Virtual Software Project Dynamics: The Human Resource Management Sector

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ABSTRACT

Virtual teams are fast becoming the norm in organizations and strategies are needed to deal with the new challenges that they create. Software Project Dynamics is a field of research that uses system dynamics simulation to explore software engineering issues. The objective of this research effort was to enhance systematically the understanding of virtual software engineering by using the system dynamics methodology and existing software project dynamic models. To accomplish the research objective, the following tasks were accomplished: First, an extensive literature review was done. Second, a Software Project Dynamics model was reproduced. Third, the model was used as an experimentation vehicle. This paper suggests that system dynamics is a viable tool in the exploration of virtual software engineering challenges. A new field of research is recommended to deal with additional challenges of virtual software project teams by using system dynamics with the proposed name: ***Virtual Software Project Dynamics.***

Keywords: Virtual Teams, System Dynamics, Software Engineering, Software Project Dynamics, Software Project Management

INTRODUCTION

"Virtual teams are fast becoming more the rule than the exception in organizations. It's time to stop thinking of them as a special case and start developing strategies for dealing with the new challenges they create." (Kimball 1997)

1.1 Research Overview

"Virtual Teams are groups of people who find themselves separated by distance and time, yet have common tasks to perform. There are many types of virtual teams and some jobs are more appropriate and adaptable to a virtual working solution than others. Software Project Teams can work well in the virtual team environment, primarily because they are comfortable using information technology for everyday communications." (Edwards and Wilson 2004) Virtual teams create many challenges (Kimball 1997; Lipnack and Stamps 2000; Edwards and Wilson 2004). The research in this article attempts, by using system dynamics, to enhance systematically the understanding of human resource management in virtual software project teams.

1.2 Research Problem Overview

"Information technology is providing the infrastructure necessary to support the development of new organizational forms. Virtual teams represent one such organizational form, one that could revolutionize the workplace and provide organizations with unprecedented levels of flexibility and responsiveness.

As the technological infrastructure necessary to support virtual teams is now readily available, further research on the range of issues surrounding virtual teams is required if we are to learn how to manage them effectively. While the findings of team research in the traditional environment may provide useful pointers, the idiosyncratic structural and contextual issues surrounding virtual teams call for specific research attention." (Powell, Piccoli et al. 2004)

Successful software development is becoming increasingly important as software is being used in systems that may threaten life, health, national security, the environment, and the economy (Vecellio and Thomas 2001), yet, the record shows that the software industry has been marked by cost overruns, late deliveries, poor reliability, and user dissatisfaction (Abdel-Hamid 1989). Considerable progress has been made in addressing issues relevant to the *technology* of software production. A comparable evolution in *management* methodologies has not occurred (Abdel-Hamid and Madnick 1991).

"Managerial systems contain as many as 100 or more variables that are known to be relevant and believed to be related to one another in various nonlinear fashions. The behavior of such a system is complex far beyond the capacity of intuition. Computer simulation is one of the most effective means available for supplementing and correcting human intuition." (Abdel-Hamid and Madnick 1991) At the same time, "as the use of virtual teams in organizations becomes more and more widespread, there is a need for rigorous research investigating the dynamics of this novel organization structure." (Piccoli, Powell et al. 2004)

1.3 What has been done before?

In the book, *Software Project Dynamics an Integrated Approach* (Abdel-Hamid and Madnick 1991), an integrated model of the software development process was developed. Over 100 individual but interdependent phenomena were identified and represented using the system dynamics modeling notation. The integrated model increased the understanding of and enabled the prediction about the management of software development and established the viability of the system dynamics methodology as an effective research vehicle. The model has been widely endorsed in the literature (Cited by 228 at the Google Scholar database).

The model was divided into four major areas of software project management:

1. Human Resource Management
2. Software Production
3. Project Control
4. Project Planning

1.4 Research Contributions and Methodology

"Truly virtual organizations create new problems for human resource management. Its core management must be adept in managing people at a distance." (Mabey and Thomson 1994)

The objective of this research effort was to enhance systematically the understanding of *virtual* software engineering by using the system dynamics methodology and existing software project dynamics models. To accomplish the research objective, the following tasks were accomplished:

First, an extensive literature review was done to gain insight into virtual software project teams. Second, a Software Project Dynamics model was reproduced using *iThink* software. Third, the model was used as an experimentation vehicle to study the dynamic implications of virtual teams.

The scope of the research was limited to the Human Resource Management Sector of the original Software Project Dynamics simulation model.

1.5 Organization

This article is divided into five sections. The first section serves as an introduction and presents an overview of the research problem and expected contributions. Section two provides a literature review which includes background material on system dynamics, software engineering, software project dynamics, virtual teams and human resource management. Section three focuses on the reformulation of the human resource management sector of the model developed in the book, *Software Project Dynamics an Integrated Approach*, to include considerations for virtual software project teams by using the system dynamics methodology. Section four provides an analysis of the model developed in chapter three using a series of experiments. The final section concludes this article with a summary of findings and suggestions for further investigation.

2 LITERATURE REVIEW

Before exploring what factors impact the dynamics of human resource management in virtual software project teams several key concepts must be defined. First, it is necessary to clarify what *system dynamics* is and how it has been used to increase the understanding of software engineering. Then, a review of the literature on the field of *software project dynamics* is required. Next, it is necessary to define *virtual teams*. It is also essential to specify what traits constitute *human resource management* for the purposes of this investigation. Finally, with an understanding of system dynamics, software project dynamics, virtual teams, and human resource management, we can continue on to the next section to reformulate the original software project dynamics model using the system dynamics methodology.

2.1 System Dynamics

"System Dynamics deals with how things change through time, which includes most of what most people find important. It uses computer simulation to take the knowledge we already have about details in the world around us to show why our social and physical systems behave the way they do. System Dynamics demonstrates how most of our own decision-making policies are the cause of the problems that we usually blame on others, and how to identify policies we can follow to improve our situation."

-Jay Forrester, Professor of Management, Emeritus and Senior Lecturer, Sloan School, Massachusetts Institute of Technology; Founder, System Dynamics (WPI 2005)

There are several other similar definitions for system dynamics. One basic definition states that: "System dynamics is a **methodology** used to understand how systems change over time. In the field of system dynamics, a system is defined as a collection of elements that continually interact over time to form a unified whole. The term dynamics refers to change over time." (Martin 1997)

System Dynamics modeling was developed in the late 1950's at the Massachusetts Institute of Technology by Jay Forrester (Collofello, Rus et al. 1998). In a Banquet Talk at the international meeting of the System Dynamics Society in Germany, Jay Forrester described the birth of system dynamics as:

"After talking with them about how they made hiring and inventory decisions, I started to do some simulation. This was simulation using pencil and paper on one notebook page. It started at the top with columns for inventories, employees, and orders. Given these conditions and the policies they were following, one could decide how many people would be hired in the following week. This gave a new condition of employment, inventories, and production. It became evident that here was potential for an oscillatory or unstable system that was entirely internally determined. Even with constant incoming orders, one could get employment instability as a consequence of commonly used decision-making policies. The first inventory control system with pencil and paper simulation was the beginning of system dynamics." (Forrester 1989)

For additional information and definitions on System Dynamics please refer to the System Dynamics Society at www.systemdynamics.org.

2.2 Software Project Dynamics

Software Project Dynamics is a field of research that uses system dynamics simulation to explore software engineering issues (Madachy 1994). System Dynamics was applied to the software development process for the first time by Tarek Abdel-Hamid (Abdel-Hamid 1984). As Collofello et al described the model, “it was the starting point for many subsequent models of the entire process, or parts of it that have been successfully used for resource management, process reengineering, project planning, and training.” (Collofello, Rus et al. 1998) There are two main characteristics of this original model: The first characteristic is that it is an integrative model. The second characteristic is that it is a system dynamics model.

The model was divided into four major sectors: human resource management, software production, controlling, and planning (Abdel-Hamid and Madnick 1991). The *Human Resource Management Sector* includes hiring, training, assimilation, and transferring a project’s human resources. The *Software Production* Sector is described as the major activity in the software development project and includes four activities: development, quality assurance, rework, and system testing. The *Controlling Sector* includes measurement, evaluation and communication of the project status. In the *Planning Sector* the initial project estimates are made to start the project, and then those estimates are revised as necessary throughout the project’s life. The model was presented and fully described in the book *Software Project Dynamics an Integrated Approach.* Please refer to the book for a full description and illustrations of the model.

2.3 Virtual Teams

"In a whisper of time, the predictions of futurists have become front page news. Work as we have known it for centuries is obsolete. If you participate in teleconferences, communicate via e-mail, or share information with colleagues on web sites, you work virtually." (Lipnack and Stamps 2000)

Teams are groups of people who share a common task (Lurey 1998). Virtual teams can be defined as teams that find themselves separated by distance and time, yet have common tasks to perform (Edwards and Wilson 2004).

Virtual teams provide several advantages in an increasingly global market. They are extremely flexible (Armstrong and Cole 1995; Edwards and Wilson 2004), provide rapid development of products (Armstrong and Cole 1995), and can reduce organization costs (Jang 2003).

While virtual teams provide the benefits mentioned above they also bring many challenges. Some of these challenges are human resource management (Mabey and Thomson 1994), geographical distance (Kimble, Li et al. 2000; Walters 2004), cultural and language boundaries (Rad and Levin 2003), trust (Gundry 2000; Tocci 2003), leadership (Gould 1997), and technology issues (Edwards and Wilson 2004).

This research attempts to enhance systematically the understanding of human resource management challenges in virtual software project development teams by using the system dynamics methodology.

2.4 Human Resource Management

"Project Human Resource Management includes the processes required to make the most effective use of the people involved with the project." (PMI 2000) As stated above, the human resource management sector is one of the four major sectors of the original software project dynamics model. This research extends this sector to include considerations for virtual teams. The figure below displays the human resource management sector:

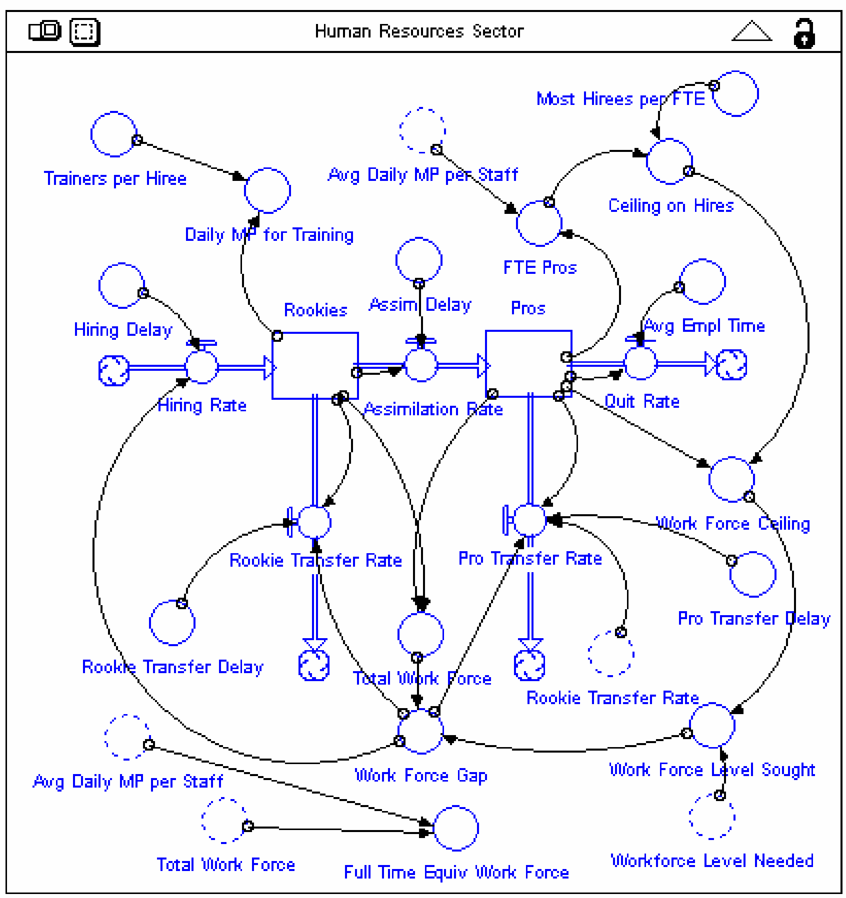

Figure 1 – Human Resource Management Sector

3 Model Development

The system dynamics methodology that was used in this research was extracted from the book *Business Dynamics* (Sterman 2000). The process is as follows:

1. Problem Articulation
2. Formulation of Dynamic Hypothesis
3. Formulation of a Simulation Model
4. Testing
5. Policy Design and Evaluation

3.1 Problem Articulation

"The most important step in modeling is problem articulation. What is the real problem, not just the symptom of difficulty?" (Sterman 2000) Section 1 of this article introduced the problem. This section will reiterate the main problem and state a clear purpose for the model.

There are many problems and challenges involved in the software development process (Abdel-Hamid and Madnick 1991; Collofello, Rus et al. 1998; Pressman 2005). Abdel-Hamid and Madnick, 1991, established the viability of the system dynamics methodology as an effective research vehicle for understanding the problems with the software development process. Mabey and Thomson, 1994, stated that virtual organizations create new problems for human resource management. The model in this article will address specific human resource management problems of virtual organizations in software project teams using the system dynamics methodology.

3.2 Formulation of Dynamic Hypothesis

"Once the problem has been identified and characterized over an appropriate time horizon, modelers must develop a theory, called a dynamic hypothesis, to account for the problematic behavior. A dynamic hypothesis is a working theory of how the problem arose." (Sterman 2000)

In dynamic environments typified by virtual software projects, the authors expect that:

H1: Shorter *"Average Daily Manpower Per Staff Member"* in virtual teams as they are "assembled and dissembled according to need" (Lipnack and Stamps 2000) and "often consist of inter-organizational participants." (Wong and Burton 2000)

H2: A shorter *"Hiring Delay"* in virtual teams compared to traditional software project teams because the virtual workforce is not limited by geographic boundaries and "transcends towns, states, countries, and continents." (Igbaria, Shayo et al. 1999)

H3: Longer *"Average Employment Time"* due to increased employee satisfaction because virtual teams "exhibit more open boundaries, flexible role structures, and self managing qualities." (Bemmel and Essens 2005)

H4: Less *"Training Overhead"* by experienced workforce because virtual software project teams are more likely to use internet-based e-learning services that "can make training programs more accessible for participants from different world regions, and may support the transfer of experiences and best practices." (Munkvold 2005)

H5: Longer *"Average Assimilation Delay"* in virtual software project teams than in traditional teams because of the added complexity of working in a virtual environment.

3.3 Formulation of Simulation Model

"Once you've developed an initial dynamic hypothesis, model boundary, and conceptual model, you must test them. Sometimes you can test the dynamic hypothesis directly through data collection or experiments in the real system. Most of the time, however, the conceptual model is so complex that its dynamic implications are unclear. Our ability to infer correctly the dynamics of a complex model is extremely poor. Further, in many situations, especially human systems, it is difficult, dangerous, unethical, or simply impossible to conduct the real world experiments that might reveal flaws in a dynamic hypothesis. In the majority of cases, you must conduct these experiments in a virtual world. To do so, you must move from the conceptual realm of diagrams to a fully specified formal model, complete with equations, parameters, and initial conditions." (Sterman 2000)

The original model was presented in Section 2. The model reformulation is described in the sections that follow.

3.3.1 Model Reformulation Method

A methodical literature review was done to reformulate the variables in the Human Resource Management Sector of the original Software Project Dynamics Model to deal with virtual teams. The following variables were analyzed:

1. Average Daily Manpower Per Staff Member
2. Hiring Delay
3. Average Employment Time
4. Training Overhead

5. Average Assimilation Delay

The following databases were searched for relevant scholarly articles and dissertations:

1. Academic Search Premier
2. ProQuest Research Library Plus
3. Gelman Library Dissertation Express
4. Google Scholar

The first three databases are provided by the Gelman Library of The George Washington University. “Google Scholar provides a simple way to broadly search for scholarly literature. From one place, you can search across many disciplines and sources: peer-reviewed papers, theses, books, abstracts and articles, from academic publishers, professional societies, preprint repositories, universities and other scholarly organizations. Google Scholar helps you identify the most relevant research across the world of scholarly research.” (Google 2005)

Results in Academic Search Premier were limited to “Academic Journals”. Results in ProQuest Research Library Plus were limited to “Scholarly journals, including peer reviewed”.

Results in the Gelman Library Dissertation Express database were limited to Doctoral Dissertations. Results in the Google Scholar database were limited to “Search only in Engineering, Computer Science, and Mathematics” and were only used when less than 10 articles or dissertations appeared in the above three databases.

A total of 68 publications were reviewed for relevant information (some publications showed up in more than one search criteria). The total results reviewed for each variable are as follows:

Average Daily Manpower per Staff	11
Hiring Delay	21
Training Overhead	11
Average Assimilation Delay	19
Average Employment Time	17

Table 1 – Literature Review Results by variable

3.3.2 Model Reformulation Results

For Hypothesis 1, shorter average daily manpower per staff, the articles reviewed suggest that virtual team members may; serve on "multiple virtual teams simultaneously" (Balthazard, Waldman et al. 2004), be part of separate organizations than other members (Lin and Lin 2001), be brought into the project temporarily (Osterlund 1996; Baroff 2002; Balthazard, Potter et al. 2004; Bemmel and Essens 2005) "as specialists providing competence resources required to solve specific problems." (Osterlund 1996) Based on this research, **Hypothesis 1 is supported.**

For Hypothesis 2, shorter hiring delay, the articles reviewed state that "virtual teams make it easier to bring together a more diverse group of skills, experiences, and knowledge about customers, supplier contacts, and interests that would otherwise be possible" (Luecke 2004) and that "team members can bring their differing expertise to bear on pressing problems from any geographic location, collaborating via network supported groupware of various types” (Balthazard, Potter et al. 2004). Research indicates that virtual teams make it easier to bring together a diverse group of skills by elimination barriers caused by geographic location. Based on this research, **Hypothesis 2 is supported.**

For Hypothesis 3, longer average employment time, surprisingly for the author the articles reviewed suggest *less* satisfaction in virtual teams compared to traditional teams (Anderson 2000; Pawlowicz 2003; Peters 2003; Redman and Sankar 2003; Whitman, Malzahn et al. 2005). **Hypothesis 3 is *not* supported.**

For Hypothesis 4, less training overhead, the articles reviewed suggest that although there is a great opportunity for creating “less training overhead” by providing media (internet, intranet, cd-rom, etc) for self training (Larsen and McInerney 2002), which virtual team members are more inclined to use than traditional team members, further research is needed to maximize this opportunity (Joy-Matthews and Gladstone 2000; Kring 2004). **Hypothesis 4 is *not* supported.**

For Hypothesis 5, longer average assimilation delay, research indicates that managers should plan for longer assimilation delays in virtual teams compared to traditional teams (Vick 1998; Barker 2000; Gallivan 2001; Kishore and McLean 2002; Lyytinen and Yoo 2002; MacGregor 2002; Newman, Daniels et al. 2003; Bodker, Pors et al. 2004), although, there is opportunity to reduce this time by implementing “systems that support expertise sharing” (Tiwana and Bush 2005). **Hypothesis 5 is supported.**

3.4 Testing

"Testing begins as soon as you write the first equation. Part of testing, of course, is comparing the simulated behavior of the model to the actual behavior of the system." (Sterman 2000)

The model developed by Abdel-Hamid and Madnick has been tested and retested for several situations. Google Scholar shows the book, *Software Project Dynamics an Integrated Approach,* as being cited by 228 scholarly articles. This article does not change the underlying, tested, formula for the system dynamics model developed in that book.

The model was originally developed using the *Dynamo* software. For this research, the simulation model has been recreated using the new and more popular software *iThink*. The EXAMPLE software project described in *Software Project Dynamics an Integrated Approach* was used. The author's describe the project by stating that: "EXAMPLE is a prototype project for the experiments. We run the model to simulate the EXAMPLE project and observe and analyze the behavior of several significant project variables. Our goal is to demonstrate that the model's behavior replicate those reported in the literature. The EXAMPLE project parameters were used to study the implications of an array of managerial actions, policies, and procedures about software development." (Abdel-Hamid and Madnick 1991)

The validity of the recreated simulation model was verified comparing four key measures of progress depicted for the EXAMPLE software project. These measures were: perceived job size, scheduled completion date, tasks developed, and cumulative man days expended. The *iThink* model was able to reproduce the original *Dynamo* model as displayed in the figure below:

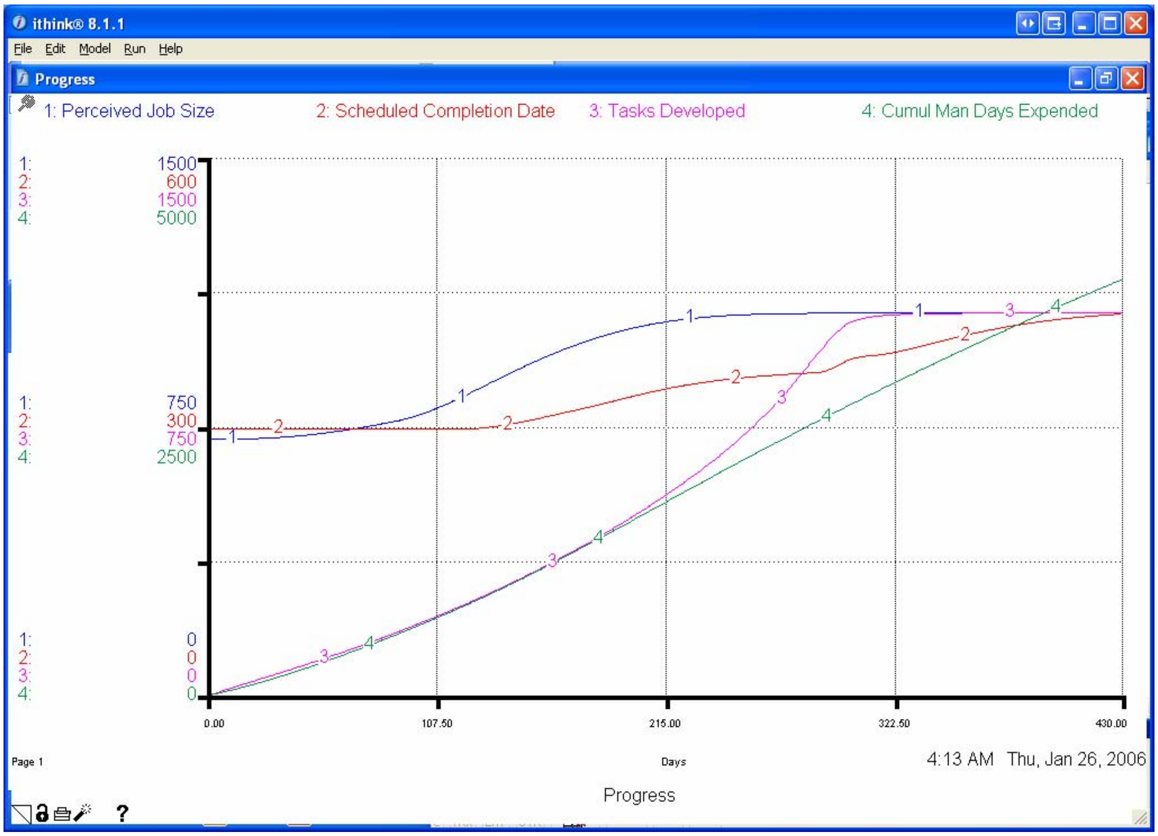

Figure 2 – Progress Measures of the EXAMPLE Software Project

3.5 Policy Design and Evaluation

"Once the model has been developed with confidence in the structure and behavior of the model, you can use it to design and evaluate policies for improvement." (Sterman 2000). Section Four, below, portrays this part of the method.

4 Analysis

"*One advantage of system dynamics modeling is that it allows us not only to generate the dynamic implications of a given set of policies but to explore the implications of new and different sets of managerial policies and procedures*." (Abdel-Hamid and Madnick 1991) The EXAMPLE simulation presented above will be used as an experimentation vehicle to explore the dynamic implications of virtual software project teams.

Let us ask some "what-if" questions the EXAMPLE Software Project's management might ponder:

1. What if a virtual team was used? What would happen to the perceived job size, scheduled completion date, tasks developed and cumulative man days expended?
2. What if a virtual team was used *and* an investment was made to reduce training overhead and average assimilation delay by providing systems that support expertise sharing and self training? Are the benefits worth the investment?

4.1 What if Scenario 1

Section Three presented five hypotheses statement that were either supported or not based on an extensive methodical literature review. The research suggested whether specific model variables were greater or lesser but did not give a specific value. For purposes of this investigation each variable will be given a 25% greater or lesser value based on the research findings. The model will then be run and progress measurements will be compared between both scenarios.

Values for the variables are depicted in the table below:

Variable Name	Original Value	Virtual Team Value +- 25%
Average Daily Manpower per Staff	1	.75
Hiring Delay	40	30
Average Employment Time	673	504.75
Training Overhead	0.2	0.25
Average Assimilation Delay	80	100

Table 2 – Original vs. *What- if Scenario 1* Variable Values

Progress measurements for *What-if Scenario 1* are depicted in the figure below:

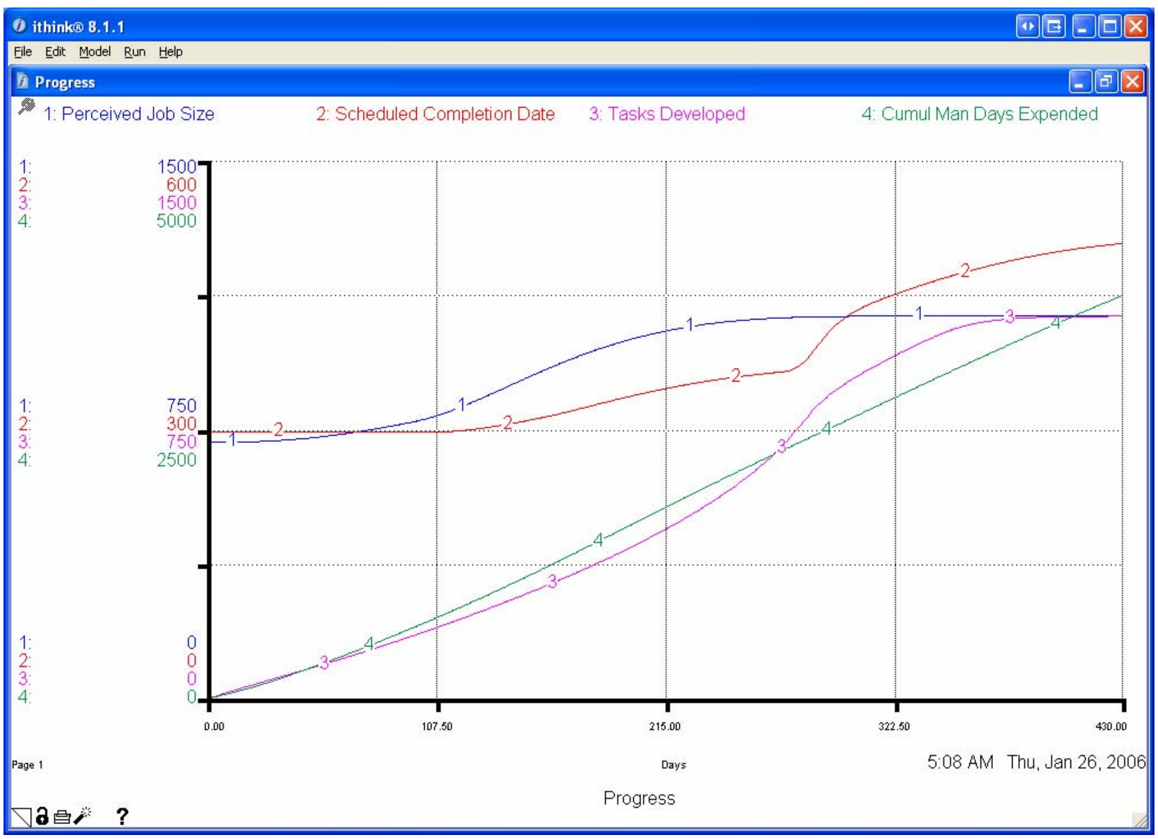

Figure 3 – Progress Measures for *What- if Scenario 1*

The final progress measurement of the original EXAMPLE model and those of *What-if Scenario 1* are compared in the table below:

Measure of Progress	**Original EXAMPLE Model Final Value**	**What if Scenario 1 Final Value**
Perceived Job Size	1067	1067
Scheduled Completion Date	427	508
Tasks Developed	1067	1066
Cumulative Man Days Expended	3864	3744

Table 3 – Original vs. *What-if Scenario 1* Progress Measurements

The simulation run suggests that perceived job size and tasks developed would basically remain the same, scheduled completion date would be greater, and cumulative man days expended would be less. Specifically, the EXAMPLE Software would take 81 days longer to produce but would cost 120 man days less.

4.2 What if Scenario 2

In *What-if Scenario 2* the values of *What-if Scenario 1* will be modified to simulate an investment in a theoretical *Knowledge Management System*. The system developers claim that the system will reduce training overhead and shorten assimilation delay in virtual teams to at least the same values as a co-located team by providing expert sharing mechanisms and self training tools. Values for the variables in both scenarios are depicted in the table below:

Variable Name	What-if Scenario 1	What-if Scenario 2
Average Daily Manpower per Staff	.75	.75
Hiring Delay	30	30
Average Employment Time	504.75	504.75
Training Overhead	0.25	0.2
Average Assimilation Delay	100	80

Table 4 – *What-if Scenario 1* vs. *What-if Scenario 2* Variable Values

Progress measurements for *What-if Scenario 2* are depicted in the figure below:

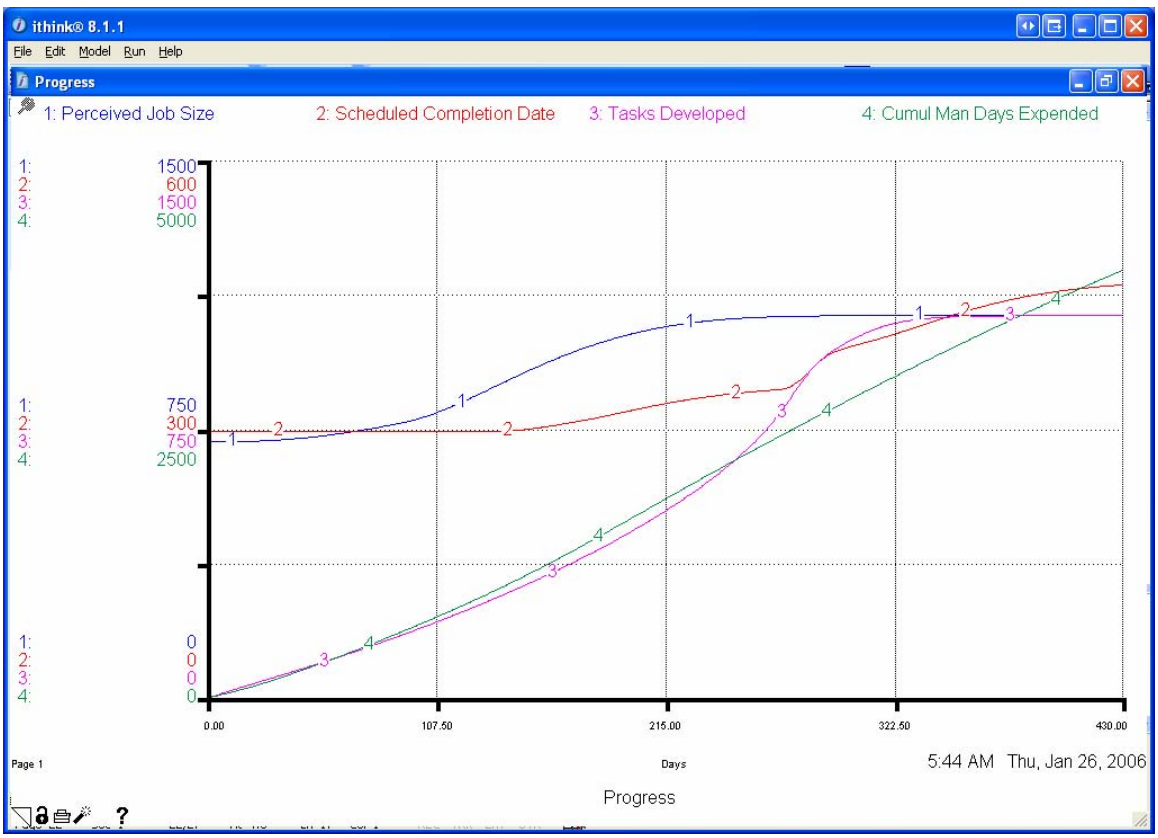

Figure 4 – Progress Measures for *What-if Scenario 2*

The final progress measurement of *What-if Scenario 1* and those of *What-if Scenario 2* are compared in the table below:

Measure of Progress	**What-if Scenario 1 Final Value**	**What if Scenario 2 Final Value**
Perceived Job Size	1067	1067
Scheduled Completion Date	508	461
Tasks Developed	1066	1067
Cumulative Man Days Expended	3744	3977

Table 5 – *What-if Scenario 1* vs. *What-if Scenario 2* Progress Measurements

The simulation run suggests that perceived job size and tasks developed would basically remain the same, scheduled completion date would be less, and cumulative man days expended would be greater. Specifically, the EXAMPLE Software would take 47 days less to produce but would cost 233 man days more. EXAMPLE Software Managers can now decide whether they want to purchase the system or they can run additional simulation runs based on specific project values or newly acquired information.

5 Conclusion

The objective of this article was to establish System Dynamics as a valid tool in the exploration of Virtual Software Project Teams. The original Software Project Dynamics model was reproduced, an extensive literature review on the field of virtual teams as related to variables in the human resource management sector was performed, and the model was used to study the dynamic implications of virtual software project teams. Two *what-if* scenarios were described and interesting outcomes were derived.

This paper suggests that system dynamics ***is*** a viable tool in the exploration of virtual software engineering challenges. A new field of research is recommended to deal with additional challenges of virtual software project teams by using system dynamics with the proposed name: **Virtual Software Project Dynamics.**

Future research may include studies similar to those presented here on the other three sectors of the software project dynamics model, expert based interviews to gain additional insight, and simulation model reproduction of an actual software project that used virtual teams. The author's are currently conducting interviews on virtual software project team subject matter experts regarding the human resource management sector of the model to further enhance the research findings in this article. The results will be released in a future publication.

REFERENCES

Abdel-Hamid, T. (1984). The Dynamics of Software Development Project Management: An integrative System Dynamics Perspective. Management. Massachussets, Massachusetts Institute of Technology. ***Doctor of Philosophy:*** *522.*

Abdel-Hamid, T. (1989). "The Dynamics of Software Project Staffing: a System Dynamics Based Simulation Approach." IEE Transactions on Software Engineering ***15****(2): 11.*

Abdel-Hamid, T. and S. E. Madnick (1991). Software Project Dynamics an Integrated Approach. New Jersey, Prentice Hall.

Anderson, W. N. (2000). Cultural values and communication mode: A study of culturally homogeneous and culturally heterogeneous groups. Business Administration. Newark, New Jersey, Rutgers The State University of New Jersey. ***Doctor of Philosophy:*** *338.*

Armstrong, D. and P. Cole (1995). Managing distances and differences in geographically distributed work groups. Diversity in work teams: Research Paradigms for a changing workplace. Washington D.C., American Psychological Association: 187-215.

Balthazard, P., R. E. Potter, et al. (2004). "Expertise, Extraversion and Group Interaction Styles as Performance Indicators in Virtual Teams." The DATA BASE for Advances in Information Systems ***35****(1): 41-64.*

Balthazard, P., D. Waldman, et al. (2004). "Shared Leadership And Group Interaction Styles In Problem Solving Virtual Teams." Hawaii International Conference on System Sciences.

Barker, V. (2000). New Contexts For Relational Communication In Groups. Meeting of the National Communication Association. Seattle, WA.

Baroff, L. E. (2002). Distributed Teaming on JPL Projects. Aerospace Conference Proceedings, IEEE.

Bemmel, I. E. v. and P. Essens (2005). Competencies of Future Commanders in Network Centric Operations. 10th International Command and Control Research and Technology Symposium.

Bodker, K., J. Pors, et al. (2004). "Implementation of Web-based Information Systems in Distributed Organizations." Scandinavian Journal of Information Systems ***16****: 85-116.*

Collofello, J., I. Rus, et al. (1998). A System Dynamics Software Process Simulator for Staffing Policies Decision Support. Thirty-First Annual Hawaii International Conference on System Sciences. Hawaii, IEEE.

Collofello, J. S., I. Rus, et al. (1998). Using Software Simulation to Assist Software Development Organizations in Making "Good Enough Quality" Decisions. Summer Computer Simulation Conference (SCSC98).

Edwards, A. and J. R. Wilson (2004). Implementing Virtual Teams. England, Gower Publishing Limited.

Forrester, J. (1989). The Beginning of System Dynamics. International Meeting of the System Dynamics Society. Stuttgart, Germany.
*Gallivan, M. J. (2001). "Adoption, diffusion, and infusion of IT: Organizational adoption and assimilation of complex technological innovations: development and application of a new framework." ACM SIGMIS Database **32**(3): 51-85.*
Google. (2005). "Google Scholar." Retrieved November 10, 2005, 2005, from http://scholar.google.com.
*Gould, D. (1997). Leadership in Virtual Teams. Education. Seattle, Seattle University. **Doctor of Education:** 220.*
Gundry, J. (2000, August 2000). "Trust in Virtual Teams." Retrieved May 7, 2005, 2005, from http://www.knowab.co.uk/wbwtrust.html.
Igbaria, M., C. Shayo, et al. (1999). On Becoming Virtual: The Driving Forces and Arrangements. SIGCPR 1999, New Orleans, LA, USA, ACM.
*Jang, C.-Y. (2003). Awareness in Global Virtual Teams: Its Antecedents and Implications. Department of Telecommunication, Information Studies and Media. Michigan, Michigan State University**:** 122.*
*Joy-Matthews, J. and B. Gladstone (2000). "Extending the group: a strategy for virtual team formation." Industrial and Commercial Training **32**(1): 24.*
Kimball, L. (1997). Managing Virtual Teams. Team Strategies Conference, Toronto, Canada.
Kimble, C., F. Li, et al. (2000). "Effective Virtual Teams Through Communities of Practice." Management Science.
*Kishore, R. and E. McLean (2002). "The Next Generation Enterprise: A CIO Persepective on the Vision, its Impacts, and Implementation Challenges." Information Systems Frontiers **4**(1): 121-138.*
Kring, J. P. (2004). Communication Modality And After Action Review Performance In A Distributed Immersive Virtual Environment. Department of Psychology. Orlando, Florida, University of Central Florida. **Doctor of Philosophy:** *257.*
*Larsen, K. R. T. and C. R. McInerney (2002). "Preparing to work in the virtual organization." Information and Management **39**: 445-456.*
*Lin, F.-r. and S.-c. Lin (2001). "A Conceptual Model for Virtual Organizational Learning." Journal of Organizational Computing and Electronica Commerce **11**(3): 155-178.*
Lipnack, J. and J. Stamps (2000). Virtual Teams. Canada, John Wiley & Sons.
Luecke, R. (2004). Creating Teams With an Edge: The Complete Skill Set to Build Powerful and Influential Teams, Harvard Business School Press.
*Lurey, J. S. (1998). A Study of Best Practices in Designing and Supporting Effective Virtual Teams. School of Professional Psychology. Los Angeles, California, California School of Professional Psychology**:** 166.*
*Lyytinen, K. and Y. Yoo (2002). "Research Commentary: The Next Wave of Nomadic Computing." Information Systems Research **12**(4): 377-388.*
Mabey, C. and R. Thomson (1994). Developing human resources. London, Butterworth-Heinemann.

MacGregor, S. P. (2002). Describing and Supporting the Distributed Workspace: Towards a Prescriptive Process for Design Teams. Department of Design, Manufacture and Engineering Management. Glasgow, Scotland, UK, University of Strathclyde. ***Doctor of Philosophy:*** *207.*

Madachy, R. J. (1994). A Software Project Dynamics Model For Process Cost, Schedule and Risk Assessment. Industrial and Systems Engineering Department. Southern California, University of Southern California: 142.

Martin, L. (1997). The First Step, MIT: 57.

Munkvold, B. E. (2005). "Experiences From Global E-Collaboration: Contextual Influences on Technology Adoption and Use." IEEE Transactions on Professional Communication ***48****(1): 78-86.*

Newman, I., M. Daniels, et al. (2003). Open ended group projects a 'tool' for more effective teaching. Proceedings of the fifth Australasian conference on Computing education, Adelaide, Australia, Australian Computer Society.

Osterlund, J. (1996). Providing Competence Resources for New Product Development. International Conference on Engineering and Technology Management, IEEE.

Pawlowicz, D. M. (2003). Media naturalness and temporal adaptation in virtual team performance: A matter of time, Temple University. ***Doctor of Philosophy:*** *139.*

Peters, L. M. (2003). Now you see them.now you don't: Toward a greater understanding of virtual team effectiveness. Business Administration. Amherst, Massachusetts, University of Massachusetts Amherst. ***Doctor of Philosophy:*** *190.*

Piccoli, G., A. Powell, et al. (2004). "Virtual teams: team control structure, work processes, and team effectiveness." Information Technology and People ***17****(4): 359.*

PMI (2000). A Guide to the Project Management Body of Knowledge. Newtown Square, Pennsylvania, Project Management Institute.

Powell, A., G. Piccoli, et al. (2004). "Virtual Teams: A Review of Current Literature and Directions for Future Research." ACM The Data Base for Advances in Information Systems ***35****(1): 31.*

Pressman, R. S. (2005). Software Engineering: A Practitioner's Approach. Crawfordsville, IN, Elizabeth A. Jones.

Rad, P. F. and G. Levin (2003). Achieving Project Management Success Using Virtual Teams, J. Ross Publishing.

Redman, C. A. and C. S. Sankar (2003). "Results of an experiment comparing the analysis of Chick-fil-A case study by virtual teams versus face-to-face teams." Journal of SMET Education: Innovations and Research ***4****(1/2): 55-62.*

Sterman, J. D. (2000). Business Dynamics Systems Thinking and Modeling for a Complex World, Jeffrey J. Shelstad.

Tiwana, A. and A. A. Bush (2005). "Continuance in Expertise-Sharing Networks: A Social Perspective." IEEE Transactions on Engineering Management ***52****(1): 85-101.*

Tocci, D. (2003). An Exploratory Field of Study Of The Impact Of Communication Technology On Trust Within Virtual Teams. Leadership Studies. Virginia Beach, Regent University. ***Doctor of Philosophy in Organizational Leadership:*** *185.*

Vecellio, G. and W. M. Thomas (2001). "Issues in the Assurance of Component-Based Software." The Edge Perspectives.
Vick, R. (1998). "Perspectives On And Problems With Computer Mediated Teamwork: Current Groupware Issues and Assumptions." Journal of Computer Documentation.
Walters, K. K. G. (2004). A Study of the Relationship Between Trust and Perceived Effectiveness in Virtual Teams. School of Psychology. Ann Arbor, MI, Capella University. ***Doctor of Philosophy:*** *107.*
Whitman, L. E., D. E. Malzahn, et al. (2005). "A Comparison of Group Processes, Performance, and Satisfaction in Face-to-Face Versus Computer-Mediated Engineering Student Design Teams." Journal of Engineering Education ***94****(3): 327 - 334.*
Wong, S.-S. and R. M. Burton (2000). "Virtual Teams: What are their Characteristics, and Impact on Team Performance." Computational and Mathematical Organization Theory ***6****: 339-360.*
WPI. (2005). "What is Systems Dynamics." Retrieved May 4, 2005, 2005, from http://www.wpi.edu/Academics/Depts/SSPS/About/systemdynamics.html.