPQA}/100 \) people to QA)

**************************************************************************
*                       !! IMPORTANT !!                             *
* * This is your final opportunity to check and change the values for this period. *
* * Press 1 then <ENTER> to change these values. *
* * If all values are correct, record them on the documentation sheet provided then *
* * Press 2 then <ENTER> to continue. *
*
**************************************************************************
dend
choice 2

display
The updated estimate for project cost (person days) = \( d_{\text{dendq}} \)
dq TOTMD1=0<

display
The updated estimate for project duration (days) =
dendq
dq PROJDR=0<

display
Your total requested staffing level =
dendq
dq WFS1=0.5<

display
The percent allocated to QA =
dendq
dq FRMPQA=0<100
cend
cend
eend
display

******************************************************************************
*   Press <ENTER> to simulate this interval and return to   *
*   the menu.                                           *
********************************************************************************
edndq
choice 1
display clear

******************************************************************************
*                                                                   *
*    There will be a short pause while   *
*    the model simulates the next period.   *
*                                                                   *
******************************************************************************
edndq
report
time=maxtime,
cend 1/1
spec md_length=#length+40
APPENDIX K:  UNCERTAINTY GROUP INSTRUCTION SET (A1)

Your Name: ..................................................  A11
SMC No.: ...........................................................

1. Introduction

The exercise you are about to undertake is similar in many ways to flight simulators
that pilots use to mimic flying an aircraft from takeoff at point A to landing at point B.
Instead of flying an aircraft, though, the simulator mimics the programming phase of a real
software project. In this simulation, you will be more than an observer. In fact, you will
play the role of manager of the programming phase of the project. Specifically, your role
will be to track the progress of the project by reviewing status reports and graphs available
every two-month interval (40 working days) during the programming phase. As the
manager, you must then make two staffing decisions:

First, the total number of staff you need. (You can hire additional staff,
or decrease the staffing level as you deem necessary to complete your
programming task successfully.)

Second, you need to decide on what percent of your total staff to allocate
to the Quality Assurance activity to be conducted throughout the programming
phase (e.g. to do inspections).

2. Project

The project that you will manage happens to have been a real project conducted in a
real organization. For the project, you will be given a project profile containing the
following initial information:

Estimated Size of the System: in Delivered Source Instructions (DSI)
Estimated Cost of Programming Phase: in Number of Person Days
Estimated Duration of Programming Phase: in Number of Work Days
Size of initial Core Team: in People

The Core Team is a skeleton staff of software professionals who are there to ensure
continuity between the requirements/design phase (which you may assume has just been
completed), and the programming phase you are to manage.

The cost and schedule estimates are derived from a new off-the-shelf estimation tool,
call it "NEW_TOOL", that has been recently acquired.

Historically, the defect density (i.e. number of defects detected during programming
divided by the number of KDSI developed) has ranged from 5 - 20 Defects/KDSI.
3. Your task

Your task at every 40-day interval is to review the project’s status, and to make any necessary adjustments to the staffing level and its allocation. In order to do so, you may feel that is necessary to first adjust the project’s cost and duration targets. The staffing decision should be done as follows:

1. Decide on the total staffing level, and

2. Decide on what percentage of the staff should be allocated to the quality assurance function (i.e. a number between 0 and 100).

4. Your Goal for the Task:

Minimize overruns in both cost and schedule.

Your grade for the simulation will be based on an equal weighing of these two factors.

5. Some Important Points to Consider in Managing Your Task

1. As the manager of the programming phase, you specify the desired staffing level. You may find that your actual staffing level (as it will appear in the reports) is different from what you requested. This would be due to the delay in hiring people. For modest additions to your staffing, the average hiring delay will be around 40 days. However if you request a large number of additional staff, the average hiring delay will be much longer.

2. Once new people are hired, they must be trained and assimilated. The assimilation/training period is typically 80 days. During this assimilation/training period you can expect the new employee to be only half as productive as an experienced employee.

3. The staff size that you select, and which appears in reports, may show fractions (e.g. 4.5 people) since people are allowed to work on more than one project.

4. Adding more people increases communication and coordination overhead as happens in reality.
5. You will need to take into account the possibility of losing people due to turnover. You will receive a staff loss notice once a turnover occurs.

6. Rules of the Game

1. You must work alone. At no time are you to discuss the progress of the project with anyone.

2. If you have a question, ask the lab attendant.

3. You are not allowed to bring any notes or other "gouge" to use during the simulation. Feel free to write on the documentation sheets provided.

4. A calculator is allowed and recommended.

7. Instructions for Starting the System

**Follow the instructions Carefully.** If any problems arise, immediately seek out the lab attendant.

1. Insert the disk into the B: drive. Do not remove the disk from the drive!

2. From the C:\ prompt, type B: Do NOT start the network!

3. Start the simulation by typing START at the B:\ prompt.

4. Follow the instructions as they appear on the screen.

5. The simulation is complete when the % Programming Reported Complete in the PROJECT STATUS REPORT is 100%. When this occurs Call the lab attendant.
YOUR GOAL IS:

Minimize overruns in both cost and schedule.

INITIAL ESTIMATES:

<table>
<thead>
<tr>
<th>Project Size</th>
<th>42,000 DSI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Cost</td>
<td>1887 Person Days</td>
</tr>
<tr>
<td>Project Duration (start-end)</td>
<td>237 Days</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TIME ELAPSED (DAYS)</th>
<th>ESTIMATED COST (PERS-DAYS)</th>
<th>ESTIMATED DURATION (DAYS)</th>
<th>STAFFING LEVEL (PERSONS)</th>
<th>QUALITY ASSURANCE (PERCENT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Decision</td>
<td>1887</td>
<td>237</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time Elapsed - 40 Days</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time Elapsed - 80 Days</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time Elapsed - 120 Days</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time Elapsed - 160 Days</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time Elapsed - 200 Days</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time Elapsed - 240 Days</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time Elapsed - 280 Days</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time Elapsed - 320 Days</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time Elapsed - 360 Days</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time Elapsed - 400 Days</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time Elapsed - 440 Days</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time Elapsed - 480 Days</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time Elapsed - 520 Days</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**** WHEN YOU ARE DONE, CALL THE LAB ATTENDANT ****

66
APPENDIX L: RISK GROUP INSTRUCTION SET (A2)

Your Name: ____________________________________________ A21
SMC No.: _____________________________________________

1. Introduction

The exercise you are about to undertake is similar in many ways to flight simulators that pilots use to mimic flying an aircraft from takeoff at point A to landing at point B. Instead of flying an aircraft, though, the simulator mimics the programming phase of a real software project. In this simulation, you will be more than an observer. In fact, you will play the role of manager of the programming phase of the project. Specifically, your role will be to track the progress of the project by reviewing status reports and graphs available every two-month interval (40 working days) during the programming phase. As the manager, you must then make two staffing decisions:

First, the total number of staff you need. (You can hire additional staff, or decrease the staffing level as you deem necessary to complete your programming task successfully.)

Second, you need to decide on what percent of your total staff to allocate to the Quality Assurance activity to be conducted throughout the programming phase (e.g. to do inspections).

2. Project

The project that you will manage happens to have been a real project conducted in a real organization. For the project, you will be given a project profile containing the following initial information:

Estimated Size of the System: in Delivered Source Instructions (DSI)
Estimated Cost of Programming Phase: in Number of Person Days
Estimated Duration of Programming Phase: in Number of Work Days
Size of initial Core Team: in People

The Core Team is a skeleton staff of software professionals who are there to ensure continuity between the requirements/design phase (which you may assume has just been completed), and the programming phase you are to manage.

The cost and schedule estimates are derived from a new off-the-shelf estimation tool, call it "NEW_TOOL", that has been recently acquired.

Historically, the defect density (i.e. number of defects detected during programming
divided by the number of KDSI developed) has ranged from 5 - 20 Defects/KDSI.

3. **Your task**

   Your task at every 40-day interval is to review the project’s status, and to make any necessary adjustments to the staffing level and its allocation. In order to do so, you may feel that is necessary to first adjust the project’s cost and duration targets. The staffing decision should be done as follows:

   1. Decide on the total staffing level, and

   2. Decide on what percentage of the staff should be allocated to the quality assurance function (i.e. a number between 0 and 100).

4. **Your Goal for the Task:**

   Minimize overruns in both cost and schedule.

Your grade for the simulation will be based on an equal weighing of these two factors.

5. **Some Important Points to Consider in Managing Your Task**

   1. As the manager of the programming phase, you specify the desired staffing level. You may find that your actual staffing level (as it will appear in the reports) is different from what you requested. This would be due to the delay in hiring people. For modest additions to your staffing, the average hiring delay will be around 40 days. However if you request a large number of additional staff, the average hiring delay will be much longer.

   2. Once new people are hired, they must be trained and assimilated. The assimilation/training period is typically 80 days. During this assimilation/training period you can expect the new employee to be only half as productive as an experienced employee.

   3. The staff size that you select, and which appears in reports, may show fractions (e.g. 4.5 people) since people are allowed to work on more than one project.

   4. Adding more people increases communication and coordination overhead as happens in reality.
5. A project risk in this organization is that of losing people due to turnover. Historically, the turnover rate averages to 1.5 people lost every reporting period (i.e., every 40 days).

The following are the probabilities of possible staff losses every 40 day period:

- 25% probability of no loss in staff.
- 25% probability of 1 person lost.
- 25% probability of 2 people lost.
- 25% probability of 3 people lost.

You will receive a staff loss notice once a turnover occurs.

6. Rules of the Game

1. You must work alone. At no time are you to discuss the progress of the project with anyone.

2. If you have a question, ask the lab attendant.

3. You are not allowed to bring any notes or other "gouge" to use during the simulation. Feel free to write on the documentation sheets provided.

4. A calculator is allowed and recommended.

7. Instructions for Starting the System

Follow the instructions Carefully. If any problems arise, immediately seek out the lab attendant.

1. Insert the disk into the B: drive. Do not remove the disk from the drive!

2. From the C:\ prompt, type B:  Do NOT start the network!

3. Start the simulation by typing START at the B:\ prompt.

4. Follow the instructions as they appear on the screen.

5. The simulation is complete when the % Programming Reported Complete in the PROJECT STATUS REPORT is 100%. When this occurs Call the lab attendant.
YOUR GOAL IS:

Minimize overruns in both cost and schedule.

INITIAL ESTIMATES:

<table>
<thead>
<tr>
<th>Project Size</th>
<th>42,000 DSI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Cost</td>
<td>1887 Person Days</td>
</tr>
<tr>
<td>Project Duration (start-end)</td>
<td>237 Days</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TIME ELAPSED (DAYS)</th>
<th>ESTIMATED COST (PERS-DAYS)</th>
<th>ESTIMATED DURATION (DAYS)</th>
<th>STAFFING LEVEL (PERSONS)</th>
<th>QUALITY ASSURANCE (PERCENT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Decision</td>
<td>1887</td>
<td>237</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time Elapsed - 40 Days</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time Elapsed - 80 Days</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time Elapsed - 120 Days</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time Elapsed - 160 Days</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time Elapsed - 200 Days</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time Elapsed - 240 Days</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time Elapsed - 280 Days</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time Elapsed - 320 Days</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time Elapsed - 360 Days</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time Elapsed - 400 Days</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time Elapsed - 440 Days</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time Elapsed - 480 Days</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time Elapsed - 520 Days</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**** WHEN YOU ARE DONE, CALL THE LAB ATTENDANT ****
APPENDIX M: CERTAINTY GROUP INSTRUCTION SET (B1)

Your Name: ____________________________
SMC No.: ____________________________

1. Introduction
The exercise you are about to undertake is similar in many ways to flight simulators
that pilots use to mimic flying an aircraft from takeoff at point A to landing at point B.
Instead of flying an aircraft, though, the simulator mimics the programming phase of a real
software project. In this simulation, you will be more than an observer. In fact, you will
play the role of manager of the programming phase of the project. Specifically, your role
will be to track the progress of the project by reviewing status reports and graphs available
every two-month interval (40 working days) during the programming phase. As the
manager, you must then make two staffing decisions.

First, the total number of staff you need. (You can hire additional staff,
or decrease the staffing level as you deem necessary to complete your
programming task successfully.)

Second, you need to decide on what percent of your total staff to allocate
to the Quality Assurance activity to be conducted throughout the programming
phase (e.g. to do inspections).

2. Project
The project that you will manage happens to have been a real project conducted in a
real organization. For the project, you will be given a project profile containing the
following initial information:

Estimated Size of the System: in Delivered Source Instructions (DSI)
Estimated Cost of Programming Phase: in Number of Person Days
Estimated Duration of Programming Phase: in Number of Work Days
Size of initial Core Team: in People

The Core Team is a skeleton staff of software professionals who are there to ensure
continuity between the requirements/design phase (which you may assume has just been
completed), and the programming phase you are to manage.

The cost and schedule estimates are derived from a new off-the-shelf estimation tool,
call it "NEW_TOOL", that has been recently acquired.

Historically, the defect density (i.e. number of defects detected during programming
divided by the number of KDSI developed) has ranged from 5 - 20 Defects/KDSI.
3. Your task

Your task at every 40-day interval is to review the project’s status, and to make any necessary adjustments to the staffing level and its allocation. In order to do so, you may feel that is necessary to first adjust the project’s cost and duration targets. The staffing decision should be done as follows:

1. Decide on the total staffing level, and

2. Decide on what percentage of the staff should be allocated to the quality assurance function (i.e. a number between 0 and 100).

4. Your Goal for the Task:

Minimize overruns in both cost and schedule.

Your grade for the simulation will be based on an equal weighing of these two factors.

5. Some Important Points to Consider in Managing Your Task

1. As the manager of the programming phase, you specify the desired staffing level. You may find that your actual staffing level (as it will appear in the reports) is different from what you requested. This would be due to the delay in hiring people. For modest additions to your staffing, the average hiring delay will be around 40 days. However if you request a large number of additional staff, the average hiring delay will be much longer.

2. Once new people are hired, they must be trained and assimilated. The assimilation/training period is typically 80 days. During this assimilation/training period you can expect the new employee to be only half as productive as an experienced employee.

3. The staff size that you select, and which appears in reports, may show fractions (e.g. 4.5 people) since people are allowed to work on more than one project.

4. Adding more people increases communication and coordination overhead as happens in reality.
5. A project risk in this organization is that of losing people due to turnover. Historically, the turnover rate averages to 1.5 people lost every reporting period (i.e., every 40 days).

To minimize the negative impacts of staff turnover on a project, the organization has instituted a policy of requiring a 40 day notice of leaving. As the project manager, this guarantees that you will be aware of any staff losses in a 40 day period at the beginning of the period.

You will receive a staff loss notice once an employee plans to leave.

6. Rules of the Game

1. You must work alone. At no time are you to discuss the progress of the project with anyone.

2. If you have a question, ask the lab attendant.

3. You are not allowed to bring any notes or other "gouge" to use during the simulation. Feel free to write on the documentation sheets provided.

4. A calculator is allowed and recommended.

7. Instructions for Starting the System

Follow the instructions carefully. If any problems arise, immediately seek out the lab attendant.

1. Insert the disk into the B: drive. Do not remove the disk from the drive!

2. From the C:\ prompt, type B: Do NOT start the network!

3. Start the simulation by typing START at the B:\ prompt.

4. Follow the instructions as they appear on the screen.

5. The simulation is complete when the % Programming Reported Complete in the PROJECT STATUS REPORT is 100%. When this occurs Call the lab attendant.
YOUR GOAL IS:

Minimize overruns in both cost and schedule.

INITIAL ESTIMATES:

<table>
<thead>
<tr>
<th>Project Size</th>
<th>42,000 DSI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Cost</td>
<td>1887 Person Days</td>
</tr>
<tr>
<td>Project Duration (start-end)</td>
<td>237 Days</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TIME ELAPSED (DAYS)</th>
<th>ESTIMATED COST (PERS-DAYS)</th>
<th>ESTIMATED DURATION (DAYS)</th>
<th>STAFFING LEVEL (PERSONS)</th>
<th>QUALITY ASSURANCE (PERCENT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Decision</td>
<td>1887</td>
<td>237</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time Elapsed - 40 Days</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time Elapsed - 80 Days</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time Elapsed - 120 Days</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time Elapsed - 160 Days</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time Elapsed - 200 Days</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time Elapsed - 240 Days</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time Elapsed - 280 Days</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time Elapsed - 320 Days</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time Elapsed - 360 Days</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time Elapsed - 400 Days</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time Elapsed - 440 Days</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time Elapsed - 480 Days</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time Elapsed - 520 Days</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**** WHEN YOU ARE DONE, CALL THE LAB ATTENDANT ****
APPENDIX N: PRACTICE EXPERIMENT INSTRUCTION SET

Your Name: ________________________________
SMC No.: _________________________________

1. Introduction

The exercise you are about to undertake is similar in many ways to flight simulators that pilots use to mimic flying an aircraft from takeoff at point A to landing at point B. Instead of flying an aircraft, though, the simulator mimics the programming phase of a real software project. In this simulation, you will be more than an observer. In fact, you will play the role of manager of the programming phase of the project. Specifically, your role will be to track the progress of the project by reviewing status reports and graphs available every two-month interval (40 working days) during the programming phase. As the manager, you must then make two staffing decisions:

First, the total number of staff you need. (You can hire additional staff, or decrease the staffing level as you deem necessary to complete your programming task successfully.)

Second, you need to decide on what percent of your total staff to allocate to the Quality Assurance activity to be conducted throughout the programming phase (e.g. to do inspections).

2. Project

The project that you will manage happens to have been a real project conducted in a real organization. For the project, you will be given a project profile containing the following initial information:

Estimated Size of the System: in Delivered Source Instructions (DSI)
Estimated Cost of Programming Phase: in Number of Person Days
Estimated Duration of Programming Phase: in Number of Work Days
Size of initial Core Team: in People

The Core Team is a skeleton staff of software professionals who are there to ensure continuity between the requirements/design phase (which you may assume has just been completed), and the programming phase you are to manage.

The cost and schedule estimates are derived from a new off-the-shelf estimation tool, call it "NEW_TOOL", that has been recently acquired.

Historically, the defect density (i.e. number of defects detected during programming divided by the number of KDSI developed) has ranged from 5 - 20 Defects/KDSI.
3. Your task

Your task at every 40-day interval is to review the project's status, and to make any necessary adjustments to the staffing level and its allocation. In order to do so, you may feel that is necessary to first adjust the project's cost and duration targets. The staffing decision should be done as follows:

1. Decide on the total staffing level, and

2. Decide on what percentage of the staff should be allocated to the quality assurance function (i.e. a number between 0 and 100).

4. Your Goal for the Task:

   Familiarize yourself with the simulation.

5. Some Important Points to Consider in Managing Your Task

1. As the manager of the programming phase, you specify the desired staffing level. You may find that your actual staffing level (as it will appear in the reports) is different from what you requested. This would be due to the delay in hiring people. For modest additions to your staffing, the average hiring delay will be around 40 days. However if you request a large number of additional staff, the average hiring delay will be much longer.

2. Once new people are hired, they must be trained and assimilated. The assimilation/training period is typically 80 days. During this assimilation/training period you can expect the new employee to be only half as productive as an experienced employee.

3. The staff size that you select, and which appears in reports (e.g. 4.5 people) since people are allowed to work on more than one project.

4. Adding more people increases communication and coordination overhead as happens in reality.
6. **Rules of the Game**

1. You must work alone. At no time are you to discuss the progress of the project with anyone.

2. If you have a question, ask the lab attendant.

3. You are not allowed to bring any notes or other "gouge" to use during the simulation. Feel free to write on the documentation sheets provided.

4. A calculator is allowed and recommended.

7. **Instructions for Starting the System**

*Follow the instructions Carefully.* If any problems arise, **immediately** seek out the lab attendant.

1. Insert the disk into the B: drive. Do not remove the disk from the drive!

2. From the C:\ prompt, type B:  Do NOT start the network!

3. Start the simulation by typing PRACTICE at the B:\ prompt.

4. Follow the instructions as they appear on the screen.

5. The simulation is complete when the % Programming Reported Complete in the PROJECT STATUS REPORT is 100%. When this occurs **Call the lab attendant**.
YOUR GOAL IS:

Familiarize yourself with the simulation.

INITIAL ESTIMATES:

<table>
<thead>
<tr>
<th>Project Size</th>
<th>20,000 DSI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Cost</td>
<td>1400 Person Days</td>
</tr>
<tr>
<td>Project Duration (start-end)</td>
<td>350 Days</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TIME ELapsed (DAYS)</th>
<th>ESTIMATED COST (PERS-DAYS)</th>
<th>ESTIMATED DURATION (DAYS)</th>
<th>STAFFING LEVEL (PERSONS)</th>
<th>QUALITY ASSURANCE (PERCENT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Decision</td>
<td>1400</td>
<td>350</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time Elapsed - 40 Days</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time Elapsed - 80 Days</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time Elapsed - 120 Days</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time Elapsed - 160 Days</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time Elapsed - 200 Days</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time Elapsed - 240 Days</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time Elapsed - 280 Days</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time Elapsed - 320 Days</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time Elapsed - 360 Days</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time Elapsed - 400 Days</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time Elapsed - 440 Days</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time Elapsed - 480 Days</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time Elapsed - 520 Days</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**** WHEN YOU ARE DONE, CALL THE LAB ATTENDANT ****
APPENDIX O: GRAPHS.DRS FILES

STATPLOT.DRS

plotxy <TM"TIME (DAYS) ",0,600>,<FTEQWF"TOTAL STAFF (PERSONS) ",0,40>,
       <PJBSSZT/1000"EST SYSTEM SIZE (KDSI) ",0,80>,
       <JBSZMD"EST PROGRAMMING COST (PERSON DAYS) ",0,6000>

STAFPLOT.DRS

plotxy <TM"TIME (DAYS) ",0,600>,<FTEQWF"TOTAL STAFF (PERSONS) ",0,40>,
       <CRQAWF"QA STAFF (PERSONS) ",0,40>,<CRDVWF"PROG STAFF (PERSONS) ",0,40>

DEFPLOT.DRS

plotxy <TM"TIME (DAYS) ",0,600>,<PRQAMD"QA PERSON DAYS PER PERIOD ",0,240>,
       <PRERD"DEFECTS DETECTED PER PERIOD ",0,240>
### APPENDIX P: RANDOMIZATION WORKSHEET

<table>
<thead>
<tr>
<th>Name</th>
<th>Row Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kelly, John</td>
<td>104</td>
</tr>
<tr>
<td>King, A.</td>
<td>150</td>
</tr>
<tr>
<td>Lamb, V.</td>
<td>015</td>
</tr>
<tr>
<td>Langhorne, W.</td>
<td>020</td>
</tr>
<tr>
<td>Larochelle, L.</td>
<td>816</td>
</tr>
<tr>
<td>Lewis, J.</td>
<td>916</td>
</tr>
<tr>
<td>Mancano, V.</td>
<td>691</td>
</tr>
<tr>
<td>Michal, T.</td>
<td>141</td>
</tr>
<tr>
<td>Nault, M.</td>
<td>625</td>
</tr>
<tr>
<td>O'Neill, T.</td>
<td>223</td>
</tr>
<tr>
<td>Onorati, A.</td>
<td>465</td>
</tr>
<tr>
<td>Pemberton, L.</td>
<td>255</td>
</tr>
<tr>
<td>Prell, M.</td>
<td>853</td>
</tr>
<tr>
<td>Robillard, S.</td>
<td>309</td>
</tr>
<tr>
<td>Sears, G.</td>
<td>891</td>
</tr>
<tr>
<td>Staten, R.</td>
<td>279</td>
</tr>
<tr>
<td>Tate, W.</td>
<td>939</td>
</tr>
<tr>
<td>Trepanier, D.</td>
<td>241</td>
</tr>
<tr>
<td>Weiss, K.</td>
<td>483</td>
</tr>
<tr>
<td>Wilcox, R.</td>
<td>225</td>
</tr>
<tr>
<td>Chou, M.</td>
<td>972</td>
</tr>
<tr>
<td>Kelly, James</td>
<td>763</td>
</tr>
<tr>
<td>Barnum, T.</td>
<td>648</td>
</tr>
<tr>
<td>Berry, E.</td>
<td>151</td>
</tr>
<tr>
<td>Bitzer, S.</td>
<td>248</td>
</tr>
<tr>
<td>Callaghan, V.</td>
<td>493</td>
</tr>
<tr>
<td>Cragmiles, R.</td>
<td>421</td>
</tr>
<tr>
<td>Downs, M.</td>
<td>930</td>
</tr>
<tr>
<td>Emdc, C.</td>
<td>062</td>
</tr>
<tr>
<td>Emwiler, T.</td>
<td>616</td>
</tr>
<tr>
<td>Encinas, T.</td>
<td>078</td>
</tr>
<tr>
<td>Franklin, B.</td>
<td>163</td>
</tr>
<tr>
<td>Gregorie, J.</td>
<td>394</td>
</tr>
<tr>
<td>Hodges, J.</td>
<td>535</td>
</tr>
<tr>
<td>Howard, L.</td>
<td>713</td>
</tr>
<tr>
<td>Johnson, S.</td>
<td>375</td>
</tr>
<tr>
<td>McGibbon, H.</td>
<td>399</td>
</tr>
<tr>
<td>McQuay, D.</td>
<td>818</td>
</tr>
<tr>
<td>Monroe, W.</td>
<td>166</td>
</tr>
<tr>
<td>Swain, W.</td>
<td>917</td>
</tr>
<tr>
<td>Tharpe, G.</td>
<td>604</td>
</tr>
<tr>
<td>Both Experiments</td>
<td>No goals Experiment+</td>
</tr>
<tr>
<td>------------------</td>
<td>----------------------</td>
</tr>
<tr>
<td>U 13</td>
<td></td>
</tr>
<tr>
<td>R 13</td>
<td>1</td>
</tr>
<tr>
<td>C 12</td>
<td>1</td>
</tr>
</tbody>
</table>
## APPENDIX Q: PERFORMANCE VARIABLES

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>FNCOST</td>
<td>Final Cost (Person Days)</td>
</tr>
<tr>
<td>FNSKED</td>
<td>Final Cumulative Time (Days)</td>
</tr>
<tr>
<td>FNERR</td>
<td>Final Errors Remaining Undetected</td>
</tr>
<tr>
<td>FNERG</td>
<td>Final Cumulative Errors Generated</td>
</tr>
<tr>
<td>FNERD</td>
<td>Final Cumulative Errors Detected</td>
</tr>
<tr>
<td>FNERES</td>
<td>Final Cumulative Errors Escaping Detection</td>
</tr>
<tr>
<td>FNPRDT</td>
<td>Final Percentage of Errors Detected</td>
</tr>
<tr>
<td>FNQAMD</td>
<td>Final Cumulative Quality Assurance Person Days</td>
</tr>
<tr>
<td>FNTRMD</td>
<td>Final Cumulative Training Person Days</td>
</tr>
<tr>
<td>FNRWMD</td>
<td>Final Cumulative Rework Person Days</td>
</tr>
</tbody>
</table>
APPENDIX R: PROJECT QUESTIONNAIRE

Your Name: __________________________
SMC No.: ____________________________

Group All

1. In making your decisions, how much weight out of 100 points did you accord to the following goals? (The numbers should total 100 points.)
   Cost ____________________
   Schedule ____________________
   100

2. Describe (in words, numbers, equation, etc.) what decision rule you followed in deciding on the overall staffing level in this project:

   __________________________________________
   __________________________________________
   __________________________________________
   __________________________________________
   __________________________________________

3. Please try to elaborate on the thinking process you went through in making your decisions in this project (use back of page if necessary):

   __________________________________________
   __________________________________________
   __________________________________________
   __________________________________________

4. Please elaborate on how you handled the problem of staff turnover.

   __________________________________________
   __________________________________________
   __________________________________________

5. How clear were the instructions regarding the task?

   1  2  3  4  5  6  7  8  9
   Not at all Clear
   Very Clear

85
6. To what extent was the graphical information provided on the progress of the project helpful in improving your own decisions?

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not at all Helpful</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Very Helpful</td>
<td></td>
</tr>
</tbody>
</table>

7. To what extent were the reports on the progress of the project helpful in improving your own decisions?

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not at all Helpful</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Very Helpful</td>
<td></td>
</tr>
</tbody>
</table>

8. In the project that you just completed, did you

(a) Use the PROJECT STATUS report (Y/N)?

(b) If you did, please describe how you used the information.

______________________________________________________________________________

______________________________________________________________________________

9. In the project that you just completed, did you

(a) Use the STAFFING LEVEL report (Y/N)?

(b) If you did, please describe how you used the information.

______________________________________________________________________________

______________________________________________________________________________

10. In the project that you just completed, did you

(a) Use the DEFECT report (Y/N)?

(b) If you did, please describe how you used the information.

______________________________________________________________________________

______________________________________________________________________________
11. In the project that you just completed, did you
   (a) Use the CUMULATIVE report (Y/N)?
   (b) If you did, please describe how you used the information.

12. In the project you just completed, did you
   (a) Use the PROJECT STATUS graph (Y/N)?
   (b) If you did, please describe how you used the information.

13. In the project that you just completed, did you
   (a) Use the STAFFING LEVEL graph (Y/N)?
   (b) If you did, please describe how you used the information.

14. In the project that you just completed, did you
   (a) Use the DEFECT graph (Y/N)?
   (b) If you did, please describe how you used the information.

15. Have you in the past participated in project management (Y/N)?
    If YES, to what extent was the task in this simulation similar to your previous experience?

    | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
    |---|---|---|---|---|---|---|---|---|
    | Not at all |
    | Similar    |
    | Very       |
    | Similar    |

87
16. How interesting was the task you just performed?

1 2 3 4 5 6 7 8 9
Not at all Very
Interesting

17. How serious were you in performing the task?

1 2 3 4 5 6 7 8 9
Not at all Very
Serious

18. How clear were the instructions regarding the task, generally?

1 2 3 4 5 6 7 8 9
Not at all Very
Clear

19. How easy was the simulation to use?

1 2 3 4 5 6 7 8 9
Not at all Very
Easy

20. Please give us some information about yourself (in absolute confidence. At no time will your name appear in the results. The data will only be used in an aggregate statistical sense).

(a) Curriculum enrolled in: ________________________

(b) Age _________

(c) Sex _________

(d) Full time work experience (in years) _________

(e) How long ago (in years) did you complete your undergraduate education? _________

(f) How familiar are you with computers, generally?

1 2 3 4 5 6 7 8 9
Not at all Very
Familiar

(g) How many hours (per week) do you use computers? _________
21. Your general comments regarding the simulation:


*** END OF SIMULATION ***
Thank you for your participation.
APPENDIX S: FORMAT OF DEMOGRAPHIC DATA

Q1S  Question 1 Schedule Percent
Q1Q  Question 1 Quality Percent
Q1C  Question 1 Cost Percent
Q5   Question 5 Response (1-9)
Q6   Question 6 Response (1-9)
Q7   Question 7 Response (1-9)
Q8   Question 8 Response (0/1 0-No 1-Yes)
Q9   Question 9 Response (0/1 0-No 1-Yes)
Q10  Question 10 Response (0/1 0-No 1-Yes)
Q11  Question 11 Response (0/1 0-No 1-Yes)
Q12  Question 12 Response (0/1 0-No 1-Yes)
Q13  Question 13 Response (0/1 0-No 1-Yes)
Q14  Question 14 Response (0-9 0-No 1-9 Yes and the value)
Q15  Question 15 Response (1-9)
Q16  Question 16 Response (1-9)
Q17  Question 17 Response (1-9)
Q18  Question 18 Response (1-9)
Q19  Question 19 Response (1-9)
CURR Curriculum
AGE  Age (years)
SEX  M=Male, F=Female
WKEXP Work Experience (years)
EDAGO Years since undergraduate education was completed
FAM  Computer familiarity
CHRSWK Number of computer hours per week
APPENDIX T: PERFORMANCE/DEMOGRAPHIC DATA

Risk experiment: Comparison of performance

1995

------------------------------------------------- PROJECT=A RISKTYPE=R
-------------------------------------------------

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>Mean</th>
<th>Std Dev</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>FNCOST</td>
<td>14</td>
<td>2941.76</td>
<td>523.7349118</td>
<td>2256.31</td>
<td>4146.24</td>
</tr>
<tr>
<td>FNSKED</td>
<td>14</td>
<td>310.2142857</td>
<td>43.5447225</td>
<td>258.0000000</td>
<td>390.5000000</td>
</tr>
<tr>
<td>FNERR</td>
<td>14</td>
<td>14654.44</td>
<td>9912.12</td>
<td>2008.65</td>
<td>32462.84</td>
</tr>
<tr>
<td>FNERG</td>
<td>14</td>
<td>1819.48</td>
<td>119.1415691</td>
<td>1676.29</td>
<td>2032.23</td>
</tr>
<tr>
<td>FNRED</td>
<td>14</td>
<td>592.0057143</td>
<td>369.7023526</td>
<td>216.1100000</td>
<td>1432.60</td>
</tr>
<tr>
<td>FNERES</td>
<td>14</td>
<td>1227.47</td>
<td>342.4663414</td>
<td>409.1300000</td>
<td>1608.85</td>
</tr>
<tr>
<td>FNPREDT</td>
<td>14</td>
<td>32.2107143</td>
<td>19.3308098</td>
<td>12.0000000</td>
<td>77.7900000</td>
</tr>
<tr>
<td>FNOAMD</td>
<td>14</td>
<td>347.5107143</td>
<td>267.8133500</td>
<td>119.7700000</td>
<td>1036.56</td>
</tr>
<tr>
<td>FNTRMD</td>
<td>14</td>
<td>233.6628571</td>
<td>39.3861243</td>
<td>163.7800000</td>
<td>316.1500000</td>
</tr>
<tr>
<td>FNWRMD</td>
<td>14</td>
<td>426.0671429</td>
<td>261.2224201</td>
<td>168.4100000</td>
<td>1006.00</td>
</tr>
<tr>
<td>Q1</td>
<td>14</td>
<td>53.2142857</td>
<td>10.6711586</td>
<td>35.0000000</td>
<td>70.0000000</td>
</tr>
<tr>
<td>Q2</td>
<td>14</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Q3</td>
<td>14</td>
<td>46.7857143</td>
<td>10.6711586</td>
<td>30.0000000</td>
<td>65.0000000</td>
</tr>
<tr>
<td>Q4</td>
<td>14</td>
<td>7.8571429</td>
<td>1.7913099</td>
<td>3.0000000</td>
<td>9.0000000</td>
</tr>
<tr>
<td>Q5</td>
<td>14</td>
<td>4.7857143</td>
<td>3.2623392</td>
<td>1.0000000</td>
<td>9.0000000</td>
</tr>
<tr>
<td>Q6</td>
<td>14</td>
<td>7.6428571</td>
<td>2.0232193</td>
<td>3.0000000</td>
<td>9.0000000</td>
</tr>
<tr>
<td>Q7</td>
<td>14</td>
<td>0.9285714</td>
<td>0.2672612</td>
<td>0</td>
<td>1.0000000</td>
</tr>
<tr>
<td>Q8</td>
<td>14</td>
<td>0.9285714</td>
<td>0.2672612</td>
<td>0</td>
<td>1.0000000</td>
</tr>
<tr>
<td>Q9</td>
<td>14</td>
<td>0.7142857</td>
<td>0.4688072</td>
<td>0</td>
<td>1.0000000</td>
</tr>
<tr>
<td>Q10</td>
<td>14</td>
<td>0.6428571</td>
<td>0.4972452</td>
<td>0</td>
<td>1.0000000</td>
</tr>
<tr>
<td>Q11</td>
<td>14</td>
<td>0.5000000</td>
<td>0.5188745</td>
<td>0</td>
<td>1.0000000</td>
</tr>
<tr>
<td>Q12</td>
<td>14</td>
<td>0.3571429</td>
<td>0.4972452</td>
<td>0</td>
<td>1.0000000</td>
</tr>
<tr>
<td>Q13</td>
<td>14</td>
<td>0.2857143</td>
<td>0.4688072</td>
<td>0</td>
<td>1.0000000</td>
</tr>
<tr>
<td>Q14</td>
<td>14</td>
<td>5.2142857</td>
<td>3.5772480</td>
<td>0</td>
<td>9.0000000</td>
</tr>
<tr>
<td>Q15</td>
<td>14</td>
<td>6.7142857</td>
<td>1.8156826</td>
<td>4.0000000</td>
<td>9.0000000</td>
</tr>
<tr>
<td>Q16</td>
<td>14</td>
<td>7.8571429</td>
<td>1.1673206</td>
<td>5.0000000</td>
<td>9.0000000</td>
</tr>
<tr>
<td>Q17</td>
<td>14</td>
<td>8.0714286</td>
<td>1.3847680</td>
<td>4.0000000</td>
<td>9.0000000</td>
</tr>
<tr>
<td>Q18</td>
<td>14</td>
<td>8.2857143</td>
<td>1.4373358</td>
<td>4.0000000</td>
<td>9.0000000</td>
</tr>
<tr>
<td>Q20</td>
<td>14</td>
<td>34.5000000</td>
<td>5.3601091</td>
<td>28.0000000</td>
<td>44.0000000</td>
</tr>
<tr>
<td>Q22</td>
<td>14</td>
<td>12.6071429</td>
<td>6.1022649</td>
<td>6.0000000</td>
<td>26.0000000</td>
</tr>
<tr>
<td>Q23</td>
<td>14</td>
<td>10.8214286</td>
<td>5.4688177</td>
<td>6.0000000</td>
<td>23.0000000</td>
</tr>
<tr>
<td>Q24</td>
<td>14</td>
<td>7.3571429</td>
<td>1.7805420</td>
<td>3.0000000</td>
<td>9.0000000</td>
</tr>
<tr>
<td>Q25</td>
<td>14</td>
<td>15.7857143</td>
<td>12.0203582</td>
<td>2.0000000</td>
<td>50.0000000</td>
</tr>
</tbody>
</table>

------------------------------------------------- PROJECT=A RISKTYPE=U
-------------------------------------------------

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>Mean</th>
<th>Std Dev</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>FNCOST</td>
<td>15</td>
<td>3333.66</td>
<td>733.0443938</td>
<td>2468.45</td>
<td>4895.83</td>
</tr>
<tr>
<td>FNSKED</td>
<td>15</td>
<td>339.1555556</td>
<td>54.8975766</td>
<td>247.5416667</td>
<td>451.7500000</td>
</tr>
</tbody>
</table>

93
<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>Mean</th>
<th>Std Dev</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>FNCOST</td>
<td>12</td>
<td>2667.01</td>
<td>425.9057526</td>
<td>1705.57</td>
<td>3299.61</td>
</tr>
<tr>
<td>FNSKEA</td>
<td>12</td>
<td>274.6428571</td>
<td>47.4928566</td>
<td>206.5714286</td>
<td>383.5714286</td>
</tr>
<tr>
<td>FNERR</td>
<td>12</td>
<td>11559.47</td>
<td>8144.78</td>
<td>2170.06</td>
<td>31597.91</td>
</tr>
<tr>
<td>FNERG</td>
<td>12</td>
<td>1711.85</td>
<td>119.6097295</td>
<td>1635.10</td>
<td>1997.45</td>
</tr>
<tr>
<td>FNERD</td>
<td>12</td>
<td>576.1850000</td>
<td>218.4170454</td>
<td>0</td>
<td>925.7500000</td>
</tr>
<tr>
<td>FNERES</td>
<td>12</td>
<td>1135.66</td>
<td>267.6175064</td>
<td>709.3500000</td>
<td>1737.02</td>
</tr>
<tr>
<td>FNPROT</td>
<td>12</td>
<td>33.9508333</td>
<td>13.4710818</td>
<td>0</td>
<td>56.6200000</td>
</tr>
<tr>
<td>FNPQMD</td>
<td>12</td>
<td>340.0333333</td>
<td>140.0635348</td>
<td>0</td>
<td>594.1300000</td>
</tr>
<tr>
<td>FNTRMD</td>
<td>12</td>
<td>262.0550000</td>
<td>44.6549005</td>
<td>184.1100000</td>
<td>327.1300000</td>
</tr>
<tr>
<td>FNRWMD</td>
<td>12</td>
<td>465.0475000</td>
<td>189.0080956</td>
<td>0</td>
<td>788.1800000</td>
</tr>
<tr>
<td>Q1</td>
<td>12</td>
<td>56.6666667</td>
<td>11.5470054</td>
<td>40.0000000</td>
<td>80.0000000</td>
</tr>
<tr>
<td>Q2</td>
<td>12</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Q3</td>
<td>12</td>
<td>43.3333333</td>
<td>11.5470054</td>
<td>20.0000000</td>
<td>60.0000000</td>
</tr>
<tr>
<td>Q4</td>
<td>12</td>
<td>8.0000000</td>
<td>1.7056057</td>
<td>3.0000000</td>
<td>9.0000000</td>
</tr>
<tr>
<td>Q5</td>
<td>12</td>
<td>4.9166667</td>
<td>2.4664414</td>
<td>1.0000000</td>
<td>9.0000000</td>
</tr>
<tr>
<td>Q6</td>
<td>12</td>
<td>8.4166667</td>
<td>0.7929615</td>
<td>7.0000000</td>
<td>9.0000000</td>
</tr>
<tr>
<td>Q7</td>
<td>12</td>
<td>1.0000000</td>
<td>0</td>
<td>1.0000000</td>
<td>1.0000000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Q8</td>
<td>12</td>
<td>0.9166667</td>
<td>0.2886751</td>
<td>0</td>
<td>1.0000000</td>
</tr>
<tr>
<td>Q9</td>
<td>12</td>
<td>0.8333333</td>
<td>0.3892495</td>
<td>0</td>
<td>1.0000000</td>
</tr>
<tr>
<td>Q10</td>
<td>12</td>
<td>0.6666667</td>
<td>0.4923660</td>
<td>0</td>
<td>1.0000000</td>
</tr>
<tr>
<td>Q11</td>
<td>12</td>
<td>0.5000000</td>
<td>0.5222330</td>
<td>0</td>
<td>1.0000000</td>
</tr>
<tr>
<td>Q12</td>
<td>12</td>
<td>0.2500000</td>
<td>0.4522670</td>
<td>0</td>
<td>1.0000000</td>
</tr>
<tr>
<td>Q13</td>
<td>12</td>
<td>0.3333333</td>
<td>0.4923660</td>
<td>0</td>
<td>1.0000000</td>
</tr>
<tr>
<td>Q14</td>
<td>12</td>
<td>0.7500000</td>
<td>2.5980762</td>
<td>0</td>
<td>9.0000000</td>
</tr>
<tr>
<td>Q15</td>
<td>12</td>
<td>8.0833333</td>
<td>1.3113722</td>
<td>5.0000000</td>
<td>9.0000000</td>
</tr>
<tr>
<td>Q16</td>
<td>12</td>
<td>8.4166667</td>
<td>0.7929615</td>
<td>7.0000000</td>
<td>9.0000000</td>
</tr>
<tr>
<td>Q17</td>
<td>12</td>
<td>8.3333333</td>
<td>0.9847319</td>
<td>6.0000000</td>
<td>9.0000000</td>
</tr>
<tr>
<td>Q18</td>
<td>12</td>
<td>7.9166667</td>
<td>1.4433757</td>
<td>4.0000000</td>
<td>9.0000000</td>
</tr>
<tr>
<td>Q19</td>
<td>12</td>
<td>32.8333333</td>
<td>3.2983008</td>
<td>28.0000000</td>
<td>39.0000000</td>
</tr>
<tr>
<td>Q20</td>
<td>12</td>
<td>10.8333333</td>
<td>3.8356627</td>
<td>7.0000000</td>
<td>20.0000000</td>
</tr>
<tr>
<td>Q21</td>
<td>12</td>
<td>9.4166667</td>
<td>2.9682664</td>
<td>6.0000000</td>
<td>16.0000000</td>
</tr>
<tr>
<td>Q22</td>
<td>12</td>
<td>6.5000000</td>
<td>1.1677484</td>
<td>4.0000000</td>
<td>8.0000000</td>
</tr>
<tr>
<td>Q23</td>
<td>12</td>
<td>20.6666667</td>
<td>7.7146064</td>
<td>15.0000000</td>
<td>40.0000000</td>
</tr>
</tbody>
</table>

Risk experiment: Comparison of performance
1995

12:21 Tuesday, July 25,

General Linear Models Procedure
Class Level Information

Class Levels Values
RISKTYPE 3 C R U

Number of observations in data set = 41

Risk experiment: Comparison of performance
1995

12:21 Tuesday, July 25,

General Linear Models Procedure
Dependent Variable: FNCOST

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>2</td>
<td>3047055.74</td>
<td>1523527.87</td>
<td>4.42</td>
<td></td>
</tr>
<tr>
<td>Error</td>
<td>38</td>
<td>13084187.33</td>
<td>344320.72</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>40</td>
<td>16131243.07</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Mean

R-Square | C.V. | Root MSE | FNCOST
---------|------|----------|---------|
0.188892 | 19.52887 | 586.788 | 3004.72 |

Source | DF | Type I SS | Mean Square | F Value | Pr > F |
---------|----|----------|-------------|---------|--------|
         |    |          |             |         |        |
### General Linear Models Procedure

**Dependent Variable: FNSKED**

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Type III SS</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>2</td>
<td>27746.5886</td>
<td>13873.2943</td>
<td>5.75</td>
<td></td>
</tr>
<tr>
<td>Error</td>
<td>38</td>
<td>91653.5577</td>
<td>2411.9357</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>40</td>
<td>119400.1463</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mean</th>
<th>R-Square</th>
<th>C.V.</th>
<th>Root MSE</th>
<th>FNSKED</th>
</tr>
</thead>
<tbody>
<tr>
<td>310.391</td>
<td>0.232383</td>
<td>15.82243</td>
<td>49.1115</td>
<td></td>
</tr>
</tbody>
</table>

### General Linear Models Procedure

**Dependent Variable: FNERR**

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Type III SS</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>2</td>
<td>62232814.9</td>
<td>31116407.4</td>
<td>0.33</td>
<td></td>
</tr>
</tbody>
</table>

12:21 Tuesday, July 25, 1995
<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Type I SS</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>RISKTYPE</td>
<td>2</td>
<td>62232814.9</td>
<td>31116407.4</td>
<td>0.33</td>
<td></td>
</tr>
<tr>
<td>Source</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RISKTYPE</td>
<td>2</td>
<td>62232814.9</td>
<td>31116407.4</td>
<td>0.33</td>
<td></td>
</tr>
</tbody>
</table>

0.7182

Error 38 3541740642.9 93203701.1
Corrected Total 40 3603973457.7

<table>
<thead>
<tr>
<th>Mean</th>
<th>R-Square</th>
<th>C.V.</th>
<th>Root MSE</th>
<th>FNERR</th>
</tr>
</thead>
<tbody>
<tr>
<td>13295.0</td>
<td>0.017268</td>
<td>72.61508</td>
<td>9654.21</td>
<td></td>
</tr>
</tbody>
</table>

97
LIST OF REFERENCES


<table>
<thead>
<tr>
<th>No.</th>
<th>Initial Distribution List</th>
</tr>
</thead>
</table>
| 1.  | Defense Technical Information Center  
Cameron Station  
Alexandria, Virginia 22304-6145 |
| 2.  | Library, Code 52  
Naval Postgraduate School  
Monterey, California 93943-5101 |
| 3.  | Dr. Tarek K. Abdel-Hamid, Code SM/AH  
Department of Systems Management  
Naval Postgraduate School  
Monterey, California 93943-5000 |
| 4.  | Dr. Kishore Sengupta, Code SM/SE  
Department of Systems Management  
Naval Postgraduate School  
Monterey, California 93943-5000 |
| 5.  | Curricular Officer, Code 36  
Department of Systems Management  
Naval Postgraduate School  
Monterey, California 93943-5000 |
| 6.  | Kimberly S. Russ  
3051 Montevideo Drive  
San Ramon, California 94583 |