# Proceedings of the
# 19th International Conference
## of the
# System Dynamics Society


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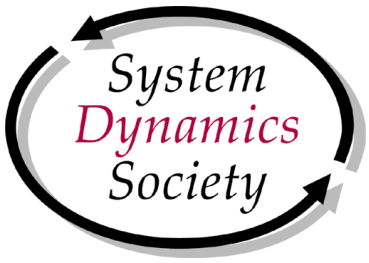




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# Navigating the Conference Proceedings

For portability and ease of use, we are distributing the electronic version of the 2001 System Dynamics Conference Proceedings in Adobe Acrobat (PDF) format. We highly recommend for you to download the latest version of Acrobat Reader, as the navigating tools described below work best with the latest version. You can download this software for free from http://www.adobe.com/acrobat/.

These instructions will help you:

- Use the general tools of Acrobat to explore the Proceedings
- Navigate the Proceedings using bookmarks
- Find authors, abstracts, and papers.

If you are familiar with Acrobat Reader, you will recognize the common navigational features, including Bookmarks, hot links, and menu icons. If you are unfamiliar with Acrobat, you may want to print this page for reference. (For information about printing, see the section "Print a PDF Document" below.)

## *Using general tools*

### Page tool

The built-in Page Tool (figure 1) allows easy navigation within multi-page PDF documents.

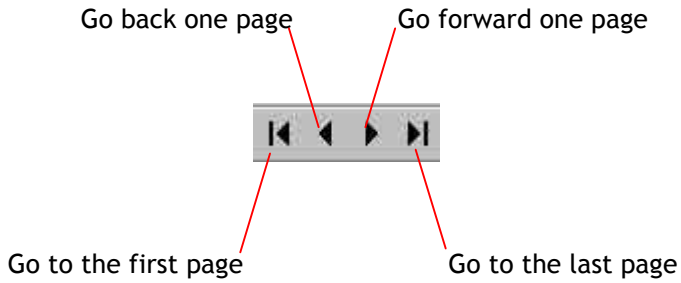


**Figure 1.** The built-in Page Tool lets you move between and across pages.

## Browsing Arrows

The built-in Browser Arrows (figure 2) allow you to move through Acrobat in much the same way that an Internet browser allows you to surf the web:

- The back arrow returns you to the page you visited last
- The forward arrow reverses the action of the back arrow (and thus only works if you have used the back arrow)

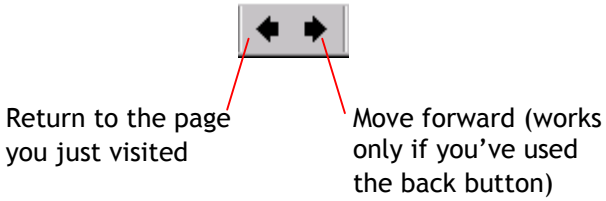


**Figure 2.** The Browsing Arrows give you greater flexibility to explore the Proceedings.

## Printing

You can print a PDF document in two ways:

- Use the Print icon on the Acrobat tool bar. 
- Select File > Print

**Note:** both of these actions will display the print dialog box with your default printer set to print. You can then set any specific options necessary to printing.

## Links and buttons

Links and buttons allow you to easily search and access the Proceedings. Links take you from the Author Index to a particular abstract, and from an abstract to a particular paper. Any text or image surrounded by a blue rectangle (figure 3).

All links are surrounded by a blue rectangle.

**Figure 3.** A sample link

Buttons allow you to move quickly between the Author Index, the Abstracts, and individual papers. The “Author Index” button (figure 4) returns you to the top of the Index of Authors, and the “Go Back” button (figure 5) returns you from a paper to its abstract.


**Figure 4.** The Author Index button takes you to the first page of the index.


**Figure 5.** The Go Back button takes you from a paper to its abstract.

## *Using Bookmarks*

Bookmarks, which appear in the left pane of the Acrobat Reader (figure 6), display the main sections of the Proceedings document. To display Bookmarks, select Window > Show Bookmarks. Clicking on a bookmark will take you to a main section of the document.

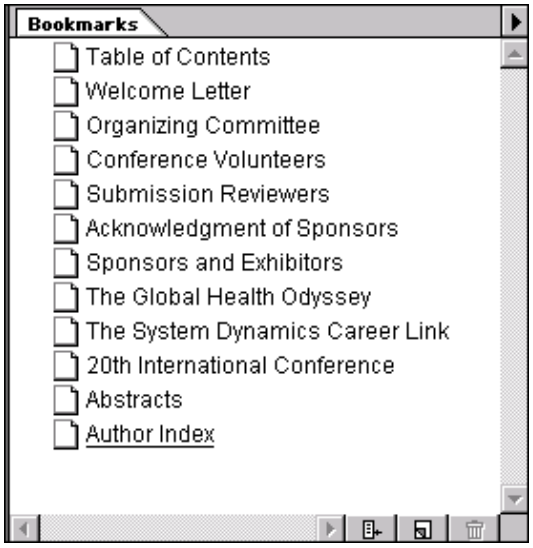


**Figure 6.** The Bookmarks pane

## *Finding abstracts*

You can locate abstracts in two ways:

1. Locate the author’s name in the Author Index
    a. Click the “Author Index” link in the Bookmarks panel
    b. Find the author’s name in the alphabetical index
    c. Click the page number after the author’s name

**Note**: authors may be involved in more than one paper or presentation, which is indicated by multiple page numbers in the index.

2. Use the Acrobat "Find" function
    a. Click the Find Icon. 
    b. Enter the appropriate title, author name, phrase, or keyword in the Find What input box.
    c. Click the Find button. The first instance of the search text will be highlighted if found by the search.
    d. Repeat step C to find other instances of your search criteria in the current document.

## *Finding papers*

You can locate papers in two ways:

1. Link from an abstract
    - A blue rectangle will surround the title of any abstract with an associated paper. Click inside the rectangle to access the paper.
    - Some abstracts do not have an associated paper.

2. Use the Acrobat "Search" function:
    a. Click the Search icon 
    b. Enter the appropriate title, author name, phrase, or keyword in the Find What input box.

    **Note**: do not include articles (a, an, the) in the search.

    c. Click the Search button. The title of any documents that include your search criteria will appear in the "Search Results" dialogue box.
    d. Repeat step C to find other instances of your search criteria in the current document.

After accessing a paper, click "Go Back" to return to the Abstracts.

# Table of Contents

# Welcome

Dear Members of the System Dynamics Society:

Welcome to the 19th International Conference of the System Dynamics Society! As you can see from the papers, workshops, and panel discussions listed in our program, the field of system dynamics is thriving. Your fellow attendees come from 40 countries and from many different institutional settings. We hope that you will enjoy the program, make new acquaintances, and renew ties with old friends.

Over the next three and one-half days you will have a chance to sample system dynamics work by leading practitioners in a variety of application areas. The 250 scheduled presentations are broken down into 25 parallel sessions, 18 poster sessions, 13 workshops, and 4 plenary sessions. We grouped the presentations by topic to help you identify sessions of greatest interest. This year's program also includes a special tribute to Dana Meadows who passed away since our last conference in Bergen, Norway.

To increase your enjoyment of the conference, we have scheduled several special events including a welcome reception, a conference banquet with live music, a southern cookout with roving singers, our first-ever pool tournament, lunch tours at the US Centers for Disease Control, and a fireside chat with Jay W. Forrester. We welcome those who may be accompanying conference participants but not attending the formal sessions. We hope that you will take part in the special events, feel at home in the conference center facilities, and enjoy the attractions of Atlanta.

This year over 100 reviewers screened and categorized submissions. Dozens more volunteers put in many hours to ensure a successful conference. Without their help our conference would be impossible. A special thanks goes to all who helped.

We hope you find the conference rewarding. If we can do anything to assist you, please tell the conference staff. Thank you for joining us.

Best wishes from the Conference Organizers

Nathan Forrester, Jim Hines, Roberta Spencer and Vedat Diker

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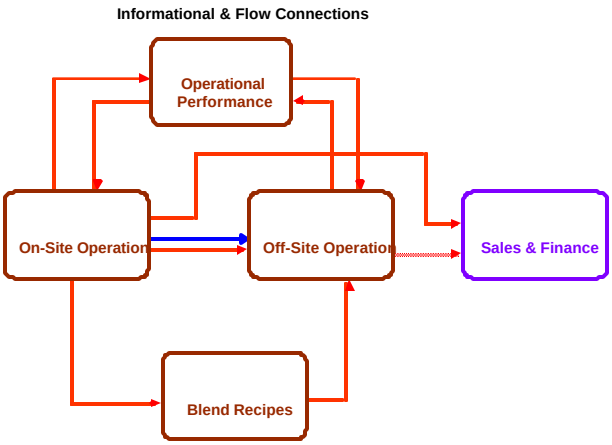


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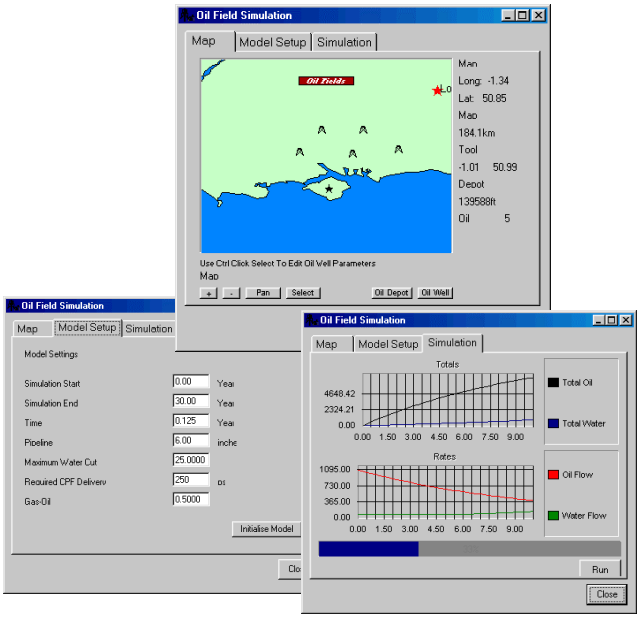

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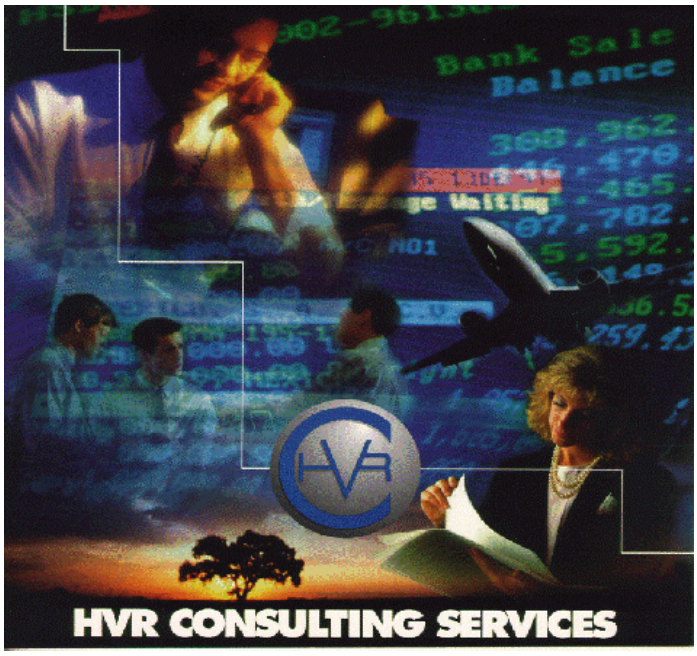


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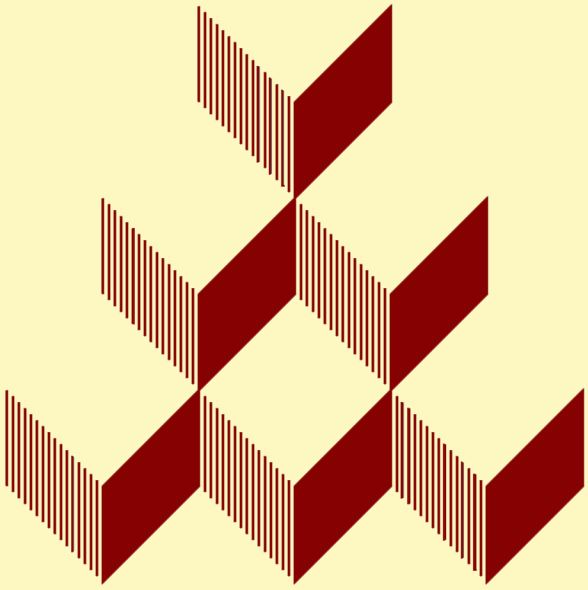

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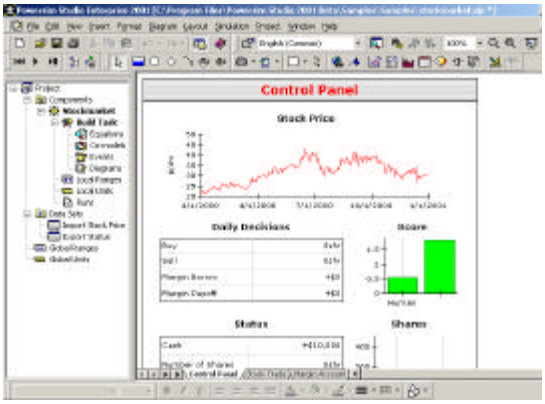


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Within our firm, the Business Dynamics Group, which I look after, is the centre of excellence for business modelling services to clients, and we are well aware of the value of system dynamics. In the right circumstances we have found it a powerful tool as we help clients improve the performance of their organisations.

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So I wish you a successful conference, as you explore the power and flexibility of this way of thinking about the world. And should you be interested in becoming a business modelling consultant, please feel free to contact us at business.dynamics@uk.pwcglobal.com, or via CareerLink on the SD Society's website.

*Gavin Potter, Partner, PricewaterhouseCoopers*

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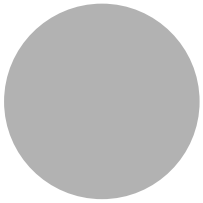

The Society for Organizational Learning

Wanted: **System Dynamicists** interested in sustaining fundamental organizational change and developing the field of Organizational Learning. Visit us at www.SoLonline.org or contact JJ Harris at jj@SoLonline.org for membership information. You can also speak to Sherry Immediato, co-Chair of SoL's Council of Trustees and acting Managing Director, at the conference.

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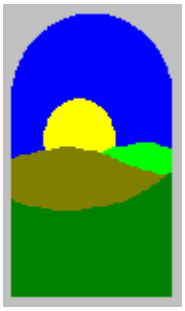

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Ventana Systems, Inc. provides consulting, software and training to help individuals and organizations plan strategy and solve important business problems. Founded in 1985, Ventana develops models with results that are defensible and fully supported by available data and experience. Ventana's charter is to combine the power of system dynamics with technologies that speed the development process and dramatically improve the quality of models and the results they give. In the absence of available software Ventana has developed new tools to meet this charter. An important result of this development is Vensim, a comprehensive tool that supports every stage of the modeling process, from conceptualization and data analysis to the development of high quality simulators and strategic information systems.

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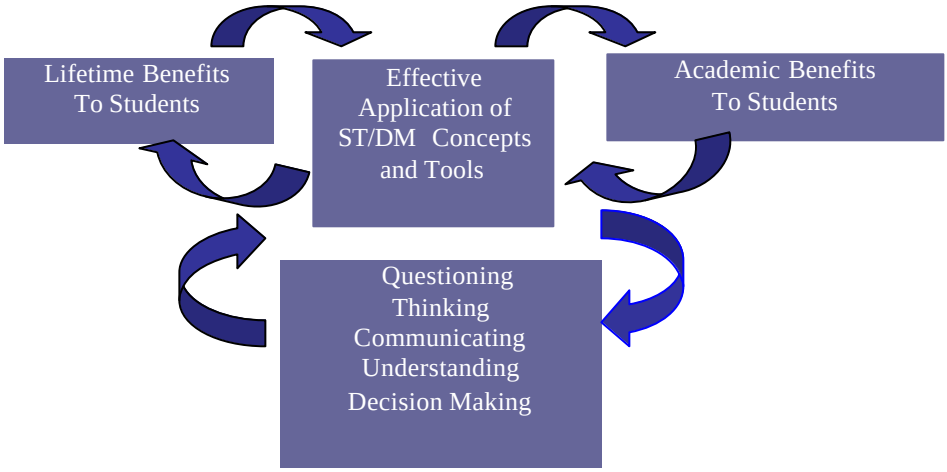


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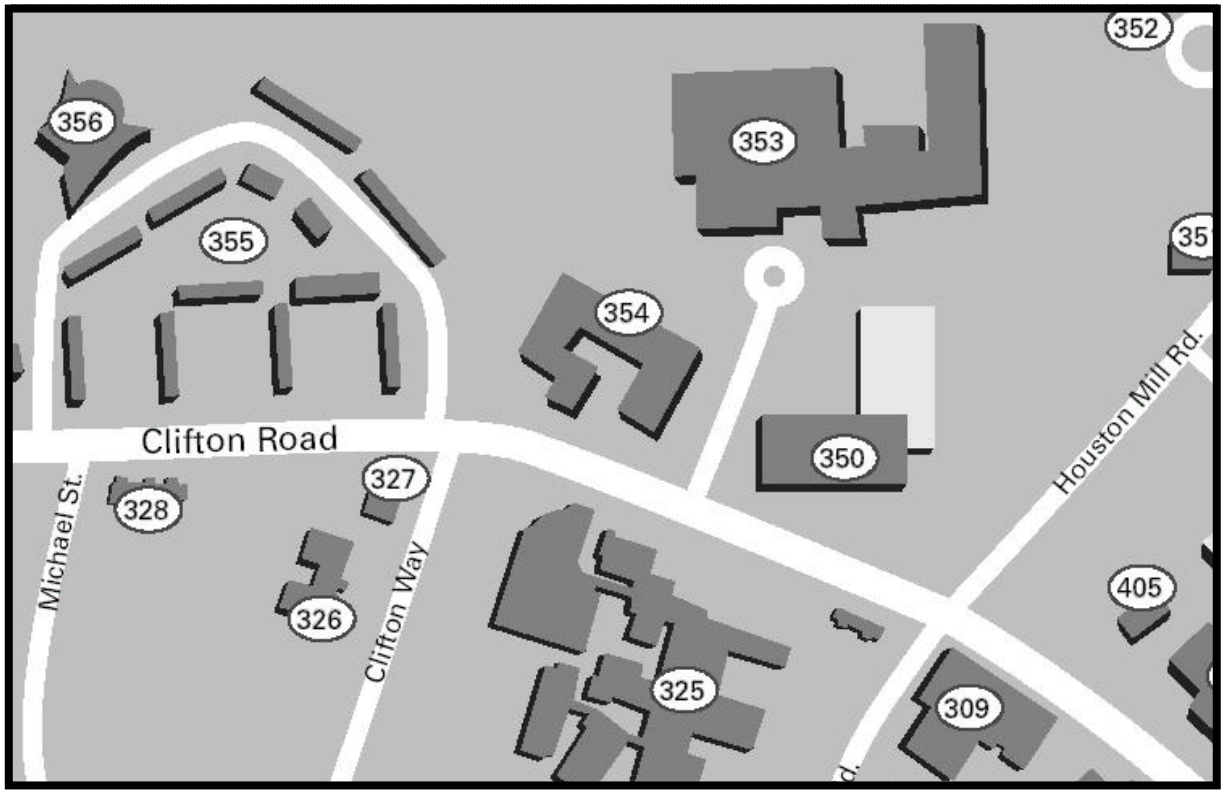
## US Centers for Disease Control and Prevention welcomes the System Dynamics Society to tour the Global Health Odyssey




The Emory Conference Center is #353 on the above map. The CDC is #325. The Global Health Odyssey tours start at the CDC main desk at 1600 Clifton Road, just opposite the entrance to the Emory Conference Center.

Global Health Odyssey tours will be available at the CDC on Tuesday, Wednesday and Thursday at 12:45 PM and 1:15 PM. Each tour can accommodate 30 people at a time and lasts about 40 minutes. Tours are available to conference participants and their guests. The CDC is located just across the street from the conference center. The GHO tour begins with a 5-minute introductory video. Visitors view displays illustrating CDC's present-day work. Historic exhibits and artifacts follow, with an overview of CDC's heritage, its development over the years, and its many accomplishments. Besides the cafeteria and a souvenir store, the museum is the only part of CDC that is open to the public. Participants and guests should have just enough time to eat, walk over to the tour, and return for the 2:00 PM session. There will be a sign-up sheet at the registration desk on a first-come, first-served basis. You must sign up by 10:30 AM so that name badges can be made for you by Security at the CDC.

CDC Liaison: Timothy A. Akers, M.S., Ph.D. Senior Behavioral Scientist
Centers for Disease Control and Prevention (CDC)
National Center for HIV, STD, and TB Prevention
Division of HIV/AIDS Prevention, Program Evaluation Research Branch
1600 Clifton Rd., NE MS-E59, Atlanta, GA 30333
404.639.0926 (Work) 404.639.0929 (Fax) takers@cdc.gov


**THE *SYSTEM DYNAMICS CAREER LINK***

***What is it?*** The *SD Career Link,* maintained by student volunteers and hosted by the System Dynamics Society at the University at Albany, includes on-line information and links to organizations seeking candidates specifically with system dynamics and systems thinking backgrounds.

We hope that the SD Career Link will provide a valuable exchange of information about positions and people in the field of system dynamics. This is our second year and this activity is starting to grow! The System Dynamics Society will not serve as an intermediary between interested parties. The SD Career Link will provide contact information only. Please visit the SD Career Link bulletin board at the conference.

***How to participate***? Please refer to the System Dynamics Society website at www.systemdynamics.org/ or send an email message to the Society office at <system.dynamics@albany.edu>. We look forward to your participation.

*Note: All information about access to and use of the site will remain confidential and information submitted for posting will be used only for the direct purpose described above.*

## Announcing the

# Twentieth International Conference of the System Dynamics Society
# Palermo, Italy July 28 – August 1, 2002

**Hosted by:** University of Palermo & CUSA - Centro Universitario Studi Aziendali
Luigi Bocconi University (Instituto di Economia Aziendale), Milano
System Dynamics Italian Chapter (SYDIC)

The 20th International Conference of the System Dynamics Society will be held in Palermo, located on the western side of the island of Sicily in southern Italy. The conference will bring together participants and practitioners interested in system dynamics and systems thinking. Presentations by practitioners and world leaders in the field will cover a wide variety of topics, including theory, methods, tools, techniques, pedagogy, case studies, and applications. Application areas will include business, economics, organizational change, public policy, engineering, K-12 education, and the social and natural sciences.

Palermo is rich in cultural and artistic heritage, the legacy of ancient cultures that have lived there over the past centuries. The city is steeped in antiquities and fascinating old buildings, but is also a new and progressive city, full of bustling atmosphere.

**Tentative Key Dates:**

| | |
|---|---|
| July 23, 2001 | Conference Announcement; Call for Papers and Sessions |
| January 31, 2002 | Deadline for extended abstracts (4 pages), session proposals and workshop proposals |
| March 15, 2002 | Notification of acceptance; Invitation to submit a full paper for consideration for a plenary session |
| May 15, 2002 | Deadline for final version papers and CD-ROM material; Deadline for plenary papers |
| June 1, 2002 | Deadline for pre-registration |
| July 28, 2002 | Attend the conference in Palermo! |

For further information and updated details, please visit **http://www.systemdynamics.org**

The program will include various formats. Plenary sessions will feature presentations on topics of general interest. Parallel sessions will be organized by theme and will feature the full range of work being done in the field. Poster sessions will provide an opportunity for participants to engage authors directly on subjects of particular interest. The program will also include workshops, tutorials, panel discussions, special interest group sessions, student colloquia, events of historical interest, vendor displays, and demonstrations. The conference schedule will provide time for relaxed social and professional interaction.

**Conference Contacts:**

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Bucaramanga Colombia

## Caleb: Microworld of the Christian Church's Membership Dynamics

This paper proposes a software named Caleb. Caleb is a microworld based on system dynamics that allows study of the dynamics of the membership in a Christian Church located in Bucaramanga, Colombia. The Church has been developed in the course of fifteen years, from zero to presently 3500 members. In this course the church has lost 6000 members. The problem is explained using system dynamics. The elements of growth and decline of membership are integrated in a system dynamics model. To finish, the paper presents several ideas for the manager of the Church, about how use the software to re-think activities to develop his organization.

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## Intervention for Organizational Learning Improvement

Because of rapid environmental changes, the rate at which organizations learn may become the only sustainable source of competitive advantage. Organizations learn through their individuals. This article describes a method of intervention by a facilitator designed to enhance organization learning through changes in individuals' mental models and vision based on Senge's concepts and approach to organizational learning. Three power plants were used as the field for the research. The facilitator made several interventions in the management teams thinking process in several periods. In each period the nature and approach of the intervention was different. Interventions included: (1) introduction to basic theories of management principles, system thinking, and organizational learning, (2) facilitating the formation of shared

vision process, (3) facilitating the formation of shared mental model process. In the second and third periods of the intervention, the discipline of dialogue was emphasized. The results and effectiveness of the interventions after each period were measured and evaluated using cognitive mapping methods.

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## Evolution and Trends About Number of Physicians in Spain: Dynamic Analysis

Nowadays, Spain has one of the biggest amount of physicians per capita. This situation is worrying in comparison with other countries in our environment (for example U.K, Italy, France or Germany).
That is due to the inappropriate planning policies carried for a long time, which basically are typified by the lack of anticipation and by the prevalence of short-term. As a result of that, in our country there is an unbalance between demand and supply of physicians (a fact which is bringing the system up to an untenable situation that risk the future of physicians profession and increases the sanitary costs).
However, past and present governmental politic trends use adjustment policies instead of preventive policies, which become the problem in a latent and permanent (in the long-term) one.
This work argues about the rationality of present planning policies and simulates the evolution of number of physicians for the next twenty years, based on the formation process carried for a long time and on the politic trends.

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## The Impact of Technological Innovation, Transfer and Diffusion in Extended Enterprise in Developing Economies

This paper proposes a model for understanding the issues related to innovation and technology transfer in developing economies. Technology innovation and diffusion theories (Romer, 1990; Schumpeter, 1961; Segerstrom, 1991; Grossman, 1993) raised important issues related economic growth in a world with limited technology and technology transfer capacity. However these theories aggregate both developing and industrialised countries into more model to represent the real issue. In the real world, developing and industrialised economies face different technology innovation, transfer and diffusion limitations and deal with different problems arising from such limits (Mashayeki, 1990).

This paper presents initial findings of the research on problems of technology innovation, transfer and diffusion of extended enterprise in developing economies (Homer, 1983; Sahrif and Kabir, 1976). While many researchers have propounded technology innovation and technology transfer theories, none of the theories proposed specifically examine problems in developing economies (Mahajan and Peterson,1985).

The framework proposed for understanding technology transfer and diffusion addresses both the adoption and the changing rate of evolving product-based technology and also accounts for endogenous factors that cause actual and perceived changes. As part of future work, the research aims to test and validate the model-based theory in developing economies, specifically, examining the impact of extended enterprise on technological innovation, transfer and diffusion. Although the paper undoubtedly still has limitations, I have suggested that the model might be useful in examining the impact on extended enterprise in the presence of new competitive technology transfer and technology diffusion in a developing country.

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## The Use of Information of Critical Structure by System Dynamics Experts

Recognizing what structures contribute most to a given mode of behavior is considered to be a major part of diagnosing and understanding of complex dynamic systems. The Pathway Participation Method (PPM) was built to support detecting of critical structure in System Dynamics models. PPM has developed several algorithms that are incorporated in a software, called Digest.

The purpose of this study is to explore how and to what extent the information about critical structures can help system Dynamics experts to understand and diagnose the behavior of complex systems.

In an exploratory study the students of an advanced course in System Dynamics, being held at the University at Albany, are taken as a sample of System Dynamics experts. Students are divided into two groups. Both groups are provided with a small System Dynamics model of sufficient complexity to challenge expert intuition. The task for all subjects in both groups is to explain the behavior of the system over a given period of time. One of the groups is required to analyze the behavior of the system using their good modeling intuition supplied by repeated simulation and other traditional methods taught in an advanced

modeling class. The second group with the same task is provided with the products of Digest, which contains information of critical structures. In addition, they are provided with a written and oral explanation to help them use these products.
The explanations and insights provided by both groups are evaluated and thoroughly analyzed to probe the differences between the two groups. Then in a series of semi-structured interviews those subjects, who were provided with the additional information of dominant structures, are asked to explain how and to what extent they have used the information provided by Digest using PPM algorithm.
This study will help us to understand how system experts use the information about critical structures to improve their understanding and diagnosing of system behavior. The results will be used to improve the Pathway Participation Method in order to meet the needs of model builders as identified in the research. Also the results are expected to help software developers to figure out appropriate formats and methods of presenting information critical structures that could lead to a more efficient use of these information.

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## Influence Diagrams in Service of Group Decision-Making

This paper recounts recent experience in the use of influence diagramming as an aid in the process of group decision-making in a school system in Illinois. Although it was never the intention at the beginning of the process to move in this direction, the difficulty of the decision situation coupled with the recognition of the potential usefulness of systems dynamics methodologies in facilitating the search for pathways to the understanding of system behavior and changing it, led in the direction eventually reported here. The paper addresses the context of the problem, its current configuration, and the way in which influence diagramming led to a breakthrough in how the problem was eventually posed and group decision achieved. The name of the district will be changed to preserve confidentiality.

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## The Physics of the "Bullwhip Effect" in Service-Oriented Supply Chains

We investigate the dynamic behavior of service-oriented supply chains in the presence of stochastic demand using an analytic two-

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Author Index

stage model. Conventional wisdom strongly supports lead-time reduction to mitigate the amplification of processing variance along the supply chain, the so-called "bullwhip effect." We show instead that lead-time reduction in a service-oriented setting can often induce the reverse effect under many real-world conditions. Further, in this environment, sharing end-customer demand reduces backlog variances as conventional wisdom suggests, but over-reliance on end-customer relative to local information may actually increase processing variances. Finally, we show that the natural tendency to pursue system-wide process improvement by imposing uniform parameter targets across the supply chain exacerbates capacity and backlog variances at stages further away from the customer. Instead, we show that a superior policy is asymmetric, holding the bulk of system backlog at the stage closest to the customer.

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## Process Innovation as an Approach to Organizational Learning: System Dynamics Modelling

The present paper is the result of an investigation project on a "Generic Model of Process Innovation that facilitates the Organizational Transformation using the systems dynamics simulation as a modeling tool", applying in a coherent way the systemic thinking to the solution of organizational problems where it is possible to conceptualize the model until arriving to an action that improve the processes or the problematic activities.

It is an investigation project that arises of the necessity of including in the organizational modeling the systemic thinking thought systems dynamics simulation, as an agile tool for making decisions in the management policies of the modern managerial world. System thinking deals with the study of the organizations (companies, public institutions, and other human organizations) as complex systems of human activities, with plurality of interests and values.

In this paper the methodological platform of the generic model of process innovation is described. This platform was applied in a company of the textile sector on Alcoy-Ontiyent industrial district and Powersim was used as the software simulation tool.

This model reproduces the parametric and economic output to a set user's decisions and it allows to understand the causes of the phenomenon's observed of process innovation, as well as to analyze different policies knowing the resulting effects on a short-/Iong term facilitating the organizational learning.

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## Democratic Exercise in Developing Countries and Changes in Leadership

Least developed countries are characterized by lower economic level and lower literacy level. While practicing the democratic exercise in selection of their leaders to run the government, these people are influenced by a number of attractions. These could range from fiscal benefits for the favorable voting judgments to promises for the local development, irrespective of the probable realities that the development may be against the national interests. The elected leaders elected to national bodies also sacrifice the national interests in the interest of pleasing the local vote banks. They allocate the national resources to an open basket which could be utilized for the projects not designed well in advance. The allocation is influenced by the pockets of the population which had helped elect.

The people gradually develop resentment at the behavior of the leaders placed at the national forum. The attempts begin to change the leader. The currents for the change and for maintaining the status quo cause a big instability in the government system that question the success of democracy. The democrats in power take it as a normal development process, though slow. The state of affairs continues until the next elections when the people could exercise change. The influence games start once. The paper attempts to develop a causal loop diagram for the leadership and change.

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## Developing a Measure of System Dynamics Understanding

We describe the development of an instrument for measuring understanding of system dynamics known as the Dynamic Forecasting Questionnaire (DFQ). The original version of the DFQ (DFQ1) was designed to explore which causal structures were most difficult for students to understand and manipulate. The DFQ1 systematically compared linear, first order feedback systems with second order systems and with positive or negative feedback loops dominant. The DFQ1 was tested with 492 school, undergraduate and MBA students. Overall the students were poor at predicting the impact of changes to simple dynamic systems. However, they were particularly poor at predicting patterns of change involving decelerating increase or changes in direction.

We also describe work currently in progress to develop DFQ2. We

intend that DFQ2 will be useful for educators, researchers and businesspeople interested in a standard but inclusive measure of system dynamics understanding. We are in the process of developing items to measure understanding of the dynamics of systems, the ability to discern the critical variables from a complex scenario, the ability to discern flows from stocks and use them appropriately and the beliefs and attitudes underlying effective systems thinking.

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## Integrating System Dynamics Concepts in an Undergraduate Engineering Course on Sustainability

This is a preliminary report on an ongoing qualitative research study beginning in the Fall 2000 semester of EGR 157, an Honors-level course for non-Engineering majors. The course fulfills a General Education science distribution and oral communications requirement. During the Fall 2000 semester, Believing Cassandra (Atkisson,1999), which uses systems thinking concepts and the World3 model as a major source of its arguments, was used as a course text and provided the basis for developing a debate topic. A preliminary observation from student interview data, debate transcripts, and students self-reports is that students articulated personalized opinions about the environmental issues which appeared to develop throughout the course and which were argued from a generally consistent set of facts contained in the text.
During the Spring 2001 semester, the course will be offered again using the same text, student interviews, and debate process. During this semester, students will also be introduced to system dynamics software and model-building in population dynamics, including exponential growth and over-shoot and collapse generic structures. A goal of the researchers is to generate additional hypotheses related to the questions: "Do exemplars from transcripts of student's discourse reflect attitude changes and/or conceptual changes regarding complex environmental problems/issues? To what extent are systems concepts or misconceptions embedded in these views? The researchers also plan to collect data regarding the effects of the modeling process on students' conception of key course concepts such as exponential growth and sustainable development.

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## An Innovative Technological Application for Group Modelling and Online Learning

Building models together with clients is crucial to integrate customers unique knowledge into the modelling process, to increase the acceptance of System Dynamics projects within the organisation and to effectively increase knowledge transfer on System Theory to the clients organisation.
With the "System Dynamics-Portal", SRC Hamburg, a start-up company from Hamburg/ Germany, is right now developing a consistent and convincing concept, using innovative internet technologies aiming to support group modelling. This offer directs primarily to decision-makers in businesses and public institutions, as well as actors in the areas of education and science.
In a Virtual Workspace, customers, consultants and modellers can work together, supported by Videoconferencing and Voice-over-IP, on system dynamic models. Additional features within the Virtual Workspace are linked data collections and a library for common submodels.
This technology is also used to realize excellent Online Learning courses based on multipoint videoconferencing and application sharing - the coming standard for long-distance learning.
A Virtual Community on System Dynamics, connects a Community of Practice (decision makers and modellers) with a Community of Interest (non-professionals). Some features are Live Videochats with experts, a public modelpool, a testbed for model evaluation and interest oriented discussionboards.
Via the System Dynamics-Portal we will aim to
- implement state-of-the-art technologies for web-based group modelling,
- promote System Dynamics to a broader public in Germany, not only to decision-makers, but through System Dynamics Contests also to younger people in education.

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## Testing the Decision Rules Used in Stock Management Models

This paper evaluates the basic decision rules typically used in dynamic decision-making modeling. The plausibility and consistency of each rule is evaluated first. Then, the adequacy of

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these rules is tested empirically by comparing them against the performances of different subjects (players) in an experimental stock management game. For this purpose, the generic stock (inventory) management problem, one of the most common dynamic decision problems, is chosen as the interactive gaming environment. Experiments are designed to test the effects of three factors on decision making behavior: two different patterns of customer demand, minimum possible decision interval and finally representation of receiving delays. The performances of subjects are compared with the simulated results obtained using the common linear "Anchoring and Adjustment Rule." Next, several alternative (non-linear) rules are formulated and tested. Finally, some typical inventory control rules (such as (s, Q)) from the standard inventory management literature are tested. These rules, compared to the linear stock adjustment rule, are found to be more representative of the subjects' decisions in certain cases. Another major finding is the fact that the well-documented oscillatory dynamic behavior of the inventory is true not just with the linear anchor-and-adjust rule but also with the non-linear rules as well as the standard inventory management rules.

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## A Method for Finding Equilibrium Points of a Non-Linear Dynamic Model

An algorithm for finding all the equilibrium points of a given non-linear dynamic model is proposed. Such an algorithm would necessitate the general solution of a set of N non-linear algebraic equations. It is well known that no such method exists in general. Our method aims to work for a rather general subset of non-linear systems, namely when all non-linearities are expressed in polynomial terms. The significance of the method is that; i- it can greatly speed up model analysis by providing the equilibrium information prior to simulation, and ii- it can help verify the results obtained from simulations (numerical simulation may skip an existing equilibrium and "create" spurious equilibria). The method is explained and demonstrated on two examples. The algorithm works well, except when there are infinite number of equilibria on an N-dimensional plane. Current work focuses on this sub-problem. Finally, there are some issues of speed and numerical accuracy, the other two main topics of current and future research.

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## From Metamodels to Models: Organizing and Reusing Domain Knowledge in System Dynamics Model Development

System dynamics models can become very complex as they grow. When a model spans through several distinct elements within a certain domain, a large number of equations are needed to describe their detailed behavior and interactions. Large models are hard to understand and develop. However, small models may not provide the desired level of detail in several applications. There is the need for techniques that enhance our capacity to develop and analyze complex models. In this paper we describe an extension to the system dynamics modeling that allows the development and specialization of domain models. Such models provide a high level representation for future developers within the domain. Our approach divides system dynamics model development in three steps. First, an expert in a given domain develops a model, which conveys the relevant categories of elements that compose the domain and the relationships among these elements. Next, a developer uses such model to describe a particular problem, by specifying how many elements of each category exist in the model of interest and the particular characteristics of each one. Finally, the model is translated to system dynamics constructors in order to be simulated and analyzed. An application of the proposed approach is also presented.

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## Explaining the Behavior of System Dynamics Models

In this paper we present a technique that helps the analysis of system dynamics models. The technique, namely Event Tracking, maps simulation trends over time to predefined events. It uses state machines whose behavior can be traced to changes suffered by selected variables in a system dynamics model. Changes to variable values trigger messages, which are presented to the model analyst to help the interpretation of the underlying model behavior.
Event Tracking is an interesting feature to system dynamics simulators, since it maps the mathematical results achieved through simulation to natural language statements. It allows a trainer assistant to define the relevant events for a model, highlighting the model major features through event messages. We have implemented the proposed technique in the ILLIUM system

dynamics simulator. The simulator also allows a student to track model behavior, executing a simulation and following the presented messages.

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## Management Causal Matrix: A Tool for Organizing Model Variables and Interrelationships

For years, the systems engineering field has developed tools to graphically represent complex system structure. Graphical representations allow individuals and teams to visually identify interrelationships and dependencies within the system. Academic research and the adoption of these tools within the industrial communities validate the utility of these tools. These tools include Unified Program Planning, Quality Functional Deployment, House of Quality, and Design Structure Matrix. Increasingly, the management consulting industry has been utilizing these tools in systems management. This paper discusses the applicability of a new tool, Management Causal Matrix, for system dynamics modeling community. The matrix is very similar to the more traditional systems engineering tools, yet has been customized for the systems dynamacist to highlight system interdependencies and organize the casual structure for a management system.

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## Functional Analysis Systems Technique (FAST) as a Group Knowledge Elicitation Method for Model Building

Information gathering is the most important and often the most difficult phase of dynamic system model building. Many methods have been proposed to elicit knowledge from systems experts. Most modelers avoid the social and political barriers found in group elicitation and have focused on various interviewing techniques. If properly employed, group elicitation can be an effective and extremely efficient method to get the necessary knowledge to analyze and model a system. This paper discusses the use of the Functional Analysis Systems Technique (F.A.S.T.) diagramming method as a tool for eliciting knowledge during the information-gathering phase of the modeling process.

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## A System Dynamics Model of Government Engineering Support During the Development Phase of a Military Acquisition Program

Due to the increase of system complexity and the existing draw down of manpower allocations, today's acquisitions environment desperately needs a systems approach to decision making. Many studies have been performed to model the entire government acquisition environment. Due to the high degree of aggregation, front line decision makers have had no use for the information these models provide.

This research focuses on the Air Force's largest functional support element in aircraft systems development, engineering. I will only consider one phase of the government acquisition cycle the Engineering, Manufacturing, and Development (EMD). This is the development cycle, which begins with initial contract award (Milestone II), through the production approval (Milestone III). This model is a building block to ultimately help leaders determine the required skill-set and manpower to perform activities which can meet short term requirements while minimizing the intrinsic cost, schedule, and performance risks associated system development. The simulation presented will be used by the as an alternative decision making tool for manpower allocations for government organic engineering workforce during an eight year development effort.

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## Operating and Support Cost Analysis Model

Cost analysis is required at all stages in the life cycle of defence systems. During the acquisition phase it is necessary to estimate the operating and support (O&S) costs of the system as well as the development and production costs. In service, one needs to estimate the costs of alternative O&S policies as circumstances change. Cost analysts use such tools as dedicated parametric costing software or simple spreadsheets which tend to be static and do not model the dynamics of operation and support.

Developed by HVR Consulting Services Ltd, the Operating and Support Cost Analysis Model (OSCAM) is a joint UK/US program aimed at developing a suite of tools that can provide rapid assessments of the O&S costs of high cost capital assets and their component systems. Using System Dynamics, OSCAM aims to represent the business processes which drive costs and their

relationship to management policies to assess the impact of alternative maintenance strategies and operating policies on the cost and availability of these assets.
Developed initially to address naval platforms, OSCAM has more recently been used to analyse the lifetime costs of the U.S. Marine Corps Advanced Amphibious Assault Vehicle (AAAV). The model has been developed from workshops, providing a common understanding of the processes to be represented and the pertinent issues to be addressed. In addition, a sense of ownership is engendered, providing users with the level of confidence required to effectively assess outputs provided by the model.

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## Planning the Implementation of Telecare Services

In many countries an ageing population places increasing strain on the social and health care system. In addition, the support of independent living in the community has been recognised as preferable to residential care. In this situation, the use of telemedicine technology in the homes of elderly people (telecare) can be seen to be promising, yet the experience of telecare implementation is so far quite limited, and not always entirely satisfactory. Some projects in the past were mainly technology driven and paid too little attention to the needs of patients and the development of service delivery models for health and social care providers.
In this project we draw on simulation as a planning tool to avoid some of these shortcomings and to improve the implementation of telecare. System Dynamics simulation is employed to analyse systemic consequences of alternative telecare service models on the care delivery system in a specific region (North West Surrey, England) and to develop sustainable business models for care providers. Simulation is also used in the project to facilitate collaboration between different types of stakeholders (health and social care providers as well as technology providers) whose differing perspectives have in the past hampered the development of telecare services.

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## Using the Holon Framework: From Enquiry to Metrication -- A Higher Education Case Study

This paper discusses the Holon Framework, which aims to improve and control processes within a School in a university in the United

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Kingdom. The developing framework has emerged from the Systems Movement and Software Engineering, combining aspects of Soft Systems Thinking and Hard Systems Thinking. We highlight the key characteristics of Higher Education Process Improvement and Control. An overview of the soft and hard part of the Holon Framework is provided. We justify the case study approach given the nature of the investigation. The soft part of the framework, which is linked to improvement, is employed to identify relevant problems and generate a baseline metrics programme. The research design of the case study is used to evaluate our findings. Finally, we outline future work in employing the hard part of the framework which is linked to control; this will complete the full cycle of research and further establish the Holon Framework.

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## SMEs' Learning and Growth Processes Through E-Commerce: System Dynamics Modeling to Depict Opportunities and Pitfalls Related to Internet-Based Strategies in Small Firms

In the last decade, e-commerce has been used as an important lever to foster business growth. In fact, it has allowed firms to pursue internationalisation strategies, to establish a direct relationship with end-consumers, to shorten logistic channels, thereby broadening potential market.

Many successful stories spread out through the management literature and the press have been encouraging a growing number of small-medium enterprises (SMEs) to recur to e-commerce to increase sales turnover. However, empirical findings have shown that a high mortality rate affects small business' web sites growth.

What are the causes of such phenomenon? What are the decision making processes underlying growth-oriented e-commerce strategies undertaken by SMEs? What are the main risks a small business entrepreneur faces concerning logistics management, production capacity adjustment, financial policies related to investments in web site and to net working capital? What competencies should be built by an SME to manage its web site, to integrate internet sales orders with internal information system, to maintain a stable business image? What management control tools should be introduced in a small firm to manage e-commerce growth strategies? What policy levers he/she uses to pursue e-commerce growth strategies?

Based on the above research questions and results portrayed by the management literature, a survey has been started to focus small businesses behaviour in pursuing e-commerce growth strategies.
Through a case study approach, this paper aims to sketch a preliminary system dynamics model explaining key variables (e.g., knowledge, image, financial resources, production capacity) driving the building and draining processes underlying e-commerce growth strategies.

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## Workshop: Implementing Dynamic Management Control Systems in SME's to Enhance Entrepreneurial Learning

Management control systems are seldom used in small-medium enterprises (SMEs) mainly because of their high implementation costs and the lean organisation structure of such firms. However, SMEs crises are often caused by lack of control and understanding of the system's dynamic complexity.
For instance, aggressive commercial policies based on rising terms of payment allowed to customers, bias in profit expectations leading to uncontrolled liquidity withdrawals, and reactive behaviour to competitors' strategy are recurring factors leading to failure.
In fact, complexity in SMEs is shaped by very peculiar variables that are to be properly perceived to manage growth. In particular, gut feeling decision making and low propensity to delegate, a weak position of the firm in the competitive system and the blurred boundaries between the business and the equity-owning family are main complexity factors in such contexts.
The introduction of management control systems in SMEs ought to exploit the enormous potential of the entrepreneur's mental database. Linking the feedback and accounting view of the business into comprehensive dynamic management control systems allows one to take into account the peculiarities of such environment and to foster strategic entrepreneurial learning.
Main issues covered in the workshop will be:
- business start-up and growth;
- tuning the balanced scorecard to the small business context;
- e-commerce.

It will be shown how interactive learning environments including system dynamics and accounting models can substantially help decision makers in drawing up business plans based on an improved awareness of the relevant system, to define sustainable growth policies, both in the short and long run.

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## System Dynamics Modeling to Introduce the Balanced Scorecard in SME's

The balanced scorecard has been widely and successfully implemented in medium-large companies, to better understand how to improve their strategic performance, both concerning financial and nonfinancial measures.
A very important outcome of the process enhanced by balanced scorecards is strategic feedback and learning. However, such a goal could be difficult to achieve without the use of a proper methodology aimed to enhance communication among decision makers about the net of causalities, delays and non-lineraities between variables impacting on business performance. The above perspective can be provided by system dynamics.
By assessing the impact of lags and other qualitative parameters (e.g., market perceptions, product quality, workers' burnout), policy makers are supported in better framing their goals and objectives' time horizon and the links between financial and non-financial performance measures.
The process of building system dynamics simulation models enhances the interaction among people who are responsible for key-decision areas' results. In fact, by comparing their own views, they are able to pursue a learning process based on a continuous comparison between the model and reality, and to achieve a common shared vision of the system to be managed.
This paper aims to illustrate an interactive learning environment to explain how system dynamics can be applied to implement the balanced scorecard approach in the smaller firm context. In such an environment, one of the main strategic assets is usually provided by the entrepreneurial mental database and tacit knowledge. The approach here suggested allows one to better exploit such intangible resources and to overcome some of the main difficulties in introducing formal strategic control systems in SMEs.

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## Workshop: A Structured Soft System Approach to Enterprise Development

In this paper we adapt the usual definitions on which soft system approaches are based in favour of those that allow us to unfold a 'closed' enterprise into an 'open', dimensioned, layered, class-based and valued system of influences derived from expressions of

interest or concerns of stakeholders. The approach is formal but we present the structures informally using a simple, novel, unfolding technique; the method of our soft system approach is developed elsewhere. A fictional example, based on airport security, is used to illustrate the structures and an example system archetype is interpreted. The intention is to make soft system structures more mechanical and therefore perhaps more acceptable to wider system engineering audiences.

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## Simulation of the Business Firm Using Different Pricing Approaches

This paper examines the behaviour of firms over time using different economic models as a basis for setting price. A simulation model was created in order to examine the behaviour of the economic models over time. The paper examines the behaviour of a firm using two standard neoclassical economic models: a model built on the principle of marginalism, i.e.. the firm produces at the point where marginal cost equals marginal revenue, and a model built under the assumption of average cost pricing. The paper also examines the behaviour of a firm over time using a variant of the average cost model developed by the author. The results of the simulation show that the long run behaviour of the firm is significantly different depending on the pricing model chosen.

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## Workshop: Building "Strategic Architecture"

This workshop complements Kim Warren's pre-conference workshop, attendance at which is not a pre-requisite. During this 1½hour session, we will review key steps of Warren's approach to strategy assessment and formulation. The focus will be on how to build a "Strategic Architecture" of a topical managerial problem, and on using this form of organisational representation to derive strategy through time.The purpose of the workshop is to demonstrate the core dynamic resource based view of strategy developed by Warren, which places emphasis on stock accumulation rather than causal loop analysis. The approach has been applied with great success in business situations, due partly to the ease with which managers grasp key dynamic concepts. Participants in the workshop who are already familiar with "Strategy Dynamics" will gain further practice and insight but those not familiar will also gain appreciation of an approach that

may complement their own teaching or consulting activities.The session will be led by Rod Brown, Managing Director of Global Strategy Dynamics and a close colleague of Kim Warren.

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## Structural Validation of Causal Loop Diagrams

In this paper, we present techniques for manually testing the validity of each link in a causal loop diagram (CLD). A link is defined as consisting of an origination quantity, a destination quantity and a connection edge between them. Each link is considered as a separate and distinct causal hypothesis whose validity should stand on its own merits. Following Goldratt, criteria for determining the validity of the CLD are adapted and demonstrated. Eight possible validation criteria are considered: clarity, quantity existence, connection edge existence, cause sufficiency, additional cause possibility, cause/effect reversal, predicted effect existence, and tautology.

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## Simplified Translation of CLD's into SFD's

In this paper, I present constructs that enable simplified translation of CLD's (Causal Loop Diagrams) into SFD's (Stock and Flow Diagrams). As conventionally rendered, there are too many connection "possibilities" presented to immature, model builders who are just getting started. In this paper I will show that it is possible to limit some of these possibilities without any loss of robustness in the models that are developed. For model-builders who are unseasoned, the advantages are simplicity and prevention from creating a construct that is nonsensical. By implication, the automated translation of "fully developed" CLD's into SFD's is also possible. Algorithms implementing such automated translation are presented in the paper.

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## Feedback Approach for the Dynamic Interactions Between Urban Transportation and Air Pollution

To solve the policy problem between transportation and environment in trade-off, above all it is necessary to understand the

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complicated relationship between transportation and environment clearly before selecting policy alternatives. From this point of view, this study will propose the logic structure to examine the complex interaction of transportation and environment and will investigate theoretically what kind of impacts the air related policies would have on the two through policy causal maps.
In this research, we used 'system-dynamics' which investigates the complexity through the flow of information and materials and the interaction of factors, which constitutes systems. System Dynamics is the approach that the variables to decide structural relationship in a system affect one another not in only-way but in inter-way and the power of influence changes time by time.
This research is trying to examine the complex interaction of transportation and air pollution. For this, causal maps in System Dynamics approach were used. The main issues are; first, to investigate the dynamic relationship between transportation and air pollution caused by exhaust gas. Second, to structuralize the logic of simulation to experiment the impacts of policies to relieve air pollution.

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## The Maple Sap Products Industry in Quebec: An Economic and Production System Dynamics Model

The SD model expounded in this paper characterizes the nonlinear and dynamic behavior exhibited in maple sap production, and the potential hazard of long feedback delays involved in fixed asset investments supporting sap collection and syrup production. Developed following the structure introduced in Meadow's (1970) dynamic commodity cycle model, this model is adapted to the specifics of maple syrup production, and integrates structural elements of price expectations, supply response, demand substitution, and inventory fluctuation. As with most commodity production, maple sap collection and syrup production are subject to production, price, and stock pileup risks. All industry participants are subject to the uncertainty associated with long time delays in the formation of price expectations, in the adjustment of the supply response, seasonal production, and the demand for exports. Illustrative simulation results are presented. Extensions to the current works are outlined in the conclusion.

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## Public Policy Timeliness to Disruptive Innovation in Biotechnology: Information Feedback and the Regulation of Balancing Loops

The objective of this paper is to identify endogenous pressures, and their time delays, that are responsible for regulatory change in the plant agricultural biotechnology area. An influence diagram, the initial step of the system dynamics (SD) method, makes explicit the role of information flows as a limiting factor for use by the various parties, and as a means of controlling strategic transactions that influence efficiency and the distribution of wealth. A SD model is developed based on the influence diagram to simulate the interaction between investors', consumers', and regulatory feedback within the model. This method is employed to clarify informational requirements, define causal relationships, and identify the main feedback loops that influence the dynamic behavior and to inform the regulatory process.

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## Simulation of the Growth of Alaskan White Spruce Under Contrary Influences of Temperature Increase and Drought

A recent report in Nature 405, 8 June 2000, p. 668 by Valerie Barber, Glenn Juday and Bruce Finney, presents evidence for most of the past century showing that selected stands of Alaskan white spruce exhibit decreased carbon uptake (growth) during conditions of increasing mean monthly summer temperatures because of temperature induced drought conditions. These conditions apply to stands of spruce in widely separated productive stands at low elevations in central Alaska. A simulation model for tree growth is presented which includes photosynthesis enhancement functions dependent upon exogenous mean summer temperatures, plant water potential (related to atmospheric humidity) and mean atmospheric CO2 concentration. Using the data from the Barber, et al., Nature article as reference modes we are able to examine and test the sensitivity of growth parameters of these trees under the influence of these input variables in the simulation. These results may assist in the determination of the overall rate of carbon fixation (storage) by the Northern Boreal Forests under conditions of atmospheric CO2 increase or climatic fluctuation.

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## Secrets of Pugh-Roberts Associates…

Over nearly four decades of changing fads in management consulting, waxing and waning popularity of system dynamics, and the fluctuating success of firms practicing in the field, Pugh-Roberts Associates has sustained a long-term path of successful operation as a center of excellence and as a business devoted to system dynamics. In this first-ever public review of Pugh-Roberts operations, we describe what we believe to be the "secrets" of PRA's success. In this paper two senior members of the firm provide an insider's view of what factors have led to that success. We identify seven key values at the core of the dynamics driving the success of our business: big-stakes work; high staff quality; a distinctive culture; a compelling compensation model; dedication to work quality; longevity of staff tenure; and a balanced view of individuals' lifestyles. Adding to these values are several forces enabled by the firm's membership in the worldwide operations of PA Consulting, our parent firm for the past decade. Now operating as PA's Business Dynamics practice, the range of client application and financial success is revealed, and their roles in reinforcing our "success" model identified.

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## Moving Forward with System Dynamics in K-12 Education: A Collective Vision for the Next 25 Years

Roughly 20 years ago experimentation began in the use of System Dynamics in K-12 Education. In the last ten years, a number of experimental projects have clearly demonstrated that the use of System Dynamics can have a dramatic impact on the depth of learning by K-12 students. This early developmental stage of K-12 usage has pointed to the next steps. For System Dynamics to have a wide-spread impact on K-12 learning, increased teacher and community exposure to the concepts, large scale development of appropriate curriculum materials, and increased support for bringing the materials into the schools are necessary. To this point, only the some of the “innovators” have been engaged in the effort. A plan for the development, testing, and distribution of these materials has been developed by a group of ten of these “innovators” who met for two days in October. This plan presents an incremental approach taking advantage of leverage points within the existing curricula and

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educational practices, while calling for increased involvement of the large System Dynamics community.

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## Workshop: Ford Motor Company Enterprise Wide Advantage: A Study in Computer Based Simulations Applied at Ford Motor Company to Drive Business Process Transformation

Ford Motor Company has always considered the Consumer its Number One priority. In order to address their Consumer's needs, Ford is changing the focus of their internal processes to allow them to reach the market and service their Consumers in more effective ways. Almost all of this focus change requires Ford to operate with an "enterprise wide mindset" rather than the traditional functional mindset – while not losing track of "the Brand".

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# A Preliminary System Dynamics Model of Intergovernmental Collaboration

Between 1999 and 2001, the Center for Technology in Government (CTG) at the University at Albany actively collaborated with the Bureau of Housing Services (BHS) of the New York State Office of Temporary and Disability Assistance to develop a new information repository, called the Homeless Information Management System (HIMS). This project involved working with a number of homeless shelter providers in New York City. The HIMS is a shared database designed to support policy and management issues related to the homeless in New York City. While the project faced some technical challenges, more important issues centered on the development of trust and collaborative work processes among the several participants in the project.

During the HIMS project, CTG received a grant from the National Science Foundation to study the development and sharing of knowledge in interorganizational networks related to IT-based systems in the public sector (National Science Foundation grant #SES-9979839). As a part of that research, we created a system dynamics model of the dynamics of collaboration and trust in the management of multi-party IT projects. The HIMS project formed the basis for this model. The model presented in this paper explores feedback loops between stakeholder engagement and task performance by all parties associated with the project. The model builds on earlier work by Black, Carlisle, and Repenning (2001) on cross boundary collaboration.

A key set of positive loops between engagement, task accomplishment leading back to engagement dominate the dynamics of this system. When properly managed, these positive loops release forces that lead to speedy completion of a high quality project. When not properly managed, these positive loops create a system trap that lengthens the project time frame, leads to low stakeholder buy-in, and increases the amount of unsolved problems associated with the final project.

This project model was developed using group model building techniques and involving the whole author team. The processes used to create this preliminary model are described elsewhere in these proceedings (Cresswell et al, 2001).

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## Group Modeling of IT-Based Innovations in the Public Sector

For the past fifteen years, researchers at the University at Albany have been developing approaches to group decision support (GDSS) using a combination of group facilitation techniques linked to projected computer models in the room (Mumpower et al, 1998; Richardson et al, 1992; Rohrbaugh, 1992; Schuman and Rohrbaugh, 1991). One facet of that larger body of work has centered on building system dynamics models directly with client groups in the room (Richardson and Andersen, 1995 and 1997; Rohrbaugh, 2000). This work related to a larger body of work on Group Model Building (GMB) with system dynamics models (Vennix, 1996).

This paper documents the procedures used and products created for a small scale GMB effort using the approaches developed at Albany. The paper reports on tasks completed over a four-month period in 2001. The paper presents the concept model used in the first GMB session, a detailed script of what was to be accomplished in each session, along with a summary of the products produced in each of the two GMB sessions. A web site provides complete documentation of all the products developed in the GMB sessions (http://www.albany.edu/cpr/sdgroup/HIMS/).

The model developed using this process examines the impact of collaborative work and client engagement on team progress on a project designed to develop an information system for public sector clients. The project team was working on an information system to support management of the homeless shelter system in New York City. The client group for the GMB was the staff in the Center for Technology in Government who worked with homeless shelter providers and representatives of the Bureau of Homeless Services of New York State's Office of Temporary and Disability Assistance to develop the information system. The actual model developed from these GMB sessions is described elsewhere in these proceedings (Cresswell et al, 2001).

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## A Proposal for Collaborative Solution-Discovery

Contemporary issues are highly complex, requiring formal tools to augment human capabilities, allowing collaborative teams to work such issues. Collaborative Solution-Discovery, is a shell within which System Dynamics can be applied to large, complex issues.

It has two important features.
1. Stakeholder engagement, so all significant stakeholder-sourced information is captured, and all stakeholders support the solution-discovery process and its result.
2. An epistemologically-based Life Cycle and Solution-Search Path, using System Dynamics to test and refine understanding of the problem, and the solution that emerges.
Project design includes Life Cycle planning of project phases from initial apprehension of need to disposal of solution remnants at end of life, full Stakeholder Engagement at each phase, a generalized Solution-Search Path for the sub-problems at each phase of the Life Cycle, and a Leadership Style based on managing the process and facilitating the best performance of all participants.

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## Modelling AIDS Epidemiology in the Era of Highly Active Antiretroviral Therapy

A system dynamics model of HIV/AIDS epidemiology is employed to simulate the effects of triple combination antiretroviral therapy in the treatment of HIV/AIDS. The epidemic data on homosexual men in the UK (1981-1998) have been used to fit the baseline model. The new combination therapies, which supplanted antiviral mono and dual therapy in 1996, are proving to be the most effective prophylaxis yet for halting viral replication in vivo, but many uncertainties still surround their use. A range of model-generated scenarios are created as a means of considering these uncertainties. Possible futures for the HIV/AIDS epidemic are constructed.

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## The Use of Computer Simulations in Fourth and Fifth Grade Social Studies

The Georgia Curriculum calls for the study of American History in the fourth and fifth grades. This is the first sequential study of history our students encounter. In order to make the events of the past real to our students and allow them to "experience" as much of the feelings of the actual participants as possible, we use a series of computer simulations.
The models are centered on major events form the past and have students experience the events leading up to them. Students play the roles of different people and imagine the feelings as people experienced the events.
The simulations provide a reality to events. Students can have

discussions about the impact of a series of events instead of memorizing them. The discussions center on why the major events happened. In this manner, students can learn from the past to help understand the present.

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## Modeling for Strategy Design: Systems Thinking, Personnel Turbulence, and the US Coast Guard

Based on previous successes using systems thinking to investigate specific workforce problems, the U.S. Coast Guard decided to use the approach to analyze the interactions among the dynamic elements that comprise the total enlisted system. A team was created of researchers experienced in operations research, human resources and modeling, human resources personnel, master chiefs as subject matter experts and modelers experienced in systems thinking and military workforces. The Enlisted Workforce Turbulence Strategy Model will reproduce and simulate the interactions of the three major processes, training, advancement, and assignments, in the enlisted system to generate a mutual understanding among personnel policy-makers of how the enlisted system actually works. Steady-state equations model the flow of personnel through the enlisted system over time. The model is not intended to calculate explicit numerical results but rather as a strategic tool to assess impacts of personnel policies prior to implementation.

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## A Mental Model Based Theory of Dynamic Decision Making

Mental models play a central role in system dynamics efforts to improve learning and decision making in complex systems. In fact, the system dynamics methodology can be generally described as a feedback process in which mental models are used to develop a computer model, which in turn creates new opportunities for learning that improve the accuracy, coherence, and complexity of mental models. However, there are surprisingly few detailed descriptions in the system dynamics literature of the cognitive processes involved in this basic learning loop. To fill this gap, the present work reviews the characteristics of mental models of dynamic systems identified by the empirical literature, with an emphasis on important flaws and limitations, and their underlying causes, that typically limit the utility of mental models for dynamic

decision making.
Previous theoretical conceptualizations of dynamic decision making in the system dynamics literature put forth by Sterman and Richardson et al. are also reviewed and critiqued. Consistent with the empirical evidence, a mental model based theory of dynamic decision making is presented that combines elements of Brunswikian psychology, the heuristics and biases tradition in judgment and decision making, and Fishbein and Ajzen's theory of planned behavior. The mechanisms by which system dynamics computer modeling can effectively improve mental models within this theoretical framework are also described. Implications of the theory for developing appropriate techniques for studying mental models, as well as specific priorities for future research to test the theory, are discussed.

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## Dynamics of Illegal Logging Systems in Indonesia: An Initial Investigation

Many factors have accelerated deforestation in Indonesia. During the Soeharto era large forest concessions were awarded to friends and family of the president who were able to dictate forest policy while the military and police protected their interests. Soeharto's fall in 1998 and democratic elections in 1999 led to the hope that equitable and sustainable forest management would be instituted. This has not yet happened. A large government forestry bureaucracy remains, but its limited control of timber harvest declined further. Weakening of central authority allowed local level, illegal, timber harvesting systems to flourish. Central government commitments to reform, especially decentralization aimed at appeasing restive provinces, will likely accelerate illegal logging, especially with continuing economic uncertainty. Investigative field reports from Sumatra and Kalimantan, macro-level studies, plus conversations with stakeholders provided information for developing qualitative system dynamics models which help explain causes of, and possible solutions to, illegal logging.

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## Technology Improvement Policy: The Case of Turkey

Technology has been one of the most important factors of the economic and social growth and globally scaled competitiveness, although not respected as a separate factor by traditional

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economists until recently. It is now widely accepted that technology improvement plays a very major role on national growth.
Technology has a number of interactive and conflicting variables and parameters, which is not allowing an analysis with quantitative tools only. Complex dynamic analysis seems to be a proper tool to handle this sophistication.
This presentation is about a system dynamics model constructed for policy analysis in Turkey with respect to technology improvement and comparison of technology improvement policies.
It is part of a MS dissertation study which is still under progress, to be finalized on May 2001. This paper is based on preliminary findings of that study.

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## Simulation for Alternative Regulations in the Power-Supply Industry: Lessons for California

This paper reviews the transformation of the electricity industry world-wide and examines the benefits that this has brought up to both generators and customers. It points to problems as well as to possible solutions for the sustainability of reforms, and establishes that under the uncertainty of the environment, the regulation has been making a rapid progress and it is expected that its evolution will continue for many more years.
We propose a non-standard System Dynamics approach for evaluating alternative regulation schemes. The objective consists on finding costs and benefits, as well as possible winners and losers. System dynamics allows also assessing the opportunity for the transformation process, as gradual implementation seems to be possible in an expanding market.
A specific regulation problem is undertaken to illustrate the proposed methodology. It shows how the capacity-charged element, which has been used for reliability purposes, might be changed for alternative schemes. The proposed transformations to the actual regime seem to overcome some of its drawbacks. Simulation results indicate that alternative regulation improves the general system behaviour.

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## Stakeholder Analysis to Enrich the Systems Thinking and Modelling Methodology

A systematic analysis of stakeholders could enrich the systems thinking and modelling methodology. Among the five phases of

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the systems thinking and modelling framework, namely, problem structuring, causal loop modelling, dynamic modelling, scenario planning & modelling, and implementation & organisational learning, the importance of stakeholder analysis in the problem structuring and scenario planning & modelling phases is explained in this paper. A New Zealand transportation infrastructure case study is presented in this paper to illustrate the potential usefulness of stakeholder analysis in the systems thinking and modelling methodology.

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## The Use of System Dynamics in a Large-Scale System Engineering Effort: Case Study of the Deepwater Project

This paper describes the use of system dynamics modeling and influence diagramming in the design and phased implementation of the U.S. Coast Guard Integrated Deepwater System. From October 1998 through April 2000, Science Applications International Corporation led a multi-company team in a large-scale system engineering effort to design the next generation system of air, sea, information, and logistics support capabilities for Coast Guard operations more than 50 nautical miles from U.S. shores. The SAIC team used system dynamics modeling in close coordination with subject matter experts, design engineers, and decision makers to support not only the development, but also the evaluation, optimization, and implementation of its design. The team leveraged the Vensim SD software package for modeling, expert-in-the-loop sensitivity analysis and optimization. This system engineering effort pushed the boundaries of the system dynamics methodology by using system dynamics techniques and software for agent-based discrete event simulation with GIS-style visualization.

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## An Introduction to Jitia: Simulation Software Designed for Developing Large System Models

PA Consulting Group's Business Dynamics Practice, formerly Pugh-Roberts Associates, has been developing over the past few years a new simulation software package designed specifically to

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support the professional model builder develop and analyse medium to large system dynamics models. Although in use at PA Consulting since mid 2000, this software will be introduced to the public for the first time during the summer of 2001.
This paper introduces many of the unique features of the software and discusses how these features support the development of large system models. These features include the introduction of a hierarchical model building construct, new navigational and editing tools, improved array handling, improved macro support, search and replace support, multiple integration methods, advance analysis tools, scenario development and management tools, and a host of other items.

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## Creating a New Economy for a New Economy Business - Strategy Development for a Kids' Online Trading Community

SwapitShop.co.uk is a UK-based new venture, launched in September 2000, that enables children to trade things they no longer want for things they do. Children post items such as CDs, books etc. on the site for auction. Bidding takes place using a virtual currency known as Swapits. To ensure privacy, the auction is blind and SwapitShop undertakes the fulfillment process. SwapitShop's primary revenue model is to attract paying promotional partners to distribute the Swapit currency with their products that children can then collect.
SwapitShop.co.uk faced a number of critical issues leading up to launch. Firstly, they needed a fundamental understanding of the Swapit economy they were creating and what instruments they had available to manage it. They also needed to understand the likely recruitment rates for the initial media and promotional partner campaigns and their impact on the new economy.
We conducted an intensive assignment to identify the economic fundamentals. A series of System Dynamics models was employed to develop scenarios for the launch and the likely economic impact. Based on this we were able to recommend specific policies for the management team to follow.
This paper provides a review of this project as well as drawing some general conclusions based on our experiences using System Dynamics as a methodology to provide strategy to new ventures.

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## Integrating Real Option Theory and System Dynamics

The second subject reflects some research I currently perform by trying to integrate Real Option Theory and System Dynamics. This subject is focusing on the integration of SD based scenario planning with the most advanced valuation methodology of an optimal economic development path of a firm. The context of this paper would very much be based on a case study illustrating the advantages of system dynamics modeling in strategy development of a firm and its impact on the firms valuation. Real Option as valuation tool will be used to valuate the outcome of an system dynamics based strategy. I will further allow to identify the critical decision variables in a the system dynamics model on which the strategy is built. The case study will show how system dynamics and real option valuation can improve strategy definition.

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## The Application of Systemic Dynamics Theory to the Checking and Ratifying of Mine Production Capacity

The cause and effect analysis of main factors which affect mine capacity is made by means of System Dynamics Theory. Based on this analysis, the feedback cycle and flow chart result. In the actual situation, the simulated model of system dynamics is established to check and ratify the mine capacity effectively.

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## Strategic Study and Dynamics Decision for Development Program of City Housing

The cause and effect analysis of the main factors which affect city housing is made, by means of the system dynamics theory. On the basis of analysis the feedback cycle and flow diagram result. According to the actual situation, the simulated model of system dynamics for developing city housing program is established in order to make possible prediction and decision for city housing.

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## The Bridge to Humanity's Future: A System Dynamics Perspective on the Environmental Crisis and Its Resolution

Human life on Earth is threatened by the growth of world human consumption which quadruples every 35 years. Major environmental imbalances may soon severely deplete our planetary life-support system. However, the world economy is designed to create and depend on consumption growth. If this growth were to stop, major economic, social, and military crises could result. We call this tragic dilemma the Ecocosm Paradox. Powerful human instincts drive the positive feedback-loop processes that generate consumption growth. This growth involves many human, technological, and natural environmental variables whose separate study has given rise to specialized intellectual disciplines. However, in order to address our current dilemma, these variables must be analyzed together as a single, complex process. A new method of analysis, synthesis, and implementation based on a new transdisciplinary field, "Ecocosm Dynamics," is herein proposed for this analysis.

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## Introduction and Application of Inquiry and Communication Tools in Planning for Systemic Educational Change

This paper presents key findings from a qualitative study which explored how one elementary school site council learned and adopted a set of tools to increase their collective ability to work together and lead school improvement activities. The communication and inquiry tools introduced to this site council were drawn from learning organization theory and learning organizations. The results indicated that the tools increased the site council members= individual and collective capacity to listen, engage, trust, and work effectively with each other. These aptitudes were developed through the use of the tools in six areas: (a) becoming aware of one=s own thinking, (b) making one=s thinking visible and transparent to others, (c) understanding the thinking of others, (d) seeing one=s interactions from a systems perspective, (e) engaging in collaborative decision-making, and (f) capturing and documenting learning. These aptitudes and activities increased the members= awareness in three capacity building dimensions: self, others, and the system.

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## Workshop: Starting a System Dynamics Program in Your School for Students in Grades K Through 12

The workshop will demonstrate a multi-faceted approach to the problem of starting a system dynamics program in a K to 12th grade school environment. Hands-on activities will be provided for the participants to help them understand what methods might work to influence teachers to try this experiment. Student work will be demonstrated. A CD containing training materials used in the National Science Foundation CC-STADUS/CC-SUSTAIN Project will be available (at no cost) for all participants. These materials have been developed over the 8 year history of the project, training high school and middle school math, science, and social studies teachers to create STELLA models and curricular materials to use in their classroom. The CD will also contain teacher created project modules that have been edited. The workshop will also introduce materials developed in Carlisle, Massachusetts for younger students in kindergarten through eighth grade.

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## Simulating the Patterns of Power Plant Construction in California

This paper describes a system dynamics model to simulate the general patterns of power plant construction that might appear in an electric system with approximately the same loads, resources and markets as those in California. The simulations reveal that construction could appear in a steady, even fashion, causing power plants to come on line exactly in time to meet the profitability goals of investors. But this is not the dominant pattern. The more likely pattern shows construction lagging behind the growth in demand, allowing prices to climb to surprisingly high values during peak periods in the summer. When new power plants are completed, they come on line in great numbers causing a bust in wholesale prices. Electricity consumers would certainly benefit from a boom in construction. Unfortunately, waiting for the boom is a difficult challenge with the current mix of state and federal rules in California.

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## Effects of Constructibility Reviews on Highway Project Duration

With the growth of transportation and highway project funding, there has been an increase in delays to motorist and an adverse impact to the local businesses during construction. Therefore, state highway agencies are interested in decreasing the duration of construction projects to minimize the impacts to motorists and businesses. One approach to decreasing the duration of a highway project is to reduce the number of change orders during the construction phase. Increasing the quality of design through constructability reviews is one method. Constructibility review brings construction experience and knowledge into the design process prior to the letting of a contract. Though state highway agencies understand the value of constructibility reviews, only about 23 percent of them currently have a formal program. Using system dynamics, the effects of constructibility on the design and subsequent construction phases of a project were analyzed. Varying the average constructibility duration and product complexity, the impact of varying levels of constructibility on the project duration was determined. Constructibility reviews can reduce the overall duration of a highway project by reducing the errors created in the design phase that are uncovered during the construction phase. However, the increasing amount of time it takes to conduct constructibility reviews eventually fails to offset the shortened construction time.

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## Time-Related Sources of Model Failure

System dynamics provides a valuable format for exploring a system and for understanding the behavior of a system. Experience suggests that this particularly true for current and near-term planning. As the time horizon for models is extended and their role becomes predictive, their value generally declines as unmodeled factors exert influence. As a consultant in long-range planning and student in studies of the future, the author has found that the source of model failure generally falls into one of several categories. This paper identifies several common sources of model failure and discusses some steps that may aid in avoiding the problem.

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## Modeling Geographic Dispersion in an Urban Area

The urban growth model published by Jay W. Forrester in his 1969 book Urban Dynamics subdivided people into economic classes and businesses into age classes but did not subdivide the city by geography. A new model illustrates issues introduced by explicitly modeling geographic subdivisions in an urban area. In particular, the model shows why urban areas drift toward a commercial core surrounded by residential suburbs, why improved transportation systems do not reduce commute time, why core density restrictions increase unemployment, and why high-density, mixed-use zoning creates an unstable and inefficient development pattern.
The model's structural formulations for job matching, migration, and construction can be adapted to market-matching problems in other economic contexts. The structures employed are compared to the ALLOCP formulation built into Vensim. The model is available in as a self-installing Venapp simulator.

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## How We Help Students Learn

Three leaders in the field of using system dynamics in Kindergarten through 12th grades explain how young students can be taught the core principles and introduced to computer simulation. They will use many examples of classroom curriculum and relate personal experiences with students.

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## Enerbiz II: Strategy and Risk Management in Electricity Trading

The electricity market in Colombia has been immersed in a competitive environment in which trading is a high-risk activity

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involving a large number of agents. Those agents should have specialised knowledge on the market to develop strategies and manage the risk.
ISA, the Colombian Grid Company, and the National University of Colombia developed a workshop for energy trading in Colombia supported by a microworld named ENERBIZ. In the first version of the microworld, the user assumes the role of a trader under different hydrology scenarios and learns about the market before confronting his task under real-life situations.
The second stage of this workshop, named ENERBIZ II, is intended to the learning of strategy and risk management tools. The strategy approach seeks to develop competitive advantage skills. With the risk management module, the user learns the more important concepts of risk, efficient portfolio and measure of the risk associated to electricity trade.

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## Modeling Dynamic Systems to Identify Theories and Indicators of Program Performance: A Methodology and Application of System Dynamic Modeling to Sex Offender Program Evaluation

Since October 2000, the Sangamon County Specialized Sex Offender Probation (SSOP) Program has been engaged in a collaborative effort to develop performance-based indicators and assess the performance of the SSOP program. The project involved the cooperation of the Institute for Public Affairs at the University of Illinois at Springfield; the Department of Management at University of Plattsburg; and the Waters Center for System Dynamics. The purpose of the project was to develop indicators and evaluate SSOP Program outcomes. A process for identifying performance indicators was developed and a model for measuring program impacts was constructed.
The project sought to develop a working model of the dynamics associated with the sex offender probation case management system. The first project objective was to develop and apply a model building process to more fully explore complex and deeply embedded forces in the management of sex offender cases. These forces produced dynamic feedback loops experienced by SSOP probation officers as they managed their caseloads. The second project objective was to identify case management flows and inventories, a model that is similar to the supply chain problem. Such modeling efforts helped to identify important indicators of

program performance and led to a validated model to assess program impacts.
Results from this project demonstrated that modeling the dynamics of organized, complex systems produced significant insights. It significantly improved the quality of conversations as a pre-cursor to the development and selection of performance indicators. It also helped to uncover personal theories of "what works" and "what counts".

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## System Dynamics Insights for Balancing in a Corporate Storm

The changing market conditions and competitive response affect the health of a corporation. The typical firm adjusts rapidly by adopting new technology and changing its culture to counter its external impacts. This causes stress in the infrastructure. A corporation can see how others rate its overall health by its stock performance. It is much more difficult for it to determine how well each of its constituent organizations are responding to those external influences and maintaining their balance in the corporate storm
In this paper, we look at an individual technology organization within Boeing that is striving for its ability to respond to such stress and further the corporate vision. It has set momentum hypotheses that focus on customer satisfaction as its key mission. Using system dynamics simulation, within a Balanced Scorecard framework, we were able to turn our insights into actions. We show how convergence of the new policies with the organization's original focus on resolving issues at root cause level the organization was able to effectively implement its policies for a longer-term affect.

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## Workshop: FRED: A First-Order Delay Model

SimHealth: System Dynamics and Health Education is a Science Education Partnership Award grant supported by the National Institutes of Health. With this grant support we are developing curriculum materials to illustrate a variety of health science and medical concepts to middle and high school students.
Models have been developed to illustrate pharmacokinetics concepts such as intravenous injections and infusions and oral dosage regimens. For the most part these initial models are based

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on the first-order delay structure.

To complement these modeling exercises we have developed a physical model that illustrates various dosage regimens. A 2-liter container simulates the volume of distribution of the drug and a small pump produces a flow-through "clearance" of the system. "Drug" dosing is accomplished via "pills" (salt tablets with food coloring) or intravenous infusions. The blue dye provides a visual indication of "drug concentration". In addition, a Vernier Software LabPro data acquisitions system and Vernier conductivity detector provides a continuous measure of "drug" (salt) concentration.

Together with System Dynamics modeling, these experiments facilitate significant experiential learning. The nature of first-order delay systems (halftime; repeated dosing; time to reach plateau) becomes intuitively obvious. Equally important, students develop System Dynamics models for the same system. By combining these two exercises, students are able to solidify the conceptual link between the physical behavior of the system and the somewhat more abstract behavior of the System Dynamics model.

## SyM Bowl 2001: A New Beginning

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SyM Bowl was conceived in 1996 as a "modeling fair", analogous to a science fair. It grew from within the CC-STADUS grant (NSF) in Portland, Oregon, in which teachers, and ultimately high school students, were trained in System Dynamics. The first SyM Bowl was held in 1996 at Oregon Health Sciences University. In May 2000 SyM Bowl moved to the Oregon Museum of Science and Industry while retaining its strong connection with OHSU. Funding and support has been provided by individuals, High Performance Systems, Amber Blocks, and the SimHealth grant (NIH).

Over the past five years the organizers have spent considerable time in developing criteria for good modeling practice. These criteria were presented at the International SD meeting in 1999 for review by members of the society. Papers have been submitted by small teams of students on a variety of topics, and the level of modeling expertise has steadily increased. Sym Bowl has proven to be an excellent window on the level of expertise of the teachers and their trainers as well!

As might be expected, there have been some unintended consequences, and we continue to apply goal-seeking concepts as SyM Bowl evolves. The emphasis on modeling practice has clearly led to an increase in technical ability, but this emphasis has tended to obscure several important goals of a good System Dynamics

project. Students were able to defend their modeling effort, but often did not step back to consider the importance of communicating clearly to their audience. When probed deeper they also did not appear to generalize their model to similar issues as well as they might. Another issue was the concept of "competition". Although competition can be healthy, many proponents felt strongly that System Dynamics was ideally suited for collaborative work, and the competitive nature of SyM Bowl was viewed as counterproductive.

These realizations led to several changes in the structure of SyM Bowl. The view for the future is a model based loosely on a progression of achievement levels as illustrated by the Boy Scouts. The highest level of achievement (Eagle) is very challenging, and only the most dedicated participants reach this level. However, this highest level is based on leadership and community service rather than competition. In addition, the barriers for entry are much lower for beginners, encouraging much broader participation.

A progression of achievement levels also affords an opportunity to emphasize communication and teaching in addition to modeling skills per se. This will be accomplished by asking advanced participants to present their work to various audiences, both inside and outside their schools, thus serving as role models for beginning students. A related requirement will ask advanced students to provide a written critique of a SyM Bowl project submitted by their peers. This requirement is expected to be very challenging, and will demand that participants pay very close attention to good System Dynamics practice.

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## Modeling Functional Quality of Rigid Pavement Systems During its Life Cycle, A Systemic Approach

Decision making about valuating, planning, design, construction and maintenance of pavement systems are realized through pavement management systems. Maintenance costs are more important that those derived from construction. Resources are assigned according to the priority results of each segment on the network. It requires a deep knowledge about the current and future state of the pavement system. The correct evaluation of the information related to pavement condition is crucial to determine the present and future necessities.

Determination and forecast of functional quality of rigid pavement systems in terms of design, construction, environmental and rehabilitation variables is presented. It will be generated a model

and several sceneries will be run in a simulation process based in a real case. Through simulation process will be possible to estimate a Combined Quality Index in a specific year of service and/or to approximate its future behavior as a function of its life cycle.
It is proposed to system dynamics, like an integral tool to model with success the current and future state of rigid pavement systems, since it is possible to incorporate statistical or Bayesian regression algorithms, data obtained from mechanistic methods and subjective information curves with information more complex to interpret as economic and environmental. It is pretended to state and to evaluate from a systemic point of view the factors and inter-relationships that affects rigid pavement, since those factors are fundamental elements to the network manager to test different strategies and to assign maintenance or rehabilitation economic resources.

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## Capturing Synergy in the Growing Multi-Business Firm

A feedback simulation model is presented which operationalizes a dynamic theory linking managerial policies to under performance of a related diversified firm. Simulation experiments demonstrate how boundedly rational managerial policies for resource sharing unintentionally undermine the gains in performance, even when the economies of scope benefits are considerable. Overstretching shared resources results in rising coordination costs, specifically opportunity costs of lost sales, which decrease sales across the combined businesses. Unless the implementation of resource sharing is managed properly, these coordination costs may undermine the economies of scope benefits for a related diversification move. Allocation of shared resources between business activities or business units is a crucial corporate policy, and is an important behavioral element in the model. The growth and underinvestment and eroding goals generic structures, which have been highlighted in numerous single business models, are also prominent components of the multi-business model discussed in this paper.

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## Circular Autopoiesis Dynamics in Virtual Enterprise Networks

Although still flying low under the popular business media's collective radar, virtual enterprise networks (or nets) do receive

increased attention in the strategic management literature. A virtual enterprise network (VEN) is a system of autonomous firms that collaborate to achieve common business objectives. VENs give participants a competitive edge in markets demanding agility and rapid response. Seen as an emerging transactional exchange governance (TEG) form within transaction cost economics (TCE), VENs and the relations among firms that form them posit challenges for researchers and managers. VENs differ substantially from markets and hierarchies, and from recurrent and relational contracts, utterly changing what it means to be a firm in today's business. This essay explores alternative TEG forms, their characteristics and the criteria that bear on the choice of corporate governance: flexible specialization, market uncertainty, product (good or service) complexity, reliance on trust, risk, self-organization, shared knowledge, and socio-territorial cohesiveness. The essay offers propositions on the relations among economic criteria and the choice of transactional exchange governance forms by exploring the dynamics of a generic TEG structure. This is a system dynamics simulation model that partially offsets the shortcomings of transaction cost economics (TCE) and points to the potentially rich contribution of system dynamics to exploring VENs beyond the ideal-type TEG forms of markets and hierarchies that dominate the TCE literature.

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## Self-Organization Dynamics

In its unparalleled wisdom nature creates adaptively complex self-organizing systems (SOS), which produce the dynamic (i.e., through-time) behavior patterns that physicists and life scientists see. A system is an organized group of interacting components working together for a purpose. Control over the system's organization is either centralized in a distinct subsystem, or distributed among evenly contributing components. Distributed control enables self-organizing systems to create globally coherent behavior patterns (i.e., dynamics) spontaneously out of local component interactions.

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## The DS-9 Transparency Dynamics: To Be or Not to Be...Transparent?

Changing the transparency of principals, agents or technologies affects power relations with the users of transparency. Drawing on Plato's allegory on the relation between true being and the illusions

of the sense world, this essay explores the complexity of such changes in three stages. First, nine Deming Scholars (DS-9) use systems archetypes to interpret some of the G7/G8 summit clarion calls for greater transparency in political and military spheres. Second, the essay presents a framework for shifting managerial attention from single- and double- to multi-loop learning, a potentially significant requirement for combating greed and fee-driven deals when they come into play. Third, using a generic system dynamics simulation model, a hypothetical pro forma example from office real estate development, investment and finance shows how the manipulation of project assumptions (whether attributable to irrational exuberance, faulty data or poor forecasts) can significantly affect real estate investment decisions and cause office space oversupply.

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## Cyprus' Tourism: Testing the Bates UK Intervention

In response to Cyprus Hotel Association's foresight to test how Cyprus' year 2010 official strategy might affect tourist arrivals, hotel bed capacity and profitability and the island's environment, this study looked at Cyprus' hotel value chain within the island's tourism customer-supplier value chain. It focused on relations among tourism sectors as well as on links with and leaks to other socioeconomic sectors, including the environment. A system dynamics simulation model helped compute 35 scenarios of what might happen to Cyprus' tourism over the next 40 years. The faithful reproduction of historical tourism and bed capacity data through a 40-year time horizon shows the model's usefulness. The 35 strategic scenarios assess hotel value-chain sensitivity (25 scenarios), tourism growth (4 scenarios) and tourism seasonality (6 scenarios), along with their potential effects on the sustainability of Cyprus' environment and hotel profit.

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## Process of Growth of a Hedge Fund: Impact of Size on Performance

A theory-based feedback model is developed to study the process of growth of a hedge fund and the impact of its size on performance. It is proposed that market environment, organizational structure of a hedge fund, behavior of investors and managers, and reaction of the market are factors in the main finding that small hedge funds are generally more efficient and

perform better than large hedge funds in the short and long terms. The result draws support from organizational studies literature as well as some results from finance and economics.

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## Tailored User Interfaces and Data Management Facilities for System Dynamics Models

This paper describes the features and benefits that a bespoke front-end with a data management facility can provide for simulation models. In particular we will demonstrate a generic system developed by HVR Consulting Services Limited for BP, which allows a user to quickly configure a tailored interface for a chosen System Dynamics model, and provides comprehensive data management facilities.

Invariably any simulation modelling will require the maintenance of potentially large data sets, which are used as inputs into a simulation and also contain records of previous simulation results. During the course of a study it is certain that changes to a baseline set of data will be made to investigate model sensitivity or to model alternative scenarios. In many cases it is essential that such changes are tracked and a rationale maintained for progressive changes to a baseline.

Many current off-the-shelf PC simulation tools do not, unfortunately, have very good data management facilities or indeed even allow separation of data from the actual model structure. In many cases a record of results against input data sets cannot be produced unless an entire copy of the model and its data is saved. As technology progressed it became possible to feed-in data from, and write-out results to an external data source, but it was still difficult to manage data from the simulation application itself, requiring external database facilities. More recently, with new standards and protocols for application automation, it has become possible for software developers to write bespoke applications that can fully control embedded simulation applications. This advance, combined with a data management facility, has allowed the development of powerful scenario management tools for simulation applications and models.

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## Dynamics of Social Development

We created a metaphor about a little village in order to discuss mental models associated with economical development. The metaphor facilitates the acquisition of social comprehension, based

on behavior and interaction of actors. Through a system dynamics model, which represents the socioeconomic activities of a little town, it is possible to generate and support pedagogical processes and the discussion of decisions and actions of actors.
Our approach to poverty and development integrates systems theory, systemic economy, and sociology. The fundamental question is about the ability of individuals and communities to generate wealth. Existence of an individual in a community can be understood as a continuous flow process, which is not transient, and where generation and consumption of welfare is permanent.
The last part of this work discusses the application of the proposed methodology to social prospective. Through the use of system dynamic models, we analyze the creation of plausible socioeconomic scenarios. We don't pretend to conclude or state a development model. Instead of that, we propose a pedagogical exercise in which a conversational space is generated and mental models can be discussed in order to gain insight about welfare and individual development.

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## Business Cycle Entrainment: A System Dynamics Approach

Models in the system dynamics tradition often consider that firms can be aggregated in a single sector. The implicit assumption is that individual firms move in phase with each other. After careful development of a simple model of two firms coupled through market share, a set of simulation tests suggests that firms can entrain even when they are different and are driven by different random inputs. However, the market share coupling may be unable to promote entrainment between firms when they differ substantially. When the market share mechanism is not present, even similar firms driven by the same sine input do not show entrainment. Given that firms within an industry are commonly linked through market share, if they do not differ substantially from each other, it would not seem unusual to observe entrainment among them. Therefore, the simplifying assumption of modeling an industry as an aggregated firm often makes sense.

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## Integrating Dynamic Simulations with an OLAP System

This paper explains how a business simulation created in Powersim Studio can be linked to an online analytical processing

(OLAP) system in order to provide enhanced strategy planning, forecasting and what-if scenario analysis. OLAP systems and data warehouses (DW) allow corporations to collect and aggregate operational data with the aim of performing analysis. The data in the data warehouse form a blueprint for the company's history and past performance, and by studying these data, a corporation can streamline performance, correct its course, and in general be better prepared to face an uncertain future. Although OLAP systems are excellent analytical tools, they operate by analyzing historical data, and can only offer limited forecasting and scenario planning capabilities. By using a business simulation to perform the forecasting and scenario planning, an OLAP system can be extended into a very powerful analytical planning tool.

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## Dynamic, Hard and Strategic Questions: Using Optimization to Answer a Marketing Resource Allocation Question

For historical reasons, optimization has traditionally been slightly outside the mainstream of System Dynamics. However, computer technology has both made quantitative data more abundant and optimization more feasible. At the same time, modelers are encountering real situations and clients with high-stakes questions that are nearly impossible to answer without optimization – the systems involved are not only dynamic, and not only highly interconnected, but also combinatorially daunting. In particular, corporate marketers currently make allocation decisions impacting billions of dollars of shareholder value on the basis of intuitive "anchor and adjust" strategies, which can be far from optimal.

This paper presents an anonymized case study of one such situation. The company is in a high-tech industry undergoing rapid change. The company needed to fashion a go-to-market strategy balancing traditional and unfamiliar markets, an important component of which was allocation of marketing resources. Optimization revealed a potential valuation increase of roughly 30% relative to executives' intuitive allocations. Scenario analysis revealed the basic policy direction (more advertising) to be robust, and in the process resolved several traditional conundrums in dealing with adverse events in the marketplace.

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## Polak's Macroeconomic Monetary Model

The Polak's macroeconomic monetary model reflecting the monetary approach to the balance of payments was developed in the International Monetary Fund (IMF). Its purpose is to integrate monetary, income and balance of payments analysis, and it became the basis of the conditionality applied to IMF credits.
The dynamic nature of the Polak's monetary model, in contrast to most academic monetary models of the balance of payments, yields not only the final equilibrium value of the endogenous variables but also the time path toward these values. This makes the model particularly suitable for presentation and manipulation in system-dynamic notation.
Based on the original mathematical form of the Polak's monetary model we constitute the causal loop diagram, first of the basic model and then the extended, goal oriented model variant. Based on the causal structure we also form the corresponding flow diagram of the model in POWERSIM notation.
Polak's model is especially suitable for operative application in IMF financial programming missions in developing countries. Since Croatia is one of these countries, it is chosen as a case to test applicability and validity of the system-dynamic version of Polak's extended monetary model. The model parameters are calibrated and validity of the model is tested on the basis of data for the period of 1994-1996 (based on the quarterly data).

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## Human Error Assessment in Complex Socio-Technical Systems - System Dynamics versus Bayesian Belief Network

Due to the complex interactions that appear between the actors (humans, computers) of complex socio-technical systems the reliability issue of the human complement in such systems is very important. Predicting human error in the context of human-machine or human-human interaction reveals important information concerning the reliability of the whole systems. In order to prevent accidents in such systems it is important to assess the implication of human error during the early stages of system requirements.
This paper compares the advantages and deficiencies of System Dynamics and Bayesian Belief network methodologies in assessing the reliability issue of complex socio-technical systems.

The BBN approach employs probabilistic relationships between influences in order to reason about uncertainty where System Dynamics on the other hand concentrate upon the interconnections of the various components and the influences between each other, expressed in a loop structure.
In both methodologies a taxonomy framework of influences that contribute to human error is applied. Components of the taxonomy are represented in a causal effect diagram. The diagram is represented in System Dynamics and BBN formats which quantifies error influences arising from user knowledge, ability, and task environment, combined with factors describing the complexity of user action and user interface quality in scenarios of projected system usage. The models predict the different types of errors (slips and mistakes) in complex socio-technical systems.
"What if" scenarios concentrate on representing critical conditions in a system that are more prone to human error. These are subsequently transformed into a sequence of scenario threads that enable the evaluation of BBN and SD models, taking into consideration the properties of humans, machines and the environment in which they reside.

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## Manpower Planning with System Dynamics and Business Objects

Organisations tend to be hierarchical with a finite number of levels (ranks). Humans are considered as the most crucial, volatile and potentially unpredictable resource which an organisation utilises. If an organisation fails to place and direct human resources in the right areas of the business, at the right time, and at the right cost, serious inefficiencies are likely to occur creating considerable operational difficulties or even business failure. In order to achieve this the co-ordination of demand and supply is required, together with the monitoring and assessment of productivity and technological changes. Staff moves around the organisation in a variety of movements and flows. It is clear that it is difficult to track and monitor these movements without the complexity of qualitative factors and the projection of resource mismatches.
Traditional approaches such as Markov based models are highly concentrated on the mathematical aspects to represent the manpower planning process. In order to overcome the problems of traditional approaches a new technique is required which combines the rich problem structuring of "system thinking" with the flexible analytical power of quantitative methods. Since system thinking enables the conceptualisation of a situation in the form of a "rich

picture" that contains the necessary interconnections between its various entities, the mathematical intricacies of each entity could be abstracted or usually eliminated. As a result realities could be presented in a comprehensible format. The technique that realises the operational and representational aspects of a business problem is system dynamics. Such models are far superior in process terms since they are not "black boxes" but totally understandable to those involved.

The proposed architecture unifies System Dynamics with Business Objects in a single framework that enables the dynamic communication of statistical information from the operational system of an organisation to the system dynamics model. This information could be: the total number of employees in each rank, transfers rates between ranks, wastages, promotions, employees productivity and so forth. All this information corresponds to the current state of the organisation and is fed into the simulation model dynamically. This leads to up to date supply of information to the simulation model and subsequently more accurate simulation results.

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## Musings About the Effectiveness and Evaluation of Business Simulators

Evaluation research on business simulators is still in its infancy, both inside and outside the system dynamics community. Experiences made with other instructional media (for instance, interactive video) and with non-computer-based simulation games suggest that this is to a great deal caused by asking the wrong questions. The paper presents a conceptual model of human learning that can be used as a basis for evaluation research of business simulators. Furthermore, it is discussed why questions about the absolute efficacy of such simulation tools cannot be answered generally. In the same way, comparisons with other teaching methods are not fruitful. The only evaluation approach open for rigorous experimentation is testing of business simulators which are systematically varied in one feature. Issues concerning this approach are discussed at the end of this paper.

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## Simulating Network Effects of New Economy Goods

The so-called New Economy is said to be driven by economies of networks instead of economies of scale. The term "economies of

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networks" is derived from a characteristic of many goods in the information and communications sector: they show a positive correlation between their utility and the number of customers. This phenomenon is called network effect, network externalities or demand-side economies of scale.

In recent years, trends towards an information society have emphasized the importance of such goods satisfying information and communication needs. Network externalities are present when the number of consumers who purchase a particular good is an important characteristic of that good, which affects the utility derived by consumers either directly or indirectly. Examples of goods showing network externalities are fax machines, e-mail, or computer platforms.

In system dynamics terms one can speak of a positive feedback: the more customers use a product, the more likely others will be attracted to its use, and so forth. Many implications have been derived from this basic structure, for example the need to grow faster than the competition with the consequence of accumulating high losses during the growth period. Also, concepts like compatibility and switching costs of customers locked-in in one network have become important.

The paper examines in which way the diffusion of goods showing network effects differs from "conventional" products. Growth strategies are compared to cost leadership strategies based on economies of scale. Limitations of networks are investigated. Also, the competition and cooperation between two networks is further explored. After this simulation-based analysis, conclusions concerning successful strategies for managing network externalities are derived from the system dynamics model.

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## Modelling a Wetland Through Sustainable Development: Uluabat Lake

This research deals with sustainable management policies in a wetland. The region consists of a shallow lake and its surroundings. Fishing is a major commercial activity. The lake is under high nutrient loads. The goal of this research is to find a balance between ecosystem and economic activities in the region. To this end, a system dynamics model of the wetland is constructed. The results obtained from the model show that there is no threat of eutrophication in the near future. The major problem seems to be a potential decline in the welfare of the inhabitants mainly due to unsustainable population increase. The scenario runs reveal the lake would have become eutrophic, if crayfish

population did not collapse due to a fungus disease in 1986. Recovery of crayfish sometime within the model timeframe results increase in crayfish harvest; hence in income from fishing leading to betterment in social conditions. 'Improved agricultural techniques' is the only policy that leads to better social conditions through increasing yield per hectare. It is hoped that the dynamic simulation model will serve as a laboratory to analyse different policy alternatives.

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## Organizational Size, Flexibility and Performance: A System Dynamics Approach

Whether organizational size has effects on flexibility has long been an issue of discussion and debate in the field of organization studies. In addition, whether organizations with a greater degree of flexibility will perform better in a rapidly changing environment has also been widely discussed in the literature of organizational change. This study intends to illuminate the interwoven nature and reciprocal relationships among organizational size, flexibility, and performance by building a dynamic model to examine the contradictory findings in existing theories. The results of analyzing the behaviors of the model suggest that organizational flexibility is a construct of multiple attributions that has been overlooked in different studies. As a result, only if we can clarify the meaning of flexibility, can we then resolve the arguments regarding whether large or small organizations are more flexible, and whether flexible organizations tend to outperform less flexible ones.

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## Hierarchy in Management: Strategic and Tactical Behavior

When a corporation is composed of many plants, how should it control the operation of these plants in the least intrusive way, that is, what is the minimal set of appropriate constraints the corporate level should apply? These constraints include specific operating conditions and the requirement of specific operational information. An analogy with ecology is presented and a specific example of a dynamic model of the optimal expansion of the corporation is developed.

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## Simulating Dynamic Carrying Capacity of the Icelandic Environment for Land Use in Relation to Past and Future Climatic Fluctuations

The presented paper aims at clarifying the complex interaction between biotic and abiotic factors influencing land cover changes in sub-arctic landscapes, especially issues regarding the carrying capacity of the ecosystem, such as land use pressure and grazing potential. This is important for the
understanding of the land degradation processes and thus for the future land use and sustainability. The results indicate that the maximum sustainable population supported by the Icelandic environment from the beginning of the Viking settlement, thousand years ago, fluctuated between 30-60.000 inhabitants. This suggests that the pre-historical population overshoot the carrying capacity on several occasions.

## Building an Integrated High School Curriculum Focused on the Biology and History of Smallpox

Recently we were challenged to develop curricular materials to explore system dynamics as a foundation for engaging high school students in interdisciplinary studies. We needed to: engage student interest, be responsive to the schools' need to meet specific learning standards, foster an appreciation for crossing traditional disciplinary boundaries to address "real-world" issues, and provide students and teachers with opportunities to develop system dynamics mind-sets and tool-sets that could transfer to other scenarios.
We revised our collegiate course, "Plagues and People," that focused on the impact of epidemic disease on human history. Here we chose to focus consistently on a single disease, smallpox, that
has, over millennia, killed more than 100 million individuals.
The package consists of 10 case studies; four of the cases have a primary biological focus, four focus on history, and two are interdisciplinary. Each is designed to be free-standing, but to also draw on the insights from other cases and to lead into yet others. Each utilizes a variety of system dynamics-based explorations and provides opportunities for students and teachers with widely differing system dynamics exposure and ability. Collectively, they provide a rich mosaic of intellectual explorations that bridge traditional but limiting barriers separating academic disciplines.

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## Crisis in Colombian Prisons: Cause or Consequence of a Flawed Judicial System?

This paper examines the crisis that has been recently detected in Colombian prisons, by investigating the interactions between the judicial system and crime.
We develop a simulation model, based on the economic theory of crime, in order to explain system behavior and to analyze alternative policies that may contribute to resolve some of the problems affecting Colombian prisons.
Among the most important variables included in the model are the profitability of crime, re-socialization of criminals, and effectiveness of justice. Simulations show that the cause of the penitential crisis is not the overcrowding problem, but the effect of flowed policies and the structure of the judicial system.
We found that in spite of its higher short-term costs, longer sentences reduce crime. Conversely, as short sentences make crime more profitable, simulations show that reduction of sentences will increase the congestion of the judicial system in the long run.

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## Teaching Causal Loops to Second and Third Graders

After introducing a class of second grade students to causal loops in general, (reinforcing and balancing types) using Nancy Robert's Picture Kit activity, it became apparent that a tangible and visual approach to transferring the tool was needed. The students had already explored the concept of looking for patterns in population relationships while studying interdependency. The use of the same strategy seemed natural.
This presentation will explain the steps we used to practice identifying patterns in IF/THEN statements and classifying the causality in them.
The students, more often than not, would have varying opinions about the type of causality, which led to thought provoking discussions. They learned to think and talk through their ideas and to justify their opinion. They learned the importance of and respect for perspective. This understanding has led to an increase of the student's ability to apply these concepts to other situations that they encounter in their own lives.

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## Environmental Study: Habitat and Interdependency

When planning a study of habitat and interdependency for second grade students, we found many ST/DM tools provided the right teaching strategy. Initially, students were led to the concept of basic needs and "habitat." To make the concepts more real to the students, a game of "Rabbit Run" was the played, and STELLA models were used. Students also graphed and discussed different patterns of population growth.

The use of ST/DM tools and concepts in this unit resulted in a demonstrable and transferable understanding of relationships within a habitat. These same students, one year later, were able to recall the vocabulary and concepts with remarkable ease. They were then able to build upon that knowledge in a group study of specific ecosystems in our area. The final assessment of their understanding was for them to draw SD maps of a basic producer, predator and prey relationship using a STELLA model.

## New Product Introduction: Does the Highest Growth Create a Competitive Advantage?

In today's markets managers are focused on growth and profits. This could affect negatively on the other important competitive characteristics, such as investments and working capital. Financial literature supports this opinion, according to it cash flow measure will reveal all these hidden problems. For example, nowadays inventories are seen more like a liability than asset, at least in the very volatile business environment (shorter product life-cycles and higher product variety). Total productivity should also be perfect measure for this kind of fast changing environment; it does not only consider traditional input items such as human, materials, fixed capital, energy and other expenses. But it will take also into account working capital.

In this paper, we demonstrate two hypothetical situations, where growth estimates will be exceeded remarkably with introduced new product family. According to the growth and profit performance measures, the highest growth scenario is the most profitable in both situations. However, the lack of manufacturing capacity and limited length of product life-cycle will generate problems. According to the analyses, the highest, and also the least volatile total productivity development was achieved in the lower

growing scenarios. Cash flow analyses will reveal the same, higher growth will give its benefits after investment, but the differences are rather marginal. In the end of the product life-cycle lower growing scenarios will produce significantly better cash flow. According to the results of this paper, the high growth is important performance measure and affordable, but it has its limitations. The real differences will be found from the discounted cash flow of the whole product life-cycle.

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## Modeling the Emergence of Multidrug Antibiotic Resistance

One of the most worrisome aspects of the worldwide growth of antibiotic resistance is the emergence of bacterial strains (or "clones") that are resistant to multiple classes of antibiotics. Such multidrug resistance has made some life-threatening diseases more difficult and more expensive to treat, and has contributed to an increase in mortality from formerly well-controlled diseases such as tuberculosis. It has also led to increasing reliance on the newest and most powerful antibiotics, sparking concerns that resistance will soon reduce their effectiveness as well, and eliminate all options for treatment in some cases. We have previously presented a small system dynamics model, drawing upon a case study of pneumococcal resistance to the beta-lactams, that portrays the development of resistance within a bacterial population to a single class of antibiotics. This model is now extended to consider growth in resistance to two different classes of antibiotics, with special application to pneumococcal resistance to the beta-lactams and the macrolides. The extended model shows how selective pressure from antibiotics may cause multidrug resistant clones to become dominant over both non-resistant and single-drug resistant strains, even when the microbiological mechanisms of resistance for the two antibiotic classes are unrelated. These results help to explain the rapid emergence in the 1990s of pneumococcal clones resistant to as many as six different antibiotic classes. We also discuss possible use of the model to inquire into the future of pneumococcal resistance to both established and relatively new classes of antibiotics.

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## Tower Cranes in Tall Building Construction: A System Dynamics Model of Resource Allocation

Tower cranes have a critical role in the construction of tall buildings in dense urban areas, being a limited resource that is shared among subcontractors to hoist materials in critical tasks. Efficient tower crane utilization can therefore be critical for project success.

Efficient tower crane utilization has been found to depend on a number of factors, including tower crane selection and placement, lift paths, vertical travel distances, operator skills, and weather. While it is generally recognized that tower cranes require more careful planning of lift schedules to avoid conflicts between subcontractors, most of the research has focused on predicting crane use with stochastic models and optimizing tower crane selection, placement, and waiting positions. These approaches have mostly assumed that crane utilization can be optimized through equipment selection and positioning and excluded the dynamics of resource allocation between subcontractors on a job site, and the tendency is to assume that materials are continuously supplied to subcontracts at a constant rate. Yet work practices indicate that most projects experience trades being forced to stop work to wait for materials or for preceding trades, reduced productivity and heated battles among trade foremen and the superintendent of the general contractor. An improved understanding of the impacts of hoist capacity allocation on project performance is needed.

This paper presents a preliminary system dynamics model of the problem of allocating limited tower crane capacity to subcontractors in tall building construction and includes such factors as floor congestion, work stoppages, schedule delays, and competition between subcontracts. Policies for improved allocation are studied.

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## Community Assessment Tool: An Evaluation of Websims for Violence Prevention

Michigan communities are in the process of developing coordinating councils to end domestic violence. Participants often include representatives from battered women's shelters, law enforcement, prosecutors, judges, probation officers, and batterer intervention programs. With better understanding and coordination of activities, they hold the promise of modifying organizational

policies to help increase the safety of victims and hold batterers accountable.

System dynamics could play an important role in this process by helping participants better understand the feedback mechanisms within their community, but only if they are actively participating in the modeling process. This entails participants being able to test and share the model with other colleagues. Each participant should therefore have convenient access to the simulations. This poses a problem in finding a way to maintain a changing model across geographically distant organizations and different computer systems. However, most coordinating council participants now have some type of access to the World Wide Web, which raises the possibility of using web-based simulations as a tool for distance education. This paper presents an evaluation of participants' use of a web-based simulation of community responses to domestic violence implemented with active server pages and components based on Vensim DSS.

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## Modeling Meaning, Not Variables: Towards an Interpretative Modelling of System Dynamics

This study suggests a rethinking of qualitative system dynamics modelling. The results highlight that "interpretative modelling" is a useful way to enhance the use of system dynamics when encountering a situation coloured by social, cultural and political factors. The paper examines the problem embedded in the current use of system dynamics and proposes a three-level analysis (process, influence diagram and frame) to show how interpretative modelling can be attempted. It argues that, for qualitative inquiries, researchers need to consider interpretative modelling that emphasises more on surfacing meaning rather than on building variables.

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## Modeling Home Care Services to Identify Service Shortfalls

As more home care services are required the ability of service providers to meet community needs and hire and retain sufficient number of workers has become an increasing challenge. A SD model was built to help understand and communicate with other players in the health sector the reasons why home care employers are having difficulty hiring and retaining workers. The model may also serve for future planning that could prevent a severe shortfall

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in services as the population ages and hospitals discharge patients with more complex health needs. Stresses were identified that eroded the employers ability to compete with other sectors for limited human resources. Through modeling it became clear that improved service integration between home care, long term care facilities and hospitals services is essential otherwise service recipients will receive less than expected care.

## ABC - Modelling of Natural Resources Use

The ABC-modeling presents a new system approach to the general management problem. Being an enlargement of the system dynamics method, this approach (called "system management" now) was formulated in terms of the dynamic tendency balances in any social-ecological-economic system, associated with the sustainable development problem. It permitted very feasible and efficient use of the standard adaptive balance modules for a system structure constructing. Scenarios for the processes to be modeled could be presented as a cumulative effect of the external forcing propagating inside the whole system through the causes functions. Adaptive stochastic methods for the determination of the causes functions and for observational data assimilation in the model were suggested . The aim of this investigation was to construct a general ABC information technology, describing the processes of natural resources use by any enterprise resulting in a transformation of common property into the private income. Rental and ecological fine payments were assumed to be the partial compensation to the society from enterprise for the consumption of environmental biological, mineral and ecological resources. The profitability of natural resources use under these limitations became the crucial factor to an enterprise. The general model gained consisted of three sub models: ABC-model of the natural resources market, ecological-economic model of an enterprise and ABC-model of the production market. In various simulation runs with the model the system management of natural resources was studied. Predicted scenarios of the environmental characteristics along with the parameters of the enterprise financial state were obtained. They presented a good ground for making decisions about the governmental and industrial policy in natural resources use. General conclusion was made, that ABC method could be used as a conventional operation research tool for the decision-making support in changing market economy conditions, natural resources management, human-environmental interactions and other sustainable development problems.

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## Long-Term Environmental Stewardship at DOE Facilities

The Department of Energy (DOE) has formally recognized its responsibilities to manage its facilities and lands into the distant future by creating a Long Term Stewardship Office. The mission of the Long Term Stewardship Program is to develop and maintain all activities necessary to ensure protection of human health and the environment at a DOE site. DOE is expected to be responsible for long-term stewardship at more than 100 sites, and will need to maintain records at nearly 50 additional sites. Development and implementation of a program of this magnitude will be enormously complex in the face of uncertain budgets, a vast array of cleanup options, conflicting stakeholder needs, and a myriad of other conflicts. DOE has also recognized the need to include the public in any management decisions involving federal lands. The challenge is to educate the public, as well as other stakeholders, of the problems that these contaminated sites present as well as the vast array of cleanup and monitoring options. The purpose of this work is to develop an approach to identify, define and model the key components of long-term stewardship associated with DOE lands and facilities. This project will use system dynamics and group model building to develop a model that will allow stakeholders to play "what-if" games to enrich their knowledge of system behavior. The model will give the stakeholders a better understanding of how the system will react to various management decisions. Enhanced understanding as well as stakeholder involvement should lead to better and more acceptable management decisions of DOE's facilities and lands.

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## Leveraging Systems Thinking Insights to Enhance Process Management

All work gets done through processes, that are building blocks of organizations. With advances in quality management and reengineering, the processes are key focal points for management. For quality management award programs process management (PM) has been the dominant theme.Given this, if systems thinking were to have any impact, the tools and insight generated should ultimately be aimed at policy elements of PM or processes governed by the existing policies. The paper uses two applications to demonstrate how systems thinking enhanced PM.

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## A System Based Inquiry of Public Policy Issues for Snowmobile Tourism

A system dynamics structure is presented for a snowmobile destination, the Keweenaw Peninsula in Michigan's upper peninsula. The structure will simulate the inter-related effects of demand; trail capacity, infrastructure, and the quality of the snowmobiling experience. The purpose of the model will be to study the short and long-term effects of various policies on issues important to policy makers, such as fluctuation in demand, environmental degradation, and profitability of businesses. The proposed structure is explained and the plan for future work is described.

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## A Rate Variable Fundamental In-Tree Modeling and Branch-Vector Approach to Evaluating Feedback Loops

A new system dynamics rate variable fundamental in-tree modeling and a branch-vector determinant approach to feedback loops analysis are expounded in this paper. These approaches offer an effective means of modeling normally while simultaneously analyzing feedback loops explicitly. A case study of a system of energy and ecology in a village with the principle of sustainable development illustrates these new approaches.

China is a country with an extreme disequilibrium of energy resources and a serious shortage of energy. Especially in vast hilly rural areas, conventional energy resources are very deficient and two-thirds of energy for daily life in these areas is from biomass (mainly including straw, firewood, manure and urine, etc.). As the energy resources from biomass in those areas are not efficiently utilized, it brings about that firewood is seriously felled. This causes that the covering ratio of forests is falling by nearly one-hundredth per annum and that the area of soil erosion is enlarging year by year.

Jiangxi is a province with energy shortage in China. Wangheqiu Village in a county of Jiangxi province is a typical hilly rural area which is lack of energy. Peasants in the village did not attach importance to the re-utilization of energy from biomass. It caused the environment pollution and strongly restricted the development of village economy. For this reason, a research project on the System of Energy and Ecology in Wangheqiu Village was

subsidized by the State Science and Technology Commission of China (SSTCC). This project aimed at the exploitation of energy, ecology and economy, while was strongly connected with the population development. We investigated the situation , and designed the interplanting , forests and fruit trees, the methane-generating , the energy-saving and so on. After having obtained a set of data, we made study on simulation, optimization and planning. In this stage, a system dynamics model was used for simulation.

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## Dynamics of Application Service Provision Business Models

Demand for e-commerce capabilities and chronic shortages in the skilled labor pool have engendered a new genre of IT firm termed as the application services provider (ASP). These firms rent applications from independent software vendors and provide these applications to end users as a service. We present a variety of business models observed in the ASP market. Viability of these business models is predicated on an ASP's ability to become profitable by adding value to the users' service needs. Typically, these business models aim at getting big fast (GBF) in order to exploit both the economies of scale and the network externality. We describe causal structures associated with these business models and argue that system dynamics simulations provide an ideal set up to conduct analysis associated the evolution of GBF policies. We illustrate our argument using evidence from an ASP engaged in development of IT based mortgage services.

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## Dances of Life

This paper adapts Bowen family systems model to complex organizational systems. It examines the various responses to stress and anxiety on group behavior. It lays out five common patterns and processes and what they mean for leadership. Recognition of these patterns can predict behavior and provide tools to effectively deal with resistance to change.

Bowen family theory has been widely researched and is rooted in biology. However, it has not been integrated with other models of systemic thinking. It posits that the relationship system impacts the functioning of individuals within a group. The structure, culture and relationships are the primary factors driving behavior of individuals within any given system. The degree and intensity

of resistance to change depends on the leadership and types of relationship that exists within the system. Leadership takes on new meaning when it is examined through the prism of Bowen family systems theory.

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## Systemability: Harnessing the Core Principles of System Dynamics Towards Sustainability

Sustainability Institute has embarked on a multi-year project to help policy-makers, community leaders, and citizens outside the modeling community lead the transition to ecological and economic sustainability. The core of our method is to design and disseminate a curriculum for training people in a systems approach and systems thinking tools through short workshops.
We come to the system dynamics community with one research question: What transmittable principles, tools, or approaches can system dynamics offer in a short period of time to help a wide range of people be more effective in leading towards sustainability?
Our poster session will present our current approach, including workshop materials, graphics and simulation models. We hope to engage session visitors in an open dialogue about our research question.

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## Forests, Acidification and the Socio-economic Cost

The ongoing acidification of forest soils, believed to cause a severe impact on the ecosystem, is one of Sweden's major environmental problems. The objective of this study is to elucidate if mitigate a future impact of acidification is economically worthwhile. The total economic value of resources affected by forest soil acidification is estimated. The impact of acidification on different values is also analysed. Furthermore, the amount of forested area, acidified due to anthropogenic activities, is explored. Finally, a model is developed to analyse how a future impact may affect the timber production in a forest stand. The results of this study show that the total economic value of resources affected by forest soil acidification amounts to 65 billion SEK annually. The total forest area in southern Sweden, acidified due to anthropogenic activities, is estimated to 5 million hectares. The abatement cost, if liming is undertaken, is estimated to at least 7.5
billion SEK with a lasting time of 20-40 years. The model suggests

that a minor decrease in forest production would result in a significant loss of value. The overall conclusion suggests that there is a significant risk of a future cost, many times higher than the present cost of mitigating the acidification.

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## Model for SME Sector Development

SME: Small and Medium Enterprise sector development is one of the key issues in external cooperation by developed countries to developing countries recently. Development of SME sector is important for strengthening the leading industries with the assistance of SME as support industries. In addition, SME development is the future candidate of leading industry because every leading enterprise has had the experience of starting their business as a SME. The future of the industry is dependent on the development of SME. For the labor market, SME development is also an important issue because it employs the labor force and offers wages to workers. In those terms, development of the SME sector could be not only the key issue of industry development but also socio-economic development for every country. The Japanese government developed many tools for SME development and has been quite successful with their performance during the past several decades. However, according to our experiences, although incentive tools for development of the SME sector have been used effectively, there are some difficulties that mainly come from the circumstantial nature surrounding SME. Basically the SME sector has a complex nature and it is the reason why the SME sector can be sustained. We are trying to develop a standard SME sector model and examine the effectiveness of incentive tools for providing powerful decision making support tools for industry development planning staff of governments.

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## System Dynamics of a Quality Class Room in a High School

Modern School Lucknow India 226024, is a ISO9002 certified school in India and is working to improve student learning methods through improving social system dynamics of group learning. This system simulation is about the quality class-room learning system recently introduced in high school classes of our K-12 school. The simulation of the quality school processes, and the variations in procedures about how to regulate the social system of the class, is designed & presented as computer

simulation in C++ and simple graphics. Results clarify the number of students and their combinations in a group, and their outputs. Alternative steps for "student group social system" learning sequences are simulated. The different effects of each are noted, for better understanding of social dynamics in a high school classroom.

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## Some Dynamics Balance of Production via Optimization and Simulation within System Dynamics Method

The purpose of this paper is to present the dynamic optimal balance of production. Two different formulations of this problem discussed here on the examples presented by authors. The constrained and unconstrained optimization are presented on the basis of many simulation experiments carried out by authors.

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Author Index

## The Role of System Dynamics Models in Improving the Information Systems Investment Appraisal in Respect of Process Improvement Projects

This paper examines issues in the Information Systems (IS) investment appraisal (IA) domain in respect of process improvement projects. It discusses the role of system dynamics (SD) models in evaluating the four (cost, benefits, risks & flexibility) aspects of an IS investment appraisal exercise.
There is evidence that many organisations perceive that they are not getting a satisfactory financial return from their IS investments. There may be a variety of underlying reasons for this problem. With references to the Software Engineering, Investment Appraisal and SD literature, this paper demonstrates that a significant factor in this problem is the failure to incorporate all of the relevant forces and feedback effects in the techniques utilised for evaluating IS investments, particularly in respect of process improvement projects. It also examines the various ways in which SD may contribute to our understanding of the IS development lifecycle.

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## Versioning of Information Products

Businesses can maximize value of their products and services if they version them appropriately. Information products are especially appropriate for versioning, and can be sorted according to dimensions that include: delays, operational speed, usability, features, and support. The objective of versioning is to be able to set different prices for different market segments- a prerequisite of which is identification of the market segments. Versioning can be achieved by manipulating the price and quality of each product version to create a distinction in the value/benefit that each provides. Deciding on the number of versions available, distribution, bundling and pricing strategies is market segment dependent. System dynamic models provide a tool for analyzing the impact that each versioning dimension can provide for an information product, dependent on the identified market segments. The models can be used to help businesses set product versioning and pricing strategies. The examples analyzed include Etrade, Powersim and online magazines.

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## Workshop: Powersim Studio: The Next Generation in System Dynamics Simulation

The release of Powersim Studio 2001 represents a major innovation to System Dynamics modeling technology. In traditional SD, flows are always continuous. Discrete phenomena such as money transactions and the movement of individual entities in a flow no longer require workarounds and specialized functions; Studio 2001 introduces accumulation as well as integration, and also supports flows of discrete values, such as integer numbers (1, 2, 3, …) and logical values (true, false, indefinite). In this workshop we will explain and demonstrate the use of these new and groundbreaking concepts, along with other highlights of our simulation software, such as: Discrete and continuous flows and data types. Connecting simulation models to corporate business data stored in spreadsheets and databases; Easy-to-use definition, simulation, storing, retrieving and comparison of scenarios;
Implicit quality assurance of models through integrated dimensional analysis (measurement units), three-state logic (yes, no, maybe), data typing, and identification of abnormal simulation results, at no extra effort for the modeler.

High-quality graphical user interface authoring with no difficult programming or scripting.
Support for currencies and currency conversion
Multiple language versions of any model developed in Powersim makes it easy to develop and share models in an international environment. Includes support for all Western and Asian languages.
With Studio it becomes easier to build and share models in a corporate and international environment, compare scenarios, connect to business data, and create intuitive and appealing simulator interfaces.

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## Cognitive Maps of Policy Makers on Financial Crises of South Korea and Malaysia: A Comparative Study

Republics of South Korea and Malaysia underwent economic crises in 1997. They both recovered by 1999 by taking radically different approaches. This study reports the comparative study of the perception of the economic crises by the policy makers of these countries. It uses cognitive maps to discover and compare the perceptual structures of decision-makers. This study finds that the causes of the crises were perceived different and so were the strategies adopted to overcome them, but there was something common in the way of thinking of policy makers of respective countries. Their cognitive maps contained feedback loops.

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## A Training Simulation for R&D Management

Many factors make management of R&D operations difficult. These factors include long cycle times, uncertainty due to technical success, and high development costs. We have developed a training simulation of our R&D operation using principles from system dynamics to educate over 500 key personnel. A causal map of our R&D system was first developed, and then a simulation was built so that intuition could be gained regarding the dynamics of our R&D system.
The simulation has been developed as a board game in which teams compete to run the most productive R&D operation. Teams decide on how they will invest funds to select new projects, improve the R&D process, and expand capacity. We include the impact of time delays and feedback so that the participants realize how their decisions affect the performance of the system. After the

simulation is run, a debrief is given so that the participants can learn basic principles. After the debrief, participants run the game again to see if their performance improves.
We will describe the development of the simulation and how it has been used in approximately 25 training sessions to educate over 500 personnel on key principles regarding R&D performance.

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## Using System Dynamics Models to Facilitate Group Learning

We describe the use of models as a tool to facilitate group learning in the context of R&D operations. A team at Eli Lilly and Company was asked to consider how to include capacity constraints into strategic portfolio decision making. We used both theoretical and empirical models to understand the impact of resource utilization and process variability on R&D throughput. While the theoretical models were useful for understanding concepts at a macro level, they were not particularly helpful in helping the team gain significant intuition.
Management of R&D systems can be difficult due to long timelines, high attrition of projects, and high resource requirements. Simulation models were used to help the team gain intuition about the factors that influence R&D throughput and productivity. We will describe how the team was involved in the construction, validation, and use of the model to arrive at a common frame of reference for the problem we considered. With this understanding, we will also describe specific recommendations that were made as a result of this common understanding. We will also discuss how the model was delivered on various computing platforms.

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## Learning Chemistry On-Line with an Interactive Computer Simulation

A web based High School Chemistry unit was designed with a System Dynamics model as the key learning experience.
The unit was designed to promote student- centered, experiential learning of Equilibrium. This unit was divided into 3 main sections: Introduction, Simulation, & Review with a Test. To move onto the next section of the unit a quiz had to be passed. If the student did not pass the quiz he/she had to redo the section. If the test was not passed the learner was given an extra tutorial to do and had to redo the previous sections as well. The intent was that ALL

learners would, at THEIR pace, pass the unit; even if several iterations were required. The central section with the SD model began with a simple, running model which the learner manipulated to check that the Theory and Simulation generated the same results. After a series of activities the learner then had to modify the model to include more parameters. The reaction chosen to simulate, the Haber process, was specifically chosen as it had huge implications in World War I. This enables the learner to link Chemistry to History and see the practical and societal implications of Equilibrium Chemistry. The hope is that on-line learning expands simulations, which are largely absent, can be included as a regular feature of many web based training courses.

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## Workshop: Group Model Building to Aid Student Decision Making

The goal of this project was to use System Dynamics to find policy levers so fewer students drop out of or fail High School and College or University when "The Double Cohort" hits. In 2003 the current grade 13 will be eliminated so that the grade 12 & 13 High Schools graduates in Ontario will be applying to Post Secondary Institutions [see chart above]. It is possible that many students will not be able to enter a Post Secondary Institution, Degree program of their choice or find it difficult to find a job. Six students worked with me to identify what they could be prepared for 2003. While the Government's "SuperBuild" Fund will result in a total of $1.8 billion invested to create more than 73,000 new student spaces in Ontario's colleges and universities it is projected by the Government that in 2003 there will be 150,000 more students trying to enter first-year college, university or the job market. Using three scenarios we analysed how students would behave under stress & the implications of their choices. We conclude with likely futures and policy recommendations that could reduce the student failure rate. This work is being presented to the School Council, Parents, Administration and Students.

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## Mergers and Long Term Industrial Performance: A Dynamic Approach

Mergers are considered an important strategic option for firms pursuing vertical integration or diversification. Mergers create value for firms, enabling them to exploit competitive opportunities or neutralise threats, to reduce costs or increase revenues (Barney

1986). But the expected sustainable competitive advantage in the long term may be offset by an "unstable" industry. I will test long term consequences of mergers at industrial level using System Dynamics and strategy theories in organisational learning process and resource based view.

Mergers reduce the diversity and the number of competitors, increasing industry concentration and increasing firm size (Cooke 1986) and thus achieving economies of scale. The concentration process reinforces the merger process, as firms in concentrated industries will have the most to lose from industry constraints, they will engage in inter-industry mergers with suppliers or buyers to reduce resources dependence (Finkelstein, 1997).

High specific assets increase innovation costs due to the necessary large investments in time and resources to reconfigure them. As organisations are more complex, the time to respond to innovations increases (Dierickx & Cool, 1989; Teece, Pisano & Shuen, 1997).

A low number of competitors increases the industrial strategic homogeneity (Oliver, 1997).

Industries learn from operative and competitive experience. Operating experience contributes to internal efficiency and competitive experience is built from other organisation competitive moves (Ingram & Baum, 1997). Few big firms may reduce the industrial learning process increasing the time to respond to innovations.

If an innovation occurs, firms in the industry may have a low probability of survival or may require significant reorganisation in order to adapt to the new environment.

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## An Experiment Using the Hexagon Technique with Semiquantitative Computer Modelling

This paper reports a small experiment carried out with Master's degree students about the development of semi-quantitative models first using the VISQ modelling system and STELLA afterwards. The conception, elaboration and representation of the models included a conceptual phase using the hexagon technique (idons – combination of idea and icon).

A classical model, for coupled non-linear feedback loops, presented by Forrester (1990), was used as a parameter to define the activity and as a validation criteria. Results suggest that it seems recommendable to take students through a phase of developing the conceptual model with idons, before working with the computer (VISQ).

Despite the fact that the model developed with STELLA is very

simple when compared to Forrester's, results show that the students were able to construct a flux diagram taking into account the VISQ model which was previously developed.

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## Estimating the Effect of Targeted Enforcement Strategies on Conviction and Imprisonment Rates for New York City

The growth in prison populations since the seventies has become an increasingly important area of study in the social sciences. Explanations for this growth have largely focused on the extent to which criminal justice policies and social forces. Interestingly, little attention has been paid to the role of system resources and the dynamics of criminal justice system behavior in prison population growth. This paper will argue that decision making in the criminal justice system following arrest is shaped largely by the dynamics of system behavior, more so than law, policy or individual discretion. It contends that it is the allocation of a system's case processing capacity between the upper and lower courts that largely determines the amount of growth in new prison admissions. Furthermore, the allocation of this capacity can be affected by policing strategies that produce substantial and protracted increases in the volume of arrests. System Dynamics is among the analytical techniques used to develop this argument.

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## A Dynamic Systems Simulation Approach to Risk Mitigation for Critical Infrastructure at the United States Military Academy

The United States Military Academy at West Point is responsible for the education and training of the United States Corps of Cadets – future leaders in our Nations defense as Army officers. Like many U.S. Military installations, West Point provides its own freshwater management for consumption by the cadets, faculty, and staff. In recent years, the freshwater supply at the Academy has reached critical levels – causing concern about the Academy's ability to conduct effective operations during peak summer months. As a result, the freshwater conservation plan was recognized as needing improvement. With the use of Systems Dynamics a Management Flight Simulator was built to analyze the current system and serve as a decision support system for future operations.

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## The Dynamics of IT Venture Business Activities in Korea

Since 1998, government-led Korean venture business boom now proceeds into the stage of market-oriented venture business growth. At such a moment, this research is to clarify the relations between the success factors of Korean venture businesses, based on domestic and foreign documentary surveys and inquiry surveys over domestic venture businesses. This research starts from the necessity to overcome the limits of the existing researches by uni-dimensional probing research into success factors of Korean venture businesses and to manifest the multi-dimensional relations between the success factors from the various viewpoints.

And this research adopts System-Dynamics methodology to manifest and utilize relations among those factors, avoiding the existing metrical approaches. This research can be called a new approach to the current ecosystems of Korean venture in which whether venture businesses success in Korea is considered to depend on the list on the stock market. For this, this research implemented verification analysis through the simulations of each factor at various levels to build causality map which clarifies the causality of success factors of venture businesses through the System-Dynamics methodology and to utilize it as a way of supporting tool for decision-making of venture businesses. This research will be able to suggest the reactions depending on various internal and external situations.

This research tried to manifest the causality map of each factor on the basis of inquiry surveys and documentary surveys to verify feedback among each factor by the SD methodology. This research will be a basis bolster up the still fragile substructure of venture businesses through an efficient analysis framework using the verification of SD methodology and resulting outcomes from this research.

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## The Dynamics of New York State Social Welfare Reform Finance at the County Level: A Feedback View of System Behavior

The 1996 welfare reform gave states an opportunity to review their own welfare programs. One of the important tasks for states recently is to examine the past resource allocation policies, and to explore the factors preventing these policies from meeting pre-set

goals. In order to help state welfare decision makers approach the 1996 welfare reform challenge and to understand the welfare system as a whole, this study tries to explore the unexpected effects that offset the intended impacts of several welfare fiscal policies from a system dynamics point of view.

This study builds on the tradition of studying the feedback mechanisms that generate unintended policy outcomes with the aim of improving policy innovations in public policy systems. A highly aggregated system dynamics model is presented for the purposes of understanding implied feedback mechanisms underlying the welfare reform financing. The model in this research elucidates feedback mechanisms where fiscal policies that were intended to achieve goals related to administrative rules or controls touch off unforeseen consequences. This research examines the dynamic impacts and consequences of various fiscal policies by analyzing the interactions among major welfare actors. This analysis may provide information regarding the factors causing past financial policies' failure to control the welfare expenditures. This thesis argues that past policies are piecemeal and fragmented because they lack insight into the feedback structure of this system.

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## Come Be a Leader in a Self-Directed Work Team: The Dynamics of the Transition from Being a Supervisor to a Team Leader

Although self-directed work teams (SDWT) have become popular since the mid-eighties, little modeling has been done on the dynamics of leadership in the formation, operation, and the sustainability of these groups. This paper describes preliminary efforts to model the dynamic problems of moving from a supervisor in a "command and control" environment to becoming a successful team leader in a supportive environment. In addition to modeling the leader's effect on the work or the service being done, this model portrays such subjective processes as role ambiguity, fear of the unknown, trust in and commitment to the team, and the leader's willingness to let go of traditional control functions. The model generates several qualitative patterns. It helps us to explore under what conditions newly formulated teams may be abandoned prematurely, and under what conditions supervisors can move to new productive roles when, at later stages, some important social loop processes dominate and performance grows.

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## Towards a Platform-Strategy for System Dynamics Modelling: Using Generic Structures Hierarchically

The question of aggregation and of system boundaries is a primary concern for all modelling efforts: How deep is the level of detail? How expansive are the boundaries? In System Dynamics we have the powerful concept of generic structures. In the following it is suggested that generic structures offer the possibility to switch between different levels of aggregation and to broaden the boundaries with first pass models. In a first step new subconcepts of generic structures are identified and put into a dependent relationship. Secondly the different concepts are organized in a hierarchical order. And finally an outlook is given how to use them for formal model building.
The aim is to operationalize generic structures for practical use – especially for model construction. Recent work on generic structures has significantly advanced the scientific discussion in this field, redefining and identifying three distinct concepts. The article takes these insights as a starting point. The steps towards an operationalization of generic structures will be illustrated. The paper focuses on methodological considerations.

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## Integrating Models of System Archetypes into a System Dynamics Platform: Limits and Opportunities

System archetypes originate from qualitative System Dynamics modelling. They characterize and explain systemic malfunctions and counter intuitive behavior that recur in diverse settings. System archetypes are the best known concept of generic structures outside the System Dynamics community. As a tool for systems thinking their practical use ranges from management principles to the structuring of complex causal loop diagrams or the classification of existing models.
However transforming system archetypes in stock–flow diagrams and using them as simulation models proves to be problematic. The structures of the resulting models are not unequivocal. A set of modelling problems can be identified that is common to all system archetypes. As a result the validation of archetypes as classes of systems and of their assertions about system behavior is limited.
Despite these difficulties a proposition is made how to use system

archetypes for a development of a System Dynamics platform. This platform serves formal model building. It consists of different model components based on the concepts of generic structures. For its development system archetypes seem particularly interesting because they offer the possibility to infer structure from behavior. Limits and opportunities for this procedure will be illustrated. A differentiation between a general and a domain specific platform is intended.

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## Demonstration of a Web-Based Learning Environment to Broaden the Audience for Systems Learning About Water Conservation in Las Vegas, Nevada

This poster describes a web-based learning environment that was developed to allow visitors to the Las Vegas water authority's web site to explore the effect of different management options on the relationship between water supply and demand. The learning environment builds on a study described in two companion posters (Cloud and Stave, and Stave and Cloud), which developed a system dynamics model of the Las Vegas water system, used it to evaluate a set of policy options, and tested the potential of using the model to improve public participation in water management decisions. Based on interest generated by the initial parts of the study, the water authority wanted to explore the possibility of broadening the audience for the model by creating a more user-friendly web-based interface. This poster describes the learning environment that was created based on the model and discusses initial results of its implementation.

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## Functionality of Banks and Hedge Funds and Contagion Between Financial Institutions

The paper studies crises and contagion effects in the framework of two financial institutions: a bank and a hedge fund. System dynamics models of a hedge fund and a bank are formulated. The concept of contagion is discussed in the framework of these two financial institutions.
The goal of the paper is to understand conditions under which each of the financial institutions can fail and determine when a failure in one financial institution can trigger a contagion effect that leads to the failure in another financial institution. Both models and the concept of contagion are validated and discussed within

established financial frameworks. The paper provides conclusions and policies how to avoid or mitigate the effects of financial crises and contagion.

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## Product Development Strategy for the High-tech Startup: A System Dynamics Post-Mortem

This study reviews the case of a failed high-technology product development effort, the Multi-Chip Module (MCM) project. Specifically it reviews the strategic decisions that led to the project's demise, and using simulation it constructs an alternate strategy that would have proven more successful. The difference between the two strategies centers on the relative timing between product development and marketing efforts. The first strategy, which was actually pursued, stresses acquiring customers early and learning about the production process while filling actual orders. The second, hypothetical strategy centers instead on learning about the production process first and then, only after production proficiency has been achieved, shifting attention and resources to the task of customer acquisition. Simulation-based scenario analysis demonstrates the second strategy's superior performance as measured by the MCM project's path to profitability.

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## A System Dynamics Model of Crime

In this paper we explore externalities associated with crime escalation. In particular, we look into positive feedbacks resulting from individuals' decisions to engage in illegitimate behavior. As the perceived probability of being punished for such illegal undertakings diminishes, crime becomes more appealing to individuals, and people's propensity to commit crime increases. As more crimes are committed, the ability of the legal system to cope with them diminishes. Thus, the probability of being punished falls, and crime becomes even more appealing to individuals. We see that crime levels are not controlled solely by public resources spent on deterrence, but by the characteristics of the criminal justice system. It is possible that exogenous crime shocks in a societal group can temporarily overwhelm the legal system, leading to even higher crime levels in the long run. Similarly, sharp and temporary increases in police resources could have little effect on overall crime rates because overloading effects in the legal system momentarily reduce the probability of being punished.

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## Understanding the Dynamic Integration of Prevention, Care, and Empowerment: A Systems Approach to HIV/AIDS Policy Innovation

Despite the remarkable and rapid innovations in both prevention and care that have emerged over the first two decades of the fight against HIV/AIDS, current epidemiological trends remain unfavorable. In general, the number of persons living with HIV/AIDS (PLWHA) continues to increase and the concentration of HIV infection among populations that are socially most vulnerable has become ever more abject. This reality suggests [1] a need to deepen our understanding of how prevention (which may be characterized as holistic, community-oriented, and psychosocial) and care (which may be characterized as individualistic, person-oriented, and biomedical) interrelate within the context of the population(s) they are intended to serve and [2] a need to build the collective will to transform such understanding into action that will lead to sustained improvement in health and well-being for individuals as well as the community as a whole over time. Seeking a mechanism by which this may be realized, and underscoring the intensifying burden of this disease among the most disenfranchised persons in society, a fresh exploration of community empowerment – as originally stated in the 1986 Ottawa Charter for 'new public health' – is called for. Using system dynamics modeling to foster improved understanding about vulnerability to HIV/AIDS and about the potential of implementing a policy of empowerment targeted to PLWHA, this study tests three hypotheses: [1] PLWHA would realize substantial improvements in their health and well-being; [2] the rate of new HIV infection in the community would be substantially slowed; and [3] HIV-related service programs would become more effective and sustainable.

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## Hybrid Modeling: Embedding A LP Solver in a SD Model

The system dynamics (SD) methodology is often criticized for its optimization weaknesses. With advancements in today's SD modeling environments, it is possible to take advantage of Linear Programming (LP) optimization algorithms inside a SD model. This paper describes how a LP solver was used to solve a network

transportation problem in a SD model with a price feedback loop.
A supply chain for a basic commodity was modeled as a transportation network to link the available supply with demand. Network models are traditionally solved using a linear program algorithm, in this case a generalization of the transportation simplex referred to as the network simplex. The algorithm seeks the optimal solution that satisfies a minimum cost objective function. The disadvantage of this approach is that the optimal solution is static -- it is solved once for a single set of conditions. Of particular interest is to examine the changes observed during a scenario of dynamically changing prices. By adding a market clearing mechanism to model price dynamics in a SD model with a feedback loop, it is possible to model the desired dynamic behavior. In essence, the SD model calculates current prices, these data are then used to calculate the optimal transportation flows using the LP solver, and the resulting deliveries (flows) are fed back into the SD market clearing mechanism for another round of price determination. An optimal solution is found for each dt (timestep) in the scenario. As a result, the hybrid model overcomes the limitations inherent with SD, namely insufficient optimization capabilities, and also with LP, namely the static solution provided by the LP solver.

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## The Challenges of Infusing System Dynamics into a K-8 Curriculum

If system dynamics is to fulfill its promise of fundamentally improving education in kindergarten through twelfth grade, then it must be fully integrated into the curriculum. This means not only developing effective lessons using the tools and perspective of system dynamics, but also finding the best ways to help teachers adopt them. Both are very challenging. Teachers and administrators at the Carlisle (Massachusetts) Public Schools have been working to infuse system dynamics into the curriculum since 1994. This paper will describe the process of developing and implementing system dynamics lessons. Using one lesson as an example, it will illustrate what the children do and what they learn. It will also present the problems of imbedding the lesson and the systems approach into the curriculum.

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## Systemic Thinking and Complex Problem Solving: A Theory Building Empirical Study

This study addresses the relationship between systemic thinking and complex problem solving. The efficacy of systemic thinking in complex problem solving has received scant attention to date in the literature. The research examines the effectiveness of the use of systemic thinking in the context of a simulation task. The Verbal Protocol Analysis methodology was used to gather and analyse data. As part of this approach, a coding scheme was developed to operationalise the systems thinking paradigm and hence enable systemic thinking to be quantified. Three research questions were specifically addressed. While the research questions guided the study, there were no clear expected outcomes due to the paucity of prior research in the area.

The findings of the study indicate that the notion that more systemic thinking leads to better task performance is a simplistic one and that in reality, the picture is more complex. While the degree of systemic thinking does matter, results suggest that in fact it is certain types of systemic thinking that are more relevant. The type of systemic thinking carried out is however not solely accountable for performance in complex problems. The subject's approach to the problem is also a highly pertinent factor in task performance. This study contributes to the field of research by providing insight to both the fields of systems thinking and complex problem solving. Specific contributions include the research approach and the approach to operationalising systems thinking. That is, the use of a simulation in combination with the Verbal Protocol Analysis method for the study of systems thinking, and the development of a coding scheme based on Richmond's (1997a) thinking skills.

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## Workshop: Creating Public/Private Partnerships to Support Public Policy Initiatives

In its early years, the field of system dynamics was primarily a domain of the public sector. Over the past few decades, however, the predominant use of system dynamics has shifted to the private sector to address issues and problems related to such varied areas as operations management, workflow patterns, product design and development, and production and distribution of products and services. The public sector, including both government and non-

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profit entities, faces similar challenges in meeting its goals and responsibilities. To address these challenges, the Institute links public and private partners to promote the use of system dynamics and insights from system dynamics studies to support the public good.

Through the Institute, synergistic partnerships with experts and leaders in the fields of system dynamics have been created to address the problems and challenges facing today's agencies and organizations in the public and not-for-profits sectors. Activities undertaken by these partnerships focus on research and evaluation, technical services, public information and education, and training. Partnerships involving representatives from the private, public, and nonprofit sectors have been brought together to examine a number of public policy issues and problems, including the delivery of mental health services and the impact of cellular phones on highway safety.

A workshop is proposed that will examine what has been learned to date from these partnerships. Moderated by the Director of the Institute, a panel of public and private sector managers will discuss a variety of issues, ranging from practical operational issues to political concerns. Specific topics and questions that will be addressed include:

Historical overview of the use of system dynamics in the public sector: Where have we been? Where are we going?

How to use system dynamics in the public sector: What successes and challenges are involved in identifying and gaining the support of partners, developing projects and studies, and making practical use of the outcomes?

What is the role of the private sector partners?

Funding of public sector projects and policy studies: Where does the $$$ come from?

Insititutionalizing a system dynamics approach in public sector organizations and agencies: Is this important, and if so, how can it be done?

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## Overcoming Path Dependence

In this proposal we draw attention to the nature of the phenomena traditionally labeled as path dependence. We seek to impress upon readers that there are at least two kinds of path dependence, given the path dependence that we have traditionally portrayed in system dynamics literature. We present a logic that discriminates between the two kinds of path dependence. This logic, taken forward, helps us develop strategies towards re-designing a system that will help

weaken the rapidity of the impact of path dependence, or even arrest path dependence completely. The nature of these strategies depend on the nature of path dependence. In the course of the proposal we also lay out how we will illustrate some detailed examples to demonstrate an application of these arresting strategies.

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## Can the Relationship Between International Clients and Intermediate Goods Suppliers Lead to Declusterisation?: A Feedback Model of the Case of the Italian Textile and Ceramic Tile Machinery Industry

The internationalization strategy of actors operating in clusters has shown over time its weaknesses, producing a negative effect over the competitiveness of some operators of the cluster itself. In fact, the internationalization of machinery producers has interrupted the innovative process which originated from the interplay of the various actors of the cluster (relational capital). This phenomenon is particularly true if we consider the internationalization in the NICs which started from the beginning of the 90's, producing a resources diversion from the market of origin to farther markets. Analyzing the demographic data on companies operating in a district, it is clear and visible the fact that many downward operators are reducing in number and are exporting even less than the average of all Italian industrial companies. The feedback model presented in the paper explains this phenomenon exploring consequences produced by export strategies of machinery producers and on the cluster as a whole.

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## Best Practices in System Dynamics Modeling

This research is set out to (a) discover of a set of core practices in the system dynamics modeling process and then (b) find the best of them according to the knowledgeable opinion of a world wide recognized group of experts in the field. The paper will address (1) what areas of the system dynamics modeling process are common to all model building regardless of the modeler, the model, the type of practitioner, the tool used or the purpose of the model? (2) Which of these areas can we describe as "best practice"?

We used a multi-method approach starting with interviews, then we conducted a virtual meeting with the former presidents and award winners from the System Dynamics Society to elicit the

practices, and lastly, we developed a discussion on the results and the implications for further research. The paper identifies 41 Best Practices grouped into categories of problem identification and definition (15), system conceptualization (8), and model formulation (11). Most importantly, the study identified seven practices of which experts appear to disagree..

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## The Dynamics of Best Practices: A Structural Approach

The Dynamics of Knowledge and Best Practices in a field is influenced by a series of factors, amongst the most relevant are: (i) the dynamics of the population of practitioners of the field, (ii) the theoretical and practical productivity of the practitioners, (iii) the policies related to information and knowledge management in the field, (iv) the social judgment processes that take place to consider a practice as a best practice, and to consider a practitioner as an advanced practitioner and (v) the politics and power related forces acting in the field. The question that drove the effort to build a formal simulation model of the Dynamics of Knowledge and Best Practices is: What underlying structure conditions the behavior observed in the dynamics of knowledge in a field? Why the best practices in several fields are not necessarily related to the best ideas? A formal system dynamics model was built using Vensim. The findings obtained with the model include the high impact of the mentoring and networking activities in the development of knowledge and the critical influence of knowledge management activities to consolidate knowledge in the field. A critical piece of understanding from the model is how the dynamics are perceived and how this perception can be mistaken for actual knowledge.

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## Dynamics of Oil Price in the World Market

Oil price in the world market has shown an oscillatory behavior. This paper presents a dynamic hypothesis for such oscillation and a model to test such a hypothesis. As price of oil increases, both oil exporting and oil importing countries react. In oil exporting countries, in the short term, oil revenues increase their financial resources. As financial resources increase, their needs to export oil in the short term drops. They may decrease oil supply. Lower oil supply can increase price of oil further. But in oil importing countries, higher price of oil would decrease oil demand over time by some lag. While in oil importing countries oil demand

decreases, oil-exporting countries spend their high oil revenues and develop a government financial structure more dependent on oil. Economic structure of the oil exporting countries also become more dependent on oil and as a result, they need more oil revenues to finance government and economic as a whole. A higher need for oil revenues make oil-exporting countries to supply more oil. Oil supply increases when oil-importing countries reduce their demand. As a result, oil supply exceeds demand and oil price drops. Lower oil price would decrease the oil revenues of exporting countries and their need for higher revenues would push oil exports higher and causes the price to drop further. Low price of oil creates a reverse chain of effects and will decrease dependency of oil-exporting countries to oil and will cause the demand for oil in oil-importing countries to rise again. Lower dependency on oil revenues lower pressure for exports and rise in demand will push the oil price up again and a new cycle starts.

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## Evaluation of a Car-Following Model Using System Dynamics

Models that describe the processes by which drivers follow each other in the traffic stream are generally referred to as car-following models. During the past 50 years, driver behavior within the traffic stream has been studied and models that attempt to describe this behavior have been proposed.

Car-following models have frequently been developed for the purpose of incorporation with microscopic simulation models. These models have then been used to evaluate a wide range of potential geometric options, operational strategies, and/or policies.

In this paper we formulate a car-following model using the systems dynamic (SD) approach. We compare the behavior of the proposed SD model to the GM model, a classic car-following model that has been extensively described in the literature. These comparisons illustrate that the proposed SD car-following model avoids several unrealistic characteristics of the GM model.

The ultimate objective is to use the proposed model to investigate the mechanisms leading to rear-end crashes and to quantify the impact that different technologies or policies (e.g. driver vision enhancement systems) may have on rear-end crash potential.

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## An Analysis of Mexico's Critical Strategic Resources: A Future Perspective

Mexico has always been a country full of diversity. Any opinion about its future would be daring. Instead of giving an opinion on Mexico's future, we identify critical strategic resources that leaders would have to manage to achieve the country's global goal, which we propose is improving the average quality of life per resident. To accomplish this task, a high-level system dynamics model will be used to guide the
identification, definition, interpretation and interrelation of the strategic resources. We are aware that there are experts that dedicate their careers to the analysis of just one of these resources or even a part of one of them. That is why we decided to leave the resource detail to the experts and dedicate this work to the identification of critical strategic resources for Mexico. The objective is to identify the strategic resources and understand how they interrelate in order to gain clarity about their impact on the behavior of the global goal, the unintended consequences, and to provide a tool to help to build a shared vision for decision making.

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## A Physical and Economic Evaluation of Argentina's Beef Production Systems

This research studies the physical, economic and financial results obtained by the application of an array of technical methods on the beef production system under grazing conditions generally applied in the "wet argentine pampa." A simulation model of a ranch was developed to represent the responses to the use of different technological packages. System Dynamics is the tool employed in this study. The Argentine beef production system under grazing conditions is integrated by two subsystems: the first is the cow-calf operation and the second is the fattening of calves after weaning. One of the most important figures of the first subsystem is the variable which reflects the number of animals per unit of surface, or carrying capacity. Carrying capacity, feedstuffs quality and ranch management practices--for example: the employment of compensatory growth--are the most important aspects of the second subsystem. The beef production system was simulated employing these variables (carrying capacity, the quality of diet, compensatory growth) as management tools. It also considered the economic and physical answers reached by modifying them. The

response to changes of the variables above mentioned variables has been observed on the economic reslut ($), return on capital (%), gross margin ($/Ha), beef production (Kg/Ha) and forage requirements (cow equivalent/Ha). These results confirm the figures mentioned in the bibliography of reference to this subject. This study has done a sensibility analysis and a risk evaluation to measure the economical support of the thesis. Also, it was useful to analyse different strategies in the beef production system.

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## Dynamics of R&D and Innovation Diffusion

The article describes a comprehensive approach to model the processes of research and development, the introduction of new products, i.e. the stage of innovation, and the process of diffusion of new products in the market place. It emphasizes the importance of an integrated view of the different stages of innovation processes. The aim is to generate insight in the complexity and the dynamics of innovation processes. After a brief discussion of modules to map R&D and innovation diffusion for different market conditions, a model which links the three stages of the innovation processes together is described and analyzed. Since the model views innovation processes from the perspective of the management of a firm, it shows the influence of corporate decision variables like pricing, R&D-budgeting or quality control on the diffusion of innovations and the development of firms.

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## The Dynamics of Product Innovation and Design

Following the logic of System Dynamics (SD) this paper presents the dynamic process of product innovation characterized by three main stages closely connected: conceptualization, design and development. According to the authors it is the lack of understanding of the dynamics of product innovation what constrains most companies to maintain an adequate response to the environmental challenges posed by changes on customer market needs and competitors moves for capturing larger market shares. Being the main conclusion that is by capturing the larger whole of the process that can be translated on shorter product innovation and increasing understanding of market trends and preferences.

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## A Formal but Non-Automated Method to Test the Sensitivity of System Dynamics Models

Sensitivity testing of parameters can add greatly to the validity of a system dynamics model. Most model builders view parameter sensitivity tests as confirming whether a small perturbation to a parameter's numerical value results in a significant change in the model's behaviour. The results of these tests can indicate the level of accuracy that is required when assigning numerical values to a model's parameters, and also narrow down the search for improved policy.
It can be impractical to run a sensitivity analysis on a trial and error basis because of the large number of permutations that exist. There are various strategies for approaching the sensitivity testing task and these are reviewed. A formal and straightforward process for analysing the sensitivity of system dynamics models is proposed. A range of single parameter sensitivity tests is performed on all model parameters. Static and behavioural performance measures are compared using Spearman's Rank Correlation Coefficient to measure the congruence between the results of the separate tests.

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## Digest: A New Tool for Creating Insightful System Stories

Creating insightful feedback rich system stories for strategy formulation and conducting model-based dialogues aimed at the advancement of a shared vision call for a shift in focus from detail complexity to dynamic complexity. One way to master dynamic complexity is to divulge the dominant structure within a mass of interrelationships in a system dynamics models. Despite its importance, tools for understanding the linkages between the structure and dynamic behavior in simulation models are lacking. A new software approach, Digest, is developed to bridge this gap. In this presentation, we introduce Digest and demonstrate how it can help you pinpoint the most influential feedback loops as the behavior of your model unfolds. Just save the equations of your model, built in any system dynamics software package, as a text file and watch how shifts in loop dominance give rise to the dynamics of the system.

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## Workshop: The Fourth R: Introducing System Dynamics to K-3 Students

It is said that "Everything I needed to know I learned in Kindergarten". In Kindergarten we started our formal learning process with the "3 Rs", Reading , Writing and 'Rithmatic. We learned letter sounds so that we could eventually read Shakespeare's work. We learned how to form letters so eventually we could write a dissertation. We learned how to count blocks so eventually we could understand Calculus. Our question has been what should we have learned in elementary school in order to help us create Dynamic Models.

This workshop will provide an overview of the concepts behind the development of "The Fourth R" and the creation of the "tool box" we give our students to help them build better mental models. It will include the general activities we use to introduce SD to K-3 students and teachers as well as specific activities students have done.

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## Estimating Environmental Carrying Capacity and Policy Implications

Since the publication of Brundtland Report, the term sustainable development has become a popular guideline for those who are concerned with environment and development. A sustainable development requires society to define sustainability constraints or environmental limits, environmental carrying capacity. Environmental carrying capacity is "the level of human activity which a region can sustain at an acceptable quality of life level". If this concept of environmental carrying capacity can be estimated, it may provide useful guidelines for city planners and policy makers. Besides, if the limitation of a human activity can be supported by a scientific data on carrying capacity, the resulting decision and actions could more easily win public support for a sustainable development.

As a result of ongoing project to estimate Seoul City's environmental carrying capacity, this paper further developed the environmental carrying capacity model by incorporating Box model. Environmental quality in the model was limited to the NO2 level of Seoul. As a part of the environmental carrying capacity model, Box model was converted into system dynamics model to estimate NO2 level of Seoul. Carrying capacity of Seoul was

estimated by figuring out the maximum number of population, industry structure, cars, houses at an equilibrium point that sustain a desirable NO2 level. With the estimated results, several policy implications for a sustainable city management were discussed.

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## Workshop: Nature DECODES all Systems of Symptoms

This workshop discusses how understanding natural systems facilitates strategic change. The dimensions of reality are interwoven: spiritual, mental, social, emotional, and physical.
The metaphors of the Chakras (India) and the Law of the Five Elements (China) are used to understand the common the "what and how" of systems. 10th grade geometry is reviewed for requisite components of change: "contra-positive", "greatest common multiple" and "lowest common denominator."
Organizational interventions are discussed: Appreciative Inquiry (Cooperrider), Holistic Management (Savory), Requisite Organization (Jaques), Open Space( Owen), Future Search (Weisbord and Janoff), TQM (Deming), The Natural Step (Robert) so that their mechanisms are better understood.
Multiple medias will be used. Experiential exercises will be included. By the end of the workshop, each participant will better understand system dynamics and will better appreciate the mechanics of their present systems Each will go away with complementary strategies for strategic, transformational change.

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## Quantification and Evaluation Issues in Group Model Building: An Application to Human Resource Management Transition

Telecommunications providers increasingly compete on Human Resource Management (HRM). KPN, the Dutch incumbent telecom provider, found that for its research department human resource policies needed to be adapted to remain competitive. KPN's Business Modelling department facilitated a group model building project on human resource management transition. Participants in the project were nine KPN employees involved in HRM. In three sessions a quantified although not fully validated model was built. We feel there are three major contributions of this project to the system dynamics literature. First, in the process of modelling we used and adapted a technique on parameter estimation. This technique clarified several complex relationships.

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Second, the content of the model and its emphasis on soft variables connects to the discussion on the merits of qualitative versus quantitative models. Third, the project was extensively evaluated, in particular with regard to its effects on participants' learning, evaluation change and implementation of project conclusions.

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## Analysing Feedback Structure in the Oil Producers' Model

The oil producers' model is a system dynamics model of the global oil industry created in collaboration with a management team from Royal Dutch/Shell. It is moderately complex and comprises about one hundred active variables. First conceived in the late 1980s the model has been adapted and used for many purposes including scenario generation at Shell, doctoral research at London Business School, and management education at a variety of business schools and oil companies.

This poster session analyses the feedback structure of the model. The posters are arranged as a story in three parts. Part 1 tells the turbulent history of oil prices encompassing notorious periods of volatility as well as remarkable periods of stability. Part 2 shows how the model originally took shape around five sectors representing the guiding policies of commercial and political players in the industry. Part 3 reveals, step by step, the feedback structure of the industry. The starting point for this analysis is a list of phrases about the oil industry derived from the modelling team. A series of diagrams then shows how to connect these phrases into a network of dynamically significant feedback loops. For example, there is a slow-to-respond balancing loop containing capital investment by commercial producers. There are floating goals representing consumer price adaptation and OPEC price control. There are success-to-the-successful loops involving quota negotiations within OPEC. Together these feedback loops form the fabric of coordination for the global oil industry. To accompany the posters there are demonstrations of scenario simulations from the Oil Producers' Microworld.

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## The Problem of Managing a Hydroelectric Power Plant: An Approach Based on Traditional Techniques and System Dynamics

The purpose of management planning is to synthesize the management's objectives and goals, and to formulate, analyze and suggest strategies that permit attaining them. So, before elaboration it is necessary to formulate the particular plans of the different component areas and immediately following, to integrate them to form an overall management plan. The state of the art of the integration processes is, at present, almost integrally based on optimization methods that, with regard to the problem dealt with here, present some difficulties, such as: 1. They are static methods, and as such, for each alteration in the initial conditions of the analysis require the repetition of the entire calculation process, 2. Do not allow feedback, a characteristic involved in management planning, and 3. There is a large correlation between the process variables, due to which, the results provided by this methodology are only adequately precise for periods of time where this correlation does not significantly affect the results.
With this background, this Paper intends to direct the preparation of the management plans based on modeling techniques that permit the development of models that are adequate for dynamic systems. This approach proposes the solution of the management problem based on the following steps: 1. The formulation of tactical plans as dynamic problems. 2. The transformation of the dynamic problems into simulation models per area, and 3. The integration of the area models to form an overall plan, by means of a continuous feedback process! The formulation of tactical plans as dynamic problems.
The Paper analyzes the advantages and disadvantages of both methodologies and concludes suggesting the joint and simultaneous application of both techniques in more refined management planning.

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## Causal Inference and System Dynamics in Social Science Research: A Commentary with Example

The focus of this paper is causal inference. A concern with causality has had a profound impact on the kinds of questions that may be addressed in social research, on how they must be formulated, and on what methodology must be applied. In the

social sciences the prevailing experimental paradigm is used to address causal inference in a way that has forced a comparative or counterfactual approach, to the exclusion of physical cause.
Recently, Lawrence Mohr has proposed a means of putting physical cause on an equal footing with the counterfactual, an achievement with important implications for system dynamics. In this paper, Mohr's concepts are joined with the resources of system dynamics. Following a discussion of the concepts, an example of social science research based on physical causal reasoning and system dynamics methodology is presented and the approach assessed.

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## Analysis of Dynamic Complexity of an IT Organization

This analysis was done as part of an organizational development in 1996. The European IT department of a computing manufacturer experienced quality and overload issues after a phase of cost reduction and centralization. Several approaches to improve the situation with conventional methods failed. As a last step a structured process to understand the dynamic complexity of the organization was applied. The organizational dependencies were documented, analyzed and communicated.
Key leanings were that key dependencies in the organization crossed organizational boundaries. This created slow, loosely coupled feedback loops and prevented improvement of the situation. Underlying shifting the burden and accidental adversaries patterns were found. Based on the learning organizational changes and metrics were introduced which finally solved the problems.

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## Averting a Tragedy of the Intellectual Commons: Using System Dynamics to Explore Digital Rights Management Issues

Digitization is changing all the rules. An average law-abiding person who would never dream of stealing a book or jumping the queue, doesn't think twice about downloading pirated material, making unauthorized copies and/or cashing in on peer-to-peer file sharing. Nor are corporate entities above reproach. Unbeknownst to most online users, content holders and providers are quietly appropriating their share of the public domain and in the process, getting ready to lock down every bit that moves, morphs, and

materializes. However, with everybody looking out for "number one," early indications suggest that we, as an information consuming society, are headed for a meltdown – a clash of self-interest(s) – that may result in a tragedy of the intellectual commons.

A system dynamics approach is being used as an exploratory tool to try and understand a relatively nascent phenomenon, digital rights management (DRM). In general, DRM systems focus on the protection and enforcement of intellectual property (IP). With respect to the present study, the purpose of the model is to investigate what impact, if any, different IP policy changes have on innovation and access. In conjunction with the model, a user interface (flight simulator) has been developed so that interested stakeholders may use it to discover: (i) how different scenarios – strong vs. weak property rights – unfold over time; (ii) what trade-offs may be necessary to restore the historic balance between rights-holders and rights-users; and (iii) who the winners and losers are most likely to be, in the tug-of-war over the digital divide.

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## Would the Glitter Persist: A Model Based Inquiry into the Rising Popularity of TV Game Show

Of all programs shown on TV game shows are probably the most popular. And among game shows nothing has attracted the attention as the one titled 'Who Wants to Be a Millionaire. First broadcast in Britain, it has been aired in a number of other countries including India. After amazing success in the UK, America and other foreign shores, the TV game show: 'Who Wants To Be A Millionaire' hit Indian TV with a bang.

The show's producers, who opted for the title 'Kaun Banega Crorepati' (hindi translation of the original title), wanted to take no risks. And what would ensure that show catches people's attention? Well, how about a huge superstar presenter in the form of living legend Amitabh Bachchan! This ensures a double treat for common man of India, at one side there are huge prizes to be won, and on the other side, a life time chance to share the stage with none other than Amitabh Bachchan! So it hasn't come as a surprise that the initial episodes have attracted huge ratings and it looks like Star TV is onto a winner.

So what that KBC is an imitation too? Did anyone ever think that KBC would be so successful anyway in India? Why is it successful? I think, it is more of the human psyche to make money.

And that too, free money! Annual per capita income in India is around Rs 10,207. Star TV computers have so far logged 5.5 million callers from across India wanting to participate in the most expensive game show in Indian TV history.
But what would happen after this initial euphoria dies down. Or more appropriately would this euphoria ever die down? Would this popularity chart, which is soaring at the moment stay like this forever, or would it ever come down.
Our paper would try to address some or all of these questions through a concept called Dynamic Brand Value Management (DBVM) (Warren et. al. 1998).

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## Workshop: Modeling Assistance

Over the course of my system dynamics studies, I have struggled with many modeling challenges, particularly in conceptualizing models that accurately represent real life at the level of (dis)aggregation of the model.
This workshop is an attempt to provide an opportunity for similarly challenged modelers to get assistance from others on their modeling problems. Process: Modeling challenges/problems to be used in the workshop will be selected by me from submissions to me by folk in response to a request for same that I would post to the system dynamics mail list.
Prior to the conference, brief descriptions of each problem will be posted to a web site to attract reviewers, and reviewers could sign up to review, say, two problems over the 1.5 hour workshop. Depending on response, the workshop could take a couple of forms.
Should response be minimal, I and one or more reviewers will facilitate a discussion among all the workshop participants (via VGA & overhead projectors) about several modeling challenges I (and perhaps some fellow modelers) are facing. Better would be if we get lots of responses to our mail list request.
In this case, following a brief presentation of all of the modeling problems in the workshop, the workshop would become very free form, with small groups working on specific problems around the room (or perhaps in other rooms too?).
The challenged modelers would present their modeling problems to reviewers via posters, on laptop computers (so the room would need power), or simply via conversations and sketches.

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## Application of Non Parametric Monte Carlo Technique in System Dynamics

Most of the modeling efforts include quantification of soft data. If the parameters to be quantified are constant then analysis can be made easily by generating these constant parameters randomly at each run. However if these parameters are a function of a system variable or another non-constant parameter (i.e. value of a converter is a function of a stock or another converter) then effects of these assumptions are usually checked by a few trial runs with different curve shapes for the function. Therefore leaving effects of many function possibilities unchecked.

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## Formalization of Model Partition Heuristics through Graph Theory

This paper builds on the argument that calibration of system dynamics models can be used as a testing strategy for dynamic hypotheses. In particular, it addresses the issue of how to partition the model for calibration and testing purposes. Working with small calibration problems reduces the risk of the structure being forced into fitting the data, increases the efficiency of the estimation, and concentrates the differences between observed and simulated behavior in the piece of structure responsible for that behavior. The premise of this paper is that it is possible to focus on the structural complexity of SD models by using the tools and insights from graph theory to design a partition strategy that maximizes the test points between the model and the real world. After reviewing the graph representation of system structure, the paper presents the rationale and algorithms and for model partitions based on data availability, and block and cycle partitions. The paper concludes by identifying future research avenues in this arena, and conjecturing on other potential applications of the tools developed for the analysis of models structure.

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## Flexible Learning as Models

The main question in this paper is how long-distance adult students experience their learning. Their apprehensions of their learning strategies and learning processes are put into models. The adults are Swedish and Norwegians joining in flexible learning. A main

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part of their learning has to be self-directed. According to the theory of situated learning the learning environment becomes more important. Important variables for learning in these cases are the environment, their homes, workplaces, course material and tutors. According to the adult students, individualisation, motivation and some sort of time structuring are crucial parts in the learning process. System Dynamics is usually used to facilitate learning and understanding. This study focuses on learning itself. The paper will discuss whether modelling can be a way of learning to learn.

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## A Basin Management Cumulative Impact Model

An aggregate systems model is used to examine synergistic links between land use planning, water quality, and watershed management policies. The systems-based runoff model is linked to an adaptation of Mackay and Paterson's ecosystem partitioning models to provide an estimate of the cumulative impact of changes in land use on downstream aquatic systems. Advantages of the model are its comprehensive structure and ease of use, allowing rapid scenario testing with minimal input requirements. Another advantage is that the output supports analysis of comparative risk not only in terms of total load but also as a function of relative persistence and toxicity.
Other features include: Options assessing the cumulative effect of stormwater management techniques (including wetland buffer zones and permeable pavements); highlight of results where concentrations exceed regulatory and risk-based thresholds; and management simulation games for use as an interactive decision and conflict resolution tool.

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## Stock-Flow-Thinking and Reading Stock-Flow-Related Graphs: An Empirical Investigation in Dynamic Thinking Abilities

This paper reports on an empirical study of the ability of university students to discern between stocks and flows, and as such is a sequel to the "Bathtub Dynamics" – study of Sweeney and Sterman (Sweeney/Sterman 2000).
The 154 subjects were given six different tasks. Some of the tasks required the ability to read and interpret time-graphs, others did not. Two of the tasks were taken directly from the Sweeney/Sterman (2000) study.
The findings of this study were alarming. On the first task, which

dealt with the difference between federal budgetary deficit (a net-flow) and public debt (a stock), the mean performance of the candidates was approximately on the same level as if they had flipped a coin for each answer. Generally the study showed severe deficits in the ability to discern between stocks and flows. These deficits did not depend upon whether the tasks required the candidates to read or to draw graphs or not. Graphs showing the development of flows over time were interpreted by many subjects as if these were graphs of stocks. In almost all tasks the females scored significantly poorer than the males. At the present stage of investigation I have no reasonable explanation for this massive gender bias. Further research might help to reveal something of this mystery. A number of extreme correlations between different criteria concerning the performance of the bathtub tasks (which have been taken from Sweeney/Sterman) suggest that there might exist a core ability which triggers all other stock-flow-thinking capabilities: this is the ability to grasp that a positive net-flow results in an increase of the corresponding stock.
The study revealed serious deficits in stock-flow-thinking, which urgently need an educational "therapy". It is a major challenge for systems-oriented education to design and evaluate appropriate courses.

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## Brand Management Facilitation: A System Dynamics Approach for Decision Makers

A well-managed brand represents a major asset for many consumer product companies. Whether it is Coke® or Kleenex®, consumers are willing to pay a premium price for established brands because of the perception of quality and the life style that the brand conveys. Building and sustaining a brand is an expensive, complex, and challenging task for a brand manager.
While there are existing models and processes for this purpose, most are based on mental models, as well as the tacit knowledge that successful brand managers have acquired through experience and practice. While tacit knowledge is extremely difficult to elicit, making it explicit in a system dynamics model could dramatically improve the brand management decision-making process. It would permit the testing of the complex mix of assumptions that underlie brand strategy and provide decision makers with the ability to explore various scenarios, policies, and decisions.
The paper presents a system dynamics model of the brand management process for fast-moving consumer goods. It makes explicit the normal mental models of brand managers and

combines the dynamic forces of markets into the decision-making process. The paper concludes with a demonstration of a brand policy implementation and its effects on a brand.

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## Analyzing Strategic Thoughts of Corporations Based on Cognitive Map

In this paper, a cognitive map-based methodology is suggested as a tool to analyze different strategic thoughts in a corporation. In order to test its validity, the proposed framework is applied to a private company. The methodology provides a framework for the identification of all the ideas relevant for the future of the company, the categorization of the ideas, the specification of their relative priorities, the construction of the related cognitive map and the detailed analyses of the map in order to specify the goals, the key issues, the options etc. to focus in the future.
The case study shows that the proposed methodology will be an important guide to the senior managers in building a shared framework for strategic thinking. It will help the senior managers to understand and learn each other's perspective and to improve their own mental models.

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## Dynamics of Organizational Change

This paper discusses a model of organizational change as described in the punctuated equilibrium model. The model builds on two previous models in this area, i.e. the one by Frechette and Spital and the one by Sastry. After discussing shortcomings in both these models a new model is presented which is believed to be (a) a more valid representation of Tushman and Romanelli's theory of punctuated organizational change, and (b) an extension of both existing models incorporating new structure not represented so far.
The paper discusses the structure of the new model and tests its validity by comparing dynamics from the model with those stated in the theory. Sensitivity analyses are conducted in order to further explore model behavior and find potential inconsistencies and areas for improvement. In a concluding section the limitations of our model are discussed and improvements for the future are proposed.

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## Poverty-Fight Programs and the Dynamics of Poverty: An Unconnected Relationship

Based on research conducted on evaluating the actual long-term benefits of governmental, private and NGOs poverty-fight programs implemented on different countries the researcher presents a model related to the dynamics of poverty and the dynamics of poverty-fight programs.
The author argues that understanding the differences between the dynamics of both, poverty and poverty fight programs, what help us to identify how certain factors such as corruption, differences on sponsors' aims, governmental other interests (i.e. electoral), mismanagement and lack of interest by supporters to follow-up the actual application of their contributions; are very much what determine much of the failure of those aid-efforts to actually revert the results of positive-feedback loops that characterize the pervasiveness of the dynamics of poverty in general.

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## System Dynamics in the Service of Strategic Environmental Assessment

Evaluation of strategic proposals before their implementation is important in strategic planning because it can catch costly mistakes early enough. However, such evaluations are based merely on forecasts - not on facts. Strategic Environmental Assessment (SEA) is a typical methodology for an ex-ante evaluation of strategic proposals, often encountered in an extensive form that is not limited to environmental issues.
Modeling and simulation have a great potential for forecasting, but have been kept away from the practice of local/ regional strategic planning mostly due to their "user un-friendliness". System Dynamics (SD) can lend its expertise in systems modeling and simulation, including its user-friendly interface.
Two Internet-based projects are created for bringing System Dynamics closer to SEA, functioning as repositories of case-specific as well as generalized models. The objectives of the SD-SEA coupling are to make better forecasts for the outcomes of strategic development proposals in complex local/ regional systems, easily and transparently.

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## Workshop: Can We Contain A Bioterrorist Smallpox Attack?: Engaging Students with System Dynamics and "Real World" Concerns

The global eradication of smallpox and the accompanying loss of immunity now renders the prospect of a bioterrorist attack, with all its consequences, especially daunting. What might happen, if smallpox was released in an American city? Could such an attack be contained? This workshop is designed for educators and others interested in exploring how the dynamics of such an event could challenge and stimulate students to participate in real world problem solving activities. An interdisciplinary team of educators will challenge participants to develop and apply an understanding of the biological and social factors that control the spread of smallpox, to forecast the impact of a modern-day outbreak, and to suggest where and how to leverage the system to minimize the consequences of such an attack. The workshop will be enriched with observations from initial field-testing of this scenario with high school students from Portland, Oregon.

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## Third Grade Students Modeling "Infection" on Stella

The last two years a group of teachers and I have worked with our students using the tools and concepts of Systems Thinking and Dynamic Modeling to improve student learning of basic second and third grade curriculum, along with extension for the gifted students in their classes. The teachers and I have learned from past experiences that if we give these students a concrete activity then they can explain their abstract thinking and put all the pieces together. After studying about infectious diseases, the next logical step in their growth of using systems dynamics was to create a Stella model. Initially our plan was to create a two stock one flow model, but as the students began telling their story they insisted on including more in the model. In this presentation the students will explain their thinking behind the model they created.

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## T21 China: An Initial Application and Analysis

The purpose of this paper is to demonstrate the uses and capabilities of the Threshold 21 (T21) model through an application to China. The first section, "Results for the Baseline Scenario," provides the baseline projections for China to the year 2020. In the "baseline" scenario, it is assumed that the past policy and a peaceful condition continue, and the scenario shows what is likely to happen over the next 20 years in five areas: population, prices and income, production, environment, and social issues. The second section, "Results for Alternative Scenarios," provides scenario analysis, or "what-if" analysis for a number of alternative policy scenarios, including two child per family policy, stricter pollution control policy, and HIV/AIDS policy. The major results of the policy change are compared to the baseline projection.

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## Dynamic Features of the Value Systems of a Firm and Stakeholder Value: An Integrated Framework

The business environment has changed drastically and dramatically over the past few decades. This competitive environment which can be characterized as complex and dynamic, demands management to cope effectively with this accelerating pace of change. Creating value for all the stakeholders is not an

pace of change. Creating value for all the stakeholders is not an easy a task. In any value-creating endeavour, management needs to effectively understand or utilize the dynamic features of value systems that include feedback systems, time delays, and non-linear cause-effect relationships among value system components. The proposition in this study is that the singular, monistic, and short-term oriented shareholder perspective fails to capture the dynamism of stakeholder values.

Thus, strategic choices cannot effectively be made without understanding the impacts of dynamic features on value creating system structures. The understanding and use of value systems dynamics which are currently used remains trapped in the intuition of experienced managers. An improved understanding of value systems dynamics is the first step in improving stakeholder value mental models, decision heuristics, and thereby stakeholder values. This research seeks to improve that understanding by increasing our knowledge of how the characteristics of stakeholder value, strategic decisions, and resources impact stakeholder values. In this article, we present a model for an improved understanding of the dynamics of value systems dynamics. An approach to operationalization and testing the model is also described.

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## Education Reform: A System Dynamics Approach to the Public vs. Private Debate

If the education of the next generation is not to be completely forsaken, education reformers feel Americans need to cast aside assumptions about how schools should be run, and consider not only major overhauls to the current system, but entirely new approaches as well. Enter the voucher system that supports schooling privatization. Several states in the US have already adopted an educational voucher system while other states contemplate and debate such a risk-intensive reform program. Many people worry that a free market approach to schooling utilizing a voucher system to distribute taxpayer contributions would have further negative effects on public education. Proponents argue the answer to the failing public school system is a competitive and accountable educational market where schools vie for parental consumers through higher quality at the lowest cost. Does the voucher system have what it takes to improve education quality at a lower price? This paper utilizes a feedback-rich model to study the long-term implications of the parental consumer-based decision to choose private education over public education.

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## Systemic Negotiation

Strategic Clarity is applying the power of SD to the negotiation process. The Systemic Negotiation process allows companies and organizations to uncover hidden value for tradeoffs, concessions and stop points in their negotiations. By understanding the global goal, key stakeholders' incentives, strategic and operational resources and critical actions that each side holds important, management will have a more robust platform for their negotiation stance.

The strength of Systemic Negotiation is in the focus it provides management in the due diligence process as well as in the integration assessment for any acquisition. In addition, long term supplier contracts can benefit as well. This poster session will outline the proposed steps in the process, a sample of the outcomes from a fictitious firm and some thoughts for further development.

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## System Dynamics Adds Power to Oil

One of the great challenges facing the larger oil companies today is the timely and effective integration of the different technical disciplines in the analysis and valuation of company oil and gas assets. Geologists, petrophysicists, reservoir engineers and facilities engineers usually work independently. The magnitude of detail complexity combined with working in serial, often drags the field valuation process from many months to years. A new company, Delta R, has tackled this problem head on and developed an integrated approach that integrates the work from these technical groups within weeks. However, they felt a key piece missing.

Many key assumptions were made around the feasibility of achieving a purely technical solution. Working with this company, Strategic Clarity added the strength of SD to the analysis of the oil company's assets. The non-technical issues we incorporated strongly impacted on the financial results of the technical analysis, ranging from $10MM to $200MM in project NPV. Never before had the oil company seen these impacts with such clarity. These issues included key approval delays, long lead time equipment contracting delays, relevant skill constraints among others. Both causal and key resource dynamic simulation approaches were used in a work group of 20 people over the course of three weeks.

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## Tightening the Iron Cage or Path Dependence in Norm Formation? A System Dynamics Approach

Observing the creation and solidification of norms in self-managing teams, Barker (1993) suggests that these teams develop rules more restrictive than those of traditional bureaucracies. Looking at the process of norm development suggests the existence of structures leading to path dependence in this process. A simple system dynamics model is developed and analyzed to describe path dependence in formation of norms in self-managing teams; observations of Barker are explained from this standpoint. Some policy issues are addressed based on the insights generated from the analysis of the model.

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## Organized Crime and Economic Growth: A System Dynamics Approach to a Socio-Economic Issue

This paper describes the potential of system dynamics models to support policy decisions and macroeconomics strategies aimed at reducing the level of organized crime in a country and promoting further economic growth. A causal loop diagram will elicit the main links found between organized crime investment safety expectations and economic growth. Additionally it will suggest the need to focus the attention on what has been defined as the risk fraction that is unemployed people which constitute the recruitment base for crime organizations. This concept sets the groundwork for the main dynamic hypothesis of a system dynamics model. Central in the structure of the model is the attempt to identify the most relevant variables defining the crime attractiveness to emphasize a dynamic conceptualization of risk fraction and to suggest alternative ways to quantify and evaluate the effectiveness of various socio-economic policies.

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## Mapping versus Modeling: THE Answer to the Debate

Recent articles and listserve discussions have raised the level of argument about the relative merits and weaknesses of qualitative and quantitative modeling - "mapping" versus "modeling." The

discussion traces to initiatives with causal-loop diagrams and influence diagrams at MIT and the University of Bradford in the 1970s. Because mapping is cheaper and quicker than modeling, the great hope is that one can generate and communicate real insights through mapping alone.

The historical debate is whether maps by themselves are adequate to support insights about complex dynamic systems. The claim of some is that they are not, while others claim they can in some circumstances stand alone and be very helpful.

With Coyle's recent paper (SDR 16,3), the argument has taken a new and striking twist: Coyle argues not only that maps by themselves can create and sustain insights useful in serious policy analysis, but that quantifying can lead to nonsense. The historical argument is turned on its head: mapping is, in some circumstances at least, more reliable, less potentially misleading, than quantitative modeling.

This presentation reveals the answer to this debate. The one, great answer (!) The "answer" emerges from rephrasing the question to avoid the camps that have solidified around debating positions. There are smart people arguing with deep conviction, and great experience, on both sides of this issue. That suggests we have the question or the debating proposition ill-posed. Indeed, an investigation of the ways mapping and modeling have been used in serious consulting or policy settings suggests that the two approaches have very different purposes and generate different kinds of insights. This paper offers an analysis of these differences in an effort to clarify for the field what is really at issue. And as we might expect, it comes down to model purpose...

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## Informing Mental Models for Strategic Decision Making with ERP's and the Balanced Scorecard: A Simulation-Based Experiment

To make efficient, effective decisions, organizational leaders use strategic frameworks to see how well the organization is accomplishing its goals and implementing its strategies. These strategic frameworks filter great quantities of information about different parts of the organization into a few, critical elements. To process this vast amount of information, these frameworks depend increasingly on sophisticated information systems. Prior behavioral decision making research supports this practice, suggesting that guiding cue selection and increasing information credibility enhance decision performance. Common practice, however, focuses primarily on increasing information credibility

and not enhancing cues. This research develops a theoretical model to explain how the cedision maker's understanding of the decision context is influenced by the strategic framework and by the information processing system. This research tests the theoretical model with a simulator-based experiment, where 118 MBA and M.Eng students run a wireless telecommunications firm.

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## Encouraging Decision-Making for Earthquake Mitigation and Preparedness: An Application of System Dynamics Modeling

Thirty-nine states are vulnerable to earthquakes (VPS associates, 1988). Escalating post-disaster costs have led the federal government to increasingly emphasize efforts in pre-disaster management at each level of government. Local government is particularly critical as the front-line of defense and primary agency for disaster management. A small community in Missouri located near the New Madrid Seismic Zone was chosen for this project. Over the past 20 years, this community has different levels of involvement in disaster mitigation and preparedness. System dynamics model was constructed for this city, based on data collected from on-site and telephone interviews, informant feedback meetings, and archival records, in order to examine disaster management activities at the local government level. Feedback processes and points of leverage are identified and discussed.

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## How Do Professional-Services Firms Compete?

What actions can professional-services firms take to create lasting improvements in their competitive performance? This paper looks at Merrill Lynch's success in building a leading investment-banking practice out of an industry laggard and PaineWebber's failure to accomplish similar objectives. The two firms' experiences and previous research are used to specify a model of competition among professional-services firms. Reinforcing feedback between the nature of a firm's client work and its capabilities combined withintendedly rational managerial policies lead to a hierarchy of industry competitors.
Analysis of the model highlights two key elements differentiating Merrill Lynch's and PaineWebber's efforts to improve their position in that hierarchy: speed in developing capabilities and discipline in accepting and rejecting client work.

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## Social Implications of Local Improvements in Small Towns at the Metropolitan Fringe: Water Quality

The impact of gentrification on residents of inner urban regions has been the subject of substantial research in the fields of planning and pubic administration. As the plight of inner cities attracts more interest, it is refreshing to find that protection for small towns and villages at the fringes of metropolitan areas is also receiving greater attention. Communities at the rural edge have been the focus of numerous exploratory studies, as Americans find that the values they have long coveted are those they are losing the quickest: community cohesiveness, local identity, and smallness of scale.

This paper uses system dynamics modeling to explore the social implications of local improvements in small towns at the metropolitan fringe, namely water quality. As local townships expend resources to revitalize, it tends to make the region much more attractive as a commuter community. Not only have property values been historically lower than the surrounding suburbs, the conveniences that often attract commuters were negligible. In the case study provided here, further avoidance of a public sewer project is impossible, regardless of its substantial cost to the community. The high cost of this project may prove to be prohibitive to a number of inhabitants, encouraging those who are dependent on fixed or low incomes to move elsewhere.

The question of how to improve regions while not displacing the current inhabitants is a classic planning problem. In the case of this study, system dynamics will investigate possible scenarios that will allow the town to develop from within, maintaining its core resident base while improving the viability of the region.

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## Simulation Model: Profitability in Ranches of Tamaulipan Shrub of Coahuila by Effect of the Ratio Bovine:Deer in the Stocking Rate

The administration of the scarce budget intended for the investigation and the traditional investigation methods, scarcely appropriate for complex systems; generate the great need of making an effective use of the available amount for the knowledge obtainment with a better solution of problems and a just channeling of the federal budgets and deprived toward the investigation. The

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ranches of the State of Coahuila, Mexico, with calves production and deer's utilization, located in the region of the Tamaulipan Shrub of Coahuila (TSC), they are an example of complex systems. In this regard, the researchers, technical and ranchers of the region, require of tools to know the better relationship bovine:deer, concerning the profitability that by this relationship is originated. The systems analysis through the present simulation model, it is a strategy to achieve the efficient use of resources in the investigation and the complex systems study, as the ranches of the TSC.

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## A System Dynamics Model for Wetland Education and Public Outreach in an Arid Urban Environment

This poster describes the development and use of a system dynamics wetland model for education and public outreach in Las Vegas, Nevada. The objective of the project is to build public understanding of the value of wetlands in this arid urban environment and enlist critical public support for wetland protection. The model is being used at the Las Vegas Wetlands Park Nature Center, a gateway for the public to a newly created 2,400-acre wetland park. It is designed to address several challenges: low levels of public awareness about the existence and function of this wetland ecosystem and park, lack of understanding about the critical connection between urban development, wetland protection and water quality, and a low level of community participation and involvement in outdoor activities. This interactive model was designed to engage learners through the use of technology and demonstrate the dynamic nature and feedback connections in the ecosystem. The poster presents the model and preliminary results of a study on public receptiveness to this educational approach.

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## Using Systems Thinking to Better Understand the Implications of E-Business Strategies

Many companies are making strategic decisions in relation to e-business without a full understanding of the implications. This paper, through the discussion of a case study, will show how systems thinking techniques can assist businesses to make better strategic decisions in relation to e-business.

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## Understanding and Controlling a Law of Advancing Capitalism

This paper refines a general model of capitalist reproduction. A compact state-space form of this model defines a hypothetical Law of capital accumulation. The state variables are the relative wage, employment ratio, gross unit rent, man-made capital-output ratio, natural capital-output ratio and indicated natural capital-output ratio. This paper identifies unobservable components of this Law through an application of the extended Kalman filtering to the US macroeconomic data. The retrospective statistical analysis (1958-99), univariate sensitivity analysis (1999-2057) and forecasting (1999-2507) support the analytical treatment of this Law. The latter ceases to impose itself as a blind force upon the human-beings and becomes more controllable stochastically. It is shown that the capital accumulation in the USA is a non-equilibrium quasi-periodic process described metaphorically as a long wave.

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## Defining Developmental Problems for Policy Intervention, or Building Reference Mode in 20 Steps Over 5 Learning Cycles

Developmental problems are invariably perceived as existing conditions, which must be alleviated. This often removes a policy from the factors that created the problem in the first instance. System dynamics method requires that a problem must be viewed as an internal behavioral tendency found in a system so its causes can be determined before a corrective action is initiated. A pattern representing internal dynamics of a system, called a reference mode, must be constructed before developing a model that serves as an apparatus to create a policy design for system change. Such a

problem definition process is also appropriate for understanding developmental problems such as food shortage, poverty and insurgence, so their causes rather than only symptoms are addressed by a developmental policy. A reference mode is, however, different from a precise time history in that it represents a pattern incorporating only a slice of the history and it requires several learning cycles to construct a reference mode from time history. A learning process based on a well-known model of experiential learning is used to describe the construction of a reference mode, which is illustrated at length by revisiting the problem of food shortage.

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## The Origins of Behavior Patterns

Can a simple positive feedback loop generate a goal-seeking behavior? The answer is yes. Can the behavior generated from a loop with a constant gain shift from a goal-seeking one to an exponential growth one? The answer is also yes. From the above answers, one can conclude that link gains alone cannot explain the origin of behavior patterns. In this paper, we propose the "curvature-contribution" of a link as a more valid representation of the link's role in generating behavior patterns. The "curvature-contribution" of link is the product of the link's gain and the rate of change in the input (influencing) state. If a link has a very high gain but there is no change in the input state, then this link does not contribute at all to the behavior pattern of the output (influenced) state. Likewise, if the input state is changing rapidly but the link has zero gain, then this link does not contribute at all to the behavior pattern of the output state.

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## The Origins of Business Cycles

In this paper, we apply eigenvalue analysis to a classical inventory-workforce interaction model in order to identify the sources of oscillations (i.e. business cycle) in the model. The inventory-workforce interaction constitutes the core of the short-term business cycle. The inventory-workforce model used in this paper is explained in detail in John Sterman's book "Business Dynamics" (Sterman 2000, chapter 19). As John Sterman puts it: "However, explaining the behavior by saying that production oscillates because the system contains negative loops with delays is not sufficient. Good modelers must strive for a deep understanding of the causes for the behavior observed in their

models…Understanding model behavior goes beyond the invocation of simple archetypes such as 'the oscillation is caused by negative loops with delays'…While true, these statements don't provide the deep insight into model structure and behavior required to develop your intuition about dynamics or your ability to identify high leverage policies".

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## Integrating System Dynamics and Multicriteria Analysis: Towards Organisational Learning for Performance Improvement

The design, implementation and use of adequate performance measurement and management frameworks can play an important role if organisations are to succeed in an increasingly complex, interdependent and changing world. Yet, despite widespread recognition of the importance of performance assessment, there are some issues which require further study if measurement systems are to be effective in supporting the decision making process. This article argues that the integration between System Dynamics and Multicriteria Decision Analysis can address some of these issues, and ultimately contribute to improve organisational performance. To support this claim, several problems that make performance measurement systems fall short of their potential are outlined and, a discussion about how the integration of system dynamics and multicriteria analysis can help organisations overcome these problems is presented.

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## Experts Facing Complexity: An Investigation Into System Dynamics Method

With the rapid growth in human knowledge, the world has been revealing its greater complexity to us. Faith is put in experts - possessing knowledge necessary to solve complex problems. But who should be considered expertsand what is the nature of the knowledge sufficient to tackle the encountered problems? In this paper, a broader philosophical and cognitive science perspective for considering expert complex problem solving is suggested. Three requirements that would successfully facilitate solving of complex problems are: (1) support a multilateral collaboration between various experts, (2) assist in the investigation of dynamic characteristics of a problem, and (3) allow for the evaluation and development of expert knowledge. System dynamics as a method for complex problem solving is examined.

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## Facilitating Learning in System Dynamics Practice

In SD practice our primary goal is to develop structural understanding of dynamically complex systems. Creating new understanding is a learning process defined by an improvement in people's mental models, which is consistent with modern theories of learning and instruction. With this paper, we intend to contribute to and energize a discussion in the SD community on the benefits of applying these theories to achieve our primary goal through improving mental models.
Our HOLICS workshop teaches personal energy management principles. A prototype interactive learning environment, based on a SD model integrating Jack Homer's worker burnout model with a project management model, facilitates it. To strengthen the workshop's learning impact, we developed and applied to its design a framework of learning and instruction theories. In this paper we demonstrate the application of our framework, and suggest how it could be generalized to, and therefore benefit, various forms of SD practice.

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## Controlling Service Business at a German Printing Press Manufacturer

Heidelberger Druckmaschinen AG is the world leader in manufacturing offset printing presses. During the last few years machine sales and profits have grown strongly and have made Heidelberg a successful brand. Heidelberg focuses on divisions to control its various product businesses. Derived from the Heidelberg strategy service activities like spare part sales and field services are considered as an own business opportunity. At first the paper describes the complex interactions between machine and service business as own cost or profit centers and the problems which result on that. In the following service business interactions will be shown in causal loop structure. Here the focus lies on important delayed relations between cause and effect on operational service and machine business as well as the whole financial success of Heidelberg in interaction with customer satisfaction. To avoid false decisions in long-term business these interactions have to be understood by the managers to plan and control their business with focus on long-term success. Based on that system conditions a first complex system dynamics model will

be developed for service business to simulate and understand the effect of operational and strategic decisions. Especially the optimisation of long-term financial success will be taken into consideration. The model analyses financial performance in short and long term context. Various simulation runs show that controlling service is very complex and each decision with long-term effect should have to be analysed in financial and operational effect to avoid the risk of a decrease in company's total performance. In addition the design and setting of suitable objectives for the management will be discussed.

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## Looking Across the Fence: Comparing Findings from System Dynamics Modeling Efforts with those of Other Modeling Techniques

The two prominent nonlinear modeling schools of System Dynamics and Agent-based modeling have studied numerous problems as they occur in complex human and natural systems. Areas of applications range from economics, ecology, and biology, over anthropology, psychology, and sociology, to traffic simulation, the military, and model testing. However, the two disciplines have rarely compared their results let alone each other's research designs. This study compares the findings from both streams of research as well as those from recent traditional research on the so-called bullwhip phenomenon.
The bullwhip effect has become well known to a wider audience through the beer distribution game. As this study shows, despite differences in methodology and other areas the findings of all three research streams converge in significant areas. Further cross study seems to be a promising undertaking. Integrated research designs may have a high potential for result triangulation adding to model validity and result robustness.

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## Rules to Grow By

We count Report Cards to be an important indicator of how well elementary children are performing in school. Academically, it's fairly easy to take test scores, average them and come up with a grade. But how does one derive a formula to assign a grade for the behavioral objectives that appear on an elementary school report card? Objectives such as: Respects Others, Accepts Responsibility, or Follows Directions vary from teacher to teacher, from classroom to classroom.

The answer was to build a Stock Flow Diagram using Respects Others as the Stock. Second graders looked for examples of respect (or the lack thereof) around school. They arranged the examples as Inflow or Outflow on a large Stock Flow Diagram which was displayed as one of our class rules. Although Respects Others may vary from classroom to classroom within a school, children who constructed a Stock Flow chart, understood what it meant in their classroom.

The following year, the same class (then third graders) designed an Action Research project. They surveyed teachers and students in order to create a teacher/student model of the behavioral objective: Accepts Responsibility. Following the same process as before, teachers' responses were grouped conceptually with students' responses and placed on a large stock flow diagram. Since teachers' and students' responses virtually duplicated each other, the children decided to use a "key" (K for kid and T for teacher) to discriminate answers. Teachers were so interested in the results, that we created and displayed the chart in the cafeteria on the main bulletin board.

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## HDS: Health Department Simulator

Managing an health department which deals with a number of variable hospital applications, usually much more than the available human resources (doctors, nurses, …) and infrastructures (beds, laboratory instruments, …) is not an easy job. In addition, in order to supply hospital services, often with time constraints due to urgent situations, creates a complex environment for department manger. Just in time decisions become an essential necessity. Building a "flight simulator" or better a "Hospital Department Simulator" can be seen with two major aims:

1. The dynamic of process can be better understood, while constructing the dynamic model.
2. The effect of decisions can be evaluated in advance through running the simulator.

The paper will describe both the structure of the model which has been developed to embed as much as possible the whole process of managing hospital applications against available resources ( low of supply and demand), and a set of results produced in reply of what-if analysis.

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## Exploring the Dynamics of Economic and Ecological Sustainability in the Northern Forest

The Northern Forest, which spans the U.S. states of New York, Vermont, New Hampshire, and Maine, is being pulled in three directions. There is increasing pressure on the forest to provide habitat and recreation, leading to a push for more "big old trees." The forest-products industry, particularly the sawmill sector, is continuing to grow and many rural communities want to retain or expand industry jobs. At the same time, urban growth may be reducing the forest-land base.

In partnership with a cross-stakeholder advisory team, we explored the relationship between the pulp and paper mills, the sawmills, the landowners, and the forest resource, focusing on the behavior of the fast-growing sawmill industry and its renewable timber supply. Questions we asked together included: What are the sawmills' likely transition from the current mode of exponential growth towards balance? Will the capacity smoothly approach an equilibrium or will it (as it already did from 1900 – 1935) overshoot and sharply contract, to the detriment of the industry, economy and ecosystems? What policies would lead to one future over the other? Results show the necessary conditions for a behavior mode of overshoot-and-oscillation and identify leverage points for improved system performance.

The paper further describes the most challenging work we currently face – using the analysis and a model-based workshop to catalyze support for positive change amidst a geographically distributed, near-term-oriented group of policy-makers who represent stakeholders from loggers to mill executives to environmentalists to landowners to government officials.

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## Workshop: The Tipping Point

Organizational change can be thought of as stretching the goals and improving the way an organization thinks about and does its work. Examples of organizational change efforts include implementing an Enterprise Resource Program, changing the compensation structure to reflect new corporate needs, or implementing computer-based-training. Organizations often experience resistance and inertia to important change initiatives that can undermine the company's competitiveness. The Tipping Point is a new model of change that applies lessons learned from

public health to make an organizational change initiative both contagious and sustainable. The Tipping Point computer simulation can provide the language that we need to understand and create constructive change. It simulates a positive "word of mouth" epidemic and models factors that affect motivating organizational change. Using the simulation in a workshop setting gives participants an opportunity to dialogue and debate among themselves about how change happens, create a change strategy within their teams, and test that strategy on the simulation. In workshops, teams have been known to spontaneously standup to cheer as their strategy unfolds in the simulation. Participants often have argued heatedly during the simulation runs about trade-offs and costs. It is easy to see the emotion during the competition. More importantly, managers have modified their approach to a real organizational change after participating in a Tipping Point workshop. In organizations that have used the simulation extensively, its concepts, terminology, and theory have helped frame people's conversations about change years after they have participated in a Tipping Point workshop. For more detailed information on the computer simulation and on the workshop see http://www.the-tipping-point.com.

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## A Framework for Understanding and Evaluating System Dynamics Requirements Engineering Process Models

This paper presents a framework for understanding and evaluating system dynamics requirements engineering process models. Although a number of studies both in general simulation and system dynamics literature raise important issues related to evaluation of software process models (Forrester, 1981; Forrester and Senge, 1980; Shanon, 1981; Balci, 1994; Abdel-Hamid and Madnick, 1991; Chickakly, 1993) very little has been discussed on how to evaluate system dynamics requirements engineering process models.

System dynamics requirements engineering process models are increasingly being used in problem finding and problem solving (Williams, 2001). Process modellers and users of these models, all the stakeholders using information derived from the results of the model, and others affected by decision based on such models are concerned with whether the model and its results are correct (Sargent, 1998). This concern is addressed through problem understanding, model verification, validation and credibility (Williams, 2001).

In this paper the term evaluation refers to validation, verification and establishing model credibility of requirements engineering process model. The author argues that developing and fostering an understanding of the requirements engineering process domain application is a key towards an effective, verification and validation and model credibility. Research in this area is vital if both requirements engineers and software development organisations are to cope with the rapid pace of change in software processes in general.

Initial tests on a requirements engineering process model suggest that the framework offers a sound approach for verifying, validating and establishing model credibility. This limited experience lead the paper to suggest the proposition that there is a direct relationship among model builders verification risk metric, model user/owners validation risk metric and model's credibility range. The trade-off among these metrics is analysed using the framework for understanding and evaluation of system dynamics requirements engineering process model described in this paper. Forrester and Senge (1990) stress this point that "confidence in system dynamics model accumulates gradually as the model papers more test and as new points of correspondence between model and empirical reality are identified" (p. 209).

The paper suggest that the framework makes a useful contribution both in providing the foundation for understanding and improving the correctness of system dynamics requirements engineering process models.

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## The Challenge of Pursuing a System Dynamics Approach in Analyzing Complex Natural Systems: Example of Solid Waste Landfills

A system dynamics approach is attempted to determine the significant processes and appropriate level of detail required to capture dynamic behavior important in managing biodegradation in landfills. The approach used in analyzing complex natural (biochemical) processes in such systems is inherently different from that used in analysis of many management systems where influences and feedback may be more easily envisioned and represented at a higher level of aggregation. Successful aggregation of natural physical-chemical processes in search of a simpler (and useful) model structure is elusive and problematic. Yet, the simplest model structure achievable, without sacrificing relevant behavioral patterns and the accurate influence of potential engineering controls, must be pursued to enable broad

implementation of a practical modeling tool in the field. This paper presents this struggle for an engineered system using complex naturally occurring biochemical processes (municipal solid waste landfill), with implications for confidence building in the model.

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## A System Dynamics Model for Assessing Housing Demand in Hong Kong

As a metropolitan city, Hong Kong is not only a nice and over-crowded place. One of the main characteristics of the city is that there are too many people and too little land. Because of this reason, the property industry plays an important role in the whole economy of the city. As an important branch of the property market, any change in the housing market can have enormous influence on the society, the economy, and many families. Can we keep the housing industry in a stable development? A key factor for this is whether or not an appropriate development plan can be prepared. The plan should be based on assessment of housing demand in the forthcoming future.
This paper presents a system dynamics model that simulates housing demand and development trend of the housing market in Hong Kong. Assessing the demand for housing involves judgement as well as monitoring a moving target, because demand varies according to economic conditions, population migration, as well as policies that may create housing demands. For simulation purposes, it is necessary to devise a model that will produce the most accurate estimate of future demand at any time. Such a model contains essentially a series of equations, which are supported by a number of reasonable assumptions, policy parameters, and dates in order to produce a simulation result of demand trend in the years ahead. If parameters change, the model can be used again to simulate the new results easily by taking into the latest situation. The simulated results shown that the system dynamics method can be used to forecast housing demand in Hong Kong successfully.

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## An Experimental Investigation Comparing the Effects of Case Study, Management Flight Simulator and Facilitation of these Methods on Mental Model Development in a Group Setting

The practice of building and exploring Systems dynamics models with groups of non-experts is still relatively new to most

organizations. One primary concern in this practice is how to structure group modeling sessions so that participants' mental models of system functioning may be most effectively elicited and made more robust given a limited time frame in which to conduct group-based activities.
This paper is drawn from dissertation research conducted at a southwestern U.S. airline. The study was designed to look at the impact of model Conceptualization (via Case Study), simulation (via Management Flight Simulator) and facilitation of the these processes on the elaboration and revision of individually held mental models and group dynamics. Included in the discussion is a summary of the background literature on which the study is based, the underlying theoretical model used for establishing the experimental framework, an overview of the research methodology and results.

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## The System Dynamics Mailing List: An Evaluation of the Year 2000

This paper analyses the electronic mails sent to the System Dynamics mailing list in the year 2000 under different aspects. The work is addressed to potential subscribers and people who do not have enough time to study each mail they receive. It should help them to decide whether or not to subscribe. The contents and subjects of the categories (QUERY, REPLY, ANNOUNCE, ...) will be analysed. The active subscribers will be classified by their geographic origin and their fields of activity. An opinion poll will complete the work.

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## The Impact of Information Feedback on Group Decision Making When Applying System Dynamics Models

The present paper addresses the development of a methodology for group decision support by applying system dynamics models. The methodology is based on the system approach, a control paradigm applying simulation and system dynamics. A system enabling the active cooperation of decision subjects was developed. The system developed is user friendly, with regards to visualization and transparency of simulation results. A reference model of the

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business system was developed and several experiments were conducted with the model. The experiments considered the task of strategy determination with an explicitly defined criteria function. The criteria function was explicitly defined in order to increase the level of experimental control. Experiments were conducted under different conditions, which differed in model application and group information feedback. Qualitative judgment of the business strategy parameters,
application of a simulator and application of a simulator with group information feedback were considered. 105 subjects, senior students, participated in the experiments. The analysis of the results, as well as hypotheses testing was conducted using statistical methods. The research treats the influence of group feedback information on the group decision process in detail. The hypothesis that positive group feedback information influences the convergence of the decision process was proven. The proposed system introduces an improvement in classical decision support systems and provides better results in terms of the criteria function value.

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## Sowing and Tending Seeds of Change in a Field of Stone: System Dynamics-Based Spatial Visualization and Dialogue-Informed System Dynamics as Public Engagement-Enhancing Resource Management Tools in Door County, Wisconsin

This paper reviews our experience using visual system dynamics-based scenarios to invite, encourage, and support community dialogue about how Western Lake Michigan's Door County, Wisconsin might cope with its experience of the intense development pressures that confront accessible and attractive communities everywhere.
The recent efforts reported here seek to adapt or develop workable and cost-effective approaches to limiting and mitigating culturally and ecologically degrading impacts on a community challenged by a worrisome combination of attractiveness, accessibility, and ecological fragility.

The experience described in the paper outlines the steps that led to the pragmatic and sometimes clumsy use of dialogue, system dynamics modeling and state-of-the art spatial visualization tools.
This preliminary summary of the experience is meant both to provide guidance to other communities and to lend intriguing

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context for advancement and application of methods and tools to further the, still under-supported, community application of systems modeling.

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## Dynamic Logistics Model for Optimal Delivery

This paper deals with the development of dynamic based logistics model aims at optimal delivery. A total logistics model covering five sub-models, namely raw material stock, production process, production stock, production order, and delivery, are proposed. Such models would, in general, require a firm control of the availability of each production components in any of in-flow stage (e.g., raw materials), processing stage (e.g., production), and outflow stage (e.g., production stock, order process, and delivery), to achieve customer satisfaction. It is, however, realized that equilibrium among the three stages is the key success of good logistic systems, but in reality discrepancies among them are hard to avoid. In this research a near-equilibrium situation may be achieved through a dynamic simulation process of the sub-models characterizing their performance as well as their interrelations. This sort of simulation can be considered further as an optimal control for delivery through which a sensitivity trends may provide strategies to producer of how to manage resource with best service. In this very early approach formulation of an objective function that maximizes revenue of sales is determined to cover the market demand. Furthermore, in the form of dynamic simulation model various strategies may be exposed to decide the best policy of delivery.

## Evaluating the Potential of System Dynamics Modeling for Improving Public Participation in Water Resource Management

This paper discusses a study testing the potential of a system dynamics model to facilitate public participation in the management of the Las Vegas, NV water system. The Las Vegas water system serves one of the fastest growing metropolitan areas in the U.S., located in one of the country's most arid regions. Management challenges include communicating information about the dynamics of the interconnected urban and environmental system and enlisting public support to reach water conservation

goals. In this study we developed a system dynamics model of the water system, scripted a workshop to present the model, and ran seven workshops for a total of 67 members of the Las Vegas community. Results of the workshop show that system dynamics models can provide a forum for analytic deliberation, in which scientific analyses are combined with structured discussion about values and objectives. Analysis of participant survey responses and facilitator observations shows the model improved group communication, technical knowledge and system insight, and promoted consensus among the participants. This paper presents the Las Vegas, Nevada water system case study, describes the workshop structure and content, and discusses findings from the research workshops.

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## Systems versus Statistical Thinking: A Demonstration Project

This poster takes a typical concern in organizational behavior, turnover, and explores its nature from both a statistical and system dynamics perspective. Managers want to know why people are leaving and what can be done about it? A system dynamics model structures the interrelationships of associated factors such as satisfaction, trust, and human resource policies. To answer the question, a typical researcher would conduct a study to measure the association of self-reported variables on satisfaction and trust along with policies and turnover. She would then explore the nature of variation and attempt to explain as much of the variation as possible in a statistical model. The resulting fit of the regression or structural equation model serves as the basis for understanding turnover. The nature of the system dynamics model, however, is such that a cross-sectional survey approach will manifest the "healthy worker" effect. In the model, women are leaving due to dissatisfaction with human resource policy inflexibility. Women who stay are satisfied and this is what the survey will find. Beyond this effect and the inability of the statistical approach to understand the problem is a deeper concern – the statistical approach with its emphasis on explaining variation is unsuited to the original question. System dynamics and its operational approach is more suited to the question. The goal is to establish a learning environment where current and future management researchers will might learn the dangers of the traditional survey/statistical approach and better appreciate a system dynamics view.

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## Product Design and Manufacturing Process: Dynamic Implications for Innovation Management

For industrial companies innovations of the product system as well as innovations of the manufacturing processes are essential. Due to technological facts there is a tight relationship between technical products and the processes implemented to generate these products. Innovation management has to take into account the dynamics of the underlying product-process interactions and the resulting constraints coming to a coherent implementation of the different types of innovation.
A System Dynamics based approach covering the essential underlying cause and effect relationships provides suitable support for understanding and managing the complexity and the inherent dynamics of the industrial innovation process. The System Dynamics model developed here links the cycle of product innovation to the innovation cycle of the related manufacturing process and allows to analyse the dynamic consequences of different activities in innovation management.
One result from the product-process connection is the existence of the productivity and flexibility trade-off. For industrial companies´ competitive strength managing production process efficiency as well as product variety is essential. Based on the simulation model the long-term effects of the implementation of different types of innovation innovations are analysed.

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## "FIMBY" or "Finished in My Backyard" Policy

This paper presents an integrated system approach to organizing and promoting people participation in designing and practicing the " Finished in My Backyard" or " FIMBY" policy as contradict to "NIMBY" or "Not in My Backyard" in previous term. In order to create community equity and eliminate conflicts in garbage management practices, FIMBY model has been developed and built in the decision support system as a tool for helping local administrators managing local planning and development with people participation. The model comprises three main linkage processes of encouraging local decision making. The first process, namely policy making, includes system dynamics concept for understanding the garbage problem structure and its impact to the quality of life in the form of feedback loops as well as how to

develop the existing associations to the win-win scenarios such as garbage recycled by bio-extract process at home. The second, namely site selection, applies geographic information system to select the target area for implementation from the digital map. The third, namely project appraisal, provides the interactive dialog forms of the three garbage management models-household, group houses and sub-district levels for comparing cost and benefits.

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## Strategic Marketing Value Net Management: A Useful Framework for Consulting Proposals

Frequently, system dynamicists have to present proposals in their everyday consulting endeavors, telling about their organization, sometimes add the principals' biographies and state the offered service scope.
Is a known matter that is difficult and complex to communicate to prospective clients how a systems thinking intervention or a system dynamics consulting engagement could help them.
In the author's opinion, any tool or framework that aims to communication simplicity should be welcome.
In this poster, the author will present two examples that take advantage of a conceptual framework called Strategic Marketing Value Net Management, developed by Professor Mohanbir Sawhney Northwestern University Kellogg's.
In this framework, there is no distinction between strategy and marketing, and the composite concept is arranged in a value net, to be managed.
In the following examples, the proposals will show the conceptual framework (one for public sector and the other for corporate clients) and describe the consulting engagements that might help the client to strategically manage their value net.

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## Facing the Upcoming Crisis in Social Security System of Iran

The social security system in Iran is facing a serious financial crisis. Whereas both revenues and spending in the system are growing, the growth rate of expenses has become much higher than that of revenues.
Experts believe that the expenses will exceed the revenues in the next two years. The challenge in the upcoming crisis is then to put off the break-even-point. This paper reports an ongoing project in the social security organization that aims at how the organization

can collectively develop effective policies for avoiding the financial crisis.

A system dynamics model is developed to investigate the effect of various policies such as the pay-as-you-go approach and actuarial system on the dynamics of resources.

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## A System Dynamics Model for Developing the Software Industry: The Case of Egypt

Studies have been conducted on the means of the development of the software industry. Most of them used traditional approaches that examine systems by taking each component of the system apart and analyze it separately and then formulate a general conclusion for the system as whole. These approaches, though its benefit, is not enough for complex systems such as the software industry because of the inter-links and overlapping among the components of the system. System Dynamics modeling offers the tools needed to draw more accurate study needed by such complex industry.

The main objective of the study is to develop a System Dynamics model of the Egyptian Software Industry and apply this model to generate time responses that may help the provision of holistic approach encompassing the myriad of variables & issues. The developed dynamic model will provide clues for leveraging and identifying potential problems. The methodology adopted in this Study is based upon building a System Dynamics (SD) model for the Egyptian software industry using the classical software for System Dynamics modeling "STELLA". The study based mainly on the sources of information; include official international and local statistics, international periodicals, previous studies conducted by very well recognized institutions, as well as conducting interviews with various key figures related to software industry.

New tools such as offshore business development centers, software development parks are essential. It also concludes that long term impacts of strategies used should be considered, as some successful strategies in the short term, may lead in the long term to deterioration of industry and finally its collapse.

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## Behavior Strips and Marbles

It was not surprising that a group of Elementary Teachers became interested in ST/DM as a tool to help in character education. If

"Everything I needed to know I learned in Kindergarten" then getting along with others and accepting responsibility for my actions was a major learning. When I began my school year, I had been exposed to the concept of having class rules correlate with the report card. I was excited about beginning a new school year and excited about a new direction in behavior modification. It really is exposing children in the direction of learning behaviors that can follow them throughout their lives and can teach when to consider others' feelings.

I believe that incorporating these elements was a winning factor in the success of my students and in their education of how choices are made and their consequences. I have the same students this year for third grade and I am proud to say that negative behaviors are at a minimum. When things become rocky, those class meetings and "Rules to Grow By" come back out as a reminder of what is expected and needed in order for all of us to gain the most we can from our education and time together, we can grow from those experiences and thrive together in society.

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## System Dynamics Modeling for the Sustainable Management of Natural Resources in Developing Countries: A Case of Mining Activities in the West African State of Sierra Leone

Natural resources are the main stay of economies of the developing world. The environmental impacts of their extraction however have proven to be counterproductive to sustainable development. Numerous strategies have been implemented to sustain development in these regions but the problems continue to get exacerbated. Recent discussions in the United Nations Conference on Environment and Development emphasized the need for sustainable development strategies to be developed. The result of this research project, in which the mining system of Sierra Leone was used as a case study, is proposed to serve as a contribution to this discussion.

This paper describes the development of a System Dynamic Model for the sustainable management of natural resources. Multi-Criteria analysis was first used to identify key variables for model development. Based on this, causal loops identified in the economic, social, and ecological subsystems were captured in the model and programmed using DYNAMO. The model was validated and used for policy analysis. Three policy approaches were analysed. The "Conservative Policy Approach" which allows mining activities to continue in its current state indicates in its

output that the resulting environmental degradation is near catastrophic. The "Radical Policy Approach", which terminates all mining activities with immediate effect, did not prove to be economically viable for a natural-resource-dependent economy. Based on these results, the "Harmonious Policy Approach" recommended a concrete gradual reduction of mining activities whilst investing in intensive agricultural development. This policy is therefore used as a quantitative approach to control environmental degradation through time-based gradual reduction of mining activities with the objective of achieving sustainable development.

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## Design Pattern Language and System Dynamics Components

This paper explores the concept of design patterns and how they relate to System Dynamic models. Design patterns began as the province of architectural structure based on the work of Christopher Alexander. His thoughts found their way to software engineering as models for design patterns.
Like Alexander, Forrester is a strong advocate of structure. Forrester bases the foundation of System Dynamics models upon the cornerstone of structure. To him structure is essential if we are to effectively interrelate and interpret our observations in any field of knowledge. He has said that if one knows a structure or pattern on which he can depend, it helps him to interpret his observations.
Various System Dynamicists have described System Dynamics structural patterns in terms such as archetypes, templates, molecules, and components. However, the potential power of patterns as presented by Alexander has not swept the System Dynamics field based on these constructs. This paper takes a closer look at the elements of Alexander's design patterns and asserts that a pattern language for System Dynamics is the missing piece preventing the power of design patterns from helping System Dynamics have further reaching impact.

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## Adaptive Balance of Causes and System Management

The new approach to the complex systems management was suggested on the basis of three research results obtained by the authors: system conceptions of sustainable development were

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formulated, the new Adaptive Balance of Causes (ABC) method for numerical modeling of complex systems was worked out and general ABC-technologies of system management were offered. The new approach takes into account the nonlinear causes – effect interactions (cause functions) operating inside a system . With the use of the Bernully type equation and special balance of causes condition a standard adaptive balance module was introduced. Any of information systems could be presented as a set of such modules reflecting local balances and influencing each others. Similar to the molecules in physics or cells in biology the standard modules form the general system structure. Current identification of the cause functions was suggested. The method of adaptation to the reality of the system' development scenarios was proposed also to enable current observational data assimilation, based on optimal filtering technique. The ABC - method's efficiency has been probed in many case studies of economic, socio-economic and ecological-economic systems and the results showed that the method has proved to be very promising general approach to the complex systems management . Implementations of the ABC - technologies to various economic, ecological-economic and socio-economic systems were considered. Dynamic systems of types: "market - enterprise - resources", "national economy", "Leontiev input-output balance", "bioresources consumption and environment pollution control", "production improvement paradox", "state investments distribution and social consciousness" were studied and discussed. Their prognostic development scenarios were obtained, and the efficiency of system management based on ABC - models was confirmed.

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## An Analysis of Tokaimura Nuclear Criticality Accident: A Systems Approach

Except for what are sometimes called ‘Act of God’, any problems arising at a nuclear plant originate in some way in human error [1]. The IAEA Report also concluded that the accident at the JCO nuclear fuel processing facility at Tokaimura seemed to have resulted primarily from human error and serious breaches of safety principles. However, unless there is a sufficient set of vulnerability causal factors and one or more triggering causal factors, neither an instance of human error nor a consequential event occurs
Based on their systemic analysis of the criticality accident the authors claim that its root cause was combination of:
(1) inadequate risk awareness by the top management and
(2) “kaizen” (production improvement) drives.

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Famous traditional Japanese culture "kaizen," an important determinant of the Japanese superior performance, had an adverse effect on the event.

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## A Study on the Process of Building and Implementing Balanced Scorecard in System Dynamics Perspective

Balanced Scorecards (BSC) make both practitioner and academic take notice these years. The reason is that BSC rethinks corporate performance measurement system, and furthermore, BSC is becoming a strategic management system that can facilitate corporate strategy formulation, communication, implementation, and learning and feedback process. The latter aspect focused on identifying the operational factors which driving future success is more important to a corporation to accumulate long-term competitive advantage.

Some literatures show that 70% of BSC implementations fail. In order to explore the reason of failure, they study on the process of building and implementing BSC. Besides clarifying the purpose of developing BSC, some leading researchers explore some pitfalls and provide solutions to the problems. This research follows this stream. In order to facilitate company to implement BSC more effectively, we explore and learn to understand the nature of complex systems formed by the whole process of building and implementing BSC. By using system dynamics perspective and tools, we can consider the process a complex system with a lot of cause-and-effect chain relationships, for example: the link relationship of business strategy, process, and performance measures, and the alignment of strategy formulation, communication, implementation, and learning and feedback activities. By building and simulating system dynamics model of our case company, we can more deeply understand the complex system of our case company to develop BSC. And we are trying to find the leverage policy for the case company to redesign a new system (rethink the cause-and-effect chain) or improve the performance of original system (transfer strategy into action more effectively).

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## Adoption of Technology: A Systems Perspective

Systems thinking in management is getting increasingly popular through out the world. Management of Technology in an industry or an organisation assumes a lot of importance in view of tough competition, globalisation and emerging of new technologies very fast across the globe. In this article a holistic view of management of Technology is presented, which may help an industry to gain competitive advantage. Importance of Technology in the organisation, Technological lockout, Adoption of new Technology, Competitive Advantage through Technology, The impact of Information Technology and HRD for Technology Management are discussed in detail in this article.

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## The Network Roleplay SME

We have developed what could easily be called a serious game where all the people that conform a SME could play a network game in their respective role as they work every day.
In essence this game is divided in two kind of activities.
a) One activity is the explanation of the case and the use of the simulation in the computers.
b) The second activity is center around a table and chairs that "simulates" the Meeting Room.
What could be obtained by the people that take this course could be resumed:
- They must prepare and develop a Budget for one year.
- The Interdependence that exist between every department in every company.
- The Importance of the Communication between departments , in essence the Dialog.
- Counter intuitive short and long term.

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## Modelling the Water Sector in the Azag Strip: A Student Project

At the School of Systems Engineering, Policy Analysis and Management of Delft University of Technology in The Netherlands, students carry out a System Dynamics project in

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groups of two upon completion of an introductory System Dynamics course. The project should take the students approximately 80 hours to complete. Over the course of the project, students have to show that they understand all the steps of the modelling cycle. The final product of the project is a modelling report including policy advice (and a working Powersim model). The topic that has been the most successful for the project to date is the water problem in the Azag Strip. This project is based on a study of sustainable development in the Gaza Strip (Lambregts and Sanders, 1996), but various assumptions and simplifications have been made in order to make it suitable for the course, hence the name Azag Strip.
The Azag Strip project has been used for three years (approximately 250 students). Every year, the case is changed somewhat to make it different from previous years. The case can easily be adapted by condensing or expanding certain parts of the model, or concentrating on certain issues in the model.

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## Quality Improvement in Knowledge Based Organizations: Capturing Tacit Knowledge to Aid Organizational Learning in Venture Capital Decisions

This paper reports the investigation of methods of quality improvement for tacit knowledge-based processes in venture capital firms. The study found that quality could be improved in investment decision processes through emergence of tacit knowledge (Polanyi, 1966) to balance the requisite variety needed for organizational steering. The methods applied yielded a doubling in decision cycle performance for the venture capital firm under study.
Metrics of information flows provided feedback on performance of knowledge processes, while heuristic cybernetic methods were tested as tools to enable emergent strategizing and organizational learning. Conceptual cognitive mapping was employed to document tacit knowledge and measure the degree of complexity, based on Ashby's (1965) Law of Requisite Variety. Neural net linguistic analysis was utilized to objectify aggregation of concepts in the mapping process to limit subjective bias (Eden, 1983). Ackermann & Eden's (1998) JOURNEY method was used for consensus building to reduce the variety in decision processes.

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## Treatment Policies for the Management of Chronic Illness: Is Specialization Always Better?

Chronic illness cannot be cured, only controlled. In this paper, we describe an investigation of treatment strategies designed to control the natural progression of type 2 diabetes. We propose that treatment strategies are often specialized to types of patients, and their performance is sensitive to accurate categorization. We investigate the proposition that when incorrect categorization occurs, more specialized strategies may perform worse than less specialized strategies. Following analysis of necessary conditions based on an expected utility model, we present a dynamical systems model of patient care and define two measures of control based on the trajectory of patient health states. The first measure characterizes the accumulated level of control (the extent that health goals are maintained); the second measure characterizes dynamic structure (the time dependencies among health states). Computer simulation is used to analyze the effect of incorrect categorization on these measures.

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## A System Dynamics Model in the Field of Electronic Business

This paper discusses common effects in the field of electronic business.The “Electronic Business Forum (EBF)” at the Humboldt-University of Berlin researches in co-operation with different enterprises in Berlin and surroundings which are involved in electronic business. Any projects of the EBF explore relations to the World Wide Web and to e-business (e-commerce, b2b, b2c).
This paper develops a System Dynamics model in which to explore the e-business effects of testing and prototyping.

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## Teaching System Dynamics Over the Internet

The use of the Internet to teach something is a great opportunity for people living far from good schools and universities and it's also a challenge for educators to increase their skills and spread their knowledge, specially in great countries like Brazil with more than 8.5 millions square kilometers. It will be showed a web interface to teach System Dynamics and it will be reported an experience held in Brazil with people connected to the Internet. All

these people are undergraduate professionals (engineers, veterinarians, etc.) and most work in agribusiness sector. The low speed of Internet connections limits the kind of material that people can download. Despite of this restrictive fact, it's possible to offer an interesting interactive learning environment that stimulates learning communities. Interactive web simulations are programmed in a like-Dynamo language running under a PHP server (www.php.net). Students can interact online by modifying model parameters and can test several situations. The more skilled students can change or test their own models. The authors are interested in contact IT professionals to create an open software written in PHP script language that implements a full Dynamo interpreter to run System Dynamics applications over the Internet.

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## Modelling and Analysis of Environmental Pollution in an Integrated Steel Plant

Gaseous, liquid, and solid pollutants that are released from the production processes in an integrated steel plant are modeled here using system dynamics. This is a macro model. This model is simulated and experimented with various pollution abating policies, mainly in terms of the investment made for pollution control. The results provide a broad idea of the extent of actions that are required to control pollution.

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## The Impacts on Sedan Demands after China Joins the WTO

China's sedan industry, which is highly protected by the government, is mainly joint ventures that produce in small scales. With the pace of China joins the WTO, its sedan market will open to the global market. The sedan provider will be producer from the whole world and the price will be highly effected by the global market. With the large potential productivity of Chinese sedan market, the main issue will be the conflict between the booming consumers' demands and the small production scales. The paper creates a System Dynamics model of the change of sedan demands in China. The model studies the change of sedan demands after China joins the WTO, and analyzes the main factors that influence the sedan demands—economic factor, highway traffic, consumer psychological factor, consumer policy and satisfaction of sedan consumption. In the end, significant conclusions are drawn.

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## Strategy Dynamics and Scenarios of Industry Evolution

The application of System Dynamics to operationalise the resource-based view (RBV) of Strategy makes possible a coherent theory of the dynamics of strategic performance. This framework explains firm-performance over time in terms of the mutual interdependence between its strategic resources, and makes explicit the process of rivalry between firms.

A broader view of this framework, however, shows that a more fundamental process is being captured – the mutual evolution of asset-stocks that determine current market demand and industry-sector supply. The potential profitability offered by a growing market raises firm incentives to invest in functionality, capacity, unit-cost reductions and marketing. Market growth ensues, until the process hits limits to the further accumulation of all demand-side and supply side resources..

When industries compete to serve mutually exclusive market needs, or compete for limited resources, the consequence is a pattern of relative industry growth and decline that reflects the resource-system viability of the respective industries. Variances in excepted rates of resource-development enable quantified time-paths of alternative industry scenarios to be described, and used to advise firm policy, an approach that can be illustrated in the context of the global consumer financial services market.

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## Strategy Dynamics in Non-Profit Settings

Whilst the Strategic Management literature has much to offer leaders and advisors of commercial firms, little attention has been given to identifying strategy insights specific to the needs of non-profit institutions (charities, Government, public services, armed forces, non-governmental organisations, and so on). Whilst these sectors have their own literatures, it might be expected that the Strategy field would have transferred significant insights from commercial to non-profit contexts. Yet a review of top management journals and research publications in Strategy over the last 3 years reveals few articles focused specifically on such sectors.

One observation provides a plausible explanation – the key insights in Strategy over the last two decades have arisen from the micro-economic analysis of competitive markets. Consequently,

research in Strategy has largely focused on identifying explanations for business profitability. Non-profit organisations operate largely outside competitive product markets, so it is hardly surprising that 'Strategy' has had little to say about such contexts. Although the principal goals of governmental, charitable and other non-profit institutions are rarely financial in nature, they still have long-term objectives to pursue, and must develop and leverage the strategic resources needed for that task. Often, these resources must be competed for (e.g. skilled staff, providers of finance). A resource-based perspective therefore offers the possibility of a comprehensive framework for capturing the strategic architecture and issues for non-profit organisations.

This paper builds on established concepts in Strategy and System Dynamics to set out a generic resource-system model of strategic performance, and its special characteristics in non-profit cases. The paper then illustrates this framework in the context of an issue that spans the concerns of charitable and governmental agencies – city homelessness.

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## The Cycling of a Decision Threshold: A System Dynamics Model of the Taylor Russell Diagram

According to Hammond (1996), any uncertain test where a threshold is used as a policy decision tool leads to unavoidable injustice to some constituency. This injustice is represented in the Taylor Russell diagram. When a measure of expected success is used for policy, but imperfectly predicts actual success, there are always cases of false positives (those who are selected but shouldn't have been) and false negatives (those who were never given a chance to realize their potential). Each type of error creates pressure on the decision threshold, to raise it and reduce the number of false positives or to lower it and reduce false negatives. The competition between these pressures is theorized to yield a cycling of the decision threshold. The effort in this paper is to elucidate the essential structure required to reproduce the moving threshold.

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## Workshop: Teaching Economics and Economic Policy

Using system dynamics (SD) to teach economics permits explicit use of time in explanations of changing economic behavior and performance. It also emphasizes the essential stock/flow nature of the economic system, and enables supply/demand graphs to "come alive" and interact. The workshop will demonstrate the use of system dynamics in teaching economic concepts in K-12, plus SD applications that are helpful when exploring macroeconomic policy issues with advanced secondary students and college undergraduates. Time permitting, workshop participants will also examine a work-in-progress model that integrates an economy's markets for goods & services, labor, money, and foreign exchange. Participants in the workshop will receive handouts that can be adapted to their own use. The workshop will provide opportunities for interaction, and will not be a lecture. STELLA models will be demonstrated on an overhead screen.
Participants will distinguish between economic stocks & flows and sketch causal loops and stock/flow diagrams.

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## Interactive Strategy Model for a Commercial Bank

This poster presentation demonstrates a STELLA model of deposit growth in a competitive local market characterized by head-to-head competition between two banks.
The banks can "grow" their deposits in two ways, or a combination of both. A direct method for gaining new deposits is by paying high interest rates on customer accounts and certificates of deposit. An indirect method involves attracting loan applications by charging low interest rates, since a loan is then credited to a customer's account and increases the bank's deposits—the classic "money creation" process. Both strategies are aimed at increasing market share of deposits. However, both approaches reduce a bank's net interest spread, either by raising costs or reducing income.
The simulation model permits exogenous local and national economic conditions to influence local demand for loans, growth in account balances, and the prevailing interest rates from which each bank cautiously departs in an attempt to gain a competitive advantage. Within that context, two teams of bankers compete

strategically, balancing their conflicting goals for market share (based on deposit totals) and earnings (based on the weighted-average spread between interest earned and interest paid).
The model was developed as part of a larger strategic planning initiative for a Virginia community bank that recently celebrated its 100th anniversary. During the 1990s, the bank's assets grew 225 percent, compared to 65 percent for all U.S. banks. The model has been an effective learning tool in strategic planning meetings with the bank's senior staff and board of directors. Conference participants can play the simulation game during the poster presentation sessions.

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## Towards a System Dynamics Theory of Requirements Engineering Process

This paper presents initial results of the research towards the development of a system dynamics theory of requirements engineering (RE) process. Poorly defined requirements cause projects to fall behind schedule, go over budget and result in poor quality system specification. Many systems (software) development organisations are attempting to increase the effectiveness of the RE process by incorporating improvements aimed at better understanding, improved communication and more effective process modelling and analysis. The need for developing such a theory as a basis for understanding and a fulcrum for debate have highlighted a strong case for integrating research approaches. In developing such a theory the paper fills an important gap in the Systems (software) requirements engineering process modelling and analysis literature. Research in systems (software) on requirements engineering process modelling and analysis is vital if requirements managers, researchers and software development organisations are to cope with the pace of software evolution, retain competitive advantages and reap the benefits of an effective RE process. The paper concludes that current management and decision-making models fail to make sufficient allowance for the complexity of requirements engineering stakeholders' business goals and aspirations in a dynamic software development environment. The paper suggests that the model-based theory provides both a foundation for theory building requirements engineering process and a basis for improving requirements engineering process modelling and analysis.

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## General Theory of Religion

A system dynamics analysis of consciousness during a ten-hour religious experience of purgation, which just preceded an estimated four-to-seven second experience of mystical union, gives purgation a scientific structure. Using that structure, my research in comparative religion shows that at the essence or core of each religion resides this same sacred structure and essence. As a result, the analysis forms a general theory of religion: e pluribus unum. The work then goes further, establishing the long-sought-for integration of science and religion by rooting this core of religion in biology. As a byproduct, the analysis solves the central problem in the emerging field of consciousness studies, Chalmers' hard problem. The presentation contains much personal material on my religious life and experiences. This is necessary as preliminary for the formalized analyses of such material. The fullest presentation - with 100's of links - is at: http://world.std.com/~awolpert

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## System Dynamics Modeling of Technological Capabilities Accumulation

This paper focuses on the system dynamic model of accumulation and path selection of firm's technological capabilities (FTC). Based on the ten years' data of West Lake Electronic Co., the accumulation process of FTC is simulated. It analyzes the impact of switching between technological introduction, in-house R&D and cooperative R&D impact on the accumulation of FTC. And it also analyzes the impact of investment of difference path on the accumulation of FTC.

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## Coordinative Development of the Social Systems by System Dynamics Modeling

To develop continuably, it's important to keep the ecosystem balance. Coordinative development between the Economic System, Science & Technology System(S&T) and Education System,

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therefore, is also important, especially for China. It's an important national level policy decision issue.
This article first discusses the theory and mechanism of the sustainable and coordinative development of the three complex systems. Then are the nature and characteristics of the relationship between them analysed. Coordinative development can greatly enhances the competitiveness of a country.
Based on above theoretical analysis, this article advances a method of multicreteria optimization of coordinative development between the three complex systems. The last, System Dynamics modeling is applied and policy analysis is made of growth rate on three systems for China. A brief conclusion was hereby drawn on the coordination of the development rate of S&T and Education. This conclusion was highly appreciated by some senior executives in the ministries.

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## Managing Side Effects of Cultural Tourism Development: The Case of Zhouzhuang

Zhouzhuang has been quite successfully to attract mass tourists. Yet, from the experiences gained from other cases, potential risks have been already embodied in the way the tourism has been developed. The physical buildings have been well preserved and reconstructed to be able to get listed in the UNESCO World Heritage List, a good way to promote its tourism. Yet, the traditional way of water-town living style, the major attraction of Zhouzhuang, is giving its way to commodification. An easy and quick compensating measure is adopted to create a staged authentic traditional life style. Cautions should be made to prevent the site to turn into a thematic park and thus lose cultural and social meaning for tourists.

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## A Step-by-Step System Dynamics Modeling of Sustainability

The purpose of this paper is twofold. (1) A step-by-step procedure of system dynamics (SD) modeling is developed from a viewpoint of a mathematical system of difference equations. Through this procedure, essential concepts for building a SD model are developed such as the difference between a moment and a period of time, a unit check, a computational procedure for feedback loops, an expansion of boundaries, and a limit to an analytical mathematical model. (2) To exemplify the above procedure, a

macroeconomic growth model is employed. Then a meaning of sustainability is clarified by expanding a model step by step from a simple macroeconomic growth model to a complicated ecological model.To be specific, sustainability is represented in terms of physical, social and ecological reproducibilities by a system of difference equations. As an implementation of the analysis, it is shown that a sustainable economic development is unsustainable in the long run with non-renewable resources being taken into the model.

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## Shock and Imbalance of the System: A System Dynamics Approach for the Effects of Lowered Retirement Age of Teachers on Education System

Since the economic crisis in 1997, the Korean government has implemented a number of reforms in order to eliminate inefficiencies in both private and public sectors. One of the reforms made in the public sector was to lower the retirement age of teachers from the original 65 to 62. The ultimate aim of this compulsory policy was to improve the quality level of education by hiring many young teachers instead of senior teachers. It was made based on the calculation that by lowering the retirement age by three years, the government can hire three young teachers with the saved wages. However, this policy has brought an unexpected result; the imbalances between the supplies and demands for teachers have become all the more serious problem in Korea's elementary education system. The purpose of this study is largely twofold; Firstly, it aims to identify the scope of imbalances occurred in the supply-demand system of elementary school teachers in a region of the nation, and also to find out why such imbalance occurred. Secondly, purpose of this study is to experiment with feasible policy alternatives and their effects on the system and to suggest some resolutions on the imbalance.
The Simulation results of the policy experiment shows that the problems might have not been serious if the government had timely implemented proper policies; the government should have predicted a serious shortage of teachers and increased the number of students of universities of education, and also tried to increase the apply rate of teacher-recruitment test in small regions by improving wages and working conditions.

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## A System Dynamics Model of Futures Market

Futures and options market have become increasing important in the world of finance and investments. But to many people they still are strange fields because of their nescience about the market. The purpose of this research is to use system dynamics to build an interactive simulation model that will help us to understand the futures market in an easier, more intuitive way. In the model we can learn how futures works, how futures prices can be determined in a variety of different situation, and what will happen to the investors' profit under the different situations and the different policies, here we can see the notorious risk in the futures trading.

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## Positioning Systems Thinking and System Dynamics

Questions of what systems thinking is and what system dynamics is have been debated for several years. In this paper, we first try to find out why researchers have such different opinions about systems thinking and system dynamics. Some reasons are identified. First, researchers talk about system dynamics and systems thinking from different perspectives. Some researchers may focus more on formal modeling of system dynamics, while others are on the broader usage of systems thinking. Second, debate about systems thinking and system dynamics is delivered mostly in the conceptual and abstract forms. It lacks actual examples to illustrate and test researchers' exact advocacy and ideas. This may raise unnecessary confusions and misunderstandings. Thus, the lack of examples makes researchers focus on their own generalized concepts and neglect the nature of problems or situation at hands. Third, limitations of systems thinking and system dynamics are seldom referred, which reduces the usefulness of researchers' suggestions and opinions. This may cause confusions, too. In order to position systems thinking and system dynamics, this paper examines the characteristics of the two approaches from cognitive perspective. We study the suitableness and limitations of systems thinking and system dynamics about the nature of different problems and situations. In addition, this paper also examines the influences of systems thinking and system dynamics on each other and identifies some opportunities for their better applications.

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