



# Proceedings of the 22<sup>nd</sup> International Conference

July 25 – 29, 2004  
Oxford, England, UK

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# Navigating the Conference Proceedings

For portability and ease of use, the System Dynamics Conference Proceedings CD-ROM was made using the latest version available of Adobe® Acrobat®. You can view the Portable Document Format (PDF) files using Adobe Reader®. For a free download go to: <http://www.adobe.com/acrobat/>

For optimum viewing, please download the most recent version of Adobe Reader® .

These instructions show you how to:

- Use Acrobat’s basic tools to explore the Proceedings
- Navigate the Proceedings using bookmarks and links
- Search for authors, abstracts, and papers

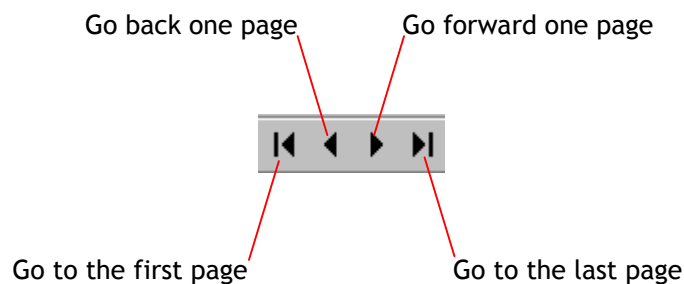
If you are familiar with Adobe Reader®, you will recognize the common navigational features, including bookmarks, links, and menu icons. If you are unfamiliar with Adobe® Reader®, you may want to print this page for reference. (For information about printing, see the “Printing” section below.) Search the “Help” file for additional instructions on all topics.

**IMPORTANT NOTE:** Information contained in any full paper file supersedes any information in the abstract section of these proceedings. Title, author information and the abstract may have been updated in the final paper.

## Using general tools

### Page tool

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

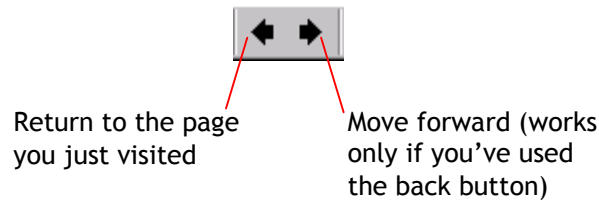


**Figure 1.** The built-in Page Tool lets you move between and across pages.

## Browsing

The built-in Browser Arrows (Figure 2) allow you to move through Adobe Reader® 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



**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 Adobe Reader® tool bar, or:
- Select **File | Print** from the Adobe Reader® menu bar.

**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 for printing.

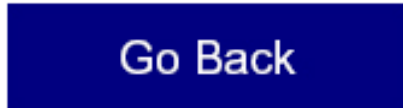
## Links, buttons, and icons

Links and buttons allow you to easily search and access the Proceedings. Links take you from the Table of Contents to a particular page, and from an abstract to a particular paper. Any text or image surrounded by a blue rectangle is a link (Figure 3):

All links are surrounded by a blue rectangle.

**Figure 3.** A sample link

Buttons allow you to move quickly between the abstracts and individual papers. The “Go Back” button (Figure 4) returns you from a paper to its abstract. The “Table of Contents” button (Figure 5) returns you from a paper to the Table of Contents.



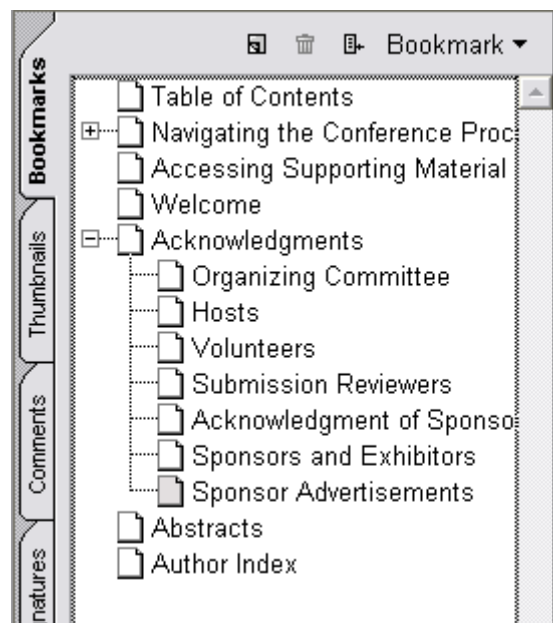
**Figure 4.** The Go Back button takes you from a paper to its abstract.



**Figure 5.** The Table of Contents button returns you to the table of contents.

### *Using bookmarks*

Bookmarks, which appear in the left pane of Adobe Reader® (Figure 6), display the main sections of the Proceedings document. Clicking on a bookmark will take you to the specified page of the Proceedings.




**Figure 6.** A sample 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 Author Index.
  - c. Go to the page number indicated after the author's name. (See "Help" if needed)

**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 "Search" function
  - a. Click the Search icon  .
  - b. Enter the appropriate title, author name, phrase, or keyword in the appropriate input box. **Note:** Do not include articles (a, an, the) in the search.
  - c. Click the Search button. Click on each item in the search "Results" to go to that item in the document.
  - d. Click on each item in the search "Results" to view that item 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 appropriate 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" dialog box.
  - d. Click on each item in the search "Results" to view that item in the current document.
  - e. Link on any abstract found to access the paper you want to view.

## *Returning to abstracts or beginning of Proceedings*

After accessing a paper from its abstract, click “Go Back” to return to the abstract or click on “Table of Contents” to return to the beginning of the proceedings.

***SPECIAL NOTE:*** Depending on the version of Adobe Acrobat® or Adobe Reader® you are using, the following message may appear.

“One of the actions closed the document. The actions following that action were not executed. To execute all actions, move the action that closes the document to the end.”

To stop this message from appearing after every instance of using the “Go Back” button, you must reset one of your viewing preferences.

In Adobe Reader® Version 6.0 Go to: Edit | Preferences | General - Miscellaneous disable (unclick) the Option: “Open cross-documents in the same window”

In other versions of Adobe Reader® you need to search for this option somewhere in General Preference Options.

Choosing this option will enable you to have several documents open at once, and will disable the message from appearing over and over.

## *Accessing Supporting Material*

See next section “Reading Supporting Material”

# Reading Supporting Material

➤ **Identifying Supporting Material:**

In the Abstracts Section and at the beginning of some papers, (S) indicates there is Supporting Material for that work. There is also a list of papers, alphabetically by first author, with the associated Supporting Material file names, at the end of these instructions.

➤ **Finding the Supporting Material Folder:**

1. Using the list on the following pages, identify the supporting material file(s) that you would like to access
2. Explore the System Dynamics Proceedings CD-ROM using the utility appropriate for your computer (Windows Explore for Windows, Finder for Mac)
3. Once you have opened the CD-ROM, open the folder named “SUP\_MAT”
4. In the “SUP\_MAT” folder, locate the Supporting Material file that you identified in step 1
5. Double-click to open or launch the file. You may need to download software to open some files. Websites where you can download the necessary software are listed below.

➤ **Viewing/Opening/Reading the Supporting Material:**

Some of these files are regular texts or presentations that are in widely accessible formats such as .doc, .ppt, .pdf, etc., but others are model files, which need to be viewed using the appropriate system dynamics modeling software. Freeware, demo or trial versions are available from several system dynamics software manufacturers. Follow the links within the descriptions below to the software needed to view the files.

In following chart, find the three-letter extension of the file name, then the software you need to view the file.

File Name Extension	Software Needed
.itm, .stm	ithink, STELLA*
.sip	Powersim Studio
.sim	Powersim
.vmf, .mdl	Vensim

\*ithink and STELLA can each be used to open both .itm and .stm files.

**STELLA/ithink** by isee systems:

[http://www.iseesystems.com/\(wzasn3554osf4qrh2mg1vx55\)/index.aspx](http://www.iseesystems.com/(wzasn3554osf4qrh2mg1vx55)/index.aspx)

This link will take you to STELLA and ithink Demo Kits. Each kit includes a free save-disabled version of the respective software which you may use to run STELLA and ithink models. The kits also contain many additional models that you may find interesting, as well as several Flash-based tutorials that will walk you through how to use the software.

**Powersim Studio** by Powersim Solutions:

<http://www.powersimsolutions.com/sdconference2004/sdconference.asp>

Powersim Studio Express is a 60-day trial version of Powersim Studio 2003. Note that this installation will automatically replace any previous version of Studio 2000 or 2001 that is installed on the PC. Studio 2003 can open Studio 2001 files, but Studio 2001 cannot open a file that has been updated or created in Studio 2003. Integrated risk assessment, model hierarchy and improved connectivity towards external data sources are among the new features available in this release.

**Vensim** by Ventana Systems:

<http://www.vensim.com/reader.html>

The Vensim Model Reader is free software which allows you to publish models constructed with Vensim and distribute them to other people. Your model and the Vensim model reader can be copied and passed to as many people as you want, giving people access to your model without their needing to purchase Vensim.

➤ **Papers and the Associated Supporting Material, *alphabetically by first author:***

<b>Author Name and Paper Title</b>	<b>Supporting Materials and Web Links</b>
Adamides, Emmanuel, "Embedding Game-Theoretic Concepts into System Dynamics Models: The Case of Complementary Products Development"	297.pdf
Akkermans, Henk, "Time for a Hundred Visions and Revisions: A System Dynamics Study of the Impact of Concurrent Engineering on Supply Chain Performance"	258.pdf
Akkermans, Henk, "Time Will Tell: The Impact of Demand Cyclicity and Supply Lead Times on Customer Order Information Sharing in Supply Chains"	259.pdf
Albrechtsen, Lise, "Making Bushmeat Hunting Sustainable: Economic Incentives or Draconian Measures?"	404.sim
Altamirano, Monica, "A System Dynamics Model of Primary and Secondary Education in Nicaragua"	122.itm
Arenas, Fernando, "Access to Credit as a Limit to Growth for SME's"	380.mdl
Bakken, Bent Erik, "The Atlantic Defense Technology Gap: Will It Be Closed?"	319.itm
Bassi, Andrea, "Strategic Analysis Evolution: Scenario Planning and Simulation Based on the Methodology of System Dynamics"	136.zip
Bayer, Steffen, "Assessing the Impact of a Care Innovation: Telecare"	275.mdl
Bayer, Steffen, "Is the Madness Home Made?: Examining Internal Causes of Workload Fluctuation in Project Enterprises"	273.vmf
Bianchi, Carmine, "Using System Dynamics ILE's to Enhance Intellectual Capital Policies in Service Businesses"	<a href="http://www.unipa.it/~bianchi">http://www.unipa.it/~bianchi</a>
Borshchev, Andrei, "From System Dynamics and Discrete Event to Practical Agent Based Modeling: Reasons, Techniques, Tools"	381.zip <a href="http://www.anylogic.com">http://www.anylogic.com</a>



## Reading Supporting Material continued

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Bourguet-Diaz, Rafael, "Design of a Community Learning for System Dynamics"	267.mdl
Capelo, Carlos, "Scenario Planning and Evaluation of Pricing Strategies in the Portuguese Bulk LPG Market"	115.ppt
Conrad, Stephen, "The Dynamics of Agricultural Commodities and Their Responses to Disruptions of Considerable Magnitude"	352.mdl
Cooke, David, "Using System Dynamics Models to Enhance the Visualization of Stochastic Price Processes"	206.mdl
Crespo Márquez, Adolfo, "A Decision Support System (DSS) for Evaluating Operations Investments in High-Technology Business"	183.zip
Crespo Márquez, Adolfo, "Introducing Autoregressive Elements in System Dynamics Models"	188.zip
Dias, João, "System Dynamics and Time Series Analysis: Two Approaches for a Convergent Answer"	114.pdf
Dudley, Richard, "The Dynamic Structure of Social Capital: How Interpersonal Connections Create Communitywide Benefits"	117.zip, <a href="http://www.people.cornell.edu/pages/rgd6/">http://www.people.cornell.edu/pages/rgd6/</a>
Duggan, Jim, "Policy Diffusion in the Beer Game"	162.mdl
Eskinasi, Martijn, "Simulating the Urban Transformation Process in the Haaglanden Region, the Netherlands"	289.zip
Georgantzas, Nicholas, "Collaborative Law Dynamics: Collegiality in Civil Litigation?"	341.zip
Gonçalves, Paulo, "The Impact of Endogenous Demand on Push-Pull Production Systems"	308.zip
Gonzalez, José, "System Dynamics Student Projects as Quality Improving Process"	167.zip
Grossmann, Wolf, "Modeling Innovation-Based Approaches to Climate Mitigation"	398.itm
Gündüz, Yalin, "A System Dynamics Approach to Modeling Business-to-Business Markets: The Case of Siemens"	133.zip
Haslett, Tim, "Simulating Hamlet: A Critique"	108.stm
Heffernan, Mark, "National Medicines Use Dynamics: Influencing Health Policy with System Dynamics"	334.itm
Heffernan, Mark, "Using System Dynamics to Analyse Health System Performance within the WHO Framework"	337.itm
Holmström, Paul, "Staff Retention and Job Satisfaction at a Hospital Clinic: A Case Study"	225.itm
Hovmand, Peter, "Managing a Prosecutor's Domestic Violence Caseload"	351.zip
Kalin, CJ, "Enrollment Management Dynamics of Adult Undergraduate Degree-Completion Business Programs at Private Universities"	315.txt

Lee, Man-Hyung, "Green Belt Policy Change and Uninvited Aftereffect in Seoul"	409.pdf
Lizeo, Elaine, "Understanding the Learning Process in Work Groups"	268.zip
Lofdahl, Corey, "Presenting System Dynamics to Social Scientists: An Economics Example"	<a href="http://mitpress.mit.edu/0262122456">http://mitpress.mit.edu/0262122456</a>
Luna Reyes, Luis, "Emergence of the Governance Structure for Information Integration across Governmental Agencies: A System Dynamics Approach"	382.mdl
Luna Reyes, Luis, "Scripts for Group Model Building: Modeling the Emergence of Governance for Information Integration across Government Agencies"	383.zip
Mandal, Abhijit, "Dynamic Balance, Executive Management and Differential Performance: A Resource-Based Approach"	282.ppt
Martínez-Moyano, Ignacio, "Exploring Change in Organizational Rule Systems: Learning Dynamics in Performance Measurement"	<a href="http://www.albany.edu/~im7797/conferences.html">http://www.albany.edu/~im7797/conferences.html</a>
Mojtahedzadeh, Mohammad, "Bringing Systems Thinking to the Spreadsheet"	<a href="http://www.attunegroup.com">www.attunegroup.com</a>
Park, Hun-Joon, "Leverage Strategy to National R&D Investment in Korea: A System Dynamics Approach"	368.stm
Petrides, Lazaros, "An Economic Analysis of the PAYG Retirement System and the Expected Consequences from a Transition to an FF Scheme"	143.txt
Pruyt, Erik, "System Dynamics Models of Electrical Wind Power"	203.pdf
Radianti, Jaziar, "Modeling Government External Debt and Sustainability of Fiscal Policy"	216.sim
Rahmandad, Hazhir, "Heterogeneity and Network Structure in the Dynamics of Contagion: Comparing Agent-Based and Differential Equation Models"	173.zip
Raimondi, Vittorio, "The Role of System Dynamics in Achieving Breakthrough Thinking in Entrenched Marketing Teams: Lessons from a Case Study in the Pharmaceutical OTC Industry"	125.pdf
Reichel, André, "(Re-)Structuration of System Dynamics"	266.pdf
Ryzhenkov, Alexander, "Profitability, Productivity and Employment in a Model of the US Long Waves"	371.pdf
Salge, Markus, "The Pace or the Path?: Resource Accumulation Strategies in the US Airline Industry"	150.zip
Sanders, Peter, "Spatial Urban Dynamics and a Vision of the Future of Urban Dynamics: Forrester Revisited"	119.pdf
Schieritz, Nadine, "Exploring the Agent Vocabulary: Emergence and Evolution in System Dynamics"	339.zip

## Reading Supporting Material continued

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Schild, Heinz, "Enforcement in Free-Flow Systems: A Case Study"	132.pdf
Scholl, Hans, "Can System Dynamics Models Have Greater Relevance to Practice When Used within Participatory Action Research Designs?"	<a href="http://faculty.washington.edu/jscholl/">http://faculty.washington.edu/jscholl/</a>
Scholl, Hans, "Using Integrated Top-Down and Bottom-Up Dynamic Modeling for Triangulation and Interdisciplinary Theory Integration: The Case of Long-term Firm Performance and Survival"	<a href="http://faculty.washington.edu/jscholl/">http://faculty.washington.edu/jscholl/</a>
Schwarz, Rainer, "Dynamics of Depreciation and Scrapping in Business Economics"	246.zip
Singh, Rohita, "Cultural Transformation Geniusys"	<a href="http://www.geniusys.com.au">www.geniusys.com.au</a>
Sotaquirá, Ricardo, "Reusability in System Dynamics: Current Approaches and Improvement Opportunities"	<a href="http://fis.unab.edu.co/gps/sistemika/index/html">http://fis.unab.edu.co/gps/sistemika/index/html</a>
Stamboulis, Yeoryios, "A Time-Based Innovation Strategy Game"	330.pdf
Stepanovich, Paul, "The New Hire: Teaching Behavioral Dynamics in Management"	169.itm
Strohhecker, Jürgen, "Simulation Based Experiments for Testing Balanced Scorecard's Built-in Performance Improvement Theory"	410.pdf
Struben, Jeroen, "Technology Transitions: Identifying Challenges for Hydrogen Vehicles"	343.pdf
Suksawang, Orasa, "A System Dynamics Approach to Applications of Buddha's Dialogues"	402.zip
Tamez, Cindy, "Implications in the Health Sector Given the Tendency of Population Aging in Mexico"	272.itm
Tanaka, Nobuhide, "Fundamental Analysis of the Attractiveness of a Shopping Street"	400.stm
Taylor, Kathryn, "Exploring the Feedback Effects of Reconfiguring Health Services: The Case of Cardiac Catheterization Procedures"	105.pdf
Thun, Jörn-Henrik, "Modeling Modern Maintenance: A System Dynamics Model Analyzing the Dynamic Implications of Implementing Total Productive Maintenance"	251.mdl
Trailer, Jeff, "Assessing Public Policy Impact on the Sustainable Growth Rate of New Ventures"	358.mdl
Trailer, Jeff, "Ten Steps to Simulate your Strategic Architecture"	356.zip
Tseng, Ya-tsai, "From Loop Dominance Analysis to System Behaviors"	228.xls
Ulli-Beer, Silvia, "A System Dynamics Choice Structure for Policy Compliance: Micro Behavior Explaining Aggregated Recycling Dynamics"	317.zip

## Reading Supporting Material continued

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Ulli-Beer, Silvia, "Using a System Dynamics-SWM Model to Inform Policymaking for Solid Waste Management at the Local Level"	320.zip
Umar, Imrana, "Improving the Collective Capacity of Managers to Execute Strategy and Create Value: A Dynamic Simulation-Based Approach to Strategy Communication and Management Training"	348.pdf
Vogstad, Klaus, "Counterproductive Environmental Policies: Long Term versus Short Term Substitution Effects of Gas in a Liberalized Electricity Market"	<a href="http://www.stud.ntnu.no/~klausv/kraftsim">http://www.stud.ntnu.no/~klausv/kraftsim</a>
Voyer, John, "Affordable Housing and Urban Sprawl Policy Choices in York County, Maine: A System Dynamics Approach"	106.mdl
Whitney-Smith, Elin, "Pleistocene Extinctions: Counterintuitive Results of Combining Hypotheses (Overkill, Second Order Predation, and Environmental Degradation)"	<a href="http://quaternary.net">http://quaternary.net</a>
Wiik, Johannes, "Dynamics of Vulnerability"	307.sip
Yeon, Seung-Jun, "A Dynamic Diffusion Model for Managing Customer's Expectation and Satisfaction"	403.zip
Yepez, Carlos, "Venture Capital Investment Dynamics during Market Boom and Market Meltdown"	138.mdl
Young, Showing, "A Model of Structural Oscillation of Conflict Goals"	243.itm
Young, Showing, "A System Dynamics Evaluation of SARS Preventing Policies in Taiwan"	245.itm

# Welcome

Dear Colleagues,

Welcome to the 22<sup>nd</sup> International Conference of the System Dynamics Society. We are sure you will agree it is very fitting that the conference should return to the UK on the tenth anniversary of our last visit to this island. In 1994, we were hosted in Stirling, in the heart of beautiful Scotland. This year, we are equally fortunate in securing this prestigious, world-renowned venue in Oxford, the heart of England.

Oxford University is the oldest English-speaking university in the world. Teaching here started in the year 1096, with the first international student in 1190. Ladies and gentlemen, we are following in well-worn footsteps to this place on a path trodden for nearly 900 years!

The thirty-nine Colleges of Oxford University, though independent and self-governing, are related in a federal system, not unlike the United States. Each is governed by a Head of House and a Governing Body comprised of a number of Fellows, most of whom also hold University posts. This federal collegiality has served well this ancient and thriving institution and we have chosen “collegiality” as our conference theme. We hope that, as we hold our discussions in the walls of this, Keble College, a collegial spirit will help us further our learning of system dynamics, its formulation and application towards greater understanding in the wider “college” of professionals, academics and students whom we seek ultimately to influence.

To this end, several of the sessions are devoted to examining the ways in which system dynamics can be used to think together, achieve consensus and assist with the implementation of coherent plans. In particular, there will be a special opening plenary session on “Bringing Coherence and Consensus to Public Policy Making”, and another special session on “Working Ideas, Insights for Systems Modelling – The Broader Community of Systems Thinkers”.

As you can see from the presentation titles listed in our programme, the field of system dynamics continues to grow. Well over 250 scheduled presentations are broken down into an exciting variety of parallel and convened sessions, interesting poster sessions, skill-building workshops, and a fascinating array of plenary and special sessions. Over the next four days you will have a chance to sample system dynamics work by leading practitioners who come here to Oxford from over 40 countries. We hope that you will enjoy the programme, learn and share, renew ties with old friends and make new acquaintances.

To increase your enjoyment of the conference, we have scheduled several on-site special events, including an Informal Gathering and a Welcome Reception. 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, sense the history of Keble College, and enjoy the attractions of Oxford!

This year over 230 volunteer reviewers screened and commented on submissions. In addition, dozens of volunteers worked many hours to ensure a successful conference, not least the Policy Council of the local UK System Dynamics Chapter. Without their commitment our conference would be impossible. A special thanks goes to all who helped.

In addition to having as our conference host HVR Consulting Services Ltd., we are also very fortunate this year to have a conference partner, Powersim Software AS. We appreciate sincerely the enthusiasm and support of our sponsors.

We hope that you find the conference rewarding and surroundings inspiring. Please bring to our attention anything that may help us to both ensure the success of this, and future, conferences.

Thank you for joining us.

*Best wishes from the Conference Organizing Committee,  
Jonathan Coyle, Graham Winch, Michael Kennedy, Jack Homer and Roberta Spencer*

*22nd International Conference of the System Dynamics Society July 25 – 29, 2004 Oxford, England*

# Organizing Committee

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*Roundtable Chair*  
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**David Ford**  
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*Stream Organizer*

**Valerie Gacogne**  
NESTEAR  
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*Session Reporter*

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*Student Assistant*

**Gary Hirsch**  
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Environments  
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**Corey Lofdahl**  
SAIC  
*Session Reporter*

**Alexander Lubyansky**  
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Programmes Coordinator*

**Kambiz Maani**  
University of Auckland  
*Session Reporter*

**Roderick H. MacDonald**  
Initiative for System Dynamics  
in the Public Sector  
*Session Reporter*  
*Volunteer*

**Ignacio J. Martínez-  
Moyano**  
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**Ken Parsons**  
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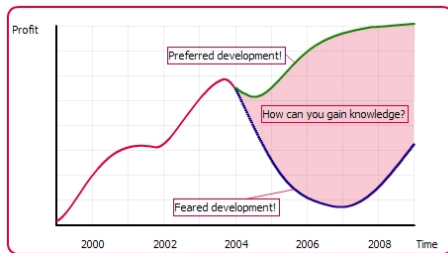
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HVR has been providing System Dynamics consultancy services to a wide range of clients in government and industry since 1994. One of many examples is a study carried out to investigate the potential risks associated with the spread of vCJD through the use of surgical instruments. Focusing on the risks of cross-infection, the study resulted in changes in policy and prompted a £200m investment in new instrument cleaning facilities.

Our strong focus on best practice is illustrated by the development of a methodology for the verification and validation of System Dynamics based models. This includes validation with mental models, ensuring that the problem has been well understood with a suitable boundary; verification of the simulation model to be certain that the influence diagram has been correctly translated into a quantitative simulation model; and finally, tests designed to validate the simulation model, comparing the model's behaviour with that of the real world.

---

## ***Defence Focus***

Our focus on the defence sector means that we bring unparalleled knowledge of the market place and the issues that face our clients to all our assignments. As part of our professional development programme, our consultants receive training in these issues from retired senior civil servants to ensure that we continue to provide solutions focused on our clients' precise needs.

---

## ***Research and Development***

The company has an extensive internal research and development programme and maintains links with the leading universities in its core competencies. This ensures that we maintain awareness of and access to the latest thinking in those fields.



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### ***How We Work***

As one of the UK's leading providers of System Dynamics consultancy, our reputation for professionalism is second to none.

We work with our clients to deliver solutions precisely tailored to their needs. HVR believes very strongly in the need to transfer its technology to clients, many of whom now have the capability to undertake entire projects on their own.

Our process of model verification and validation ensures that our clients receive recommendations and conclusions that they can have total confidence in.

HVR's team of consultants is also proficient in a wide variety of other methodologies so we know when, and when not to apply System Dynamics.

---

### ***Model Integration***

In the course of our work, we have developed a number of tools for integrating System Dynamics models with other applications.

We also develop sophisticated model harnesses that can manage scenarios and outputs. This has the benefit of making models easier to use and more sustainable in the long term.

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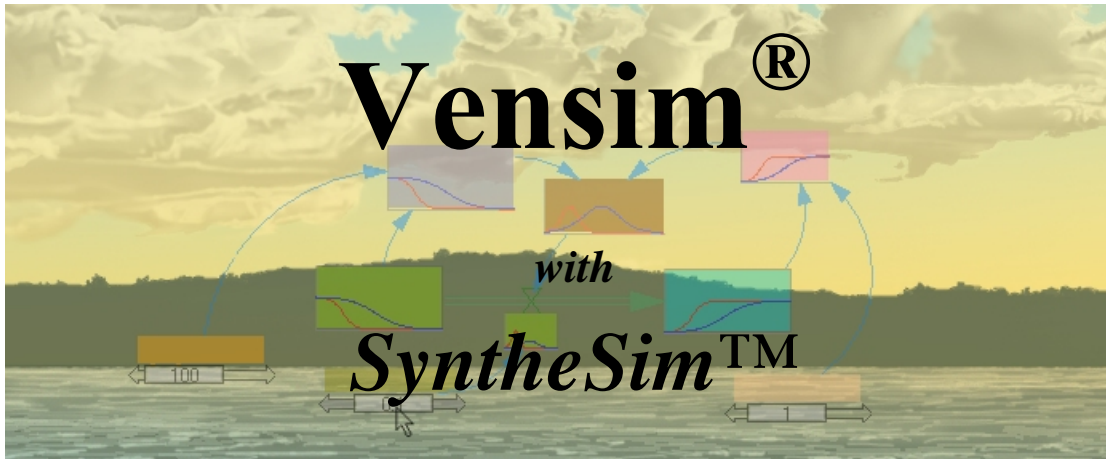
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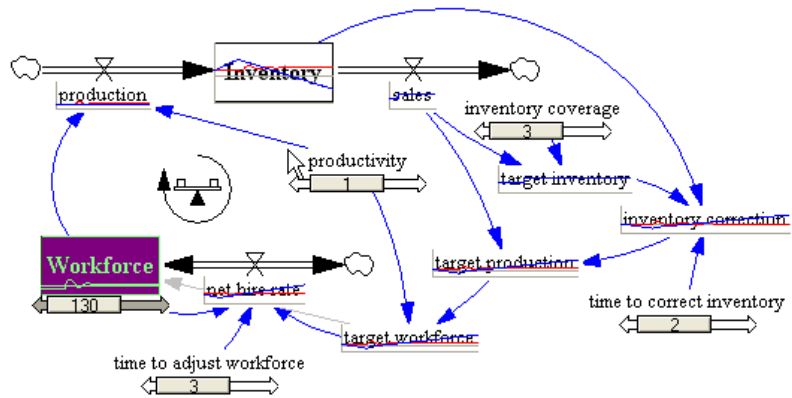
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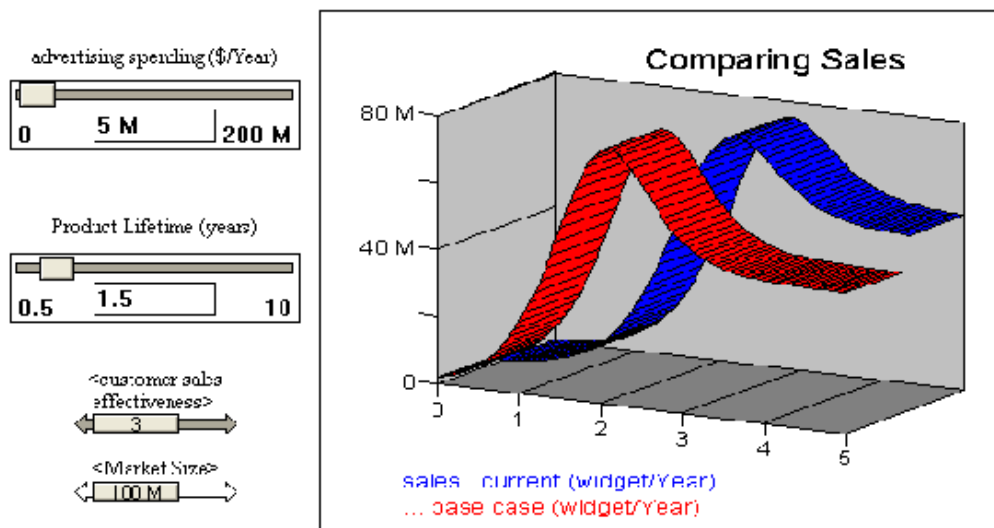
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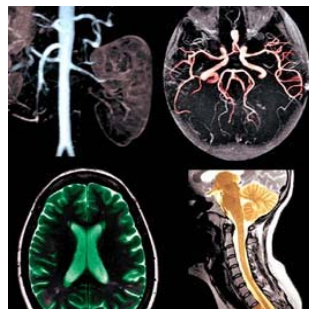
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### **THE SYSTEM DYNAMICS CAREER LINK**

*What is it?* The *SD Career Link*, in its fifth year of operation, is hosted by the System Dynamics Society at the University at Albany. It includes on-line information and links to organizations who employ candidates with system dynamics and systems thinking backgrounds. We hope that the *SD Career Link* will provide a valuable exchange of information about organizations, positions and people in the field of system dynamics. Please visit the *SD Career Link* bulletin board at the conference.

*Career Link Allows Companies and Universities to Describe General Career Information as Well as Specific Job Opportunities.* The Career Link section of the Society web site has two subsections: (1) career information; and (2) specific job postings. In the career information section, employers and universities provide general descriptive information about how system dynamics fits into their organization, typical jobs, career paths, and other aspects of employment with the company. This subsection allows employers to provide information about system dynamics opportunities within their firms, to supplement the more general information contained on their corporate or academic websites. Such career information is valuable to those interested in studying system dynamics, and we urge companies and universities to describe system dynamics in their organization even if they do not have specific open jobs at the present time. The subsection on specific job postings allows employers to advertise active openings.

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### Program

The conference program will consist of plenary, parallel, poster and workshop sessions demonstrating the state of the art in the theory and application of system dynamics. In addition, panel

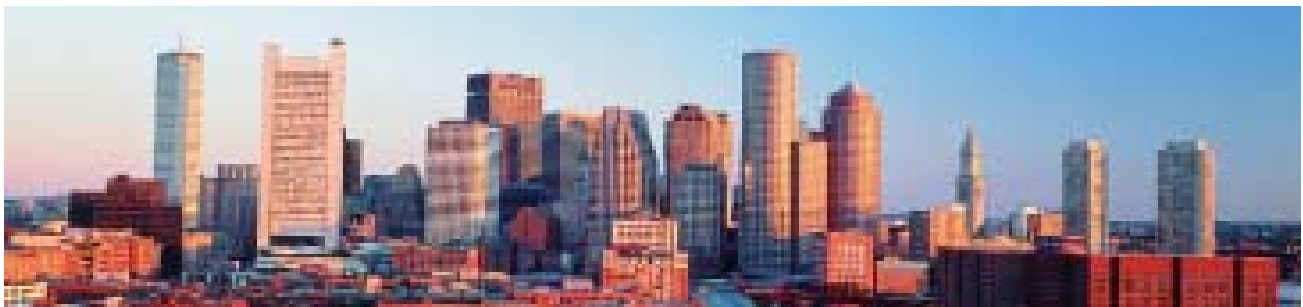
discussions, special interest group sessions, student colloquia, events of historic interest, vendor displays, exhibits, demonstrations, Society business meetings and other related gatherings will be scheduled. The conference schedule will provide time for relaxed social and professional interaction. The conference will bring together diverse perspectives on the application of system dynamics to broaden perspectives and foster dialogue and debate.

### Deadlines and Key Dates (tentative)

January 2, 2005	Opening date for presentation submissions and workshop proposals.	June 17, 2005	Early conference registration deadline and hotel room registration deadline.
March 18, 2005	Paper submission deadline and Workshop proposals due.	July 17, 2005	PhD Colloquium and Policy Council Meeting.
May 2, 2005	Notification of acceptance.	July 18, 2005	Boston Conference Opening!
May 4, 2005	Session proposals due.	August 19, 2005	Final papers for CD-ROM Proceedings.
May 9, 2005	Final abstracts due for Proceedings.	September 2005	CD-ROM Proceedings mailed out.
June 1, 2005	Tentative program schedule.		

### Contacts

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# Papers

## Ahmed Mounir Abd El Azeem

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## Boosting the Egyptian Exports: Toward Developing a Comprehensive System Dynamics Based Tool for International Market Selection

Egyptian exports are not proportional to the efforts exerted to increase it, nor to the potential of the Egyptian economy. Most of these efforts target the laws and regulations related to export issues, which is not enough alone, as there is a lack of efforts towards increasing the base of Egyptian exporters as well as their effectiveness. There is a reluctance to engage in export business among the major part of the Egyptian producers while the smaller part engaging in export business lack the up-to-date knowledge and tools needed to maximize the export benefits, as they just react to spontaneous orders from international markets. The research will give a comprehensive advisory guide for the exporting business and introduce the first step towards achieving comprehensive systematic process to be used for selecting the optimum international markets, by integrating international business aspects with economic concepts in a dynamic system thinking approach. Since the main concern of any exporter is the financial benefits and market share that he will get from exporting, though the research output will identify the major factors that affect the financial results of the product in the international market under study and the way each factor affects these results.

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## Stirling Revisited: Practical Approaches to Merging Two Systems Thinking Streams

The 1994 International System Dynamics Conference, held in Stirling, reviewed a range of related Systems Thinking approaches. This paper focuses on the specific approach described by Eden in Stirling and proposes a number of guidelines that can be used to explicitly and formally link Eden's Systems Thinking approaches to formal simulation models. The specific case presented involves linking semantically rich scenario maps to a formal causal influence diagram that was in turn used as the basis for a formal simulation model. While the case reported on is quite specific, we suggest that a broader range of complementary systems thinking approaches can and should be integrated with more traditional SD simulation methods. The specific case study reported on examines a scenario-based simulation of the promotion of renewable energy sources in the UK electric power market. This work also informs on-going research in group model building, strategy modeling (especially using scenarios) and the on-going debate about qualitative vs. quantitative system dynamics.

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## Embedding Game-Theoretic Concepts into System Dynamics Models: The Case of Complementary Products Development

The problem of mutual resource commitment during the development of complementary products is modeled as an evolutionary Prisoner's Dilemma game. To investigate the effect of different pure and mixed cooperation and/or defection strategies over the period of a technology cycle, a system dynamics simulation model has been built using the resource-based view of the firm. The dynamics of tangible and intangible assets, such as customer base and technological learning, were included in the model. Cooperation

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and defection payoffs have been assumed to be time-dependent. The model was calibrated using data from the video games industry. Simulations run for different complementors' strategies show the importance of early cooperation during technology cycles. The model can be used in an interactive mode to evaluate more complex industry-specific strategies.

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**The Dynamics of Twin Crises in Asia: A  
Comparison between the Egyptian and the  
Indonesian Currency Crises**

The study attempts to identify the extent of similarities, and/or differences between the conditions that surrounded the Asian tigers economies from 1994-1999, and those in Egypt from 1998-2003. A generic "Business Dynamics model" is developed, based on a simplified causal framework of three main independent groups of variables; economic fundamentals, Real and Financial links, and vulnerability indicators, the relevant data for Indonesia is chosen for the simulation model. Although similar symptoms between the two cases were identified, the origins for trouble were quite different; while the Indonesian crisis was mainly attributable to the combination of fixed exchange regime, moral hazard, and excessive financial liberalization, the Egyptian economy has suffered a weak real sector, undiversified and exogenously determined sources of hard currency, and a long-lasting rigid exchange rate system. In summary, the authors contend that even a floatation of the Egyptian pound has taken place, the Egyptian currency crisis would not have been resolved, unless drastic measures were to be taken to trouble shoot the other two main sources of trouble; low levels of exports, and undiversified sources of dollar flows.

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**Time Will Tell: The Impact of Demand Cyclicity  
and Supply Lead Times on Customer Order  
Information Sharing in Supply Chains**

Sharing of end customer information with suppliers is often cited as adequate way of improving performance in decentralised supply chains, but its effectiveness remains problematic in practice as well as in theory. Benefits of information sharing appear to relatively limited and located mainly with the supplier, not the buyer. This paper investigates if this mixed picture is perhaps due to a number of implicit assumptions. Perhaps customer information sharing is highly beneficial in some settings, and not at all in others. If that is the case, then what are the factors that will tell if information sharing is worthwhile? We introduce a generic system dynamics simulation model of a supplier-buyer supply chain to investigate what happens if these characteristics are changed. Here we find that cyclical demand patterns as well longer lead times make sharing of end customer order more advantageous for both the supplier and the buyer. If lead times for both parties are short, information sharing yields little value to either side.

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**Time for a Hundred Visions and Revisions: A  
System Dynamics Study of the Impact of  
Concurrent Engineering on Supply Chain  
Performance**

Concurrent engineering is now commonly seen as a fruitful approach to shortening development times in product development. Concurrent

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engineering leads to earlier feedback and more intense communication between the different stages in product development. But, what is its effect on supply chain performance once the design that has thus been detailed out has to be manufactured? This paper focuses on this question. It presents a quantitative system dynamics study of a real-world case from the aerospace industry. In aerospace, product development typically takes many years and costs tens to hundred of millions. Our analysis suggests that concurrent engineering can have a major impact on performance in aerospace supply chains, not just because production can start sooner and hence go down the learning curve earlier, but also because early feedback from production leads to improved designs during product development as well. These will then need less rework once they enter into manufacturing.

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## Making Bushmeat Hunting Sustainable: Economic Incentives or Draconian Measures?

Central African peoples have been and still are very dependent on the natural resources they collect from the forest. One of these resources is wild meat (bushmeat), which is hunted in large quantities. Offtake of several species are currently higher than their reproduction rate. In the long run, this will become a conservation crisis on the one hand with the possible extinction of several endemic species, while on the other hand the survival and quality of life of the people dependent on these resources are jeopardized. A dynamic programming model is developed to introduce a method to show explicitly the impact of different policies on the animal population dynamics, the effectiveness of bushmeat hunting, price of bushmeat in the market, and the availability of alternative work opportunities for the hunters. The paper concludes with the simulation of three different policy recommendations for managing bushmeat trade. The model and its simulation show an interesting perspective of the complexity of the wild meat extraction issue. No one single policy will be able to alter the current pattern of unsustainable use – only a combination of policies and other measures will have a chance of succeeding with the conservation of the Central African fauna.

**Monica A. Altamirano***m.a.altamirano@student.tbm.tudelft.nl*

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## A System Dynamics Model of Primary and Secondary Education in Nicaragua

A System Dynamics model of primary and secondary education in Nicaragua has been developed to assist the National Ministry of Education in analysing the system of schooling and investigating the impacts of different possible policy decisions. The model shows that without a change in policy there will only be a small increase in the percentage of primary and high school coverage and that the number of illiterate people will more than double over a period of twenty years. The consequences of various policies have been investigated using the model. These policies include implementing literacy programs and introducing a program in which families in extreme poverty receive a subsidy. Preliminary results show that by combining these two policies, an effect on school coverage as well as on the number of illiterate people can be achieved.

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**Preliminary System Dynamics Maps of the Insider  
Cyber-Threat Problem**

Twenty five researchers from eight institutions and a variety of disciplines, viz. computer science, information security, knowledge management, law enforcement, psychology, organization science and system dynamics, found each other February 2004 in the “System Dynamics Modelling for Information Security: An Invitational Group Modeling Workshop” at Software Engineering Institute, Carnegie Mellon University. The exercise produced preliminary system dynamics models of insider and outsider cyber attacks that motivated five institutions, viz. Syracuse University, TECNUN at University of Navarra, CERT/CC at Carnegie Mellon University, University at Albany and Agder University College, to launch an interdisciplinary research proposal (Improving Organizational Security and Survivability by Suppression of Dynamic Triggers). This paper discusses the preliminary system dynamic maps of the insider cyber-threat and describes the main ideas behind the research proposal.

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**Access to Credit as a Limit to Growth for SME's**

Access to credit has been considered as one of the main problems that SMEs have to deal with in order to survive and keep growing. This document describes a system dynamics model based on the case of a medium-sized manufacturing firm, located in Colombia, where the author worked as operations manager, and subsequently as a consultant. The model integrates the operations and finance of the firm including variables associated with trade credit and banks credit. A sensitivity analysis is made in order to find high leverage variables. The results obtained indicate that operational or financial policies, when applied alone, are not sufficient to solve the firm stagnation problem. An appropriate combination of access to credit, credit conditions, and adequate financial and operational policies, is the unique way to deal with the complex problem of SMEs survival and growing.

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**Bathtub Dynamics at the Tor Vergata University  
in Rome, Italy**

In a context of changes in education and Research, Systems Thinking appears to be a valid alternative to help students speedup their learning processes. Trying to validate such belief, Prof. Sterman has tested on his MIT students both their understanding of systemic concepts without prior knowledge of System Dynamics and their ability to improve learning skills by a SD education. Other Universities have also taken up the challenge, fitting it to their own educational environments, thus providing useful and interesting data. Statistical analysis has been carried out on different groups of students and has provided valuable information on their behaviour, as well as an interesting collection of all the most frequent and typical mistakes or misunderstandings that helped us in clustering the rationales beyond them. However, very few has been done according to inquiring about such rationales or even about difficulties that students have found in confronting themselves with the tests. May SD help students in devising correct solutions? Does a particular academic background help or improve one's ability to think sistemically? We have directly asked the students such questions, inquiring about which logic processes they followed in text comprehension and graph understanding and if SD constituted an effective aid or instead it was only "another confusing" tool which didn't add much to their counterintuitive and non-linear system analysis skills.

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**A System Dynamics Approach to a Chemist's  
Inventory and Finance Management**

A Chemist's can be considered in many countries as a Small Enterprise and it constitutes a complex business environment where several different and mutually dependent issues, technical, economic and financial, may be identified. The growing complexity of an SME environment and the use of traditional analysis techniques, don't allow for an effective forecast of a behavioural dynamics of the entire system. The need for coordination among the many management issues give enormous evidence to the important need of correctly planning, in the light of collegial decision making, all of the enterprise's activities, as well as understanding the underlying dynamics due to the firm's internal structure. Thanks to the new IT Technologies, the Chemist has the great opportunity to use such data in order to optimally drive his strategic and operational management decisions. Towards this end, the implementation of specific management control/decision support systems, based on SD models, allow first for a better learning of the

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environmental dynamics which influence the economic behaviour of the firm, and second, for a deep understanding of the results of the decisional policies which the Chemist himself, together with his collaborating staff, may choose among a plethora of strategic choices.

**Decision Making Tests with Different Variations of The Stock Management Game**

This study aims to demonstrate and recognize the systematic errors underlying the decision making behavior of subjects by analyzing the results of controlled experiments. An interactive stock management game; inventory management game is used as the experimental medium, in which the order decision is the only player input in the simplest case. The dynamic-complexity is gradually increased by adding delay and secondary stock. In two sets of experiments, the effect of increasing dynamic complexity is analyzed with respect to three response variables. ANOVA results of these 2-factor, 2-level experiments revealed that as the clarity of feedback is reduced with increasing dynamic complexity, subjects' performances decline. Majority of subjects had difficulties in controlling the inventory via a secondary stock even when the external conditions are at steady state. The presence of delay has a statistically significant effect on each response variable.

**Perception and Handling of Complex Problems in Dynamic Settings: Three Cases of Relevance to Military Command and Crisis Management**

Command of military operations requires leaders and teams who are able to make decisions and respond in an appropriate, timely manner even in highly uncertain situations. The degree of situational uncertainty has continued to increase as military requirements have evolved in response to changing conditions around the world and advances in information systems that have made more information available. To provide a basis for better understanding of the dynamics of operations, we suggest an approach linking Effects Based Operations (EBO) modelling and analysis with System Dynamics (SD) principles, yielding valuable insights in the complexity of modern warfare and conflict resolution. To illustrate our approach, we present the following dynamic cases: 1) operational logistics, 2) strategic investments, and 3) crisis management.

**The System Dynamics Approach to Network Centric Warfare and Effects Based Operations: Designing a "Learning Lab" for Tomorrow**

Command of military operations requires leaders and teams who are able to make decisions and respond in an appropriate, timely manner even in highly uncertain situations. The degree of situational uncertainty has continued to

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increase as military requirements have evolved in response to changing conditions around the world and advances in information systems that have made more information available. It is in the light of recently developed, but not yet matured, concepts such as Network Centric Warfare (NCW) and Effects Based Operations (EBO), we discuss the radically changed conditions for acting and learning in the military operational environment. We suggest a new approach, linking the principles of best practice EBO modelling and analysis with system dynamic insights, yielding design requirements for a “learning lab” for Network Centric Operations. The purpose of the learning lab would be, through man-machine and inter-team interaction, to improve mental models of commanders and teams, and thus improved outcomes of future operations.

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## The Atlantic Defense Technology Gap: Will It Be Closed?

US defence budgets are about 60 % higher than EU's. In terms of advanced military hardware, US inventory is however five to ten times bigger. A System Dynamics simulation model is built to explore policies for closing this so-called technology gap. In a base case scenario, the Atlantic divide concerning military hardware continues to grow. Three policy tests are run: EU defence budgets are increased by 60 % to US levels; EU transforms its forces to expeditionary non-conscription units; European military industry is consolidated combined with a tripling of R&D efforts. Neither policy is successful alone, yet with all three policies combined, the gap is significantly reduced and in about twenty-five years marginally closed. The political likelihood of such a combined policy is discussed. It is argued that since the EU favours a softer security strategy, it will not want to bear the high political costs of this combined policy. Consequently, the EU will have to be content filling the western world's soft power niche.

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## Building a New Specialization of Integration and Implementation Sciences: Would System Dynamics Fit?

The theory and methods of integration across disciplines and sectors and of implementation of research into practice need substantial development. I suggest they would benefit from becoming an academic specialization, analogous to statistics. Such a new specialization would draw on systems thinking, participatory methods, complexity science, diverse epistemologies, and inter- and trans-disciplinarity. I argue that understanding system dynamics would be a cornerstone of a new specialisation. The aim of this paper is to stimulate discussion both about such a specialisation and about the role of system dynamics in it.

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## Impact of Context in Selecting Decision Tools for use in Both the Public and Private Sectors

An important first step towards “bringing coherence and consensus to public policy making” is to ensure there is coherence and consensus in how decision makers view the context surrounding the decision to be made. The paper describes three prototypical approaches that distinguish alternative points of view in considering a decision's context. The approaches anchor the ends of a continuum that encompasses the worlds of simplicity/certainty and complexity/uncertainty as well as a midpoint that offers a point of view to help clarify the opportunities found at the ends of the continuum. The



three prototypical designs are captured by the terms: make-and-sell, sense-and-respond, and anticipate-and-lead. To demonstrate the impact of the mindset of context on decisions tool choice, an example using agent-based systems dynamics modeling to address questions related to the acculturation of the Hispanic population in the United States will be presented.

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**Analysis of Stock Management Gaming  
Experiments and Alternative Ordering  
Formulations**

This paper investigates two different yet related research questions about stock management in feedback environments: The first one is to analyze the effects of selected experimental factors on the performances of subjects (players) in a stock management simulation game. In light of these results, our second objective is to evaluate the adequacy of standard decision rules typically used in dynamic stock management models and to seek improvement formulations. To carry out the research, the generic stock management problem is chosen as the interactive gaming platform. In the first part, gaming experiments are designed to test the effects of three factors on decision making behavior: different patterns of customer demand, minimum possible order decision ('review') interval and finally the type of the receiving delay. ANOVA results of these 3-factor, 2-level experiments show which factors have significant effects on ten different measures of behavior (such as max-min range of orders, inventory amplitudes, periods of oscillations and backlog durations). In the second phase of research, the performances of subjects are compared against some selected ordering heuristics (formulations).

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**From Ivory Towers to Learning Organizations:  
The Role of System Dynamics in the  
"Managerialization" of Academic Institutions**

Higher Education organisations face today strong pressure to adopt renewed structures and management systems. Efficiency, efficacy and market principles have become common words within the University and management practices and principles are migrating to the academic context, boosting a process of "managerialization". However, preliminary results show that the new policies adopted by university managements have led to counter-intuitive and undesired results, thus adding further ambiguity to the understanding of the dynamics existing within the HE sector. This paper explores the role that System Dynamics could play in the "managerialization" of universities. System Dynamics tools could allow academic decision makers to better keep under control the complex and dynamic university environment: in these terms, the paper suggests the use of modeling and simulation techniques in order to capture the complex and dynamic structure of the university system and to explore the consequences of the policies and decisions that academic managements are currently taking.

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**A System Dynamics Model of Economic Growth  
with Environmental Aspects**

Our objective is to foster the understanding of the economic, natural, and social components - that make up the global system. We apply SD modeling methodology and conduct our simulation with system dynamics software. We investigate five major trends of global concern: rapid population growth.

Industrialization, deteriorating environment and depletion of nonrenewable resources. We list the important and causal relationships and trace the feedback loop structures. In describing an economic and environmental model we focus on the relationship among income, pollution, and non-renewable resources. This paper yields insight into the possibilities for replacing non-renewable fossil fuels with more renewable ones. Next, we present the simulation runs of the model, conducted with the help of existing system dynamics modeling tools.

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## Strategic Analysis Evolution: Scenario Planning and Simulation Based on the Methodology of System Dynamics

The present study is aimed at developing the optimal instruments for dispelling the uncertainty factors during the formulation of strategies for corporate development. The objective is the creation of a complete model of strategic analysis, which encompasses both the environment (internal and external) and the management rational component. This model – built on the analysis of three business cases - is concretized by a simulation for testing the strategy by the means of software which enables the users to cope with a dynamic and complex corporate environment. The research questions regard the development of a complete strategic analysis, which covers the entire decision-making process; the concrete assessment of the business strategy on the basis of quantitative data; the identification and enhancement of the critical variables of business administration, in such a complex and dynamic reality as the corporate environment.

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## Is the Madness Home Made?: Examining Internal Causes of Workload Fluctuation in Project Enterprises

A common challenge for project enterprises is a fluctuation in workload: periods of low capacity utilisation are followed by periods characterised by an excessive workload when "fire-fighting" becomes a standard activity and catching-up to demanding project schedules increasingly difficult. The variation in workload of a project enterprise over time is influenced by changes in the demand for its services and products. However, the external environment does not provide a comprehensive explanation of workload dynamics. This presentation concentrates on the internal causes of workload fluctuation. Using a simple, highly stylised simulation model of business processes within an architectural practice we examine how the typical bidding behaviour (in particular the time allocation to project acquisition and execution) creates workload fluctuations even within a smooth, benign market environment.

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## Assessing the Impact of a Care Innovation: Telecare

The provision of health and social care for an increasing elderly population is a challenge facing many societies. Telecare, the delivery of health and social care to individuals within the home or wider community, with the support of ICT systems, has been advocated as an approach to reduce the rise of the number of elderly people in institutional care and to contain costs. This presentation uses a system dynamic model to investigate the systemic impact of the implementation of telecare. A dynamic model is required to understand the consequences of implementation over time. The presentation

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cautions against overoptimistic expectations of the impact of telecare in the short term and emphasises that the benefits of implementation will only become fully effective with a significant delay.

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**Assessing Economic Impacts of Infrastructure Disruptions: Comparison of Input/Output and System Dynamics Approaches**

The DIISA team provides modeling and simulation capabilities for analyzing critical infrastructures and their interdependencies. We use system dynamics to improve understanding of systems under unusual, disrupted conditions and to evaluate potential economic consequences. DIISA simulation capabilities provide an alternative to the input/output (I/O) models commonly used to propagate perturbations through the economic interconnections binding diverse sectors and regions. I/O models misestimate losses due to disruptions in low-cost critical infrastructure services because they use historical data reflecting normal production to characterize interdependencies. Responses to demand changes predicated on long-term equilibrium production functions are unlikely to capture reactions to acute disruption. System dynamics provides a better basis for estimating economic consequences of sudden changes in availability or cost of input factors and the potential effectiveness of mitigation. Our poster contrasts I/O and systems dynamics approaches to estimating economic impacts of infrastructure disruptions, using several idealized examples to illustrate the differences.

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**Implementing Dynamic Balanced Scorecards to Link Strategy and Execution: Methodological Issues**

In spite of its merits, the classic "balanced scorecard" has a number of drawbacks, which can be summarized as follows: - feedback loops, delays and non-linearities are not made explicit; - dynamic relationships between strategic initiatives, "lead", "lag" indicators and strategic objectives are not explored; - cause-and-effect relationships between financial, customer, internal and learning & growth dimensions are not analyzed; - strategic assets and other relevant factors impacting on "lead" and "lag" indicators are not defined. This is likely to make difficult and superficial the analysis; - policy levers on which decision makers may act to affect strategic assets, in order to impact on business performance are not made explicit; - simulation is not an option. This paper tries to develop a methodology based on System Dynamics modelling to support the creation of effective balanced scorecards.

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**Innovative Strategies to Teach System Dynamics Applied to Business Growth Management in a Post-Graduate University Context**

This paper outlines main ideas underlying a Masters Programme launched this year at the University of Palermo on the following subject: "Managing business growth through System Dynamics and Accounting Models. A strategic control perspective". The Master programme aims to educate

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experts in business growth management, with particular reference to the contexts of small-medium enterprises (SMEs) and Public Administrations. Innovating teaching strategies are outlined and main results are discussed.

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## Using System Dynamics ILE's to Enhance Intellectual Capital Policies in Service Businesses

Knowledge is a primary strategic asset impacting on business growth. It significantly affects the accumulation of other strategic resources. Assessing knowledge is, therefore, a substantial activity to support policy makers in balancing trade-offs related to different alternatives in business growth management. Several approaches have been suggested by the business literature and practices to assess knowledge; also the System dynamics method has been applied to this issue. This paper tries to contribute to the research debate in this domain by focusing the concept of Intellectual Capital (IC) and exploring cause-and-effect relationships underlying its dynamics and business growth. Such relationships are embodied in an ILE that has been tailored to the context of a service business, where knowledge plays a crucial role for the firm success and continuity. In particular, the generic structure of the ILE has been applied to a telecom mobile service provider and to an insurance company. The first context offered the basis for the application of the ILE into an educational setting; the second one provided the arena where a business application was developed. Main key-issues underlying model development and the ILE application are discussed in the paper, and some significant outcomes from simulations are commented.

## Integrated Modeling Approaches and System Dynamics in Education Related to Sustainable Resource Management, Forestry, and Land Use Management

The School of Forest Science and Resource Management at Technische Universität München, Germany, offers two different streams of education. These are education in Forest Science and in the newly (2001) founded international master course Sustainable Resource Management (SRM). With the SRM program, the organisers put more emphasis in education on teaching systems thinking and practice system dynamics skills to increase the number of qualified academics in this field. Thus, resource management and forestry education included and improved system dynamics (SD) and modeling issues in their curricula. The goal is to improve the student's systems thinking skills to enable them applying resource management and forestry highly based on systems principles. This paper describes the structure of the courses and demonstrates, which aspects of SD, modelling and models are currently used for which purpose in these fields of education. We also show our experiences up to now and present our conclusions and future perspectives.

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## Developing System Dynamics Models from Causal Loop Diagrams

In this paper we discuss how a Causal Loop diagram (CLD) can be labeled and structured incrementally in order to finally transform it into a Stock and Flow diagram. A CLD does not contain enough information to describe a model uniquely. Hence the decisions on how to transform the CLD cannot be made automatically; they must be based on information about the modeled system. We describe a general set of possible transformation steps and offer guidance on when to choose which step. Some suggesting simplifications of the general setting will be discussed and illustrated by an example. The main application area of the described interactive algorithm is software development. However, it might also give suggestions on the reorganization of the system dynamics workflow.

## 3rd Generation Mobile Technology Impacts on Profitability: A System Dynamics Approach

Mobile operators in Egypt are facing a number of challenges due to the decline of the average revenue per user combined with local currency devaluation yielding to a difficult business position. Additionally, the ongoing competition between the existing two operators MobiNil since 1997 and Vodafone Egypt since 1998, the challenges are mounting. The competition adds more pressures on existing operators to differentiate their services and introduce innovative solutions to maintain their competitive edge. Therefore, newly diffused technologies with diversified revenue channels are needed. This paper documents the findings of a study conducted in 2003 investigating the possibility of using the 3rd Generation mobile services as a tool for generating additional revenues and accordingly profits to mobile operators. To support the findings a system dynamics approach has been conducted to capture the dynamics of the current industry to help explain its profitability.

## Modeling the Mobile Service Market of the Region and a Control Problems Solution

The paper presents a system dynamics approach to analysis and considers the model of the mobile service competitive market. The model includes a dynamic competition between two major operators, dominant operator and the others. Their market share concerning the number of subscribers is influenced by the pricing policy, service quality, subscriber base, potential subscribers, marketing, etc. The method for identification of the market carrying capacity is considered. The problem of optimal management for price is formulated. The obtained results can be used in research to forecast and improve decision making in real dynamic systems.

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## Decision Support within Complex Systems: An Experimental Approach Using the Stratagem-2 Computer Game

In 1989, John Sterman published his seminal paper, *Misperceptions of Feedback in Dynamic Decision Making*. His misperception of feedback hypothesis deals with the difficulty people have in managing complex environments. Over time, several authors have attempted to consider how human failures, which are a prominent part of the misperception of feedback hypothesis, can be reduced. However, these authors have achieved mixed results in attempting to make improvements to human decision support. It is the purpose of the current research to provide meaningful decision support to managers of complex environments. Specifically, the research used the STRATEGEM-2 simulation game and developed a decision support method designed to improve human performance. The experiment required subjects to make a single decision within a dynamic system where the task involved feedback delays, nonlinearity of system processes, positive feedback loops, and multiple cues. The decision support included a decision rule and a newly developed game instruction designed to improve participant knowledge and information about the microeconomy of STRATEGEM-2. Results of the research have discovered that the new instruction and the decision support rule produced significant results in improving decision making. Additionally, this research demonstrates that the lack of participant motivation levels can mask decision support interventions.

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## From System Dynamics and Discrete Event to Practical Agent Based Modeling: Reasons, Techniques, Tools

This paper may be considered as a practical reference for those who wish to add (now sufficiently matured) Agent Based modeling to their analysis toolkit and may or may not have some System Dynamics or Discrete Event modeling background. We focus on systems that contain large numbers of active objects (people, business units, animals, vehicles, or even things like projects, stocks, products, etc. that have timing, event ordering or other kind of individual behavior associated with them). We compare the three major paradigms in simulation modeling: System Dynamics, Discrete Event and Agent Based Modeling with respect to how they approach such systems. We show in detail how an Agent Based model can be built from an existing System Dynamics or a Discrete Event model and then show how easily it can be further enhanced to capture much more complicated behavior, dependencies and interactions thus providing for deeper insight in the system being modeled. Commonly understood examples are used throughout the paper; all models are specified in the visual language supported by AnyLogic™ tool. We view and present Agent Based modeling not as a substitution to older modeling paradigms but as a useful add-on that can be efficiently combined with System Dynamics and Discrete Event modeling. Several multi-paradigm model architectures are suggested.

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## Design of a Community Learning for System Dynamics

Shown the objectives, model, functional structure and elements plants in the design of a knowledge community. This proposal of the design is motivated by the need to work and facilitation of the learning in a collaborative way for

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the members of the community of systems dynamics in Latin America in the fields of investigation, teaching labors, and consulting. The objective is to effectively to attend the demands in: actualization of contents related with the subject in the Industrial Engineering career, the design of contents in Politic Science Master programs, reinforcement of investigation lines in the ITESM, and the application of models for government and industry. The article concludes with the discussion about possible benefits to apply administration knowledge in the question design.

### **Using Simulations to Define the Product Development Strategy Expected to Achieve the Shortest Time to Profitability**

Small entrepreneurial companies are challenged by the need to achieve profitability rapidly with limited resources. Such companies often face an uncertain prime product path; consequently, resources must be allocated among multiple products or platforms as the company establishes market demands. These allocations must be made within the context of the newness and complexity of the technology and products, uncertainty in market adoption rates, and unknowns in maturation of the supply chain. A system model is proposed that will identify a product introduction strategy that minimizes the time to profitability given the constraints of fixed resources and assumptions regarding key parameters such as product development time and costs, market adoption rates, and cost learning curves. This model compares a product product platform strategy with launching multiple point products unrelated by a technology platform. By accounting for product lifecycles, the model considers parallel and serial product development.

### **Understanding the Influence of "Not Invented Here" and "Blind Faith" on the Implementation of Innovations**

Repenning's1 innovation adoption model demonstrated the need for balance between perceptions of success and management support through commitment, patience, careful resource deployment, and control of the speed of implementation. Two factors are added to the model: the tenure of the manager who champions the innovation, and the use of objective, quantifiable success metrics. The "Not Invented Here" effect suggests long-time employees resist processes not championed by individuals with similar experiences and tenure within the company, thereby slowing implementation. Royer's2 "Blind Faith" effect results when perception of success is more positive than objective metrics would support, thereby allowing implementation to continue despite little real success. Implementation of a Technology Development Process at a small company is simulated. It is shown that championing of new innovations by long-term members of the organization shortens the time to complete implementation. Objective metrics either accelerate implementation or support discontinuation of unsuccessful implementation projects.

### **Achieving What Cannot Be Done: Coping with the Time Constants in a Dynamic Decision Task**

This study examines how people handle the time constants in dynamic tasks, using a firefighting simulation. The participants did not discriminate between fires requiring different number of units if they were not allowed to move any units before the fire started. If they were allowed to do so,

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performance improved. This suggests that the participants did not learn the time constants, and that they used the heuristic to preposition the units to avoid having to do so. Using such heuristics may well be how people handle dynamic tasks also in other circumstances. More effort should therefore be put into studying what people actually do in dynamic tasks, and not only into whether or not they perform optimally.

**Approaches to Diagnostic Business Simulations**

System-dynamics based micro-worlds in general hold no diagnostic features. However, these could be extremely valuable for giving feedback within learning processes and for the adaptive adjustment of micro-world based learning environments. This could be applied too for evaluating the level of performance at which participants can act when they have to control a given scenario by means of interventions into the system. For setting up such diagnostic systems it needs a theoretical foundation. In that respect we refer to the approaches of complex-problem solving theory as well as to Cognitive Complexity Theory in order to reflect on their potential use for grounding diagnostic SD-based simulations. There is a prototype of such a diagnostic business simulation under development which shall be available within the presentation.

**The Principle of Acceleration and Investment in Developing Countries: A Discussion Based on System Dynamics Methodology**

The purpose of the article is to formulate a more realistic version of the accelerator-multiplier model, based on systems dynamics methodology. In the present version, the accelerator is flexible and the model presents dynamic stability for much wider intervals of the marginal propensity to consume, in comparison to the original formulation. Based on VENSIM model simulations, we also intend to evaluate if the mechanism can be useful to inform economic policies in developing countries such as Brazil.

**Is Your Organization Collegiality-Challenged?: A Case Study Demonstrating the Effect of Unconscious Gender Bias**

Most people conceptualize gender bias in terms of individual behavior – men discriminating against women. This creates a tendency for men to feel personally blamed for gender bias. Yet feminist theories emphasize that gender bias is the resulting behavior of a cultural system, not individuals, and this system influences the behavior of both men and women. System dynamics has often been used to understand the systemic nature of social problems and clarify social theory, but has not yet been applied to a feminist theory of gender bias. Using a simple organizational case study, we describe and explore a feminist theory of the systemic nature of gender bias with system dynamics. The paper introduces key concepts, demonstrates how system dynamics clarifies the theory's systemic issues and potential solutions, and suggests how this new way to view gender bias might improve the collegiality of our personal and professional relationships for the long term.



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**Scenario Planning and Evaluation of Pricing Strategies in the Portuguese Bulk LPG Market**

Portugal has the largest LPG (Liquefied Petroleum Gas) share of primary energy demand in the EU (about 5%). Due to the increasing international cost of LPG in the last years and the high price sensitivity of the consumers the preference for substitute energy sources in new and existing consumers has been increasing. To select the kind of energy, some consumer estimate and compare the total costs while others follow agents (equipment sellers) recommendations. It takes time to build agents perception about the most advantageous source of energy, which is seen as an important resource that drives client resource accumulation and retention. Marketing strategies have to take into consideration some market dynamic effects derived from the accumulation and depletion of these resources. A simple system dynamics model was built, combined with Economic Value Added framework, to evaluate some pricing strategies under different scenarios of LPG international cost.

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**Inter-Organizational Learning: Lotka-Volterra Modeling of Different Relationships**

AS the creation of new knowledge by an organisation is the key factor to allow radical innovation, and as radical innovation ability demonstrates increasing importance to face environmental upheavals, the understanding of the mechanisms favouring knowledge acquisition is of prime importance. In this paper, we try to understand some of the mechanisms that govern knowledge creation and transfer through the relationships developed between organisations. Our approach is based on system dynamics modelling with Lotka-Volterra set of equations. This approach is a first step in a research dedicated to the study of complex adaptive systems, a well-suited framework to understand the influence of inter-organisational relationships on various characteristics responsible for organisational learning and growth.

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**A Systems Thinking Study of the New Zealand Army Electronic Technician Trade Group**

Since the mid-1990s, the New Zealand Army has experienced difficulty retaining personnel in the Electronic Technician trade. The problem will be exacerbated by the Army's force modernisation programme, as the introduction of new technologies into service will place increasing demands on this diminishing specialist trade group. In late 2002 and early 2003, a qualitative system dynamics study was undertaken to establish a better understanding of the causal factors of poor retention, their interconnections and complex relationships, and to identify leverage points to develop a turn-around strategy. This involved using systems thinking concepts to work with the different stakeholder groups associated with the electronics trade group, to develop mental models based on the soldiers perception of the system in which they serve. Separate group model building workshops were held with the apprentices, tradespeople, management, and external stakeholders. The shared mental models (or causal loop diagrams) developed for each internal stakeholder group were combined. This was used as the basis for the analysis of leverage points within the system, and to facilitate the development of action plans for the trade group. The paper will outline this systems thinking study and the subsequent implementation of the recommendations.

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**Policy Design by Fitting Desired Behavior Patterns to System Dynamics Models**

The paper proposes a policy design method for system dynamics models based on neural network and genetic algorithms. Algorithmic approaches to policy design traditionally are accomplished by either optimization or modal control methods, which achieve the designer's goal through an indirect way. The approach presented here instead is more directly. A model designer can specify any desired behavior pattern and let the learning algorithm to point out where to consider for changes. It needs no objective function as required by optimization algorithms nor suffers the limitations of linearization and complex control mechanism as modal control approaches usually do. The approach is based on our previous work that shows a system dynamics model (i.e., a flow diagram) is equivalent to a specially-design partial recurrent network which both operate under the same numerical propagation constraints. Several experimental studies are conducted to evaluate performance of the new approach. The results show that it is at least as effectiveness as other competent approaches but more convenient and straightforward.

**Bifurcations in Nonlinear Kaldor's Model**

The article is devoted to research of nonlinear dynamic Kaldor's model which describes the behavior of the income and the level of capital stock. The function of investment and the saving function are nonlinear. The analysis of stability of the model considered was carried out and the parameter fields of the initial equation localized. The situations at the bounds of field stability with appearance of the corresponding pitchfork bifurcation and Hopf bifurcation. The critical parametric meaning when the pitchfork bifurcation, the Hopf bifurcation and the global bifurcation become possible were found. Bifurcations diagrams are presented.

**Feedback Loops and Policy Scenarios in The Chinese Private Vehicle Demand Model**

This paper develops a system dynamics model for China's fast growing private vehicle market. The basic structure of the model relating to income and vehicle affordability is presented. Both the baseline projection and the sensitivity cases for private vehicle sales over the next decade are discussed in light of feedback loops between the economy, the vehicle market, the energy sector, and the transportation infrastructure.

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**Perception of Information Value Production of  
Influence Diagrams versus Level-Rate Models:  
The Opinion of Decision-Makers**

This paper is about the debates on the use, and contribution, of influence diagrams, or the display of more qualitative dimensions of feedback structures, versus the use of level-rate models, or quantitative models, in system dynamics. The research question we are asking in this paper is: What is the perception of decision-makers regarding the use value of influence diagrams and of level-rate models? The objective of the paper is to understand the perception of individuals familiar and unfamiliar with SD methods, and to find out what they think about various dimensions of this issue as raised by Coyle (2000) and Homer and Oliva (2001). This paper reports on a simple exploratory research that analyses the viewpoints of two groups of decision-makers, one that has familiarity with SD and one that does not. The results are mixed, and by an interesting twist, substantiate some dimensions of both Coyle (2000) and Homer and Oliva (2001).

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**Coordination of the Agrifood System: Managing  
Feedback from Accidental Adversaries to  
Cooperation**

Relationships between agricultural producers and other linkages in the agricultural value chain are notoriously adversarial (Street, 1990; Cloutier, 1999). The nature of this adversarial relationship is deeply rooted in the way agricultural commodities are produced and traded all the way to the final end-user. Earlier research clearly has shown that more information is required to improve the relationship between suppliers and customers in the agrifood system. The objective of the paper is to report how a producer commercialization group in Quebec is trying to learn to work together to address the issues facing the industry using system thinking methods. Over the years, the industry has introduced several management programs to help producers and to develop the industry and markets. However, the industry is at a crossroad, and the participants must look at the bigger picture issue together to understand systemic benefits and risks. The research presents the results of a survey showing the impact on the issues facing this group on their shared and unshared understanding of the system.

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**Introducing Feedback Thinking and Simulation in  
ECOSTATO Training Programme**

The ECOSTATO model in an application of system dynamics modelling and simulation to the training programme of hired civil servants of State Department of Human Resource Management of Ticino in Switzerland. The project was undertaken by the Laboratory for System Modelling in Lugano University (USI). The simulation model was developed as a pedagogical tool to rejuvenate an existing role playing. The paper describes the modelling process with particular regards to interface building and integration of balance sheet information with social and macroeconomic dynamics. In particular, a number of considerations are derived on problems related to the development of a brand new teaching process that, on the one hand, impinges upon a new teaching technology (computer simulation), on the other, substitutes a well entrenched training programme.

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## The Dynamics of Agricultural Commodities and Their Responses to Disruptions of Considerable Magnitude

An agricultural commodity production cycle model consisting of corn, beef, and dairy sectors was constructed for the purpose of exploring the propagating effects of large-scale disruptive events. In an initial proof-of-concept exercise, we considered an agricultural disruption scenario in which foot-and-mouth disease (FMD) is introduced into the U.S., causing a large-scale outbreak of the disease in both beef and dairy cattle. The magnitude of disruption to the beef and dairy sectors are presented under the existing FMD response policy and then improvements under two alternative policies are shown.

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## Using System Dynamics Models to Enhance the Visualization of Stochastic Price Processes

The market prices of many financial assets and commodities can be described by stochastic processes. For example, the famous Black-Scholes formula for valuing options on common stocks is based on the assumption that stock prices move according to a geometric Brownian motion. This paper describes some models for stochastic price processes and shows how they can be formulated using the methodology of system dynamics. System dynamics lends itself to visualization of both the structure of the models and of the resultant price dynamics. For this reason, it is suggested that students' understanding of stochastic price processes can be enhanced by using such models as teaching aids. Another advantage of system dynamics as a modeling environment is that feedback loops and time delays can be easily incorporated into the models. This should facilitate the integration of stochastic price models with supply chain models and provide richer insights into the dynamics of financial and commodity markets.

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## Impacts of Environmental Condition on Human Social Well-Being

Humans have wide ranging impacts on many of the world's ecosystems, but the reciprocal effects of changes in ecosystem condition on humans are poorly understood. Dynamic modelling provides a useful tool to investigate the ways in which specific aspects of well-being might be impacted by changes in the condition of surrounding ecosystems. Understanding the positive linkages between ecosystem condition and human well-being can potentially reduce the apparent conflict between environmental improvement and human interests, thus improving management of local ecosystems. The aim of the model presented here is to examine the impacts of changes in coastal waterway condition on social aspects of human well-being. As there are currently few examples of modelling of social well-being, one of our aims is to present this model as a basis for further discussion and exploration of possible approaches to modelling social structures. Further stages of modelling aim to also incorporate impacts on human health and regional economic production and employment.

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**Introducing Autoregressive Elements in System Dynamics Models**

Autoregressive, vector autoregressive and structural vector autoregressive models may be described, in general, as those models that explain, at least partially, the values of a variable or set of variables, based on the past values of this variable or set of variables. During the last decades these models have increased their presence and importance within the field of economic and econometric analysis. It has been found that this kind of simple models, with a small number of variables and parameters, can seriously compete in terms of their forecasting capabilities with the large macroeconomic models, with hundreds of variables and parameters, developed during the fifties and sixties. This paper explains how System Dynamics models built using Vensim simulation environment may easily incorporate the main elements of autoregressive models. In order to do that we have developed a structural autoregressive model using stock and flow diagrams built with Vensim software and provided the code for the mathematical formulation in a way that this tool can be later used in System Dynamics models. This tool provides short term forecasting capabilities to System Dynamics models built using Vensim. As an illustration, we present an application to the study of the Spanish labor market.

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**A Decision Support System (DSS) for Evaluating Operations Investments in High-Technology Business**

The evolution in the way that businesses approach markets has been a frequent literature topic in the last few years. In the high-tech industry, even the most successful companies have been mainly focused on the features of their products and processes, trying to develop their technology to gain a price / performance advantage, and thereby protect or increase market share. However, this approach is disconnected from their beliefs about what target customers really care about, nor does it consider which of those underlying assumptions are most critical to business growth in share, revenue, and profit. This paper proposes a Decision Support System to connect customer value to business targets, providing scenarios to show the customer responses and business results that will enable future funding, with optimization techniques to compare alternatives.

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**Keep on Rolling: Understanding the Migration Dynamics of a Large Railway Improvement Project**

This paper describes the application of system dynamics to planning a major upgrade for an underground railway system. The upgrade involves new train and signals introduction along with other engineering works. A working system needs to be maintained during the upgrade process, necessitating a carefully planned migration process. The operators receive financial payments based on service performance against incremental targets. A system dynamics model was developed that represented progress on train introductions and engineering work, its impact on system performance, and the corresponding financial implications. The model allows analysis of different options for work scheduling and activities under conditions of

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restricted access to the line in order to understand the performance and financial impacts throughout the migration period.

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## Extreme Event Policy Analysis: Identifying Stakeholders and Preferences for Natural Hazard Mitigation Policies

Extreme events can cause severe damage and potential harms to many people in a very short period of time. Considerable challenges confront policy makers who seek to change individual and community behaviors to mitigate disasters. The model developed for this research develops an endogenous view of changes to extreme event policies through stock and flow feedback structures. Floods are among the costliest natural hazards in the United States, account for the largest category of federal disaster declarations, and the hazard is broadly distributed across the United States. While the first piece of this work begins with floods, the ultimate goal of this research is to develop a generic structure for extreme event policy making and implementation. Future research will replicate this effort with other natural hazards, and with technological or social problems such as terrorism or aviation safety. A key insight from the modeling process showed some tensions in extreme event “policy analysis.” The modeling effort recognized the contributions of several disciplines that study different aspects of the “policy process.” By taking a multi-disciplinary approach to extreme event policy making, this research opens up new avenues for policy analysis.

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## MISS: A Model of Sustainable Human Development

The MISS (MeasurIng Sustainability in Sen’s framework) Project started at the beginning of January 2004 and will last one year. It aims to define a possible operative map of sustainable human development as intended in the capability approach, related to the Nobel Prize for Economics Amartya Sen. In Sen’s view well-being must be considered in terms of human functionings and capabilities. Functionings relate to what a person may value doing or being: they are the living conditions achieved by an individual. Capabilities concern the ability of an individual to achieve different combinations of functionings, and define the freedom to choose the life that she prefers. The MISS model tries aims to define a model of sustainable human development based on Sen’s paradigm and built within the tradition of system dynamics. Our main purpose is to verify, for Italy and over a 50 years time horizon, the variations of some achieved functionings, due to structural dynamics and to variations in the institutional setting, and to study the role played by the institutional context. The model contains the following modules: Economy, Environment, Residences, Mobility, Health, Security, Employment, Poverty, Institutional and Fiscal Response.

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**System Dynamics and Time Series Analysis: Two Approaches for a Convergent Answer**

Norway and Portugal are the biggest players in the huge cod World market. Norway is the largest producer and exporter while Portugal is the largest importer and consumer. Moreover they are the only ones with an important salting and drying cod industry. So, it is important to know (i) if these markets are integrated (in the economic sense) and (ii) the dynamics of the mark-ups along the international value chain. For that we use the system dynamics and the cointegration analysis of prices. This communication shows how the results from both approaches were used for (i) cross-validation, (ii) analysing the monetary exchange pass rate through, and (iii) getting insights about the feedback information used in the salting process. In conclusion, if those different approaches are used in a complementary way they can contribute to build a robust and rich model.

**A Heuristic Model on the Role of Education in Complex Humanitarian Emergencies**

This heuristic model, which we will submit as a poster, informs dialogue and decision-making about the benefits of educating children and youth in complex emergencies. The target audiences are stakeholders in humanitarian assistance and international development, donors and lenders, ministries of education, and other international, national, and indigenous private, governmental, and non-government organizations working in conflict regions. The model will take the form of a “flight simulator” and a debriefing model that simulate a refugee population settled within a region of ongoing conflict. Operators of the model will examine the impact of education programs—or the lack there of—on individuals, their communities, and on the trends that sustain the surrounding conflict. The model’s purpose is to inform dialogue among stakeholders about the importance of education as a form of humanitarian assistance, and to encourage stakeholders to examine their assumptions about the dynamics of the conflict system, including the impact of aid programs.

**"Instantaneous Processes": A Practical Requirement of System Dynamics!?**

In many of the systems that are subject to System Dynamics modelling in client projects, iterative information processes take place. The purpose of such processes is to conduct a numerical analysis (incl. optimization) to support decision making. The time-span on which these processes take place is insignificant compared to the time span on which we investigate the system at hand. The implication is that such processes are considered to take place instantaneously, i.e. without the passing of time, i.e. at distinct points in time. Most modelling and simulation software, developed within the context of system dynamics, have not been designed to incorporate iterative numerical processes of this kind. This paper intends to open up a debate about the necessity, usefulness and possibilities of incorporating instantaneous processes into System Dynamics models. It presents first research results and possible areas of application in which iterative information processes play a significant role.

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**Analyses of a Repair Cycle in a High-Tech Company with System Dynamics Methodology**

During the last years the demand on companies concerning product-life-cycle-management grew because of strict environmental laws and an increasing world-wide competition. Repair cycles have been established in the industry and in the military in order to support a sustainable development in environmental and economical aspects. This paper presents a client project in which the repair cycle of a high-tech company was analysed using System Dynamics Methodology. The company detected high inefficiencies in respect to capital lockup and storage costs due to long and varying time delays in shipment processes. In order to enhance cost efficiency and customer satisfaction, it was important to represent and understand structure and dynamic behaviour of the repair cycle. The System Dynamics model allows analysing consequences of changes in time characteristics. Major insights could be gained about the behaviour of the repair cycle during the transient phase but also in respect to long term effects.

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**Confidence Interval Estimation in System Dynamics Models: Bootstrapping vs. Likelihood Ratio Method**

In this paper we discuss confidence interval estimation for system dynamics models. Confidence interval estimation is important because without confidence intervals, we cannot determine whether an estimated parameter value is significantly different from 0 or any other value, and therefore we cannot determine how much confidence to place in the estimate. We compare two methods for confidence interval estimation. The first, the "likelihood ratio method," is based on maximum likelihood estimation. The likelihood ratio method is computationally efficient but requires strong assumptions about the model and data. These assumptions are frequently violated by the autocorrelation, endogeneity of explanatory variables and heteroskedasticity properties of dynamic models. The second method is called "bootstrapping." Bootstrapping requires more computation but does not impose strong assumptions on the model or data. We describe the methods and illustrate them with a series of applications from actual modeling projects. We consider the advantages and disadvantages of the methods and discuss practical considerations in their use. Finally, we close with recommendations for modelers seeking to develop robust estimates of the uncertainty around parameter estimates in dynamic models, and call for the automation of bootstrap methods in system dynamics software.



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**The Dynamic Structure of Social Capital: How Interpersonal Connections Create Communitywide Benefits**

Social capital is built via the network of connections among individuals in a community. Interactions among individuals within such a network make various endeavors more successful than they would be without such connections. The community becomes something more than a collection of individuals, because this structure has beneficial effects on economic and other efforts of community members, and provides benefits to the community as a whole. While benefits of social capital are well documented, the mechanisms of social capital -- how it produces such benefits -- are less well understood. Several mechanisms have been suggested, however, and these can form the basis for the structure of system dynamics models with which these various hypothesized mechanisms of social capital can be examined. One can more clearly define social capital by using the structure of these models.

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**Policy Diffusion in the Beer Game**

This research studies the classic beer game simulation model from a new perspective. It does so by providing each agent with two ordering policies, and creating a set of rules that allow an agent to change its policy. Such a change is triggered based on an agent's confidence in their own performance, and on the relative confidence of their nearest neighbour. The overall effect is that policy diffusion can occur, where, under certain circumstances, an agent will mimic the behaviour of its neighbour, if it believes that its neighbour is performing better. The motivation behind this research is to provide an experimental base upon which the decision making strategies of business agents can be studied.

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**The Chicken or the Egg: Does Interdisciplinary Collaboration Enhance Systems Model-Building or Does Systems Model-Building Enhance Interdisciplinary Collaboration?**

Does interdisciplinary team collaboration enhance the knowledge generated and shared in systems model building or does model building enhance the collaboration and collegiality of interdisciplinary team members? This paper addresses the processes involved in constructing dynamic system models of "deep complexity" related to scientific and environmental issues. Typically such model-building requires the knowledge and expertise of specific disciplinary specialists. The examples used in this analysis come from modeling an urban airshed, which requires input from atmospheric chemists, biologists, engineers, meteorologists, and urban planners -- just to name a few. The authors argue that addressing an emergent class of problems characterized by deep complexity requires an iterative process of interdisciplinary communication facilitated by model building. This model building, it is argued, serves as the "Rosetta Stone", which can lead interdisciplinarians to create an organic narrative to describe the system and enhance the quality of knowledge generated.

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## A Conceptual Framework for Applying System Dynamics to the Question of Urban Growth

The past two decades have seen many efforts around the globe to manage urban growth, principally toward the simultaneous goals of sustainability and quality of life. While progress is being made at the micro levels (individual building and sometimes neighborhood levels), the results of broader city and regional-scale efforts have been disappointing. These macro-level initiatives typically begin well enough, often using a strategic planning approach, but typically bog down quickly in the complex web of connections within and between the dimensions of an urban system. We suggest that system dynamics can provide the means for understanding these connections and support the development of effective urban growth policy. In this session, we present a conceptual framework for the application of system dynamics to the question of urban growth and sustainability.

## Analyzing Stakeholder Dynamics in Environmental Conflict: A New Zealand Transport Infrastructure Project

There is an increasingly common argument in the environmental management literature that much of the environmental and resource management is the management of conflict. One of the challenges, while managing such environmental conflicts, is to understand the dynamics of stakeholders in terms of their changing positions and interests. In this paper we present how a systems thinking and modelling study based on system dynamics, was used to understand the changing positions and interests of stakeholders in an environmental conflict. This study involved five phases, namely, stakeholder analysis, group model building, dynamic modelling, scenario planning and modelling, and implementation and organisational learning. The methodology was applied to a New Zealand case relating to a transportation infrastructure project, called the Transmission Gully project.

## Effects of Regulation on the Dynamics of Liberalized Power Sectors: A Cost Benefit Analysis of the Capacity Payment of Hydro Based Systems

In this paper, a cost benefit analysis associated to the application of the capacity payment in the Colombian power system is reported. The analysis results in two relevant conclusions. The first one is that the capacity payment as it is designed today will not maintain acceptable levels of reliability in the long run as it does not succeed in restoring private investments in the short to medium terms. The second conclusion is that an increase in the value of the capacity payment today, which succeeds in effectively attracting the required investments in capacity to maintain minimum levels of reliability, has higher net benefits when long terms effects are taken into consideration.

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**The Sociopolitical Destabilization of Venezuela: A System Dynamics Perspective**

This paper uses a system dynamics framework to analyze the rapid and dramatic transformation of Venezuela from an exemplar of prosperity and democratic stability in Latin America to a nation on the brink of socioeconomic and political collapse. In Venezuela, unaddressed grievances of a large marginalized class, in combination with a loss of faith in the traditional political system permitted the election of Hugo Chávez. His rhetoric and actions, leveraging the power of his position, accelerated the political polarization and economic collapse of Venezuela. This dynamic may be characterized in terms of positive feedback effects which overwhelmed traditional restraints embodied in the institutions and political culture of Venezuela. This paper uses system dynamics to explain why the rapid disintegration of Venezuela was possible, suggests a range of possible futures for the troubled country, and derives implications for the region as a whole.

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**Collaborative Development of Narratives and Models for Steering Inter-Organizational Networks**

The power to direct and manage change within metropolitan areas is increasingly dispersed among a loosely interconnected set of mostly local organizations, agencies and actors that form a special type of urban inter-organizational network. Increasingly, the quality of metropolitan regional governance depends upon IO network capacity to articulate systemically insightful urban development strategies, i.e., to exercise a capacity for network steering. We outline an IO network steering capacity-support process that combines collaborative learning, narrative storytelling, and system dynamics modeling with the goal of deepening insights into urban human/biophysical processes and securing greater resilience in metropolitan regional governance. Our process promotes comprehension of complex urban processes through stories about past trajectories and future growth scenarios that frame issues within collaborative learning workshops for deliberation by local opinion leaders. This initiative is part of a larger research study on greenhouse gas emissions in relation to human and biological activities within metropolitan areas.

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**Simulating the Urban Transformation Process in the Haaglanden Region, the Netherlands**

This paper describes a recent modeling project on the dynamics of new housing construction, transformation of outdated dwellings and the impact of both processes on a regional social housing market. The study continues and adds to the work of Forrester and others on urban dynamics. A team of seven stakeholders and experts participated in model construction. The model was constructed over a period of about 14 months and yielded several counterintuitive insights. The housing allocation system proved to have far smaller effect than expected, while the proportion of new greenfield construction to transformation (demolition and new construction within the city) has emerged as a crucial steering factor. The migration multiplier is a very important external parameter. A strategic workshop for policy makers, managers of housing associations and other stakeholders in the region offered a chance to present the final model and operate it in the form of a flight simulator. In line with the recommendations of a recent survey of group model building projects, participants' insights and conclusions from both the project and the workshop are evaluated. The evaluation is based on the Ajzen model and focuses on the effect of group model building on attitudes, intentions and behavior.

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**Women in System Dynamics Modeling: Out of the Loop?**

“System dynamics deals with how things change through time, which includes most of what people find important... System dynamics demonstrates how most of our decision making policies are the cause of the problems that we usually blame on others, and how to identify policies we can follow to improve our situation.” (Jay Forrester) How can this field be unattractive to women? This paper presents statistics showing the level of representation of women in the sciences in the United States in 1998-1999. It presents some issues women face when trying to participate as a minority in a technical field such as computer science or engineering. A summary of responses from both men and women to a questionnaire that was posted on the System Dynamics Society listserv regarding under-representation of women in the System Dynamics field is compiled. Suggestions for potential action are listed.

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**Evolution and Behavior of System Structure:  
Eight Perspectives for Examining a Complex Issue**

Quantitative models based on systems thinking and system science are routinely used to explore and anticipate the likely behavior of broad and highly complex issues and problems. While such models can provide valuable insights, they are invariably simplistic and frequently face controversy in both structure and quantitative details. The end result is that, while they may prove valuable in understanding the dynamics of the system, their value in understanding the evolutionary and behavioral tendencies of the system may be quite limited. A qualitative approach based upon structural perspectives can suggest tendencies beyond the scope of quantitative models. This paper presents eight interrelated perspectives for examining a complex issue or problem and for inferring potential evolutionary tendencies or behavior based upon the structural characteristics of the system under study. Experience suggests these perspectives may be useful not only in dealing with qualitative system models, but also in validating and troubleshooting quantitative models.

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**Operational Labor Productivity Model**

Construction processes inherently involve complex interactions among variables including, but not limited to, physical attributes, resource availability, budget restrictions, and management techniques. Labor productivity, a key variable in the profitability of a project, is influenced by complex and competing factors such as skill level, motivation, and schedule pressure. Contractors continue to struggle with a fragmented industry where competitive pricing and labor productivity are defining factor in their competitive advantage. The current management tools for the industry are inflexible and slow when planning and controlling work on a fast-track project where information is knowingly incomplete, both in final design and construction means and methods. Actual events and conditions are more challenging than anticipated, which demands rapidly pulling together resources to ensure the project is still delivered on-time and within the budget. The data used for the model was provided the subcontractor installing intelligent highway system components on Boston's Central Artery/Tunnel Project.

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**Impact of Freight Transport Costs and Pricing on  
Logistical Systems: A System Dynamics Modeling  
Approach (The SANDOMA Model)**

The aim of this research is to evaluate the possible impacts of an increase in freight rates on traffic in a logistical perspective. At the present time road pricing appears as a key issue for current public policies in Europe in a context of an increasing concern for sustainable development. However transport costs take part in several kinds of trade-off decisions that affect a complex logistical system, involving the whole production and distribution organisation. A complete analysis of their role in the logistical organisation

needs a systemic approach in order to be able to evaluate the impacts of a significant freight rates increase on traffic. In addition costs are not considered as the only decisive factor in the organisation, and some qualitative attributes are taken into account. The SANDOMA model is thus designed to evaluate the impacts of public policies on freight flows and for a pedagogical use. This work was carried out in the framework of a PhD research at the French National Institute for Transport and Safety Research, and was completed in June 2003.

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## **Innovative Enterprises and Regional Economic Systems: The Case of Canton Ticino**

Based on the literature and on empirical evidence provided by the analysis of the Canton Ticino's economic system, the paper explores how innovative enterprises can contribute to the competitiveness of a local economic system. Innovative companies are able to introduce innovations in strategic positioning, operational effectiveness and organisational process and context. Thanks to these flows of innovations they can remain competitive and achieve a profitable growth within a current competitive environment characterised by discontinuity, instability and uncertainty. Innovative enterprises can play a fundamental role in enhancing local economies' competitiveness, thus helping the Canton Ticino to face the challenge of economic and social development. Visibility and creation of social consensus around the model of innovative enterprise can stimulate emulation which contributes to the diffusion of innovative business models. Political and institutional actors play a major role in managing processes targeted to create visibility and social consensus around innovative entrepreneurial values and culture.

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## **Collaborative Law Dynamics: Collegiality in Civil Litigation?**

Four system dynamics game models portray two-contestant, paradoxical self-referential games of non-constant sum conflicts. Two players or groups compete with dynamic (time varying) probabilities of collaboration. Their game is paradoxical because both parties can either win or lose simultaneously. It is self-referential when the payoff, prior discord and loss parameters depend on the players' collaboration probabilities. Past research has found similar game models with exogenous parameters to be conservative, possessing two centers around which games can oscillate forever. But with endogenous parameters the dynamics becomes dissipative, possessing a single fixed-point attractor of moderate equal gains. Large subsets of initial discord tactics converge on the fixed-point attractor to sustain collegiality equilibria. The game ends once the point attractor has absorbed all dynamics, leaving the system in a stable, negative feedback state. If both players collaborate without undue bias and preconceived opinions, and equally discount each other's collegiality or lack of it, then the stable attractor moves closer to maximum payoff, where both parties collaborate with probability 1 (one). In the asymmetric model, however, one of the players can take less into account the other's collegiality or discord tactics. Then, it is the most impartial player or group that profits the most!

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## **Modeling the Irrigation System in Egypt**

This paper partly describes the empirical part of the ongoing PhD thesis where we aim to incorporate the system dynamics methodology (approach) with the associated GIS capabilities in Environmental modeling domain. We

will emphasize on the need for integration, the significance of this approach, the potential mutually benefits, and the framework we adopted to implement this integration. Modeling the environment with GIS, is not a new idea, but modeling the dynamics of space, time, and human choice is our main contribution. Our motivation is driven from three assumptions. First, the spatial representation is crucial to environmental problem solving, but GIS currently lack the predictive and related analytic capabilities necessary to examine complex problems. Second, SD Modeling tools typically lack sufficiently flexible GIS like spatial analytic components and are often inaccessible to potential users. Third, System dynamics approach and GIS technology can both be made more robust by their linkage and co-evolution. SD would benefit by the better engagement of the visual senses in evaluating the assumptions, operations, and results of the models. We have adapted a new methodology based on the Object Orientation to incorporate SD with GIS. We applied this methodology to model the irrigation system in Egypt. This paper describes the irrigation system from SD viewpoint.

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**Managing Organizational Change: Integrating Strategy through the Exploration of Detail and Dynamic Complexity**

This Presentation will explore how multimethodology – combining areas of strategy, system dynamics and the Viable System Model in a single study – can be used to inform the management of change. The process of managing change defines the gap between where an organization currently is and where it would like to be. This makes the process a goal seeking one and performance measurement is thus required to ensure the “gap” is reducing over time. The Balanced Scorecard is used for this purpose. It is hoped that a debate on the ramifications of this approach may develop and these comments will be fed into the final draft for the Conference Proceedings. Key words: Strategy, Resource Based View of the Firm, Balanced Scorecard, Viable System Model (VSM), Deployment Flowcharting, System Dynamics, Strategy Dynamics and Multimethodology.

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**The Impact of Endogenous Demand on Push-Pull Production Systems**

Though often analyzed separately, supply chain instability and customer demand interact through product availability. We investigate the feedback between supply chain performance and demand variability in a model grounded in first-hand study of the hybrid push-pull production system used by a major semiconductor manufacturer. While customers’ response to variable service impact company profitability, previous models exploring supply chain instability do not account for it. This research incorporates two effects of customer responses to availability. The sales effect captures the negative feedback whereby product shortages cause customers to seek alternate sources of supply. The production effect captures the delayed impact of changes in demand on the manufacturer’s production decisions: lower demand leads to reduced production, prolonging shortages that depress demand, a destabilizing positive feedback. We show how these effects interact to destabilize the supply chain and lower performance. Supply chain models that assume exogenous demand therefore underestimate the amplification in the chain. In addition, accounting for endogenous demand leads to policy reversals for inventory and utilization policies. The model yields insights into the costs of lean inventory strategies and responsive utilization policies in the context of hybrid production systems and endogenous demand.



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## System Dynamics Student Projects as Quality Improving Process

We have been teaching system dynamics to Master students of Information and Communication Technology and Master students of Industrial and Information Management for six years. To improve the quality of student performance in the courses we have defined student projects requiring as first step in the project work an explicit definition of project goals and formulation of quality criteria for self-evaluation of the projects by the students. Students are required to apply the self-evaluation criteria to guide their project work and to include in their report a final evaluation of their project. We describe our methods and how our approach has improved from insight derived from our experiences. Generally speaking the students' quality of work improves during the term and the examination grades are consistently and repeatedly better than for traditional approaches in past experiences. On the other hand, a significant number of the students complain that the system dynamics course demands from them significantly more effort than what they perceive as justified. Our approach is still evolving. We are interested in criticism and potential collaboration with other institutions.

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## Deregulation: New Understandings, New Responsibilities

Deregulation has created notable successes. But as time passes, notable flaws have emerged in several deregulated industries. Three cases, in electrical power, rail transport and broadband telecommunication, illustrate both the nature of the problem, and an analytical approach for understanding and mitigating the unintended consequences of deregulation. The nature of the problem is unexpected consequences in patterns of investment, which in turn impacts prices and level of service. Often, all of the stakeholders, corporation and consumer alike, suffer. The analytical approach is System Dynamics simulation, which has proven to be a reliable method to address these complex issues. Investment response under different regulatory regimes in the three cases is modeled variously by classic SD decision rules, and by (appropriately constrained) optimization. The simulation analysis accounts for historically observed unexpected investment behavior, and offers guidance on how to avoid the undesirable aspects. The responsibilities of both corporations and regulators would seem to call for the use of System Dynamics in considering further regulatory changes.

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## Quantification Makes Sense Even When Empirical Data Is Limited: A Model of the Bhopal Crisis

Quantifying and simulating formal models can be useful even when empirical data is limited. Models which are developed without extensive calibration against real world data are called 'conceptual simulation models'. When used with caution, additional insights from quantification, formulation of policies and simulation analyses outweigh potential problems regarding the external validity of such models. The discussion is exemplified using a conceptual simulation model of the Bhopal accident, which was developed to investigate the linkage between system's structure and bounded rational behaviour of agents.



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**Modeling Innovation-Based Approaches to Climate Mitigation**

Mitigation, decrease of greenhouse gases, is often regarded as expensive and as a major hurdle to innovation and economic development. Here we describe a systems model that allows to assess integrated policies for mitigation and economic development. It is highly likely that such policies might give gains instead of causing costs, up to a considerable decrease of present emission. This model, and this expectation, is based on accepted knowledge regarding costs of mitigation. The model describes interrelationships between three complex realms that are at the heart of innovation: human knowledge, new key people with the new knowledge of a new basic innovation and the economy. Real policies usually can only succeed if they address, simultaneously, appropriately, and in an integrative pattern, all three realms. Development and assessment of such policies might help overcoming the present deadlock in mitigation. Through such policies it should become possible to decrease risks in innovation and to learn to utilize innovation not only for economic growth but, simultaneously, for decrease of emissions of greenhouse gases. But such integrated policies are fairly complex to develop and to assess. The regionalized global model on innovation and mitigation described here should, eventually, help to facilitate this process of integrated successful policy development.

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**A System Dynamics Approach to Modeling Business-to-Business Markets: The Case of Siemens**

This study focuses on estimating the size of the electrical and electronical market, i.e. electromarket of Siemens Turkey using system dynamics modelling. Corporate management has recognized the need of a comprehensive model of the electromarket in Turkey, due to the dynamics of the Turkish market, consolidating the data of nine operating groups in different business areas. The backbone of the model resides in the dynamic relationship between served, unserved and inaccessible segments of each electromarket. Nine models have been constructed for groups that operate in energy, telecommunications, medicals, transportation, and automation industries. Each model is converted to a management flight simulator giving each operating group manager the chance to simulate the results of their governance of the group's electromarket. The final deliverable is a consolidated management flight simulator, which will be a support tool for exercising different market approaches and strategic options for corporate management.

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**Exploring Structure-Behavior Relations: Eigenvalues and Eigenvectors versus Loop Polarities**

The main motivation behind this study is to clarify the distinction between the loop polarities and the eigenvalues/vectors of a system in the context of system behavior. To this end, the phase plane analysis is utilized to emphasize the need for the system dynamics practitioners to use more of the already available analytical tools in studying structure-behavior relations. The main advantage of phase planes is that one can observe the motion of

system state on a space defined by system structure. Particularly the eigenvectors characterize the system structure on this space and create trajectories for the system state to follow depending on the initial conditions just like magnetic fields created by a magnet. It is also shown how investigating phase plane clarifies issues such as positive loops giving rise to goal-seeking or oscillating behaviors. The analysis is accompanied with the corresponding system stories. The main disadvantage of the phase plane approach is that at most three states can be represented at the same time on a phase plane.

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## **A Principle on Structure-Behavior Relations in System Dynamics Models**

Can a negative feedback loop take part in the generation of exponential growth? This study examines such questions and consequently presents a principle regarding the roles of feedback loops in the unfolding of system behavior for second-order linear models. In general, uncovering system structure-behavior relation is crucial in understanding the functioning of a system. In this paper, using the eigenvalue elasticity analysis, it is shown that associating loops with certain behavior modes based solely on their polarities is misleading. Six linear second-order models with similar structures are used as examples in the analysis. The models consist of three feedback loops. The resulting principle suggests that the relative locations and magnitudes of feedback loops have more significance than their polarities in the generation of system behavior. The principle may seem to state the obvious for some readers; however, its significance is its reliance on a concrete analytical analysis. There is potential for the formulation of more such principles especially for higher-order systems.

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## **Systems Thinking Curriculum as Strategy**

The number of Industrial Engineering Departments has recently grown to more than 30 in Turkey, and competition for good students is tough. Most departments follow conventional industrial engineering curricula based on the North American model where systems concepts and systems thinking are not as much in focus as quantitative analysis and mathematical modelling. The IE Department of Middle East Technical University has a tradition of emphasising the systems approach and has recently decided to develop an educational strategy by expanding and building upon this tradition. It is thought that emphasising critical systems thinking is a prerequisite for making effective use of mathematical models and for effective IE practice. This paper reports on the methodology and the process of curriculum planning as strategy.

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## **Human Resource Modeling Using System Dynamics**

Effective human resource planning allows management to recruit, develop and deploy the right people at the right places at the right times to fulfil both organizational and individual objectives. Firms are constantly looking out for strategies to cope with staff shortages which is particularly acute in the "knowledge intense" industries due to high staff turnover. This paper describes how System dynamics may be used as a tool to model and analyse the human resource planning problems associated with staff recruitment,

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staff surpluses and staff shortages. An integrated system dynamics framework is discussed. The Inventory and Order Based Production Control System (IOBPCS) construct has been introduced to develop various feedback and feed forward paths in the context of human resource management. The model is mapped onto an overseas petrochemical company's staff recruitment and attrition situations and subsequently tested using real data. Strategies for HRP are developed by conducting time based dynamic analysis. Optimum design guidelines are provided to reduce unwanted scenario of staff surplus and/or shortage. We anticipate that system dynamics modelling would help the decision maker to devise medium to long term efficient human resource planning strategies.

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**Modeling Capacity Requirements for BBC IT Services Storage Area Network: Experience and Research**

The research provides BBC Technology Ltd with a system dynamics model as a decision support tool that can be used to facilitate the understanding of capacity storage utilisation. The model creates learning environment that enables efficient and effective management of the storage area network (SAN) capacity in different planning time frames. The results have significant implications for long-term capacity investment decisions for IT Service managers and capacity planning managers.

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**Simulating Hamlet: A Critique**

This paper explores the implications of the use of System Dynamics models in drama. It examines the model used in Pamela Lee Hopkins' "Simulating Hamlet in the classroom". The paper addresses this issue from a literary, rather than a modelling, perspective. It begins by discussing two general issues in the use of SD modelling in literature. Two aspects of the model, motivation and evidence revelation, are then examined against evidence from the text, supported by some historical information. Some of the difficulties inherent in modelling drama are highlighted and the paper concludes that the model does not adequately capture the complexity of the play because SD modelling is not an effective tool for literary analysis.

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**Using System Dynamics to Analyse Health System Performance within the WHO Framework**

The World Health Organisation has developed and refined a considerable body of work on Health Systems Performance Assessment, reflected in the World Health Report 2000 on comparing countries' health systems and ongoing worldwide debate. This paper contributes to this debate by presenting an overall System Dynamics simulation of the key features of the WHO framework, including some feedback interactions among financing, resource generation, service delivery and stewardship which affect healthcare systems performance and the aggregate and distributional effects on health status and outcomes. The model is calibrated using Australian healthcare statistics trends over the past 40 years and explores what-if simulations over the next 40 years. It discusses the current status of work in progress to clarify the wider issue of the contribution of the health system to the overall well-being of individuals, groups and the nation. The gaps in theory and practice and contentious areas for ongoing research and refinement are explored and potential future enhancements of the simulation are discussed. These enhancements include: More compelling and engaging

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animations and their potential to influence public debate about health policy; Including datasets and comparisons among other developed countries; Health systems evolution in developing countries; and Global health policy options and debates.

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## National Medicines Use Dynamics: Influencing Health Policy with System Dynamics

The Australian Government is required to report every five years on the impact of current fiscal policies on future generations. The first Intergenerational Report (IGR) in 2002 projected future Federal income and expenditure for the next forty years based on expected demographic changes due to the baby boomers effect of increased fertility rates from 1946-1973. The projected growth in GDP was 2.5 times while the federal Government outlays on prescription medicines through the universal Pharmaceutical Benefits Scheme (PBS) was expected to grow fifteen-fold by 2042. We developed with The National Healthcare Alliance a system dynamics model of a broader view of future medicines use. This joint model replicated the IGR case as context, with additional detail on drivers of new drug use, feedback of benefits of medicines use on macroeconomics, and structural changes in over, under and mis-use of medicines over the next four decades. Main findings are: IGR projections are sensitive to assumptions, especially workforce participation and productivity growth; effective medicines use contributes to National Health and Wealth, and this contribution depends on the level of under-use, overuse and misuse of medicines. The results from this System Dynamics modelling formed the basis for a 2004 Federal Budget Submission to Treasury from the Alliance.

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## Productivity Challenges of Food Manufacturing: A System Dynamics Analysis of Demand Uncertainty and Value of Time

Managing the supply chains of fast moving consumer goods includes industry specific challenges. For instance food products may have very short life cycle although the routing from factory to distribution centres and finally to wholesale can include several options. Due to competition in the market, there is very much pressure on cost effectiveness. The delivery time is also crucial: the value of the product may disappear in 7 to 14 days. The productivity of food manufacturing may be sensitive to product mix variations too. This paper presents a productivity analysis of a food supply chain, which illustrates some managerial implications. The key elements of the model are the value of the delivery time for the wholesale and the manufacturing costs. There are certain trade-offs between capacity utilisation and lead-time performance. The results of the model suggest the value of sales time to be very important for the retail. By using make-to-order type of production, the total supply chain could create more value for the retail customers.

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## Development of a Measurement Tool for System Dynamics-Based Learning Activities in Business Subject Matters

Learning activities based in the System Dynamics approach are intended to be supportive for learners. A core objective is to elaborate the understanding of complex subject matters. In that respect researchers are exploring the

effectiveness of different sd-based learning approaches e.g. ‘using’ versus ‘building models’. A diagnostic instrument for sd-based learning approaches has recently been published (Hillen 2004). The central question has been at which level of higher order thinking the students were able to express their learning residue. From a system dynamics view the existing diagnostic approaches which stress declarative knowledge or sometimes structural knowledge seem to be insufficient because of the missing perspective to feedbacks and to dynamics. In the developed approach the policy concept sensu FORRESTER (1968) becomes interpreted as a quality of knowledge and represents the basis of the diagnostic approach. To be able to define an appropriate policy or to be aware of policy concepts is probably an essential competence in business administration. This meets the demands within enterprise settings. Moreover the use of the policy concept avoids a break between the learning and the measurement approach. To take this concept into consideration can be seen as an advancement for measurement approaches.

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### **Modeling the Dynamics of Health Care Services for Improved Chronic Illness Management**

System dynamics models have shown considerable value for planning and designing chronic illness management (CIM) programs. Such planning should take into account the need for sufficient capacity in health care delivery systems to accommodate the additional workloads created by CIM programs. Without the necessary capacity, feedback effects may undercut the effectiveness of these programs or even threaten their viability. After discussing, in the form of general propositions, the interplay between CIM and delivery system capacity, we present two relevant SD applications. One uses a model of a diabetic patient population to evaluate the contribution of clinical care specialists, community nurses who assist patients in a CIM program. The other application uses a health care simulator to demonstrate the need for coordination between improvements in care delivery and the implementation of CIM programs. The paper concludes with a discussion of future work that can be done in this area with system dynamics modeling.

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### **Modeling the Consequences of Major Incidents for Health Care Systems**

Health care systems are complex entities that are difficult enough to operate under normal circumstances. Catastrophes such as natural disasters or terrorist acts can have severe impacts on health care systems by overloading them with casualties. At the same time, these catastrophes can greatly reduce health systems’ capacity for dealing with this demand by damaging health care facilities or causing a loss of critical services such as electric power or telecommunications. This paper describes a System Dynamics model that has been used to simulate the effects of major incidents on health care systems. The model can simulate a variety of events from tornadoes or explosions that occur in a short period of time to epidemics that evolve over a number of days. These events can be simulated with or without assuming damage to health facilities and injuries to health personnel. An important use of the model is evaluating various investments that can be made (e.g., backup capacity, stockpiles of pharmaceuticals) that reduce the vulnerability of health care systems to these incidents. The model can be used as a standalone simulator or in connection with models of other critical infrastructures.

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## Staff Retention and Job Satisfaction at a Hospital Clinic: A Case Study

In this study system dynamics has been used to explore staff retention and job satisfaction at a maternity department, which was in an unfavourable spiral of attrition after an expansion period. This raised the issue about how to stop this downward spiral. To understand and explore this a causal loop diagram and a system dynamics model were developed, integrating factors of attrition and hiring rates, workload and qualitative contents of the work. The causal loop diagram shows an unbalanced system, which may spiral favourably or unfavourably after a relatively small disturbance. The system dynamics model shows that an unfavourable spiral may be reversed by qualitative interventions. The conclusions are that system dynamics is an interesting method, which may increase the understanding of the factors determining staff retention, job satisfaction and work pressure in a hospital setting. There is need for further examination of the qualitative factors incorporated in the model.

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## The CDC's Diabetes Systems Modeling Project: Developing a New Tool for Chronic Disease Prevention and Control

The analytic tools presently used for planning and evaluating health policy are not well suited to capture the dynamic complexity of chronic diseases, which involve long delays between causes and health consequences. To explore the potential of system dynamics for addressing chronic disease policy, the U.S. Centers for Disease Control and Prevention (CDC) commissioned a dynamic model of diabetes prevalence and complications that can be used for designing and evaluating intervention strategies. The rapid growth in diabetes in the U.S. and elsewhere has been driven by a similarly rapid growth in obesity, which is a leading risk factor. The model was developed through a series of meetings over several months with participants from the CDC Division of Diabetes Translation and other Divisions with relevant expertise. The CDC and other public health stakeholders may use the model for policy analysis at the national, state, and local levels.

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## Managing a Prosecutor's Domestic Violence Caseload

This paper summarizes a single case study design of a prosecutor's office from 1998 to 2001 using a system dynamics modeling approach. Data sources for the model building included numerical time series from the prosecutor's office Violence Against Women (VAW) database, key informant interviews, and police reports. The specific problem modeled was the prosecutor's office could balance two competing goals: managing caseloads and resources while trying to increase accountability. The study



proceeded in three distinct stages: descriptive models of the problem, baseline model of the case flows, and revised model based on key informant interviews. The main results included finding support for the hypothesis that case dispositions were being affected by caseloads and the existence of a feedback loop explaining the increase in female victims being arrested.

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**A System Dynamics Approach to Conflict  
Resolution in Water Resources: The Model of the  
Lerma-Chapala Watershed**

A System Dynamics simulation model of the Lerma-Chapala watershed, in Mexico, was built to develop an improved Surface Water Distribution Agreement among five states of the Mexican Re-public and the national water authorities. The model, the main analytical tool in a politically charged and confrontational water resources allocation, has proven to be very useful for conflict resolution because: [1] it presents an objective vision of the complex reality being analyzed that enables its user to focus on the watershed behavior; [2] it allows the stakeholders of this process to test the policies that they deemed most im-portant to their own states, and [3] it enables policymakers to examine the economic, social, environmental and political impacts of the hydrological policies being considered.

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**A System Dynamics Model for the Financial  
Problem of the National Health Insurance in  
Taiwan**

The National Health Insurance (NHI) program was officially launched in Taiwan on 1 March 1995. The initial balance of revenues and expenditures was stable, but there was a deficit from 1998 to 2001. Therefore, the Bureau of NHI (BNHI) carried out some measures such as implementing the global payment system, raising the premium rate and expanding the payroll-related premium base. Although there was a surplus during 2002, what are the long-term influences of these policies?

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**A New Tool for Improving Planning Capability of  
Local Government Staff**

The key issue facing local Japanese government is improving the planning capability of local government staff; municipal governments in particular want to do more but lack the geo-political power. For example the city of Tatebayashi, as well as the towns of Itakura and Meiwa located in the Gunma prefecture are not well known to many Japanese people. Unfortunately, these areas have long been ignored and without any serious political representation mainly due to their geo-political location. Under such conditions, improving the planning capability of those municipal governments is required to further develop the local economy using the present resources of the tourist industry. Professor Makoto Ikeda and Mr. Kunio Nakamura developed a new Japanese ST/SD tools, SimTaKN, for support developing models more easily. Using this new software in alliance with municipal governments, referred to as MIT, an abbreviation of the towns of Meiwa and Itakura, and the city of Tatebayashi, staff of the MIT created very excellent plans. In this poster session, we hope to introduce how new SimTaKN software is useful for developing ST/SD model and how

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it could improve the planning capacity of Japanese local government staff using the case studies of MIT.

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## **System Dynamics as a Useful Tool for Value Engineering**

Value Engineering, Value Management and Value Analysis are terms which refer to function oriented problem-solving techniques that have been successfully applied world-wide to reduce costs, improve performance and quality, and “add value” to products and services. System Dynamics technique is used to study the dynamic behavior of a variety of complex systems. This paper describes how system dynamics models can be created to model changes and that occur in value over time. There are many parameters were used to monitor changes in value that occurs as supply and demand change. The value of all of the products is changed during time. Some of them are changed in a short period of time for example day and week, however the other period changes are years and decades. It is important that this behavior can be simulated during this periods and System Dynamics helps us to model all of these situations for the related model. Keyword(s): System Dynamic, Value Engineering, Value Management, Value Analysis, Simulation.

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## **System Dynamics Modeling to Propose Educational Policy and Computational Tools**

This article presents a system dynamic model to represent the learning process. The basis of model was proposed at the beginning of author's work in educational software, and a former version was published in IV Spanish American Educational Software Conference, in 1998. The present stage results from theoretical research in education, implementation of the model thru systems engineering projects, and rationalizing ideas ten years after the start. The objective is not to give an exact quantitative measuring of learning, but to understand its qualitative behaviour, which as occurs with all systems, emerges because of the system structure, not because of the parts.

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## **Assessing Strategies for the Market Introduction of Natural Gas Vehicles in Switzerland**

The market introduction of cars fueled with natural gas, a technically and economically mature option to reduce air pollution, was studied for Switzerland. Worldwide experiences have shown that the market introduction is a complex dynamical problem. The process demands well timed actions and investments of numerous stakeholder groups, from car industry to gas companies and fueling stations, whilst economic chances and risks are distributed highly unequally. Stakeholder analysis and system dynamics modeling techniques were used to characterize the system. The developed model incorporates all relevant stakeholders, and shows the consequences and indirect feedbacks of their possible actions. It enables to simulate numerous future scenarios and test different market stimulation policies, yielding a better understanding of pitfalls and success factors. Analyses identify difficulties in the market penetration process of gas cars. For example, a critical balance between fueling station upgrade investments

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and gas car sales is needed. The approach of this balance is challenged by a short supply of car types running on gas, unclear profitability expectations for fuel station owners, and limited financial benefits for customers. However, a considerable variety of policy options exists to foster successful market introduction.

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**Impediments to the Understanding of a Simple Dynamic System**

Reasons for the weak ability, demonstrated by Jensen and Brehmer (2003, *System Dynamics Review*, 19, 119-137), of undergraduate psychology students to achieve a balance in a predator-and-prey system, were investigated. Efforts to overcome identified obstacles by interface design met with little success. A new study examined whether the participants were at all able to understand the information provided, and they were. A subsequent study investigated why the participants still did not benefit from the information. Their results indicated that the participants were confused when seeing the system as a whole. Their interpretations were more varied than one might expect for such a small system. Creating shortcuts to the understanding of dynamic systems does not appear feasible (perhaps the participants simply lack natural understanding of such systems that can be elicited by such short cuts). Efforts are probably better spent on finding efficient ways of teaching system dynamics.

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**Enrollment Management Dynamics of Adult Undergraduate Degree-Completion Business Programs at Private Universities**

This paper presents a general system dynamic model for enrollment management of adult undergraduate degree completion programs at private institutions. It focuses on a university goal of maintaining a quality business education program given the rapidly changing business environment and shifting demographics of the prospective student population. The model is based on experiences of the authors with undergraduate degree completion programs at two different private universities in California. The model is concerned with the structures and decision points within the university which create a successful program in the 'good times', but fail to anticipate and build for the 'bad times'. It is time to use system dynamic tools to focus on characteristics which could stabilize enrollment for these degree programs. We recommend that management explore strengthening student, faculty and infrastructure quality, developing strong alumni programs for its graduate, and supporting adult students through scholarships.

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**Findings From Four Years of Bathtub Dynamics at Higher Education Institutions in Stuttgart**

The 'Bathtub Dynamics' tasks, first introduced by Linda Booth Sweeney and John Sterman in 2000, have been widely used by the System Dynamics community around the world to challenge people's stock and flow thinking before being taught SD. Students at schools and universities have been taught 'Bathtub Dynamics'. The instructors' motivation was often to enlarge the sample size and hence to participate in the longitudinal analysis started by John Sterman and Linda Booth Sweeney and also to learn about their own students' systems thinking skills. We have been taking part in this

ongoing research project since Fall 2000. The present paper discusses the recent results of 'Bathtub Dynamics' at the Universität Stuttgart and at the Stuttgart Institute of Management of Technology (SIMT). Overall, students' performance was poor and therefore confirms previous studies. The results contribute to the research as the two groups studied were very different regarding the demographical data and also performed differently.

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## **Modeling General Motors and the North American Automobile Market**

This article discusses General Motors' North American Enterprise Model, a system dynamics model of the entire North American automobile market. The Enterprise Model takes a broad look across the corporation and its marketplace, combining internal activities such as engineering, manufacturing and marketing with external factors such as competition for consumer purchases in the new and used vehicle marketplaces. Eight groups of manufacturers compete monthly for a decade across eighteen vehicle segments, making segment-by-segment decisions about price, volume and investment. The model enables Monte-Carlo analysis of alternative strategies. The goal is to find and assess the likely impact of improved strategies for managing the business that are robust across uncertainty about consumers, competitors, and the macro-economy. This article presents a high level overview of the model. We discuss why and how the model was built and what sorts of results came from it. We discuss software tools we wrote to supplement Vensim: a profiling tool for finding inefficient equation formulations, and a syntax coloring tool for automatically color coding Vensim sketch diagrams according to selected criteria. Finally, we discuss the limitations of the System Dynamics paradigm for large models, and how Agent Based Models might complement traditional system dynamics.

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## **Community-Level Systems Thinking**

Regions are evolutionary and dynamic, and examining the notion of sustainability requires a new way of thinking about systems and communities. Improving the sustainability of a region must take into account the interconnections and interdependence of the economic, social, environmental and governance systems. Pursuing the goal of sustainability requires continual monitoring and reassessment. The Regional Development Futures (RDF) framework developed by a multidisciplinary group of scientists in Australia is being used to develop location-specific sustainability options. The methods and techniques combine systems thinking and collegiate research approaches. The RDF provides processes that ensure 'the future is everyone's business', as well as simulation modelling underpinned by quantitative data to allow evidence-based decision-making. A central feature of the framework is ensuring regions acquire the systems processes, skills and systems tools to ensure sustained learning. Examples from a number of case studies are used to demonstrate the usefulness of the approach.

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## **Corporate Restructuring Dynamics: A Case Study Analysis**

Corporate restructuring has recently been subject to vast criticism on the grounds of the low turnaround success rate and the high level of insolvencies. Our analysis goes beyond this discussion by investigating the

inherent complexity of restructurings as a critical success factor with a particular focus on portfolio restructurings. Based on theoretical findings we develop a system dynamics model for a case study in portfolio restructuring. Thereafter, we evaluate this research approach in the outlined context and derive a roadmap for subsequent research. Results of the analysis indicate that the complexity of restructurings can be reduced to a reasonable level with a system dynamics model. Further, the model enables a comprehensive sensitivity analysis that allows management to develop an intuition for the underlying dynamics. The key implication is that managers should consider system dynamics models complementary to conventional modeling, as the conceptual and numerical benefits can outweigh the related costs.

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**Development of a Reference Mode for  
Characterization of the Salinity Problem in the  
Murray Darling Basin**

Reference modes are the patterns of dynamic behaviour produced by feedback structures linking variables considered key to a specific problem. Identifying reference modes can be a challenge when data is scanty or available from a variety of sources and presented at different levels of aggregation. Lack of unequivocal reference modes can lead to ambiguity and conflict among stakeholders. This paper describes an attempt to identify and specify reference modes for the problem of dryland salinity. The method suggested by Saeed (2002) was applied. Dryland salinity in the Murray Darling Basin of Australia is used as a case study. The extent of the salinity problem in the Murray Darling Basin is described. Sources and availability of data for key salinity parameters are then evaluated. Insights gained from application of Saeed's method are discussed. Shortcomings of the method can be reduced through extensive and close involvement of stakeholders right from earliest stages when attempting to identify the preliminary model boundary.

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**Operational Challenges that Confront the  
Profitability of DSL for Internet Service Providers  
in Egypt: A System Dynamics Approach**

The Digital Subscribers Lines (DSLs) services were considered one of the most important sources of revenues that the Internet Service Providers (ISPs) used to depend on in generating profits. Since the evolution of the Internet DSL services in Egypt in year 2000, the market had witnessed several transformations that ended up with the introduction of the Asymmetric Digital Subscriber Lines (ADSL) model in January 2002. The ADSL technology in the Egyptian Internet market had arrived accompanied with negative effects on other dedicated DSL services. The researchers worked on analyzing the challenges that affected the profitability of the DSL for the ISPs in Egypt from two levels a macro level which includes all the challenges whether external or internal and a micro level which focuses on the operational challenges only. A system Dynamics methodology has been adopted in this paper. At the end, data gathered from interviews as well as secondary data was fed into a system dynamics model, in order to be able to predict the effect of changing any of the operational variables and its effect on the profitability of the DSL.

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## Toward a Concept of Dynamic Fit in Contingency Theory

This paper utilizes System Dynamics (SD) methodology to preliminary assess recent dispositions for dynamics and disequilibrium in Contingency Theory (CT). These are important, since CT has received continuous critique for being insufficient in explaining structural adaptation. Focusing on the design process, our analysis finds that these dispositions seem to have substantial potential for dealing with dynamics. However, we also find that existing CT research strategies on organizational fit are rendered inapplicable to such dealings. We therefore propose a concept for dynamic fit and sketch two different strategies for its implementation in future CT research; one for axiomatic and one for applied research. We conclude the paper with an agenda for future research, demonstrating the role which SD may play in its implementation. Key words: Structural organization design; Contingency Theory; System Dynamics; Fit; Viability.

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## Warehouse Optimization in an Uncertain Environment

This paper describes the warehouse stock optimization using two optimization algorithms for products belonging to different classes according to ABC and XYZ analysis. For simulation mathematical tool Matlab was used. The basic system dynamics model of the warehouse was built according to system dynamics methodology and then validated. Several ordering strategies were analyzed with a goal of producing lower total warehousing costs than the actual costs provided by the observed company. Together with total costs two restrictions had to be considered: no stockouts should occur and the warehouse capacity should not be exceeded.

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## SimTour: The Simulation Model of the Foreign Tourist Flow to France

The simulation model SimTour was elaborated on the demand of the French Ministry of the Tourisme to make possible the tests of various scenarios of the foreign tourists frequentation evolution in France at a 5 -10 years horizon, and more anticipate the actions to be carried out. SimTour is the System Dynamics model. The model approach presents the following aspects: Potential Market trends of the tourists, Evolution of the capacity and reception quality for the tourists in France, Evolution of the capacity reception quality for the tourists in the competitor countries of France, Relative Attractivity of France and another competitor countries, Generation of the tourists flows. The SimTour model was created and calibrated by using Vensim software. Two types of the scenarios were tested with the SimTour model. The various tests of sensitivity of the model's parameters and then the simulations of the contrasted scenarios showed a reasonable and coherent model behavior: all the subsets react in a coherent way with the variations of the parameters and the decision's variables.

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**Processes and Determinants of Rural Development in Switzerland**

In peripheral micro-regions in Switzerland, population decline, demographic change, and a narrowing economic base constrain future development perspectives and threaten the fulfilment of the national policy goal of a decentralised settlement. At the same time, Swiss regional policy is undergoing fundamental changes. Instead of distributive measures, emphasis is given to the competitiveness of rural localities and to local initiatives. This implies an increasing need for policy concepts and analyses based on an integrated view of the processes and actors affecting rural development. The paper focuses on the local dimension of employment and population dynamics in rural Switzerland and on an ex-ante analysis of development perspectives. The simulation model developed for this purpose is based on the literature in regional economics and rural studies and combined with insights from related fields such as urban dynamics and innovation management. Model analysis emphasizes the need for national and regional policy concepts that focus on the support of local actors to bring about new development routines.

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**Investment Cycles in Newbuilding Market of Ice-Strengthened Oil Tankers**

Investment cycles and their modeling have been under interest of system dynamics from its early days. Most often these cycles are caused by the uncertain profitability expectations involved in the long-term large capital investments as well as delayed manufacturing process of these needed buildings, machines and/or equipment. This paper is concentrated to the investment decisions of newbuilding market of class I A ice-strengthened oil tankers. In the European oil transport market these tankers are required only in the Baltic Sea region, and especially in the oil terminals of Gulf of Finland. The demand for capacity of these special class tankers can be derived from the handling capacity available in the most important Russian oil export terminal, Primorsk. However, in the near future planned capacity enlargements in Primorsk will create additional dynamics for the results. According to the simulation results we argue that terminal capacity could not be used in full scale in the near future, if the use of appropriate ice-strengthened tanker capacity is favored. If this ice-strengthened policy is followed, this class of tankers will face boom in newbuilding market, which is estimated to last at least for next ten years.

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**An Attempt to Better Understand Waste Recovery Policies in a Solid Waste Management System in Cambodia**

There is an economic reason to extend the useful life of the landfill because once the old landfill is filled, the new one can be found only at greater distance, and this increases remarkably the transportation cost. Therefore, waste has to be recovered as much as possible. To do this, in developing countries context, small scale composting promotion is widely accepted and the contribution of informal recycling is also widely recognized. The question remains to what extent waste can be diverted if these two sectors are integrated into the waste management system. Can composting and informal recycling contribute significantly to the waste diversion without

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other supporting policies? To create a platform for discussion and learning, a model is established. The model in this paper is based on the system dynamics (SD) approach. The simulation results with the data collected in Phnom Penh city, Cambodia, show that waste recovery through small-scale composting and informal recycling cannot contribute significantly to the waste diversion without other supporting policies.

## **Dynamics of Competitive Industries: A Micro Behavioral Framework**

Most published work in business dynamics is conducted either at the level of the individual firm or at the level of an industry comprising an aggregate of similar firms. However, there are situations where the performance of industries is better understood by modelling the behaviour of competing individual firms. When firms in the same industry adopt quite different views of the best set of resources and the overall system of resources in the industry is tightly interconnected, it is important to model the heterogeneity of rival firms. We propose a micro-behavioural approach that captures the essential interactions between firms. To illustrate our approach we run a series of experiments using Fish Banks, Ltd. to show the wide range of firm and industry performance arising from such heterogeneity. We further develop our micro-behavioural approach into a framework for understanding the dynamics and evolution of industries based on selected ideas from system dynamics, the resource-based view of the firm and managerial cognition.

## **Simulating the Evolution of Industries Using a Dynamic Behavioral Model**

Investment decisions determine that not only the evolution of industries is hard to forecast with certainty but also industries may have different dynamic behaviour and evolutionary paths. In this paper we present a behavioural framework to simulate the evolution of industries. Two factors determine the dynamic behaviour of an industry: managerial decision-making and the interconnected set of resources. Managerial decision-making significantly affects the dynamic behaviour of firms. Bounded rational managers define rates of asset stock accumulation to achieve a competitive advantage using different mental models. However, the set of interconnected internal and external resources existing at industry level affects the expected performance of the firms. Consequently, the effect of the feedback structure existing in the industry, which consists of managers in competing firms making similar decisions over an interconnected set of resources, determines that the dynamically contingent behaviour of firms influence on the industry evolutionary paths. In our simulations, we found that simple managerial choices, such as the definition of a market share or an expected market size, lead to diverse firm and industry performances even though management of competing firms emphasises different sets of resources required to carry out their strategy.

## **Movie Marketing Strategy Formation with System Dynamics: Toward a Multi-Disciplinary Adoption/Diffusion theory of Cinema-Going**

This paper proposes a formal theory for the causal mechanisms underlying viewing figures for cinema films. It draws upon a range of diffusion theories, introducing them by using specific illustrations from sociology,



epidemiology and marketing. These theories are employed in the construction of a system dynamics model which is then used to explore the marketing of movies. In this model these mechanisms are used to represent interest-based word-of-mouth effects, advertising, experience-based word-of-mouth effects, positive network externalities and disengagement. The model generates a range of behaviour modes and these are described. They offer one possible explanation for why the product lifecycle of many movies is relatively short. By demonstrating the relevance of the various model mechanisms to this particular phenomenon the paper also re-emphasises the isomorphic nature of the constituent diffusion theories. Finally, the model also has potential both for further extension and for use in supporting policy making in the actual social system that was modelled.

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**The State of Education: An Examination of  
Systems Thinking in the K-12 Environment in the  
United States**

The movement to integrate systems thinking into the pre-college curriculum has been championed by Forrester, Senge and Richmond and has been supported by a variety of groups. These efforts have had a clear impact upon some schools and classrooms. The implementation leaders in the schools, such as Fisher, Heinbokel and Potash, and Sheetz, have, at times, encountered and overcome resistance to adopting a systems thinking approach. This poster presentation will review the initial findings of interviews with individuals involved in advocating and introducing the use of systems thinking in the pre-college classroom. Using the Apple Classroom of Tomorrow research as a framework, we have examined the phases that teachers have passed through; entry, adoption, adaptation, appropriation and invention, as innovations have been introduced into the schools. We have probed the thinking of educators to identify the factors that lead to movement to the next stage of utilization or withdrawal from the system. Our initial model of the spread of systems thinking may be useful to educators and others who are interested in introducing systems thinking into schools.

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**Case Study and Grounded Theory: Sharing some  
Alternative Qualitative Research Methodologies  
with Systems Professionals**

Tensions in practitioner research are endemic and inescapable but if these tensions are embraced rather than avoided, they can often provide access to useful energy and sensitivity, which in turn can be used to inform practice. Systems research professionals adopt a wide platform of research methodologies when they engage in research projects. These research methodologies range from the use of systems computer simulation models to highly developed quantitative statistical models. Some systems researches have engaged the full gamut of qualitative methodologies and others have adopted the soft systems approach. The aim of this paper is to review two methodologies that are available to systems researchers and practitioners and to analyse the effectiveness of these methodologies in gaining valid and reliable research outcomes. The paper will focus on the use of case study and grounded theory as possible methodologies for systems researchers to consider for future research projects. Both methodologies have been successfully used by the authors to gain cultural change in organisations striving to become learning organisations.

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## Tuberculosis Transmission in Settings of High Multidrug Resistant Tuberculosis and Explosive Epidemics of HIV: A System Dynamics Approach

This study sought to determine the impact of an effective programme of control of multi-drug resistant (MDRTB) on a population that is witnessing an explosive HIV epidemic amongst injecting drug users (IDUs) where the prevalence of MDRTB is already high. To analyse this impact, a system dynamics (SD) simulation model representing the transmission of drug sensitive tuberculosis (DSTB), MDRTB, and HIV was developed. The model is used to predict the cumulative number of tuberculosis deaths under two scenarios of programme effectiveness for MDRTB. The simulation results indicate that in the presence of an immature HIV epidemic failure to actively control MDRTB may result in approximately a third more deaths than if effective treatment is given. As the HIV epidemic matures then the impact of MDRTB grows substantially if MDRTB control strategies are ineffective. The epidemiological starting point for these scenarios is present in many regions within the former Soviet Union and this analysis suggests control of MDRTB should be an urgent priority.

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## Resource Allocation Policy Design for Reduced Project Duration

Minimizing duration is critical to success in many construction projects. As a primary driver of progress and an effective management tool, resource allocation among development activities can strongly influence durations. Limitations and costs of improving development processes and increasing resource quantities and productivities make improving resource allocation policies an important source of schedule improvement. Policies for reduced project duration are difficult to design and implement because of closed loop flows of work that generate dynamic demand patterns and delays in shifting resources among activities. Two policy features that managers can readily impact and influence project durations are resource demand estimates and resource adjustment times. These are used to describe allocation policies in a simple system dynamics model. Optimal policies under perfect and limited managerial control are described by testing myopic and foresighted policies across a range of project complexities and adjustment times under both deterministic and uncertain conditions. Counter-intuitive results include that minimum delays do not produce minimum durations, myopic policies can produce shorter durations than foresighted policies, and increasing uncertainty decreases durations under certain conditions. The model is used to explain these results and future research topics are discussed.

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## Green Belt Policy Change and Uninvited Aftereffect in Seoul

This research revisits the basic premises defined by existing UD documents and examines the feasibility of alternative UD models. As a specific example, this research focuses on behavioral changes of urban dynamics if the Green Belt areas in Seoul and the Capital Region as a whole are readjusted. The measurements are based upon a series of simulation works on the urban system, going beyond the traditional triplicate set of population, housing, and business activities. This research estimates that the removal of Green Belt control would definitely exert a significant impact on the urban

dynamics of Seoul. The government-initiated Green Belt cancellation, however, would rather decrease the population size of Seoul and at the same time result in deterioration of overall quality of life (QOL) in the long-run as both Seoul and the Capital Region are interconnected by causal loops. Sensitivity analysis suggests, among others, that Seoul may lose 1.5 million or more people while the rest of the Capital Region would have to accommodate most of the out-migrated Seoul population over the next three decades.

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**Bridging Systems Thinking to Policy Networks:  
An Application to Network Accountability Analysis**

This study intends to propose a combination between systems thinking and policy networks perspective in developing network accountability of contracting out. Systems thinking and policy networks have applied to the field of public policy for many years. Both are considered as new perspectives and analytical tools for public policy analysis. Systems thinking offers an effective and time-tested approach to uncover structural flaws that hinder system performance. The concept of policy networks emphasizes interdependent relations among network participants and encourages policy analysts to focus on the resource exchanges in the network. Both approaches share several characteristics, such as interdependence of the system parts / network actors, multiple objectives in the network/system, power distributed among system parts / network actors, and so forth. In the meanwhile, each of them has distinctive point of view in analyzing the network/system. This paper intends to examine the similar and different characteristics of both approaches. With a goal toward enhancing existing traditional method for public policy analysis, this study intend to explore a strategy of integrating policy networks and systems thinking into network accountability development.

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**Why and How Should We Replace the Tank-Pipe  
Analogy of our Stock Flow Models by a Chemical  
Process Metaphor**

Abstract: At the 2002 Congress, the author presented a stock-flow language replacing the tank-pipe analogy by a generalised chemical reaction. He argued that it results often in more intuitive and less spaghetti-like stock-flow diagrams. The paper was well received by its reviewers but its presentation was disappointing. Despite its confrontational character, it elicited no reactions. Our hindsight was that we focused too much on the new language and not enough on why the current method is unsatisfactory. Henceforth, the present paper presents this detailed study, focusing on tangible flows. Using models in population dynamics we present the basic problem: a spaghetti aspect. We argue that, in addition, they do not match our mental models. We show that a new metaphor, generalised reactions, eliminates these problems. We show how to combine these reactions in an intuitive and parsimonious map which may also be used in other applications like Business Dynamics. We refer to our previous paper for a discussion of the translation of these maps in computational models, "Kinetic Process Graphs or KPGs" which complement the stock-flow diagramming method currently used.

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## An Intelligent Decision Support System (IDSS) for Public Decisions Using System Dynamics and Case Base Reasoning (CBR)

This paper presents the design of an IDSS that allows the decision makers to identify key issues that matter for the future of a social system and helps them to improve the policy-making processes. The implementation is in process. It combines IA techniques with qualitative models and System Dynamics Simulation. The selection of strategies and policies for complex social systems needs to take into account non-quantifiable variables. For this reason, we build models that allow the treatment of these kinds of variables. We propose a methodology divided into three phases. In the first one we build a model and simulate particular scenarios, using this module as an analysis tool. The results obtained by simulation are stored in a database and are used as entries in the reasoning process. So, they are the start point of the second phase. For this phase we use the CBR (Case Based Reasoning) technique. The last phase produces different solutions, giving to the decision maker explanations about pros and cons of these alternatives. IDSS is an instrument to promote and facilitate the attainment of a coherence and consensus between the decision makers.

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## Understanding the Learning Process in Work Groups

Drawing on theories of organizational learning, group learning, group dynamics and effectiveness, and using the system dynamics approach in three case studies of work groups, this paper seeks to improve our understanding of the factors influencing group learning and effectiveness in organizations. I propose that the relationship between group effectiveness and ineffectiveness is not symmetrical and is characterized by an amplification phenomenon. Groups that present a low level of learning tend to enter into a vicious cycle of low effectiveness or to stagnate, while groups that present a high level of learning are able to identify sources of ineffectiveness, manage limitations and implement the necessary changes to recover or to elevate their level of effectiveness. Regarding work groups as complex social systems, I suggest that the explanation of the level of learning and effectiveness of a group lies in the interrelations of structural, cognitive and behavioral factors in interpersonal contexts. Key words: group learning, group dynamics, group effectiveness, leadership, organizational learning, system dynamics.

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## Presenting System Dynamics to Social Scientists: An Economics Example

The social sciences provide a rich repository of open, interesting, and unsolved questions that can benefit from the application of system dynamics (SD). After “solving” a problem, SD researchers must present their results, which is not as straightforward as it might seem. This study describes lessons learned presenting system dynamics results to an economics audience during the publication of Lofdahl (2002) and is organized according to four dicta of Repenning (2003): 1) size your model appropriately, 2) build the intuition of your reader, 3) do your homework, and 4) choose your audience wisely. The study finds that the skills necessary to perform and to communicate system dynamics research can be quite different.

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**High Strong Order Implicit Runge-Kutta Methods  
for Stochastic Ordinary Differential Equations**

The modelling of many real life phenomena for which either the parameter estimation is difficult, or which are subject to random noisy perturbation, is often carried out by using stochastic ordinary differential equations (SODEs). In this paper, a class of high strong order implicit Runge-Kutta methods for SODEs is introduced.

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**Conflict Resolution and Group Decision-Making:  
Exploring the Dynamics of Conflict Resolution at  
the Group Level**

Conflict resolution in decision-making groups is studied using a System Dynamics model. The model is developed using a grounded-theory approach. Some preliminary results are shown. The results seem to be in line with much empirical research done in the management literature about conflict and conflict resolution at the group level of analysis. Ideas for further research are discussed.

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**Emergence of the Governance Structure for  
Information Integration across Governmental  
Agencies: A System Dynamics Approach**

The Criminal Justice Information Technology (CJIT) group of New York State (NYS) was tasked with developing a framework to fulfill the goal of giving users of criminal justice data and information systems “one-stop shopping” access to the information needed to accomplish their mission. The action research team of the Center for Technology in Government (CTG) collaborated for an eight-month period during 2003 with the CJIT group to accomplish this task. This poster session reports on a system dynamics

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model for understanding the dynamics of the social processes and collaboration that took place during this project. This model building effort is looking for the development of a theory of interorganizational collaboration. The model is being developed in facilitated group model building (GMB) sessions with the team at CTG.

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## Scripts for Group Model Building: Modeling the Emergence of Governance for Information Integration across Government Agencies

The system dynamics group at Albany has been developing approaches to decision conferencing using a combination of group facilitation techniques linked to projected computer models in the room for more than 20 years. Over the years, the group has developed a series of pieces of small group processes to build system dynamics models with groups, i.e. scripts. This poster documents the scripts and products for a GMB effort using the approaches developed at Albany from November 2003 to March 2004. The GMB process reported here has several characteristics that make it different from most other experiences in the group. While the common setting involves managers interested in tackling a specific problem, this work involves a research team interested in building theory about the complexity of intergovernmental information integration. Additionally, the reported GMB process has taken place in small sessions of two to three hours, while the common practice at Albany involves intensive one or two-day meetings. In this way, the poster will include general thoughts about the implications of these differences for the GMB process.

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## The Shape of Change: Introducing Teachers and Students to the Basics of System Dynamics

System dynamics has a great deal to offer to K-12 education – much more than building computer models. With the system dynamics approach, students are actively engaged in problem solving, working together in teams, discovering similar patterns of behavior across disciplines, and asking much better questions, all in the process of building and using computer models. But, because this approach departs significantly from traditional teacher-centered methods, and because there is a lot to learn at once, it is often difficult for willing teachers to adopt. Also, for many beginners the technical language, the math, and the computer focus of system dynamics can be early obstacles. In Carlisle, Massachusetts, two Waters Foundation systems mentors have faced this challenge while helping their colleagues use system dynamics in their classrooms. They have developed a series of lessons based on games and other hands-on classroom activities for students in Grades 3-8. Students and teachers learn about patterns of behavior, basic stocks and flows, simple feedback processes, discovery learning, and teamwork. The teachers hope that these lessons will draw a larger audience of teachers to system dynamics, and that some of those teachers will use this foundation to take the next step toward computer modeling. The poster session will present several of these lessons.

## Dynamics of Managerial Intervention in Complex Systems

Research as well as decades of working with managers from diverse cultures, nationalities, and industries has exposed consistent counterproductive patterns of behaviour in relation to decision making in complex systems. In this regard, there appears an unmistakable tendency for managers to “over intervene” in the systems (companies, organisations, units, etc) they are responsible for. Hence, generating unnecessary fluctuations and instability in their organisations. Maani, et al (2004), and Sterman, et al (bathtub dynamics, 2000; supply chain system, 1989) have studied these phenomenon in experimental and simulated environments,



respectively. Anecdotal evidence as well as research results highlight a number of mental models and assumptions held by managers. This paper proposes seven managerial assumptions and will empirically test their validity.

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## **The Theory of Constraints and Systems Dynamics: A Suitable Case for Multi-Methodology**

Prior work using the classificatory frameworks of Mingers, Mingers and Brocklesby has proven useful in understanding the complementary nature and characteristics of traditional Operational Research/Management Science (OR/MS), Theory of Constraints (TOC) and systems methodologies, by examining the philosophical assumptions that underpin them. This paper uses a case illustration to demonstrate how the specific methods and methodologies known as TOC can be used to complement the use of traditional systems approaches involving the associated tools of Systems Dynamics (SD) such as Causal Loop Diagramming (CLD) and to develop a better understanding of operational and strategic decision-making. In doing so, the paper surfaces the systemic qualities of TOC methodologies, methods and tools, and identifies the communality and complementarity of TOC and SD approaches to problem solving.

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## **Membership Growth Goals Meet Demographic Trends: The Case of Hong Kong Scouting**

System dynamics models have often been used to help organizations deal with real or potential problems. This research build a system dynamics model that attempts to link the membership growth goals of the Scout Association of Hong Kong (SAHK) with the reality of a declining birth rate and restrictive immigration policies. The initial model indicates that larger proportions of available youth would have to be attracted to scouting to maintain their current market share with respect to youth served, and this would have to be greatly expanded to accommodate membership growth goals. Without additional immigration or a higher birth rate, the SAHK will have to obtain overall levels of youth participation at almost three times their current level, even with higher quality levels that attract a higher proportion of eligible youth.

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## **Dynamic Balance, Executive Management and Differential Performance: A Resource-Based Approach**

In strategic management literature, strategic positioning and dynamic capabilities have been recognized as rational and deliberate responses by the top management team to a felt need for attaining a new strategic position. This implies a certain delay between the stimulus, acknowledging the

stimulus and a considered response. This paper asserts that executive management steps in to respond to certain stimuli much faster using “dynamic balancing capabilities”. After defining dynamic balancing capabilities, a series of simulation experiments (based on events in the British life insurance industry) shows how heterogeneity in such a capability may lead to the creation of differential performance and competitive advantage among otherwise identical firms. This is the result of differential accumulation in critical resource stocks through varying resource interactions, initiated by the heterogeneity. The conclusion suggests that concepts such as “key success factors” and “best practice” should not be applied universally to a large variety of firms in a given industry. Rather they need to be applied keeping in mind the context that may vary with time.

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**Exploring Change in Organizational Rule Systems:  
Learning Dynamics in Performance Measurement**

The paper uses the case of the performance measurement system of the Job Training Partnership Act (JTPA) of 1988 to articulate an endogenous theory to explore the impact that changes in performance measurement systems have in the way in which these systems evolve over time. A model of how systems of rules in organizations are used and, over time, changed by learning processes and rule-following preferences of their actors is presented. In the model, the principal presents a system that the agent learns how to use (and possibly game) over time. The mutual learning (agent’s learning about opportunities present in the system and the principal’s learning about the problems generated by the agents’ activities) creates pressures to change the system and modify the existing rules. Implications of the model results are presented.

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**Dynamics of Food-Prey-Predator Systems and  
Agricultural Practices**

Crop fields are complex systems where the basic crop interacts with species that feed from it, and are, in turn, depredated or parasited by other species. These relations create a dynamic system with several counterintuitive behaviours. On the other hand agricultural practices based on pesticide application have been subject to debate and the economic benefits of chemical pesticides and their externalities are questioned. This paper presents a food-prey-predator model of an agricultural system. The singular dynamics of this system and the effects of pesticide application on it are studied. There are many examples of agricultural plagues subject to predation, each one having its particular dynamics, but the model presented in this paper is a general one that aims to capture the most general features of pests dynamics. The results show that the prey-predator dynamics is an important fact to take into account if pesticides are applied, the effects of several agricultural practices concerning pesticide application and the development of pesticide resistances are investigated.

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**How to Avoid Global Catastrophe?: The  
Information Basis for Sustainable Development  
Policy and Economy**

To avoid global catastrophe it is necessary to create a wisdom-based global information society, which would be far-sighted and flexible. To achieve sustainable development of the world society it is also necessary to possess knowledge regarding the limits to growth and methods of overcoming them.

For these ends we have to build FEED FORWARD into the world's socioeconomic inter-relationships, based on large development and widespread of the System Dynamics. We need commonly accessible World (integrated and distributed) Sustainable Development Information System for Monitoring, Prediction and Measurable Evaluation - of effects of policy, work and other changes in the life conditions of human- and other beings. These conclusions have been done by means of system analysis with general conceptual model of reality: System of Life, which contains the knowledge about the logic and dynamic of limits to growth as well as means for crossing them in developmental way.

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## **Merger Dynamics: A System Dynamics Analysis of Post-Merger Integration Processes**

Mergers and acquisitions (M&As) have drawn the attention of researchers for several decades now. Manifold viewpoints have been taken and numerous factors apparently influencing the success of an M&A project have been identified, leading to an extensive, yet extremely fragmented body of knowledge. Although the logical strive for integration has been expressed by several authors, in most cases the focus on small sections of M&As persists. The aim of this study is to offer a different way of synthesis that allows to test well-established theories of post-merger integration processes. With the help of a literature-based system dynamics model and by analysing the simulation runs it produces we are able to open up a new perspective on the organisational processes which are dominant during post-merger integration. Particular emphasis is put on the investigation of capability transfers, the change of corporate culture and the employees' perception of the integration process.

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## **Representations of the Chaotic Dynamics of Social Systems: Mathematical Backgrounds**

The general mathematical representation of hierarchical structure of arbitrary system is analysed. Formal description of arbitrary hierarchy is presented. General mathematical properties of the models of social structure are studied. It is that such models are shown to be based on a non-standard analysis. The origin of the probabilistic nature of social systems is studied. The entropy and chaotic properties of the dynamical hierarchical system are found. The general equations of the process of learning as a three-level hierarchical process are presented.

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## **Assessment of the Free Internet Access Project on the Internet Market in Egypt: A System Dynamics View**

In January 2002 a major step was taken by the ministry of communication and Information Technology in Egypt towards increasing the penetration of the Internet through the launch of the "Free Internet" project. New Rules and regulations were imposed on the ISPs of which; sharing their revenue with TE from the Internet calls instead of the subscription fee. The research revealed that telephone and computer penetration has a positive effect on the penetration of the Internet in Egypt. Local content is another factor attracting the users, but e-commerce is not yet mature in Egypt, so it does not actually have a high effect. Although tariff is one of the factors limiting the number of users in Egypt, it is not the main factor. The research also revealed that

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competition between ISPs changed from a pricing competition to a competition over content and differentiation. Data gathered from interviews as well as secondary data were fed to a system dynamics model, in order to be able to predict the future of the Internet market in Egypt in the coming years.

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**Research and Development Resourcing When Faced with Fundamental Market Dynamics**

System dynamics has been used over a number of years to explore and explain the role R&D can play in shaping the dynamics of a firm or industry. This article describes how a dynamic simulation model can be built which broadly characterises and captures the causal feedback structure and performance behaviour inherent to a generic R&D system within a firm. Alternative futures are played out to explore the long-term consequences of a confluence of R&D resource decisions, coupled with changes to market demand.

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**Bringing Systems Thinking to the Spreadsheet**

While introducing Exposé, a new software package add-in to MS Excel, this paper proposes a practical approach to bridge the gap between system dynamics and spreadsheets. The use of spreadsheets has grown dramatically since the release of VisiClac—the first spreadsheet software—in 1979. Despite the widespread application of spreadsheet programs, tools and techniques to support the development of spreadsheet models for complex systems matured at sluggish rates. Exposé brings systems thinking capabilities to the spreadsheet enabling users to understand, audit, analyze, and communicate their spreadsheet applications more effectively. Exposé interacts with spreadsheet in real-time and creates maps of interrelationships in spreadsheets in the form of tree diagrams and feedback loops. It also provides several tools to characterize the nature of the structure including revealing the polarity of the interrelationships; translating cell reference equations into "real equations" with fully spelled-out variable names; identifying dynamic variables and stock variables. For policy analysis, Exposé uses sliders and comparative graphs, both of which are embedded in Microsoft Excel but inaccessible to average users.

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**Dynamics of Strategy: A Feedback Approach to Corporate Strategy-Making and Adaptation**

The paper capitalises on a grounded field study of companies undergoing radical turnaround in their corporate strategies. A set of hypotheses is developed by organising empirical data using system dynamics logics and symbolic language. System dynamics approach provides a theoretical environment within which the forces, tensions, inertia and pressures that shape corporate strategy in organisations are scrutinised. Suggestions are derived on possible pathological unfolding strategic behaviours.

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## The ACMI Adoption Model: Predicting the Diffusion of Innovations

**Abstract** The ACMI (Adoption Curve Modelling Instrument) Model takes two well-known System Dynamics Models and combines them with the sociological theory of Memetics to form an Innovation Diffusion Model that can be used to predict the uptake of innovations within specific target consumer markets.

## Systemic Influences on the Economic Performance of the Ukraine

This paper deals with a systemic attempt to understand the economic transition of the Ukraine which represents a typical former Soviet Republic which gained independence in 1990. Our approach uses a combination of various Cybernetic, System Dynamics and Operational Research approaches. This paper concentrates on the Qualitative System Dynamics approach taken. We give a brief overview of the cybernetic approach explaining our view of production units and production chains. We then explain a major causal diagram that is embedded in the recursive structure of the cybernetic approach. We also explain the appearance of barter by using a causal approach.. The paper illustrates how System Dynamics and can work together.

## Misperceptions of Global Climate Change: Information Policies

Previous experimental studies of people's understanding of climate change and of other renewable resource problems have revealed that people misperceive the basic dynamics and that they favour decisions that are systematically biased in the direction of over-utilisation. In the present laboratory experiment, with 251 students, the focus is on understanding why people misperceive and how misperceptions could be avoided. Using a simulator, the subjects are asked to control total global emissions of CO<sub>2</sub> to reach a given target for the atmospheric CO<sub>2</sub>-concentration. Compared to a previous study we find that full information about a simplified system leads to improved performance, particularly among students with a background in mathematics. Subjects perform better in an analogous, however more easily visualisable system, indicating that they have difficulties forming appropriate mental models of the more abstract atmospheric problem. Two information treatments, thought to improve mental models, turn out to have insignificant effects. Finally, information feedback about the development of the CO<sub>2</sub>-concentration helps. According to our findings, current information from the IPCC and the standard media coverage is not effective in helping people to choose policies that are consistent with their own preferences.

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**System Dynamics Explanations as Mechanisms and some Implications for Theory Building**

This paper introduces a framework to characterize system dynamics explanations. In order to accomplish this task it shows different ways to explain phenomena and underlines the tendency to use mainly causality as the way to do it, illustrating this point with mainstream management studies. Presenting the problems linked with causality the article looks for alternatives connecting ideas of Hayek and Russell regarding explanations and structures. Likewise, the paper presents some implications for theory building. System dynamics explanations are labeled as mechanistic and non-causal ones and are placed naturally in this framework.

**Keep It Simple: A Dominance Assessment of Short Feedback Loops**

Two approaches have been developed to establish a formal link between system structure and behavior. Eigenvalue elasticity approaches take a system-wide perspective and have been based either on ad-hoc selection of loops (Forrester 1982; Kampmann 1996)—resulting in non-generalizable explanations—or on loops formed by the aggregate paths between state variables (Gonçalves et al 2000)—resulting in low-resolution explanations. The second approach, Pathway Participation Method (PPM) (Mojtahedzadeh et al 2004), considers pathways as the building blocks of influential structure, but frequently identifies loops as the structure most responsible for an observed behavior. In this study we show, for various models, that the Shortest Independent Loop Set (Oliva 2003) contains the loops identified as most influential by PPM. Since the SILS is structurally derived, and under most circumstances unique, we propose it as a starting point for Kampmann method to derive complete, granular, and generalizable structure-behavior explanations.

**Representing Heterogeneity in Complex Feedback System Modeling: Computational Resource and Error Scaling**

Heterogeneity plays a critical role in shaping the behavior of many complex systems. In the context of a system exhibiting non-linear relationships, it is not in general possible to design models that capture behavior of interest or permit reliable reasoning about policy impact without explicitly representing system heterogeneity. This paper provides a brief overview of the mathematics underlying the need to represent heterogeneity in non-linear systems, introduces a motivating example, and compares three approaches for representing heterogeneity. Specifically, the paper examines how computational resource demand and error introduced by approximations needed to ensure acceptable resource use scale with growth in the set of heterogeneous characteristics and the level of detail with which they are represented. Our analysis shows that attribute-based disaggregation is best suited to problems in which few heterogeneous attributes require representation or which feature very large population size, while agent-based disaggregation are well suited to problems that require representation of heterogeneity with respect to medium or high numbers of attribute dimensions and population sizes that do not exceed agent population size by more than a few orders of magnitude.

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## **System Dynamics and Dynamic Systems Integration in Regulatory Environments**

System Dynamics evolved from Dynamic Systems, which are often associated with classical mechanical engineering. However, today System Dynamics (SD) and Dynamic Systems (DS) are differentiated in theory and application. We believe that the link between SD and DS shall be reemphasized if not re-established in certain fields in order to advance system development and understanding. In some regulatory environments (e.g. energy, medicine, ecology, and aviation), the integration of SD and DS techniques can be especially beneficial. Many systems and simulations developed in these fields omit important first principal parameters used in modeling a specific problem or task. We believe that the combination of SD and DS can provide for a higher level of precision in the system building process and a better understanding of its fundamental behavior. In this paper, using an example of medical clinical trials, we will demonstrate how SD and DS can be used together to yield more sophisticated models. Key words: system dynamics, dynamic systems, modeling techniques, regulatory environments, pharmaceuticals.

## **Interorganizational Learning: A Dynamic View of Knowledge Development in Strategic Alliances**

The objective of this paper is to develop a dynamic theory of interorganizational learning and knowledge acquisition in strategic alliances. Strategic alliances are becoming an increasingly important organizational form to gain access to new knowledge and to leverage existing knowledge. By establishing an alliance with one (or more) partner, an organization will gain valuable learning opportunities to acquire knowledge and to enhance their competitiveness. The degree with which the partners can realize their learning objectives is dependent on their absorptive capacities and the collaborative strategies adopted by the partners. These collaborative strategies may include the trust between alliance partners as well as the willingness from an organization to share its existing knowledge. In order to gain insights into the dynamics of interorganizational learning and knowledge acquisition we propose a simulation model to test different conditions influencing the outcome of an alliance. Although the model is highly aggregated the results can improve our understanding of the key factors determine success and failure in strategic alliances. We conclude the paper with a discussion for guidelines to assess and manage the outcome of strategic alliances.

## **The Application of System Dynamics for Market Strategy: The Local Government Server Market of Korea**

Continual building and reviewing business strategies are indispensable for the profit organizations to gain or maintain competitive advantage in the market. But such strategies sometimes mislead the companies to hazardous conditions. This is mainly because symptomatic reaction in short-term perspective overrules holistic response in longer term. Quite often the importance of investigating the dynamics and the delayed feedback effects of structural mechanism underlying the environmental changes is overlooked in the process of building strategies. Systems thinking may be



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the best alternative in analyzing structural features of the target market as a whole. By introducing a case of the local government server market of Korea, this paper attempts to depict how systems thinking and system dynamics simulation approach can be effectively applied to exploring alternative proposals and finding a best strategic option.



**Leverage Strategy to National R&D Investment in Korea: A System Dynamics Approach**

Dilemmas surrounding investment decisions for national research and development projects include difficulties of determining the total funding amount (the strategic loop), R&D systems (the structural loop), and the process of realizing initial investment objectives and priorities by assigned researchers (the efficacy loop). This study purports to arrive at a feasible policy alternative to these decisional dilemmas by providing a simulation model that can detect inherent problems within the unobtrusive dynamic structure of the Korean national R&D investment institution. Three simulation models produced various results for different scenarios. In sum, we found that emphases on application and “add-on” or developmental technologies resulted in long inter-stage temporal gaps, although their short-term economic benefits were obvious. In a similar vein, myopic investments in specifically targeted technologies in strategically designed R&D projects led to decreasing levels of absorptive capabilities, whereas far-sighted investments brought in adversary results. Finally, we found that an initial investment package did not have significant impact on the level of researcher efficacy, which augurs a more complex dynamics of researcher motivation structures than is usually assumed. Therefore, in the Korean case, it is imperative that the national R&D institution concentrates resources in long-term and far-sighted projects to enhance strategic technologies, while it is necessary for it to increase funding for fundamental research projects to beef up its R&D capabilities.

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**An Explanation of System Dynamics Recognition Experience According to an Interpretation of Biology of Cognition Theory: The Nature of Feedback Loop Structure**

This paper presents the partial research insights about an explanation of the phenomenon of the system dynamics recognition (Parra, 2002), according to an interpretation of Biology of Cognition Theory proposed by Humberto Maturana (Maturana, 1985,1992,2002). This article presents a conceptual model of the Biology of Cognition. This model is used to distinguish and configurate elements and relations to permit the construction of the notion of recognition according to Biology of Cognition. Next, we consider the principal System Dynamics foundations: the feedback cycle under the view point of the Biology of Cognition Recognition. For this, we interpret a Jay Forrester’s classic paper. With this interpretation, we propose two ways for the System Dynamics Recognition according to Biology of Cognition. The insights about this research may be pertinent to study the implications of the more important System Dynamics process: the organizational learning and educational applications.

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**Emotional Decision Making in System Dynamics**

This paper tackles decision making agents, who control rates, in system dynamics. The decision is made based on the information of the levels received at the decision points. In socio-economic systems it is common practice to assume that decisions are made according to a definite law or a guidance table or graph. This deterministic rational approach is hardly able to model systems in which decisions are taken by humans. Rationality is assumed to be independent of persons; therefore understandable for all, i.e., the decision maker is always trying to maximize her/his explicit profits by taking decisions that are known to the modeler. On contrary, emotionality is very personal and often leads to un-justifiable decisions. To capture the nature of decisions made by people we have to consider the characteristics and personality of the person who is in charge. This way, the rational decision maker may be replaced by a rational-emotional one. In this paper an emotional decision maker, which is called sometimes an agent, is integrated into a socio-economic system dynamic model. It receives information from the environment and decides in-line with its personality. The environment is being changed by the decisions made. So the agent faces a new condition to decide in. The environment also encourages or punishes the agent by the result of the decisions taken.

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**Information Filtering: A Service by Business Intermediaries**

Business intermediaries are often blamed for not adding any value to the product. Therefore, it is always recommended to make direct business connections between producers and consumers. E-business made this connection more possible and realistic than ever in a large scale. The core assumption behind this value analysis is that the intermediaries' role is limited to the exchange of products and money. The present work recognizes the information flow through intermediary channels. This information, that is used in business for market analysis and forecast, advertisement and so on, like any other information is mixed always with noises, is produced in a format that may not be suitable for end-users, and reports facts with a delay that may be too short for decision makers to judge upon or too long to be useful at all. A sharp increase in demand in a very short time can be misleading for the producer to increase production capacities. The intermediary inventory can absorb this increase of demand if it does not survive for long; otherwise will pass it to the producer. Intermediaries can filter the information to eliminate noises, to present it in a proper format, and to deliver it in critical time steps.

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**A Dynamic Analysis of an Institutional Conflict Induced by Online Music Swapping**

Peer-to-peer technology has made massive music piracy possible, which, in turn, has arguably had a significant economic impact on the recording industry. Record labels have responded to online piracy with litigation and are also considering self-help measures. It is currently not obvious whether or not these counter-piracy strategies will ultimately stifle online file sharing in the long term. With this paper we attempt to add to our understanding of the conflict within the institution that is the commercial music industry. We conduct an institutional analysis of the industry in transition and extend the

traditional pattern modeling methodology with a formal resource-based model of a representative online music network. In a series of experiments that emulate anti-piracy scenarios we show that a peer-to-peer system may be quite resilient to outside disturbances. The experiments also demonstrate that policies rank differently in their effectiveness based on a selected yardstick.

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**Evaluation of Alternative Development Strategies  
for Papua, Indonesia: A Regional Application of  
T21**

Papua-Indonesia is a region characterised by a huge territory, a small population and an incredible abundance of natural resources, which make it a potential thriving ground for many production activities. After a period of transition from a centralised to a decentralised form of government, the region is now facing a delicate moment in its growth, as the choices and the politics of the local government will dramatically influence Papuan's development chances. The biggest challenge now faced is how to manage the production of resource-based products while protecting the environment. The objective of the work described in this paper is to identify a developmental path for Papua that would generate a real increase in local people's quality of life and guarantee a proper use of natural resources. Given the multisectoral and multidisciplinary nature of the issue investigated, (our client and) we decided to implement and use a System Dynamics model, the Threshold21 (T21), to support our analysis. From the analysis carried out on the results produced by the model for various scenarios, we concluded that a more long-term sustainable alternative to the present regional development plan exists, and we recommended in particular one of the strategic plans analysed.

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**An Economic Analysis of the PAYG Retirement  
System and the Expected Consequences from a  
Transition to an FF Scheme**

In this paper an attempt is made to illuminate the basic problems that are associated with financing retirement. The currently prevailing, in most developed countries, Pay-As-You-Go (PAYG) system and its deficiencies are analysed initially from a traditional economic perspective and the expected consequences from a transition to a Fully-Funded (FF) scheme are also presented. A System Dynamics model is subsequently described which enables the employment of considerably more realistic assumptions than are commonly employed in economic models, and its results prove to challenge mainstream economic findings. In addition many novel features of PAYG schemes are uncovered.

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**Towards a Valuation of Knowledge in Systems  
Using Qualitative System Methods**

Knowledge in a firm is a highly desirable intangible resource imbuing competitive advantage due to its inimitability, but often that linkage between knowledge and competitive advantage is not explicit. Moreover, it is often not explicitly valued by an organisation so that exhortations to train, develop, disseminate and publish are often met with resistance since no valuation on the knowledge (and particularly tacit knowledge) in a firm is easily available. After a discussion of the types of knowledge immanent in a firm (knowing what, knowing how, knowing why and knowing who), we

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present a method of modelling the knowledge in an organisation and of relating that knowledge specifically to its business survival. This method of modelling allows the representation of knowledge types and the mechanisms of their contribution to the generation of value. Using the real-life case of a professional firm we show how the system of that firm can be modelled and used to establish the knowledge usage and requirements of the people in that system in support of their intent for action.

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## System Dynamics Models of Electrical Wind Power

This paper describes the gradual transformation of the spreadsheet model from the Wind Force 12 report by the EWEA and Greenpeace -which assesses the world wind power potential by 2020- into system dynamics models on the same problem. First the (static) spreadsheet model is replicated in a system dynamics structure, which allows us to correct some errors crept into the spreadsheet model and the report. Second, this static model is turned into a first system dynamics model very close to the spirit and dynamics of the original Wind Force 12 report. Then, the unsatisfactory structures from this first system dynamics model are replaced by more appropriate structures in a second system dynamics model. Finally, the three resulting models with different degrees of complexity are compared and some conclusions are drawn.

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## Value Cycle Model for Stakeholder Value Management

In today's competitive and dynamic environment, creating value for all the stakeholder is not an easy a task. In any value-creating endeavour, management needs to effectively understand the dynamic features of value systems of the firm including feedback systems, time delays, and non-linear cause-effect relationships. The proposition in this study is that the singular, monistic, and short-term oriented shareholder perspective fails to capture the dynamics of stakeholder values. We provide a new characterization of stakeholder value in terms of four constructs; interdependency, mixed-tangibility, temporality, and commitment-intensity. Based on this characterization, we propose a conceptual model - Value Cycle Model (VCM) – for stakeholder value management. This research seeks to improve the understanding of the dynamics of stakeholder values by increasing our knowledge of how the strategic decisions, systemic leverage, resources, and the characteristics of stakeholder value impact stakeholder values. Finally, we present an approach to operationalize and test VCM.

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## Modeling Government External Debt and Sustainability of Fiscal Policy

Development theories assume that developing countries are trapped by vicious circles of poverty due to low incomes, savings and investments. External debt financing is viewed as a means of escaping from the cycle of poverty and a way to to relieve bottlenecks in development process. This work focus on public external debt and government public finance since its fiscal policy is important in development process as well as in securing stability and growth. It attempts to show how spiraling external debt has harmful effect on fiscal sustainabilit, using system dynamics model. An experiment with a set of policy options is carried out, to find a better strategy that is able to reduce the dependency on external debt and to maintain fiscal sustainability.

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**Expectation Formation and Parameter Estimation  
in Nonergodic Systems: The System Dynamics  
Approach to Post Keynesian-Institutional  
Economics**

Twenty years ago, Davidson first put forth his view that any economist practicing normal science within the Post Keynesian paradigm must produce models and theories that are, among other things, nonergodic. Since it is self-evident that actual economic systems are nonergodic, Davidson argued that any economic theory that utilizes the rational expectations hypothesis cannot be considered Post Keynesian, and is most probably invalid. In a separate stream of thought, Radzicki has suggested that, due to striking similarities in their underlying methodologies, Post Keynesian economics, institutional economics, and system dynamics computer simulation modeling can be combined to form a superior form of heterodox economics. In an effort to extend this line of thinking this paper will lay-out three arguments that lend support to Davidson's ideas and should be of interest to heterodox economists. The first is that economic systems are indeed nonergodic. The second is that it is possible to produce models that mimic the formation of actual human expectations and can thus be used when modeling nonergodic systems. The third is that the issue of model validity is complicated and goes far beyond the ability of a model to mimic time series data.

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**Heterogeneity and Network Structure in the  
Dynamics of Contagion: Comparing Agent-Based  
and Differential Equation Models**

When is it better to use an agent based (AB) model, and when should differential equation (DE) models be used? We compare and contrast the dynamics of AB models with those of the corresponding mean-field DE model, using the common and important context of the spread of contagious disease as an example. We compare the dynamics of the well-known SEIR model of contagion, a lumped nonlinear DE system, to those of an explicit AB model of the same system. We examine both the impact of heterogeneity in agent attributes and the impact of different network structures for the interactions among the agents, including fully connected, random, Watts-Strogatz small world, scale free, and ring-lattice networks. We further show how agent based models can be formulated in continuous time while preserving the full stochastic character of state transitions, allowing AB and DE elements to be combined in the same model. Sensitivity analysis demonstrates the conditions under which the extra complexity of the AB representation leads to different conclusions compared to the aggregated DE model.

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**The Role of System Dynamics in Achieving  
Breakthrough Thinking in Entrenched Marketing  
Teams: Lessons from a Case Study in the  
Pharmaceutical OTC Industry**

Breakthrough in a strategy-consulting project can be achieved also in severely entrenched marketing teams, that is in teams that are stuck in their way of looking at their brand. This paper describes how model conceptualisation, resource structure mapping and model parameter

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quantification have enabled a project team to challenge the client's "view of the world" and create consent and excitement around the new recommended strategy. In particular, it has shown how stock and flow diagrams have allowed for new ways to visualise critical challenges posed by the industry, segment the market, and support research designed to quantify the value creation from the identified strategic initiatives. Based on a real case, this paper summarises the lessons learned and provides an actionable framework to guide consultants and practitioners achieving breakthrough thinking in entrenched marketing teams. Additionally, it represents evidence supporting the claim that the value creation of System Dynamics engagements goes beyond the insights that can be achieved through model simulation.

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### (Re-)Structuration of System Dynamics

System dynamics, as a methodology of structure and behaviour, can play a significant role in theory building in the social sciences... if not for the language barrier between systems approaches and the main stream of social theory. To most social scientists, the true concept of system dynamics remains hidden within its computer simulation apprenticeship. Lane (2001) rightfully demanded to engage with the main streams of social theory to overcome this unsatisfying situation. In this paper, the theory of structuration is suggested as an appropriate ontological background, providing a more sociological access to the core concepts of system dynamics. In return, system dynamics is thought to hold much promise for structuration theory in aiding reflexive control and system reproduction. An emphasis is laid on qualitative system dynamics, the concept of mental models, and the connections between the system dynamics and structurationist nomenclature.

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### Might Twenty Models Cover Ninety Percent of All Situations Managers Encounter?

Jay Forrester's call for a set of 'general, transferable computerized cases' to cover most managerial situations is one of the great tasks standing before the field of system dynamics. A library of widely applicable cases, if accompanied by reliable guidelines for when to apply them, would be a boon to research, teaching, and management. Researchers could use these cases as strong null models when evaluating new situations and new theories {Bell, 2001 #1844}. Teachers could use the most widely applicable cases for a general management course or a thematic subset of the cases for specialized courses. Managers could approach a new situation by selecting then tailoring the model or models most likely to shed light on that situation. This paper discusses progress that has been made toward this library of general and transferable models, and describes a research project under way to evaluate models for the library and produce the application guidelines needed for the library to fulfill its promise.

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### Soft System Dynamics Methodology (SSDM): A Combination of Soft Systems Methodology and System Dynamics

Soft System Dynamics Methodology (SSDM), a systemic methodology product of the combination of two widely used systems-based methodologies from two different systems thinking paradigms, Systems Dynamics (SD) and Soft Systems Methodology (SSM), is introduced and its intellectual premises presented. The paper argues that by combining some of SD and SSM stages, within the intellectual framework proposed by SSDM,

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a methodology already in use in various countries in Latin America, much can be gained in a systemic intervention that tackles complex situations. A framework for comparing the ontological, epistemological and methodological principles of SD, SSM and SSDM is suggested. The ten stages of SSDM are outlined followed by an application of SSDM on a small Peruvian enterprise where it helped to clarify its problematic behaviour, and to analyze and propose culturally desirable and systemically feasible changes to improve the problem situation. Finally, conclusions and points for further research are suggested.

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**Modeling Crime Control in the Netherlands**

This paper is about a group model building project with the Ministry of Justice in the Netherlands. The aim of the model is to gain insight into the combined effects of an increase in the case load and investments in different phases of criminal justice administration and contextual developments such as increased complexity of cases. A group of representatives from the police force, public prosecution, courts and sentence execution participated in constructing the model. The modeling project is to be concluded in August 2004, and at the moment of writing this paper the conceptualization phase is finalized. In this paper we report on reasons for starting the modeling effort, the process thus far and preliminary conclusions. At the time of the system dynamics conference in July 2004 a more complete presentation will be given of the resulting model and the way results are going to be implemented by the participating organizations.

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**Teaching the Dynamic Balanced Scorecard**

Rising variability and complexity in business, force managers to undertake the effort of continuous and effective learning. The process of learning increases the organisation's adaptive capacity and resilience, and it helps to derive a skilful combination of operational effectiveness and strategy. It is essential to identify performance indicators which help to steer towards long-term goals in the presence of short-term turbulence. The Balanced Scorecard has become one of the most popular performance measurement systems in recent years. However, there are some reservations about certain aspects of this technique. Its effectiveness can be increased by application of System Dynamics tools. We report here on methods to teach ways to apply systems tools to the Balanced Scorecard. We integrated a series of lectures, exercises and a simulation game in a workshop setting using the methodology developed by IBM Business Consulting Services as an example of implementation of the Dynamic Balanced Scorecard.

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## **Profitability, Productivity and Employment in a Model of the US Long Waves**

This paper elaborates the notion of viable quasi-periodic motion bounded in the phase space that generalises stationary growth and stationary cyclical growth. This paper contributes to finding a hypothetical law of motion of the modern economic system (HL) that is characterised by resilience and fragility. It is shown, in particular, that Okun's law and some other prominent empirical regularities are, likely, the manifestation of HL. The application of the HL with exogenous growth of labour force to the U.S. economy reveals and explains a trade-off between long-term improvements in profitability and larger volatility of economic-ecological reproduction. A focus of this work is on possible adverse social consequences of a more aggressive substitution of living labour by man-made capital during the current Kondratiev quasi-cycle, or long wave. Key words: profitability, productivity, employment, volatility, long waves, modelling.

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## **System Dynamics Modeling for Technology Forecasting**

Abstract For industrial companies forecasting of the technology is essential. Due to technological facts there is a tight relationship between technical forecasting and evaluation of market for new technologies. Technology forecasting has not certain "lows" because of the inherent complexity of the systems that are forecast. A System Dynamic based approach covering the essential underlying cause and effect relationship provide suitable support for understanding and managing the complexity and the inherent dynamics of the technology forecasting. The article describes a comprehensive approach to understand the process of technology forecasting, technological innovation, the introduction of new technology, the state of growth, and the process of maturity and aging in the market place.

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## **The Pace or the Path?: Resource Accumulation Strategies in the US Airline Industry**

In the well documented case of the early low-fare and no-frills carrier "People Express Airlines" the common explanation for the rapid rise and decline is excessive corporate growth. Based on a dynamic resource-based view, this paper finds that it is not only the pace but the path of growth — embodied in the resource accumulation processes — which determines the outcome of a corporate growth strategy. In comparison to "Southwest Airlines" — the prototype of nearly all nowadays low-fare and no-frills carriers — People Express' strategy did differ in the speed of corporate growth and in other vital strategic decisions, e.g. implementing a hub and spoke network and giving service to heavy congested major airports instead of flying to secondary airports in a loose coupled point to point system.

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**Spatial Urban Dynamics and a Vision of the Future of Urban Dynamics: Forrester Revisited**

The development of a dynamic spatial model of an urban area is described in this work. The system dynamics method is used to create a model that copes with the criticism on the original Urban Dynamics model (Forrester 1969) by disaggregating the urban area into 16 zones. It was found that the trajectory of the behavior (growth, overshoot and stagnation) in the Forrester model is observed in each zone, but the overall behavior of the city shows a relatively small overshoot. The zonal division creates opportunities to explain and understand the dynamic behavior within the city in a more satisfactory manner. Finally, it is concluded that the system dynamics method remains very useful for creating insight in urban management for urban planners and students, despite the fact system dynamics has never become an established method in the field of urban planning (Alfeld 1995).

**Model Simplification and Validation: Illustration with Indirect Structure Tests**

The simplification and validation of a large system dynamics model is illustrated. The original model represents agricultural and environmental problems of irrigation development in Southeast Turkey and consists of 62 stock variables. Its simplified version with a narrow model boundary and higher level of aggregation is a general representation of its selected dynamics and consists of 15 stock variables only. Analysis of reference behaviours, indirect structure tests and scenario runs reveal simplified model as a valid and useful version of the original. Simplification helps distilling essential model structures that cause selected problems and increases the quality and understanding of models. It can also be a step towards general representation of case specific problems in various application domains.

**Do Models Evolve?**

This paper starts with the idea that learning in the context of system dynamics modeling does not only happen during the modeling process, but also goes on between the iterations of the inquiry process modeling is part of. The notion of model version is introduced and it is suggested that the differences between successive versions of a model represent what has been learned in the inquiry process. A set of structural elements with a set of indicators are proposed in order to capture these differences and give them meaning in terms of the learning process. This seems to be a valuable conceptual possibility, in domains where such inquiry loops exist beyond an individual modeling work.

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**Exploring the Agent Vocabulary: Emergence and Evolution in System Dynamics**

Agent-based simulation is an approach increasingly used to describe and explain social phenomena; the areas of application are similar to those of the system dynamics approach. Whereas system dynamics more or less ignores the agent-based method, scholars from the agent-based community intensely argue for the superiority of their approach. This paper analyzes in more detail two of those arguments: the impossibility claim concerning the ability of system dynamics models to explain emergent phenomena as well as their flaw as to not consider individual diversity.

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**Enforcement in Free-Flow Systems: A Case Study**

Sometimes System Dynamics tools are not suitable for solving dynamic problems although on a high level of abstraction they can be modelled as “stock and flow” diagrams. A typical example is the design of an enforcement schema for a free-flow motorway toll system. This case will be used to discuss how to deal with these problems by starting with a “stock and flow” diagram and then proceeding to implement them as an agent-based simulation. To do this a graphical backcloth must first be designed which models the relationships between the dynamic and static agents in a topologically correct way. Then the dynamic behaviour of the agents must be formulated, which is possible on the agent level but probably would be too complicated on the aggregate level needed for implementation with common System Dynamics software. Based on a behaviour space generated by simulating key combinations of the design parameters, recommendations for a satisfactory enforcement schema are possible. Pseudo-empirical data produced by the agent-based simulation could be used to calibrate aggregated behaviour equations suitable for modelling with System Dynamics software tools.

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**Hariolf Grupp****The Innovation Process for Fuel Cell Vehicles: What Strategy Promises To Be Most Successful?**

Many car manufacturers recognize fuel cell vehicles as future substitutes for conventional cars with internal combustion engine. According to press releases and brochures, different strategic approaches of the automobile companies concerning fuel cell technology can be identified. Those strategies match the market entry strategies known from strategic marketing literature to a high degree. A system dynamics model that reflects the beginning innovation process and the strategic approaches of a pioneer (first to market), an early follower (early to market) and a late follower (late to market) has been build. It examines the future prospects of the car manufacturers' strategies in three different scenarios, which illuminate possible future developments of external influences like politics or fuel infrastructure.

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**Can System Dynamics Models Have Greater Relevance to Practice When Used within Participatory Action Research Designs?**

Over the years, the field has produced numerous rigorously researched SD models, which have helped suggest detailed policy changes to organizations. However, the application of model-based insights and the implementation of

practical changes to policies, structures, and processes has not been observed as frequently, even though, various approaches have been used to increase ownership in models and results among practitioners and decision-makers, for example, via group model building. In this paper, a more radical approach is considered, which would amalgamate SD and its analytical wealth with Participatory Action Research and its practical problem-solving and change orientation, such that the relative strengths of both disciplines complement each other and reliably produce an SD- influenced organizational outcome. The feasibility of the proposed approach needs to be empirically tested yet.

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**Using Integrated Top-Down and Bottom-Up  
Dynamic Modeling for Triangulation and  
Interdisciplinary Theory Integration: The Case of  
Long-term Firm Performance and Survival**

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System dynamics (SD) modeling has been classified as a “top-down” approach to modeling dynamic and complex systems, whereas agent-based (AB) modeling techniques are referred to as a “bottom-up” approach. Various papers have recently proposed the use of both approaches when studying complex, dynamic problems in the social; sciences, particularly, when hard data for important variables are hard to find. Furthermore, human and social dynamics typically have been studied through the lenses of various disciplines. When modeling those problems, insights from those various disciplines should be integrated. Dynamic modeling might provide an important instrument for such theory-integration efforts. In this paper, the problem of long-term firm performance is taken as an illustration for such a research design, in which theory-integration is undertaken along with a design, in which top-down and bottom-up modeling are iteratively combined. It is concluded that besides arriving at deeper understanding of the problem through theory-integration, cross-validation and dynamic triangulation may be among the potential benefits in such multi-disciplinary and multi-method research designs.

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**System Dynamics and Cybernetics: A Necessary  
Synergy**

In line with the conference theme – „Collegiality“ – the authors propose to build a bridge between two Systems Approaches, namely System Dynamics (SD) and Management Cybernetics (MC). This synthesis is aimed at opening a path for superior capability to deal with complex issues of actors in both organizations and society. With their respective strengths – modeling and simulation of content issues for SD, and providing a viable organizational context for MC - a combination appears to be potentially very promising. The authors propose the Integrated Systems Methodology as a framework for combining SD and MC, and they give practical illustrations to support their argument.

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**Dynamics of Depreciation and Scrapping in  
Business Economics**

With the aim to bring in SD deeper into management education we compare the concepts of depreciation and scrapping used in the literature of SD on

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one side and business economics on the other. We demonstrate that the business economics concepts of straight-line depreciation and of sudden scrappage can be formulated within the SD methodology and software. The economic results are better in line with the textbooks of business economics than those given by the current SD equations. As a result we recommend using a pipeline delay instead of a third-order delay for modelling scrappage. The concepts of straight-line depreciation and sudden scrappage are then combined with the concepts of aging chains and co-flow in the framework of a simple model of a firm. The simulation results are in line with fundamental expectations of business economics. This will be the basis for our further work on a generic model of a firm which could meet both the didactical challenges of management education and the sophistication of modern System Dynamics.

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**Emerging Theories about Deep Collective Learning**

Deep questions and issues arise when we try understand how systems thinking tools and capacities can better enable social and institutional change – like, How does a social system arise out of the mental models of its participants, and in turn condition those mental models? And, how are change efforts limited by traditional (Western) perspectives that assume that the “external” system (formal structures, strategies, and policies) is disconnected from the “internal” system (people’s thinking, feeling, and quality of relationships)? Quantum theory has led physicists to a view where observer and observed are interdependent. In its most radical interpretations, it suggests that self and world continually co-evolve because each interacts through a field that includes both. From this viewpoint, the deepest processes of social change might arise from more conscious participation in such fields. This session will explore a synthesis of approaches to enable such participation: like system dynamics to look at interdependency from an observers’ viewpoint, and “learning journeys,” generative dialogue, and “rapid prototyping” to enable seeing our selves as part of the system, as it is and is it might unfold.

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**Global Warming and Gaia Theory: A Systems Approach**

A recent report written for the US Department of Defence global warming as the major threat facing the world today. Global warming has been discussed for many years, but the general level of knowledge of what global warming actually is, what its consequences are likely to be, and therefore about what can realistically be done to avert its most harmful effects, is woefully low. The purpose of this paper is to offer a small contribution to enhancing our appreciation of this potentially catastrophic problem. For surely global warming is the example, par excellence, of why taking a systemic view of the whole, rather than a parochial view of the parts, is so important. A particular feature of my analysis is the incorporation of Gaia theory, James Lovelock’s revolutionary concept of the entire globe as a system.

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**Making the Whole Greater Than the Sum of the Parts: A Pragmatic Approach to Building High-Performing Teams**

This paper is a challenge. An inspiration, or indeed call-to-arms, to the System Dynamics community to make a real impact. For one of the major needs of all organisations – from government departments to major corporates, from local voluntary organisations to family businesses – is to



improve teamwork. What organisation doesn't have 'teamwork' as one of its core values? But how many organisations actually deliver it? This paper argues that the systems perspective can add intellectual integrity, pragmatic robustness and – most importantly – real value to that oh-so-important process of building high-performing teams, and suggests some powerful actions as to how actually to do it. It also introduces the three laws of a new science: the science of 'organodynamics'.

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### **Cultural Transformation Geniusys**

The Cultural Transformation Geniusys model is best presented as a parallel session at the 22nd International System Dynamics conference 2004. At this presentation participants will explore how we can use systems thinking to understand the organisational structures that drive the momentum of a cultural transformation programme (CTP). Next we will use systems thinking to develop a strategic planning framework to maximise the efficiency of the CTP. We will also explore how we can use the Geniusys psychology dynamics model to work with staff to increase the conversion rate of staff from the current to the desired culture. We will do this by using the Geniusys model to lower their resistance towards the changes and then increase their motivation towards the programme. The subsequent workshop will demonstrate the "motivation linguistics pattern", which is the key tool used to increase the motivation of staff towards the CTP.

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### **Using System Dynamics in Modeling Mental Health Issues in the UK**

Over the past two years OLM Consulting, initially in partnership with Cognitus, have used system dynamics modelling in a wide range of health and social care settings to shed light on a number of difficult and complex issues. A related paper presented to this conference (Using System Dynamics to Influence and Interpret Health and Social Care Policy in the UK) describes the experience of introducing System Dynamics in a public service setting. This paper describes the work done in 2003 with two parts of the Mental Health (MH) services in London. It includes discussion of the approach to facilitating dialogue between commissioners and providers, as well as stages in the development of models and some findings from the experimental runs. The paper also discusses the potential to create a template for a "whole system" view of the wider MH arena, based on current work and consultation with experts in the MH field. Proposals to produce a template have now been accepted by a national agency (National Institute for Mental Health England, North West region).

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### **Reusability in System Dynamics: Current Approaches and Improvement Opportunities**

Several companies in Colombia, and also some public institutions, are beginning to use formal methodologies for strategic analysis. Unfortunately, System Dynamics modeling is an almost unknown option for these potential users. One answer to this poor diffusion is based on the concept of model reusability. It will be revealed, by means of a framework of levels of reusability derived from the object-oriented approach, that the state of the art in system dynamics reusability shows the same evolution stage of software reusability before the 1960s. This interpretation will expose too a major

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opportunity for encourage the practice of model reuse in our System Dynamics community and for widening the spectrum of users. A first implementation of a software tool for system dynamics modeling with higher level of reusability is being developed.

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## Dynamics of Co-opetition in Platform Industries

The study of industrial organization, competition and strategy usually assumes direct competitive interactions amongst firms or vertical relations in the value chain. However in an increasing number of industries the situation is more complex. Product complementarity is only one aspect of co-operation. Platform-based competition is built on the basis of complex interactions amongst the diverse sets of assets accumulated by various players. Each may built an alliance with another player in order to utilize its assets in exchange for a share of total profit. The problem of mutual resource commitment during the development of complementary assets is modeled as an evolutionary Prisoner's Dilemma game. To investigate the effect of different pure and mixed cooperation and/or defection strategies, a system dynamics simulation model has been built using the resource-based view of the firm. The dynamics of tangible and intangible assets, such as customer base and technological learning, were included in the model. Cooperation and defection payoffs are assumed to be time-dependent. Simulations run for different platform participant strategies show the importance of asset accumulation and synergy. The model was calibrated using data from the mobile telecommunications industry and can be used in an interactive mode to evaluate more complex industry-specific strategies.



## A Time-Based Innovation Strategy Game

Innovations strategies, based on the introduction of new products to the market with the aim of gaining larger market share and raising profitability, have a significant time element. The work presented examines the behavior of two firms based on the time-strategies they follow, with the help of a system dynamics simulation model. The inability of a firm to follow the competition's rate of introduction of new products undermines its own long-term competitiveness. On the other hand accelerated introduction of new products may undermine the amortization of investments in existing products. Here, the evolution of corporate performances in a duopoly environment is presented; firms adopt strategic behaviors in response to the competition's choices. The model developed, provides to decision makers the ability to assess the advantages and disadvantages of different strategic choices and commitments and to analysts the opportunity to explore the formation of equilibria under different industry environment parameters and time-strategies.

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**The Process of Problem Definition in a Group Model Building Project for Sustainable Urban Planning in Las Vegas, Nevada**

This poster describes the first phase of a project to integrate land use, transportation, and air quality planning in Southern Nevada. The project clients are city planners and resource managers in the Las Vegas metropolitan region. The clients recognize that integrating land use, air quality and transportation planning is critical to improving livability, mobility, environmental conditions, and economic stability in the region. They also recognize that integrated planning is difficult, however, because connections among these sectors are complex, uncertain, and not completely understood. In January 2004, we began working with the group on a two-year project to develop a system dynamics model to support integrated planning and build long-term capacity for interagency and intergovernmental collaboration. This poster describes the facilitated group model building process of problem definition, which has taken the first five months. Problem definition includes articulating the purpose, appropriate scope and scale, users, inputs and outputs of the model.

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**The New Hire: Teaching Behavioral Dynamics in Management**

System dynamics is conspicuous by its absence in the major management education journals. At the same time, there are calls for better handling of complexity and new theory generation; areas where system dynamics can make a major contribution. This paper presents a simulation within a learning environment aimed at reinforcing organizational behavior concepts, especially emphasizing the interconnectedness of these concepts. While the intent is not to teach system dynamics, the simulation provides an opportunity to introduce system concepts. This paper concludes by suggesting a strategy for entry into the management education journals involving a longitudinal quasi-experimental design to evaluate alternative techniques.

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**Simulation Based Experiments for Testing Balanced Scorecard's Built-in Performance Improvement Theory**

Kaplan and Norton's balanced scorecard (BSC) is, without a doubt, one of the last decade's major improvements in management and controlling tools. In their various articles and books, the authors maintain that use of a balanced scorecard will ultimately improve an organisation's performance. Their theory about the scorecard's performance impact, however, is not explicitly described. Based on Kaplan and Norton's publications, this article reconstructs a system of hypotheses about the impact of a balanced scorecard on performance and describes a research design, which uses a System Dynamics-based micro-world, to test the theory. The implementation of the research design is portrayed and statistically tested. Finally, some preliminary results are presented, indicating that the balanced scorecard's effect on organisational performance might be overestimated.

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**Technology Transitions: Identifying Challenges for Hydrogen Vehicles**

Automobile firms are now developing alternatives to internal combustion engines (ICE), including hydrogen fuel cells and ICE-electric hybrids. Adoption/diffusion dynamics for alternative powered vehicles are more complex than those typical of most new products, due to the enormous size and importance of the automobile industry, the size and impact of the vehicle fleet, the presence of scale and scope economies, learning by doing and through research, and the critical role of complementary resources such as fueling and maintenance infrastructure. We describe a model to examine the diffusion dynamics for and competition among hydrogen, hybrid and ICE vehicles. In this paper we focus on the generation of consumer awareness of alternative propulsion technologies through feedback from driving experience, word-of-mouth and marketing, with a reduced form treatment of network effects and other positive feedback (subsequent papers will treat these in depth). Through detailed model analysis we show the existence of a critical threshold for sustained adoption of new propulsion technologies and its importance for the diffusion dynamics. We further show that word-of-mouth from those not driving an alternative vehicle is important in stimulating adoption.

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**Modeling the Penetration of the Information Society Paradigm**

Recently it has become obvious that the creation of an information society in accordance with the eEurope objectives presumes governmental support. The programs and action plans, that are to support and accelerate the transition, have been developed in almost every country. However, at developing the strategy the policy-makers have to consider the complexity of the environment and the diverseness of potential effects. This complicates the forecast of the impact of the different measures. The scope of the research was to set up a model in order to support decision- and policy-makers. With the model the ones responsible will be able to estimate the impact of different measures, and the alternatives can be compared with each other.

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**A System Dynamics Approach to Applications of Buddha's Dialogues**

This paper presents how to formulate the structure of the Buddha's teachings in the form of feedback loop and to investigate the use of this system as a solution to "narcotic problems in a community". The Singalovada case study, the Buddha dialogues from the Suttanta, is a teaching for every layperson on how to improve quality of life by peaceful methodology and resulting in a sustainable development. The interactions between the key components of this dialogue such as the bias, the defiled actions, the six roads to ruin, and the harm of six directions imply critically the decay of the societies at present and the potential to get worse in the future, if the loops continue to imbalance. The Noble Eightfold Path components, the heart of Buddhist's practice to eliminate suffering, are included in this model to provide the system balance. The use of system analysis to look at the teachings of the Buddha helps people gain more understanding into the mechanism of the system and the concept of the dialogues. This paper helps the reader better to appreciate how to apply the Buddhist teachings systematically to solve social problems.

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**Learning System Dynamics: Cognitive Processes and Constraints**

We present results from a study of how students learn system dynamics modelling, and the involved group- and cognitive processes. The preliminary results indicate learning constraints by pre-conceived concepts and models. Furthermore the interaction by the students sometimes improved the learning process, but not always. We particularly studied the initial phase where the model is laid out with the help of causal loop diagrams. Iterations of the causal loop diagram construction improved the learning, and specific breakthrough points could be distinguished. The phase shift from a qualitative causal loop model to a quantitative stock-and-flow model was more problematic for some students, which often tried out pre-conceived solutions. The students were followed through four consecutive modelling tasks, where they were working in groups. We saw a particular progression in the appropriation, in terms of terminology used among the students, while the modelling skills differed considerably.

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**Implications in the Health Sector Given the Tendency of Population Aging in Mexico**

The increase in the life expectancy will have serious repercussions in the support of the system of pensions that at the moment governs our country. This situation will influence in determining form in the predictable collapse of the social security systems of the country. The increase in the life expectancy of the Mexicans, will make that the future generations, are in average greater in age of which they were the last century, since the greater adult population duplicates every 19 years, which took us to the fact to a considerable increase in the demand of services of health, combined that the number of pensioners with time also will be greater than the productive population, which implies that the economic support for the sector health no longer occurs supply for so many users, and this will gradually take it not to be able to support as much load and by consequence, to the closing of the official health systems. Using the model, we have found that these changes in the population have serious implications that impact the future generations of pensioners and the services of which they are beneficiaries.

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**Fundamental Analysis of the Attractiveness of a Shopping Street**

Previously, we have got some research results in order to explain how retailers agglomerate in a city. We compared two simulation results, one condition in a uniform distribution of population, the other radially populated so that we investigated how population distribution affects the spatial structure of retailers' accumulation in a city (2003). These simulation models did not even consider the attractiveness of shopping areas in consumer choice because these models are based on rational assumptions. Of course although some methods such as Drezner and Drezner (1998) consider the attractiveness of shopping areas, these models did not explain dynamically change under time series. So in this presentation we show two types of SD models. They are conceptual models on shopping street or shopping district in Japan. They are dynamic models of agglomerate retailers, shopping district, in which the attractiveness is an important element.

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## Exploring the Feedback Effects of Reconfiguring Health Services: The Case of Cardiac Catheterization Procedures

The reconfiguration of health care, shifting services ‘closer to home’, is a well established trend, which has been motivated by the desire to improve the provision of services. However, these efforts may be undermined by the improvements in access stimulating demand. Existing analyses of this trend have only considered isolated parts of the system and have led to recommendations to control demand with stricter clinical guidelines or to meet demand with capacity increases. By failing to appreciate the underlying feedback mechanisms, these interventions may only have a limited effect. We demonstrate the contribution offered by system dynamics modeling by presenting a study of two cases of the shift in cardiac catheterization services in the U.K. We describe several mechanisms by which demand is stimulated and clarify the roles for stricter clinical guidelines and capacity increases. We also demonstrate the potential benefits of changing the goals that drive activity.

## Funding University Research Networks for Results: The Canadian Research Councils Approaches

The two major research councils in Canada, Natural Science and Engineering Research Council and the Social Science and Humanities Research Council, have both embarked on fostering joint initiative research networks in their respective areas. These University Research Networks are dynamic, complex organizations that are based on the collegial behavior of academics. In this context, collegiality can be defined as professional interaction between peers that contribute to a shared academic commitment to a research area. Funded university networks require a group of academic researchers to transcend both institutional and disciplinary boundaries, and for them to interact in a way that the research network provides a value added output greater than the sum of the individual research projects. Such an organization is both complex by its very nature and changes over time. The paper will use system dynamics methods to represent the development of two networks, one in the social sciences and the other in the natural sciences. Both have developed using different governance structures and feedback mechanisms. The model identifies the drivers and constraints on network development.



## Modeling Modern Maintenance: A System Dynamics Model Analyzing the Dynamic Implications of Implementing Total Productive Maintenance

In recent years maintenance has become an important factor for operations management. Total Productive Maintenance as approach for improving maintenance has therefore evolved as the most popular manufacturing concept. But often the concept cannot evolve its full potential. In this paper reasons for the failure of Total Productive Maintenance will be presented with respect to dynamic implications. The analysis focuses on the changes for the maintenance department and the machine operators due to the

implementation of Total Productive Maintenance. Based on the ongoing changes a dynamic analysis is performed to identify important implications for a successful implementation of Total Productive Maintenance.

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**System Engineering and System Dynamics Models**

Abstract System Dynamics (SD) set its roots in servo- mechanism systems that were a combination of the earliest hardware and software systems known. Over time, SD grew and evolved into a multiplicity of domains and coevolving was the domain of Software Engineering. Today, Software Engineering has its own sub domains of architecture, design, performance and modeling. The Software Engineering topic of modeling has reached the stage of development where structure and behavior are of high- interest; and they are the very cornerstones of System Dynamics. There is enough Software Engineering interest in structure and behavior that entirely new procurements are being considered for a simulation capability based on the Unified Modeling Language™ 2(UML2™). This paper looks at the possibility of applying System Dynamics to the problem of modeling the structure and behavior of software engineering architectures, designs and performance. It postulates the opportunity to rejoin the roots of System Dynamics from the servo-mechanisms systems to 21st century software enterprises. It offers the opportunity to bridge System Dynamics and its structure and behavior capability with UML2™. SD offers the Software Engineering domain an opportunity to leverage a compatible field of interest and its modeling tools without delay or costly development.

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**Dynamic Aspects of the Security Management of Information Systems**

The dependency of enterprises on information systems makes security of information systems one of the mayor concerns for enterprises. An incorrect management of these systems can increase the number of vulnerabilities in an enterprise, becoming sensitive to problems and attacks. By presenting and analyzing a vulnerabilities model, this paper provides insights to the problem that poor security management combine with vulnerabilities can harm an information system. By implementing robust Technical Controls (mechanisms that protect the system from incidents or attacks), Formal Controls (business structures that allow a proper use of technical controls), and Informal Controls (security controls that deal with the workforce), vulnerabilities can be eliminated improving security management of information systems. These security controls could minimize the risk of security failures originated by the existence of vulnerabilities on the system.

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**Ten Steps to Simulate your Strategic Architecture**

This paper discusses a solution to the problem of introducing system dynamics into a traditional strategic management course. In this paper we provide an example set of assignments that introduce undergraduate business students to system dynamics modeling. Students provide feedback on what they liked and disliked about these assignments. Overall, the students were very positive about this learning experience. It is hoped that these lessons learned may help others to integrate system dynamics into their strategy courses.

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## Assessing Public Policy Impact on the Sustainable Growth Rate of New Ventures

The growth of firms is fundamentally based on self-reinforcing feedback loops, one of the most important of which involves cash flow. When profit margin is positive, sales generate cash, which may then be reinvested to finance the operating cash cycle. We analyze simulations of a sustainable growth model of new ventures to assess the importance of taxes, and regulatory costs in determining growth. The results suggest that new ventures are particularly vulnerable to public policy effects, since their working capital resource levels are minimal, and they have few options to raise external funds necessary to fuel their initial operating cash cycles. Clearly, this has potential consequences in terms of gaining competitive advantage from experience effects, word of mouth, scale economies, etc. The results of this work suggest that system dynamics modeling may provide public policy makers a cost effective means to meet the spirit of the U.S. Regulatory Flexibility Act.

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## Business Dynamics Supported Security Policy Management

During recent decades a great part of efforts for provision of security in information systems was focused on technology. Although it was noted in the eighties that human factor plays an important role, it is becoming evident only now that it plays a central role. Ensuring appropriate security for information systems thus requires not only addressing of technology, but at least as much human and organization related issues. These are usually embodied in security policies, thus the paper focuses on the latter and a model is presented that is intended to support security policy management. The model is based on business dynamics.

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## From Loop Dominance Analysis to System Behaviors

Loop dominance analysis is central to system dynamics study and practice. However, no clear progress in loop dominance analysis has been made since 1999. Considering the inseparable nature of system structure, this study aims to bridge the gap between loop dominance analysis and system behaviors. This study identified and clarifies some critical but obscure concepts related to loop dominance. After clarifying loop dominance, this study devises a loop dominance analysis approach. The analysis process comprises two parts. The first part identifies the dominant loops and the second part explains the dynamic behaviors in terms of dominant loops. Dominant loops are classified into pseudo dominant loops, local dominant loops, and systemic dominant loops based on their impact on the whole system. The loop dominance analysis process proposed here not only provides a straightforward process to identify dominant loops, but also emphasizes the twofold behavioral explanation of dominant loops and their shifts.

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**Using System Dynamics Modeling to Inform Strategy Development at the National Level: Societal Trends and Dynamic Interactions**

This contribution describes a system dynamics modeling approach for exploring the influence of social trends on dynamics interactions between transport behavior and spatial development in Switzerland. It aims at informing strategy development at the national level and at enhancing goal alignment between different policy sectors. While considerable knowledge about normative objectives of sustainable transport has been elaborated, there is a lack of knowledge about dynamic interactions between transport needs, societal trends, and spatial development. Hence, the study aims at enhancing system understanding and closing the identified knowledge gap as well as at enabling multi-loop institutional learning in strategy design. Within the strategic management process, the modelling approach helps to develop a common vocabulary and an effective basis for communicating complex and sometimes paradoxical conditions and strategy options (Georgantzas and Acar 1995; Georgantzas 2003) (Senge and Sterman 1992; Sterman 2000) (Morecroft 1988).

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**Using a System Dynamics-SWM Model to Inform Policymaking for Solid Waste Management at the Local Level**

This paper presents a comparative policy analysis drawing on the System Dynamics Solid Waste Management model that is based in a feedback perspective about human behavior and public policy (Ulli-Beer 2003). The model is suited to address the following request. What local policies increase recycling, and help to establish / ensure a solid waste management system that fosters competitive recycling markets? Subsequently, the model is used as a policy laboratory in which various policy experiments addressing “what-if-questions” under controlled conditions can be conducted. Subsequently the impact and outcome of recycling initiatives and strategies at the local level were analyzed under different scenarios. Various policy experiments illustrate crucial dynamic interactions between flexible preferences and contextual factors (Ulli-Beer et al 2004). Furthermore policy sensitivity of personal factors could be identified that explain the success or failure of recycling initiatives. The policy experiments show that combinations of interventions altering personal and contextual factors are crucial for policy compliance and for designing robust recycling initiatives especially under uncertain and adverse conditions in the system.



**A System Dynamics Choice Structure for Policy Compliance: Micro Behavior Explaining Aggregated Recycling Dynamics**

This paper presents a System Dynamics Solid Waste Management model that is based in a feedback perspective about human behavior and public policy (Ulli-Beer 2003). A SD-choice structure is suggested that both



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highlights the interactions of personal and contextual factors and is suited to explain and forecast the impact and outcome of recycling initiatives and strategies at the local level as well as to explore different scenarios (Ullibeer, Andersen et al. 2004). The model structure indicate crucial dynamic interactions between flexible preferences and contextual factors. Furthermore policy sensitivity of personal factors could be identified that explain the success or failure of recycling initiatives. The policy experiments show that combinations of interventions altering personal and contextual factors are crucial for policy compliance.

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## **Improving the Collective Capacity of Managers to Execute Strategy and Create Value: A Dynamic Simulation-Based Approach to Strategy Communication and Management Training**

This paper presents a unique and successful case study of the application of systems dynamics for large scale management training and strategy communication. It tells the story of how Novellus Systems, a Fortune 1000 company, with the help of an outside consulting firm, successfully trained managers over a period of two and half years to understand and execute the company's strategy using a system dynamics based simulation model. The paper presents lessons learned from the simulation events organized to help Novellus achieve its objectives. It illustrates a unique context of system dynamics in action at a very high level. It further illustrates how system dynamics was used to foster dialogue, collaborative team learning and create a shared vision which profoundly affected understanding, influenced and even changed some management practices. It reveals how the simulation game enhanced management's ability to think systemically, communicate effectively, and collectively execute with confidence. This project has been so successful that Novellus continues to use it in its semi-annual management meeting for nearly three years now in a row and we are jointly working on presenting a paper in one of the industry's leading publications.

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## **Transitions and Transition Management in the Surface Passenger Transport System: A System Dynamics Model**

In order to evolve towards a more sustainable society, fundamental changes need to take place in the domains of energy, transport, housing,... Few theoretical frameworks are available, which can bring order in the complex flow of events. However, the idea of socio-technical systems (Geels, 2002) achieves just that. By looking at societal transitions as the outcome of interactions between different levels and different dimensions in a socio-technical configuration, the future challenges and options for sustainable development become more clear. Geels (2002) even has a point when he defends the use of case-studies in order to better understand the different dimensions of technological transitions. However, by describing quantitative models as too narrow, too much based on extrapolation and too top-down, he fails to acknowledge the future added value of system dynamics in the development of scenarios and in the scientific learning process concerning societal transitions. This paper will present a system dynamics model concerning the possible transitions in the surface passenger transport system. In the final paragraph, a simulation game will be played in order to clarify the concept of transition management.

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**The Impact of ICT Diffusion on Growth: The Case of Germany's ICT Sector**

Ever since the rapid economic growth in the US in the 1990s ICT-capital has been considered as one of the primary reasons for economic growth and the Solow Paradoxon seemed to be resolved. However, the recent economic slow-down and the burst of the dotcom-bubble contradicted these findings as investments in ICT were cut down drastically. In this paper we look closer at the recent data and evaluate the German economy using a model of the ICT-sector and its impact on the economy as a whole. By taking into account the diffusion of key technologies in different segments of the ICT-market we take a new approach on macroeconomic modelling in this area. Especially the effect of internet and the introduction of UMTS will be discussed in our projections using the system dynamics model.

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**Counterproductive Environmental Policies: Long Term versus Short Term Substitution Effects of Gas in a Liberalized Electricity Market**

In Norway, the environmental impact of building gas power in a liberalised market has been the main controversy in the for over a decade. Proponents of natural gas argue natural gas substitute more dirty sources of electricity generation within the Nordic market, while opponents argue there is no such guarantee and choose to focus on national emissions. Despite several efforts, energy models have failed in resolving this controversy satisfactory. A survey of previous studies using present energy models (EMPS and NORDMOD-T) for decision support is presented. The models have been re-run and their sensitivity towards specification assumptions examined, showing that the results were highly sensitive to the assumptions made. Second part presents a system dynamics model particularly designed to address the short- and long run impacts of energy policies. The results show that gas power will substitute some coal in the short term, but this substitution effect is modest. When including long-term substitutional effects of new investments, gas power also substitute future investments in renewables which results in a net increase in CO<sub>2</sub>-emissions in the long term. This finding raises serious questions about the environmental benefit of the fuel substitution strategy.

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**Affordable Housing and Urban Sprawl Policy Choices in York County, Maine: A System Dynamics Approach**

York County, Maine, filled with typical New England “home rule” towns, is experiencing a lack of affordable housing and too much “urban sprawl.” After a thorough examination of the situation in a typical York County town, including a causal loop diagram based on interviews with knowledgeable informants, a system dynamics model is used to test five possible policies for the town: the status quo (large house lots and modest construction levels), smaller house lots, a cap on construction, increased construction, and smaller house lots and increased construction. The policy testing shows that the “status quo” is not a terrible policy, that the “smaller lots” has some things to recommend it, but that the combination of smaller lots and increased construction gives the best mix of outcomes—better housing affordability and less urban sprawl. Implications for policy and future modeling are discussed.

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**A Simulation Model for Organizational Evolution**

In today's ever-changing and complicated environment, organization faces a difficult challenge. The keys to success in an organization lie in its flexibility, creativity, and ability to learn. This implies that change is the center of managerial and organizational theory. During the recent developments of organization theory and other fields' effects, self-organization has obviously become the core concept among all the theories. With the unpredictable environmental changes, self-organization clearly demonstrates an organization's flexibility, creativity, responsibility and the ability to learn. The goal of this research is to explore the process of how a team can restructure itself through self-organization to successfully adapt to the changing environment. Similar to other areas of self-organizational research, it has been discovered that a successful self-organizing team relies on a mechanism called "evolutionary feedback". In addition, this research will help us understand the usefulness and contribution of organizational changes during the process of self-organization.

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**Disrupting Mature Markets with Innovative Technology**

Many markets are dismissed because they are "mature." The conventional wisdom is these markets are lacking in opportunity, particularly for new entrants or new products, because their growth is quite slow, asset lives are long, operators have strong incentives to stretch the life of existing assets rather than replace them, and the markets are dominated by a small number of well entrenched suppliers. Innovative technology can disrupt a mature market and change its dynamics. The incumbent suppliers may be more vulnerable than they appear. The business opportunity could be enormous for a company who understands the market dynamics, constructs an effective competitive strategy, and has the strength and persistence to see it through. This paper presents a model of the market for technology-intensive assets. It is applied to the market for military transport aircraft, a classic case of slow growth and replacement and dominance by a few suppliers. But the model is more general. It explains important dynamics of many other markets, e.g., industrial process plants, telecom infrastructure, IT systems, media production and distribution, motor vehicles, and not surprisingly commercial aircraft.

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**How Does a Model Facilitate Learning?**

The author is developing a system dynamics model and interactive learning environment ("MacroLab") that he uses in a macroeconomics distance-learning course for Virginia community college students. He is also developing a set of experiments to test the effectiveness of MacroLab as an instructional tool. The purpose of one of the experiments is to compare the learning that takes place with three different methods of delivering essentially the same information about Gross Domestic Product to three student groups. This experiment was recently administered to secondary students in the Harvard Public Schools system in Massachusetts. The results were generally supportive of the hypothesis that Group 2 would "learn more" than Group 1, although the differences were not statistically significant due to small sample sizes. Group 3 did not show learning gains over Group 2, but there may have been some learning-curve issues related to running and interpreting a simulation. Additional experiments are underway

this spring at both secondary and higher education institutions in the United States and in Venezuela. It is hoped that, with additional data, more conclusive results will be available for sharing with the system dynamics community at the Oxford Conference.

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**Pleistocene Extinctions: Counterintuitive Results of Combining Hypotheses (Overkill, Second Order Predation, and Environmental Degradation)**

There are two popular hypotheses to explain extinctions at the end of the last ice age, Climate Change and Overkill (humans hunting herbivores to extinction); each has significant problems. Some have suggested that the two hypotheses in combination would yield a stronger explanation. The Pleistocene Extinction Model (PEM) was originally developed to test a third hypothesis, Second Order Predation (2OP)– humans reducing carnivore populations – and test it against Overkill\*. Now, PEM has been expanded to include a simplified Climate Change factor. Its results show that, in combination, Climate Change counteracts the effect of Overkill, reducing not increasing extinctions, while exacerbating the impact of 2OP, hastening extinctions. Archaeologists have only used quantitative models as descriptions to clarify the assumptions underlying a single hypothesis. The continuing development of PEM shows the value of a model that can be used to test multiple hypotheses, alone or in combination, using consistent assumptions. \*Whitney-Smith, E. 2003 Theory Building with System Dynamics: Ice Age Extinctions. NYC Systems Dynamics Society meeting.

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**Dynamics of Vulnerability**

Many of the contributing factors to computer security problems are non-technical in nature – that is, they are dependent upon human and organizational actions and interactions in the political, social, legal, and economic realms. However, much of the research in computer security has had a predominantly technical focus. This paper represents a first attempt at using the concepts of system dynamics to model some of the human and organizational actions and interactions that impact the software vulnerability lifecycle, which represents the relationship over time between the discovery of security vulnerabilities (i.e., flaws) in software and the occurrence of computer security incidents based on the exploitation of those vulnerabilities by attackers. Although our initial model relies on several simplifying assumptions, it points the way towards richer and more comprehensive models that can increase our capabilities and understanding in ways not possible through traditional computer security research approaches.

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**Understanding Technology Innovation and Transfer through System Dynamics Modeling: Implications for Requirements Projects Managers**

Requirements engineering managers in software technology transfer projects are faced with an increasingly dynamic, complex and uncertain environment in which they make decisions. A different modelling tool is required to navigate this increasingly complex environment. This paper demonstrates the utility of systems dynamic modelling approach in aiding requirements

engineering project managers' decision making. The system dynamics model developed provides insight into the use of such models to evaluate potential technology diffusion patterns and transfer rates of software systems requirements projects. The model allows for comparative analysis of possible effects of different return on investment assumptions on technology transfer and adoption.

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## **Making the ASP Model Work: Using System Dynamics to Explore Leveraging in Software Access Options**

The value-added potential of e-business is the driver behind many firms engaging with new information technology products and processes. However, promise has not always been fulfilled. An apparent mismatch between customer expectations and vendor offerings also suggests a lack of appropriate methods and techniques for evaluating strategic benefits from e-business, and some have argued that IT in many respects is now merely a commodity infrastructure. This paper draws from a longitudinal research study on application service provisioning (ASP), an e-business model targeted mainly at small and medium businesses (SMBs). By addressing the inherent complexity of the ASP model, the paper demonstrates how a series of critical inter-relationships between key performance indicators (KPIs) will impact the business value for customers. The paper offers insights into critical factors that could make the ASP model work, and, if it could, then how clients could still obtain competitive advantage from engaging their services.

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## **Using System Dynamics to Influence and Interpret Health and Social Care Policy in the UK**

Over the past two years OLM Consulting, initially in partnership with Cognitus, have used System Dynamics (SD) modelling in a wide range of health and social care settings to shed light on a number of difficult and complex issues. At the national level we would claim to have used models to moderate legislation significantly, by influencing national agencies and the upper house of parliament. At a local level we have used SD to help health communities interpret legislation in a meaningful and shared way to achieve a more balanced and sustainable consensus for change. Modelling was the means to review investment decisions from a "whole systems" and multiple agency perspective. We have also helped communities to own models and to work towards consolidating the modelling process into regular planning activities. This paper describes the work carried out and its achievements with particular reference to the role of models and the process of application. It describes: The current state of the health field, including the challenges created by the legislative agenda Experiences in creating a whole systems view of hospital discharge and exploring various elements of the mental health system. These are described in more detail in the accompanying papers presented at this conference.

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## **Using System Dynamics in Modeling Health and Social Care Commissioning in the UK**

Over the past two years OLM Consulting, initially in partnership with Cognitus, have used System Dynamics (SD) modelling in a wide range of health and social care settings to shed light on a number of difficult and

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complex issues and to influence and interpret health and social care policy in the UK. This work has been instrumental in causing health legislation to be modified in the Upper House of Parliament as well as helping local health communities implement sustainable performance improvement. This paper describes the work done in 2003 with two local health economies. It shows the commissioning models that resulted from applying a nationally-developed template in a local context, as well as some of the findings obtained from running those models. The emphasis has been on demonstrating strategies that achieve efficiency improvements for all agencies across whole patient pathways. By modelling whole pathways from primary care through acute care to post acute care, and focusing on admission prevention and delayed discharges, it has been possible to show that significant resources can be saved within agencies along the pathways, without influencing performance.

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### System Dynamics Based Traffic Flow Simulation

This paper demonstrates the possibility of interconnecting System Dynamics (SD) methodology and one-lane traffic flow simulation. The main advantage of modelling traffic flow using the principal of System Dynamics is to provide an understanding of the changeable system structure, which can lead to different traffic behaviours. The work is developed on a basic traffic model built with System Dynamics, which simulates the transport behaviour of a one-lane road section using vehicles' moving rules. From the basic model, all kinds of road networks could be modelled by connecting numbers of similar road sections. Furthermore, these road components are joined with different traffic control infrastructures such as traffic lights, pelican crossings or roundabouts. Therefore, different scenarios could be produced by the changeable inputs. Using the nature of changeable objects of road sections and controlling infrastructures, should allow transport planning and policies to be produced and easily evaluated based on simulation processes.

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**Money Supply and Creation of Deposits: System Dynamics Macroeconomic Modeling**

This is a first paper of the series of macroeconomic modeling that tries to model macroeconomic dynamics such as the determination of GDP (Gross Domestic Product) and money supply from system dynamics perspective. This paper tries to model money supply and creation of deposits on a basis of the principle of accounting system dynamics developed by the author. For this purpose, a simple model based on gold standard is constructed first that requires the introduction of high-powered money and monetary base as two different stocks, contrary to the macroeconomic tradition that treat them identically. And it is shown how money supplies based on these stocks differ each other. The model is then expanded to a complete money supply model that includes government securities so that central bank can exercise a discretionary control over money supply through open market operation.

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**A Generalized Stock Control Formulation for Stock Management Problems Involving Composite Delays and Secondary Stocks**

It is well established that if the stock management formulation ignores the supply line delay, the behavior of the system can be quite oscillatory. There are naturally other types of delays in stock management problems such as information delays in decision processing and implicit delays involved in controlling a primary stock indirectly via a secondary stock. But there exist no general decision rules in system dynamics that explicitly consider these complex delays in stock management structures. In this research, we first show that the behavioral consequence of ignoring information delays or ignoring the delays implicit in secondary stock control is equivalent to ignoring the supply line delay in the standard case: large oscillations. Next we introduce the notion of 'virtual supply line' and derive a generalized stock control heuristic that does take into account these more composite delays and show that the result is a stabilized dynamic behavior. Finally, we implement our decision heuristic on an example involving all three types of delays, demonstrating the "generic" nature of the proposed formulation structure. The combined result is a significant improvement in the stability of the system, when compared against the standard policy that considers the supply line delays only.

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**A Dynamic Diffusion Model for Managing Customer's Expectation and Satisfaction**

Being successful can be just as dangerous to long-term health as being unsuccessful. Even success can sow the seeds of failure by stressing and overburdening the current system. While suppliers may be tempted to hype up their products to obtain additional sales in the short term, those customers persuaded by 'hype' are often disappointed with their experiences, which in turn bears a negative impact in the long run. Starting from this point, this paper aims at answering to the generic question on how suppliers make the suitable and well-timed decisions in diffusing new technology effectively to adopters. To meet this research objective, the paper attempts first to investigate the entire process of the adoption and diffusion of technology

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innovation, and then proposes an integrated model by concatenating in structured manner the three prominent models for the management of technology innovation such as diffusion model, adoption model, and customer satisfaction model. An exploration of the dynamic mechanism underlying outward behaviors of the integrated model is presented in the study by introducing the system dynamics simulation technique.

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**Venture Capital Investment Dynamics during Market Boom and Market Meltdown**

By the end of the 90's a huge amount of venture capital money was invested in the communications and internet industries that became over-funded. During the first years of the new millennium the landscape for venture capital activity collapsed dramatically from its record levels. The purpose of this study is to understand what are the drivers of venture capital over-investment in specific industries during periods of market boom and bust, as well as the implications of such over-investment. Prior studies suggest the boom and bust dynamic is due to a dysfunctional response of venture capital supply to the shifts in demand. However, these studies have failed to explore the effect of decision making speed in venture capital performance. We develop four investment strategies based on decision making speed, and draw lessons to be learned by venture capitalists (VCs) when riding the next big wave of technology investments.

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**A System Dynamics Evaluation of SARS Preventing Policies in Taiwan**

The early year in 2003, Severe Acute Respiratory Syndrome, SARS, has brought the global panic, and caused 8,422 SARS patients including 916 deaths. In Taiwan, SARS has affected 665 persons including 180 deaths. In order to control SARS situation, each area took several policies. Because SARS was an emerging infectious disease, we didn't have the immunity and treatment method in the short-term. Therefore, the most important point was to prevent the spread of SARS. We evaluate the policy effectiveness on preventing transmission of infectious disease from the flow and feedback viewpoint. We divide policies into three categories. The policies are "Lower contact policy", "Protection Policies", and "Quarantine policy". In our research, we proved that the "Protection policies" is much more effectiveness on preventing SARS. But we still proved that if the infectivity reach as high as 10%, the spread of SARS never stop until all people affected. We believed that Taiwan is lucky, because the infectivity of SARS is low enough. Consequently, we ought to ponder the way to live with viruses in the long-term, and not to resist any virus reactively.

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**Exploring Some Dynamically Aligned Principles of Developing a Balanced Scorecard**

The Balanced Scorecard (BSC) facilitates managers to balance strategic focuses on four perspectives, on complex cause and effect relationships, and on developing more systemic aligned strategy. But some literatures showed

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that the BSC theory and practice had some limitations. The root of limitations is “cause and effect are not closely related in time and space”. And that will mislead managers to generate misperceptions of feedback information and execute wrong strategy. This research employs system dynamics as a method to overcome the limitations, and focuses on generating some dynamically aligned principles for the theory of developing BSC with system dynamics. We perform a case study on a hospital (K Hospital) in Taiwan, which using BSC to develop strategy, and we use systems thinking and system dynamics to inquire its BSC strategy. We generalize some dynamically aligned principles, including using the dynamic pitfalls to inquire a BSC and remind managers abidingly, and propose some critical dynamic structures to diagnose problems and generate solutions. These principles could facilitate other organizations to inquire their BSC and to develop their new BSC strategy. We suggested a more dynamically aligned BSC for the case hospital.

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**A Model of Structural Oscillation of Conflict Goals**

About the research on structural oscillation, we tried to work from a slightly different angle. Although a large number of studies have been made on, little is known that put conflict goal and second-order system together. This paper is intended as an investigation of the oscillation model. The point about this model is “Success to Successful” archetype, and central to this issue is the problem of “nothing grows forever.” It might cause oscillation due to limited time resource. We have chosen an example about the conflict of work and family to illustrate this model. These results lead to transform the conflict goals model into a generic model. We may go on from this to the conclusion that we must be aware of warning variable and then we present the two solutions. First, we must understand what we really want to do and consider the priority. Second, we must change the measurements of performance in the organizations. So the conflict goals can help us leading into reflections.

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**A Dynamic Model of Quality Costing: The Case of ABC Printing Company**

This paper attempts to formulate the practical means for implementing the Quality Costing in Printing Industry. The importance of quality costing and its benefits is not fully tapped by the production managers. Quality means productivity and both win the industrial growth, generate the profit and reaps the crop of money which is the language of industrial manager. Unfortunately, the industrial managers only focus the cost of non-conformance like waste percentage and customer rejected material but usually ignores the cost of conformance like better planning, proper tools for quality enhancement etc. Most of the publications deal with better quality and high productivity issues but rarely address the quality costing and its real benefits which can be achieved. This paper depicts the model of quality costing in medium scale printing unit. The quality costing elements are drawn from the literature of American Society of Quality (ASQ) and from the Juran ‘s Handbook of Quality Control The benefits of the quality costing have been taken by implementing the different policies devised with this practical model and implemented in actual environment. The different elements of cost of non-conformance have been identified and then policies are designed on the basis of experience to bring improvement.

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**Developing an Interpretive Dialogue for Group Model Building**

This paper builds upon the review of the literature in Group Model Building exploring the tension between modeling as a representation of reality – models as micro-worlds, and modeling as a tool for negotiating a social order –models as boundary-objects (Zagonel, 2002, ISDC). This line of research advocates a particular view: there are tensions in group modeling, and these tensions may be identified and characterized by differentiating micro-world from boundary-object approaches in model building and use. It builds upon the premise that tensions in model conceptualization exist, and that they are important for theory and practice. This essay suggests ways of operationalizing the identification and characterization of these tensions, and it reports the results of applying this framework to a small sample of documents from one intervention.

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**Some Remarks on the Benefits and Limitations of an Analytical Solution Approach to Sterman's Generic Supply Chain Model**

The management of supply chains is a well described policy design problem in the System Dynamics (SD) literature. Nevertheless, its treatment is often only interpretive with respect to the causes for the dynamical behavior derived from numerical solutions for such systems. This situation hampers a deeper understanding of the relationship between structural parameters of a supply chain represented by its physical flow (material flow) and its information flow (policies) and its dynamical characteristics e.g. general dynamics, oscillation frequency, amplitude amplification and phase lag. The author proposes to improve this situation through the use of an analytical approach that translates the policy problem into a mathematical problem represented by the solution of a differential equation. The feasibility of this approach, questioned in the literature for complex systems, is demonstrated for Sterman's (2000) generic supply chain model, for which closed analytical expressions between system parameters and the resulting dynamical characteristics are derived.

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**A Critical Review of the Use of System Dynamics for Organizational Consultation Projects**

System Dynamics (SD) based organizational consulting projects show a diversity of process models, conceptual frameworks and terminology. As a consequence such practices do not meet the criteria of fully consistent and solid consultancy approaches. Nevertheless, SD based consulting contains a number of valuable elements. The authors propose to save and integrate these into an existing consultancy framework, namely the systemic intervention practice, that is derived from a systemic theory of social systems, which is based on Maturana's concept of autopoiesis. This strengthens the already existing subjective worldview in parts of the SD community and thus integrates the exploratory strength of SD, that allows a formalized reflection of the perceived logical structure of mental models, into a coherent consultancy framework based on interpretive and constructivist perspectives.

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# Special and Convened Sessions

## Bringing Coherence and Consensus to Public Policy Making

These three sessions will explore the populist political notion of 'joined-up thinking' in government and public policy, wherein decisions and public funding are targeted in a coherent and efficient manner towards issues that really matter. This plenary will feature a presentation by Nick Mabey of The Prime Minister's Strategy Unit. He will identify the issues and challenges in co-ordinating thinking across a wide range of government departments, followed by an input from Prof. Eric Wolstenholme, one of the world's leading system dynamics practitioners whose modelling work on National Health Service planning has been highly influential. These sessions will be chaired by Peter Day, who is a leading BBC business correspondent and analyst. A second complementary session will contain contributions from Vince Barabba who will examine how decision makers view the context surrounding the decision to be made. Vince, a former senior executive with General Motors who is well known in the States for his work on decision tools to improve decision making in both the private and the public sectors. The second paper is from Richard Dudley who will examine how Social Capital is built via the network of connections among individuals in a community. Later the same day we are holding a special session debate on the topics raised in these sessions.

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### **Military Roundtable**

The Military Roundtable is the arena for sharing ideas and experiences on the application of System Dynamics to military problems. The list of topics includes, for example: strategy development; force-on-force analysis; war-gaming; military decision making; training of military decision makers, including command-post exercises; preparedness studies; human resource management; development and management of military capability; management of materiel acquisition; military logistics modeling; in-service management. We suggest the following main topic for this year's meeting: "The application of SDM in a network centric context". Opportunities exist for participants to provide updates on recent research and consulting activities, to discuss opportunities for the future and challenges that confront those working in or having an interest in system dynamics modelling (SDM) in a military context. We will continue the work on assembling a compendium of models and readings on SDM in defence.

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**Working Ideas, Insights for Systems Modeling:  
The Broader Community of Systems Thinkers**

In 2001/02, a series of research meetings funded by EPSRC and organised by Lancaster University explored in depth the relationship between hard and soft approaches to systems modeling. This plenary session will replay selected insights from the meetings of particular relevance to the system dynamics community. Talks by Peter Checkland, Michael Pidd and John Morecroft will be followed by discussion facilitated by Kim Warren.

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**Economic Roundtable**

The economic dynamics roundtable offers a discussion forum for system dynamicists who are interested in economic modeling. This year, the economic dynamics chapter of the System Dynamics Society will reveal its new web site and lead a discussion on the ways it can be enriched. A report on the most recent uses of system dynamics in heterodox economic modeling will be presented and WPI's "History of Economic Thought via System Dynamics" project will be introduced. All interested persons are welcome.

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**Business Roundtable**

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**Modelling Assistance Workshop**

In recent years, there has been a modelling assistance workshop at the International SD conference (many thanks to Paul Newton and Jack Homer for establishing this). The Oxford conference will also be including such a workshop. The objective of the workshop is to enable anyone to discuss any aspect of SD modelling they may be undertaking with experienced modelling coaches. Topics could include assessing the applicability of SD, conceptualisation, detailed formulation, analysis and communication. We will be following the successful approach of assigning coaches to modellers needing assistance. It is intended that these will be one on one sessions and we will match the most appropriate coaches to the modellers' needs.

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## Security – Information Security

The session consists of three papers: Business Dynamics Based Template Model For Security Policy Management; Preliminary System Dynamics Maps of the Insider Cyber-Threat Problem; Dynamics of Vulnerability. The first paper uses a basic model of an information system (IS) to highlight the broad impact of security policies. The other papers are fruits of a collaboration that begun when cyber security experts at CERT Coordination Center contacted the Security SIG of the System Dynamics Society for the purpose of exploring the ability of SD to deal with aspects of the cyber security threat far defying satisfactory treatment. The second paper deals with the threat posed by insiders to cyber systems and formulates a “dynamic trigger hypothesis” as escalating mechanism exposing the IS to attack. Dynamics of Vulnerability discusses the lifecycle of attacks on information systems via software vulnerabilities – i.e. bugs that can be exploited by hackers to run malicious code.

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## PhD Colloquium

The 5th International Ph.D. Colloquium is an event of the System Dynamics Student Chapter. Its objective is to bring together Ph.D. students who are involved in System Dynamics research and to give them the opportunity to raise key questions and/or concerns related to their research and discuss these in depth in a constructive and enjoyable atmosphere. The diversity and the interactive setting provide a unique learning opportunity for all participants. Students who intend participating in the Ph.D. Student Colloquium should be in the early phase of their research, but after having settled on a research area or thesis topic. The students closely interact with established faculty and others of the wider system dynamics community. This year, the all-day colloquium will open with a series of faculty talks. Three presentation blocks will follow them. In each block there are two consecutive 20-minute presentations. The presentations are followed by two parallel 30-minute workshops during which participants can discuss the questions/concerns raised. There will also be a 1-hour poster session after the presentation sessions in order to give all the students who have submitted a proposal the chance to present their work.

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## Environmental Roundtable

After a request for proposals through the ED SIG's communication channel, *SDsustain*, three main issues are set to be discussed at the 2004 Environmental Dynamics Roundtable: (a) the possibility for collaboration with the US EPA-CREM, regarding their environmental models; (b) the possibility of creating synergy with other entities that take interest in Sustainable Development: i.e. other SDS SIGs/ chapters (e.g. Economic Dynamics, Strategy Dynamics), governments or NGOs, and societies/ associations related with Sustainable Development, Planning, Environmental Impacts, Economics, etc.; (c) how to make Environmental Dynamics more “dynamic”: online discussions (*SDsustain*), case studies/ projects/ collaborations, collection and registration of existing published material in ED SIG's Resource Database, the new initiative of the Repository of Working Papers, and other ideas.

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**System Dynamics Model Database: An Online  
Repository for System Dynamics Models**

The knowledge and the exchange of system dynamics models is an essential part for the development of the methodology in and outside the System Dynamics community. The online model database available at the URL <http://www.systemdynamics-database.ch> has been built up for this purpose and should become a central repository for SD models and SD knowledge. The models can be uploaded by researchers, consultants, institutions and all parties interested in the development and distribution of SD models. The models are categorized by topic, an abstract can be added to describe the model content and they can be downloaded from the database. To evaluate the practical value of the model, there is also rating and review functionality for the users of the model.



# Workshops

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## **Riding the Seven Waves: Mastering Supply Network Dynamics**

This workshop discusses different aspects of complex dynamic behavior in supply chains and networks. More and more companies operate in effect as parts of highly decentralised interorganisational supply networks. This makes the challenge of coordinating activities within these networks all the greater. Companies have to "ride the waves" of many dynamic developments that they alone cannot control.

In this workshop, we look at seven of those waves: - How to avoid the bullwhip effect of upstream demand amplification? - How to keep capacity in sync with sales as market demand keeps increasing? - How to smoothen the transition from product development to production ramp-up? - How to smoothen the effects of the business cycle on your company's performance? - How to grow effective and close partnership with key suppliers and customers without losing flexibility in the market? - How to make the dynamics of market standardisation work for instead of against you? - How to manage timely transitions in organisational change? Workshop format will be highly interactive, with tailored presentations on the one hand, and group model-building sessions on the other. Computerised models of these policy issues will be available. Pre-session input by participants of relevant supply network dynamics issues is highly appreciated.

## **Impact of Context in Selecting Decision Tools for use in Both the Public and Private Sectors**

An important first step towards "bringing coherence and consensus to public policy making" is to ensure there is coherence and consensus in how decision makers view the context surrounding the decision to be made. The workshop elaborates on a description of three prototypical approaches that distinguish alternative points of view in considering a decision's context. The approaches anchor the ends of a continuum that encompasses the worlds of simplicity/certainty and complexity/uncertainty as well as a midpoint that offers a point of view to help clarify the opportunities found at the ends of the continuum. The three prototypical designs are captured by the terms: make-and-sell, sense-and-respond, and anticipate-and-lead. To demonstrate the impact of the mindset of context on decisions tool choice, an example using agent-based systems dynamics modeling to address questions related to the acculturation of the Hispanic population in the United States will be presented.

## **Methods to Make Your Simulation Run on the World Wide Web**

Simulations that run in web browsers have the advantages of global accessibility, simple distribution, and the ability to monitor simulation usage. However, simulations need to be modified in order to effectively use the online medium. Online simulations need to engage the user, be accessible in multiple formats, be simple to navigate, and correspond to the

user's learning objectives. Usability design is critical to create simulations that will be used by a diverse, global audience with limited knowledge of simulation, short attention spans, and unarticulated use objectives. During the workshop, Michael Bean will demonstrate how to create web simulations, discuss commonly occurring web simulation design challenges and potential solutions, and show examples of web simulations that have been used by thousands of users. Michael will also provide a series of guidelines for creating simulations online. Michael will provide handout booklets, sample simulations, and sample HTML pages that can be used to create your own first web simulation.

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### **Using Kalman Filtering to Compare Data and Model Behavior**

Noise and other disturbances can make the trajectories that variables follow very unpredictable. A consequence of this is the difficulty of comparing a deterministic simulation with data. By applying a Kalman filter it is possible to adjust the trajectory based on the data and make this comparison more meaningful. This is the solution to the dilemma described in appendix K of industrial dynamics. The workshop will describe how this is done and demonstrate the results of doing it using the Vensim software. This will be a lecture style presentation.

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### **Starting a System Dynamics Program in Your School For Students 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. 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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### **Technology Adoption Strategies in Energy Production**

### **Brenda Burke**

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**Using Semantica as a Scaffold to Systems Thinking**

Semantica is a cognitive tool that enables users to build a publicly shared web of understanding about a problem. This workshop will briefly review the research on the problems that students encounter in developing and using systems thinking and the research on semantic networks. Semantica will be demonstrated using a variety of networks from different disciplines. The audience will collaboratively develop a semantic network about a topic selected by the audience at the workshop. A comparison of the cognitive processes and the specifics of tools, such as Semantica and STELLA, will clarify the comparative advantages of each application. Finally, the application and utility of the use of semantic networking, based upon experiences with pre-service teacher education students and in-service teachers, as a precursor to introducing and using systems thinking, especially in the pre-college academic environment, will be explored with the participants.

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**Planning Health and Social Care Services for Older People in North West London Using System Dynamics**

This is a demonstration and discussion of the latest iteration of the *ithink(c)* model outlined in the plenary conference session (E. Wolstenholme et al), applied to older people's use of health and social care services in three boroughs, to assist strategic planning. Older people move between modes of care (community, hospital, intermediate, long-term) differently depending on their levels of dependency. This presents a significant challenge to those charged with strategic planning across sectoral boundaries. The model illustrates the complexity of joint planning, providing a tool for learning and mutual understanding across operational divisions. Feedback loops include operational management responses when services operate near capacity. Planners learn that they need to balance service capacity against rates of flow (where the main variables are length of stay and service capacity), across the whole system. The presenters will be able to report on the current impact of the modelling project on strategic service planning.

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**Recognising Cybernetic Principles Manifested in Self-Organising Systems**

Given science's search for invariant laws and the quickened pace of change that organisations are confronted with, the question we want to address in this workshop is 'what is the relationship between the invariant laws and self-organising teams?' For this purpose the workshop we will call upon the participants to self organise into teams in order to produce a result in the context of a fast paced changing environment. Having experienced this game, the participants will be invited to reflect upon the laws that were evidenced in the way that they self organised. In this regard, we will examine the evidence to see if we can detect such laws as: A: McCulloch's Law of Redundancy of Potential Command; B: Ashby's Law of Requisite Variety; C: Beer's Law of Cohesion. From the results of the exercise, we seek to elucidate how the laws help us to deal with changing and turbulent environments. Attention will also be drawn to how the self-organising teams cope with the need for dynamic change of purpose(s) and what are the requirements to sustain viability.

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### Making Creativity Deliberate

Creativity - the ability, and confidence, to generate new ideas – is an integral aspect of much of systems thinking and system dynamics modelling. We all do this intuitively – but is creativity necessarily an intuitive process? Or can it be made deliberate and systematic? And can people be trained to become more creative? In this highly interactive and energising workshop, Dennis Sherwood will argue – convincingly – that the answer these questions is ‘no’, ‘yes’ and ‘yes’ respectively. To prove the point, he will show you how to use his InnovAction!™ process - and you will be amazed how many new ideas you will be able to discover!

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### Fast-track Strategic Modeling

Scenario planning is, arguably, the most powerful of the strategic planning methodologies, and system dynamics modelling is a wonderful way to simulate the dynamic behaviour of any scenario. Strategy planning models, however, are complex, and since each business is different, we are always starting from scratch. But is this necessary? Are there ways of making strategic modelling a much more generic process? In this workshop, Dennis Sherwood will describe some work he has been doing recently in creating a generic strategic modelling structure. Of course, this is not a complete answer to all strategic modelling problems, but Dennis feels that the structure he will be describing is a very useful core. Dennis will much appreciate your views!

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### Cultural Transformation Geniusys

How do you create an organisational culture where you can get the best out of your people while still improving on your bottom line? If this question is one that interests you, this workshop will provide a forum to explore some new and innovating ideas. First we will explore how we can use systems thinking to develop a strategic planning framework that addresses key issues that impact the success of cultural transformation programmes (CTPs). Next we will use systems thinking and the Geniusys psychology dynamics model to explore how we can implement the strategy through coaching and training staff. Hands on exercises will be provided that demonstrate how we can use the Geniusys model to lower resistance and increase individual motivation towards the CTP. This workshop will demonstrate the “motivation linguistics pattern”, which is the key tool used to increase the motivation of staff towards the CTP.

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### ExTrain®: Management Training Platform for Simulation-based Learning and Knowledge Management

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System dynamics models having long been used for management training and decision support through the use of Management Flight Simulators or Microworlds, but there has never been an environment especially designed to facilitate the complex process of strategic planning. Powersim ExPlan® is a web-based application platform which enables managers to engage in strategic management, namely, applying strategic thinking and planning to

the job of running their organization. They can incorporate scenario and strategic planning in the day-to-day management of their organization. This includes the integration of corporate-wide planning and budgeting, continuous (rolling) forecasting and a linkage and alignment between operations, management and strategy. After a brief introduction to the ExPlan® environment, participants will learn in details the design and use of ExPlan®, as well as have the opportunity to create and test their strategies using the application.

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**Integrated Systems Methodology for the Mapping, Measurement, and Modeling of Knowledge Based Processes**

The modern firm creates value by operating assembly lines of thought, however process improvement practices remain tethered to methods developed for factory floors. Organizational value chains are often intangible and resistant to improvement using methods developed for simple probabilistic systems. The knowledge of how work gets done is typically qualitative, implicit, tacit and individually owned. Firms struggle to make their processes tangible, explicit, quantitative and organizationally owned. Improvement of knowledge based processes requires heuristics for organizational learning and anticipation to enable viable emergence, agility, adaptation and sustainability of self-organizing systems, in contrast to the traditional emphasis on process optimization. This workshop will present an Integrated Systems Methodology, using case studies and exercises, that has been designed for mapping, measurement, modeling and improvement of knowledge based processes that incorporates System Dynamics, Cybernetics, Information Theory, Emergence Theory, the Viable Systems Model, Neural Net Cognitive Modeling, Requisite Variety Engineering and Decision Automation Engineering.

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**Reaching Out to Others: Helping 'Dynamic Virgins' Understand with Models and Microworlds**

Microworlds have long featured as powerful tools for helping newcomers see the implications of feedback in business, social and other systems. A larger prize can be had, however, by re-presenting phenomena that are well-known in other fields in a form that will be readily familiar to professionals in other fields. The dynamic performance and policy implications for staff-development, customer acquisition, product development, asset-aging, and a host of other examples, can only truly be grasped through hands-on experience - and simulations offer a much faster and lower-cost form of experience than the real world! This workshop will show how well-known phenomena can be captured in models ranging from small spreadsheets up to fully-featured learning environments, then used in a wide range of educational settings, both within organisations and universities. Participants will be able to experience some of these examples for themselves, and explore opportunities that may exist for increasing dynamic insight amongst their own audiences.

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### **Wielding the 'Choice Pipeline' for Stakeholder Development in Strategy Dynamics Projects**

Strategy studies that pay rigorous attention to dynamic coherence frequently surface some common, and powerful frameworks. One such framework that has proved especially powerful is the 'choice pipeline', and this workshop will both show why and how this framework works, and give participants practice in its use. Organisations of all kinds 'compete for choice' of key stakeholder groups - customers are the most obvious example, but staff, investment providers, volunteers, advertisers and many other groups may feature in businesses, public-sector organisations, NGOs or voluntary groups. These groups cannot simply be switched from ignorance to total commitment, but must instead be taken up a 'pipeline' of states - through awareness, understanding, tentative participation, for example. This workshop will show how the simple stock/flow structure that captures this process, and demonstrate how ubiquitous and powerful it is. It will also show how to coach a management team through its use, to bring them to a clearer understanding of 'what to do, when and how much' so as to achieve much-improved performance. Workshop participants will be coached in small groups to tackle challenges of their own, using this framework, and see how to use a simple dynamic models to explore its implications in real situations.

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### **MacroLab: Model Facilitated Learning of Macroeconomics**

What is MacroLab? A system dynamics model and interactive learning environment (ILE) used in a macroeconomics distance-learning course at a Virginia college. Who should attend? Anyone interested in how models can be used to facilitate learning. What will you do? Gain economic understanding by test-driving the model; gain insight for an ILE in your own field. What will you take away? A MacroLab demo disk and user guide; insights gained from hands-on activities and group discussions. Who is the facilitator? An experienced consultant, award-winning instructor, and PhD candidate in system dynamics. How is this workshop different from last year's? More feedback from students, preliminary experimental findings on MacroLab's effectiveness as an instructional tool, and a complete semester curriculum.

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# Addenda

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## **The Supply Chain Collaboration Online Research Simulator**

Supply chain collaboration is set to accelerate in future years. Evidence from a survey conducted with funding from the Canadian Purchasing Research Foundation is presented and it is argued that understanding of the exploitation of this environment is in its infancy.

Recently Athabasca University commenced a research project on supply chain collaboration. Funded and supported by the Canadian Foundation for Innovation, the Alberta Provincial government, SAP and IBM, this project is focused on developing an online model of a fully data integrated supply chain. A simulation model is being used to help us learn how the business community will best use this supply chain environment of the future.

Networked private communications between supply team members, data visibility, push versus pull systems, post-simulation performance analysis, group strategy formulation, strategy delivery and team discipline in networked environment are all aspects of research under consideration.

A fully functional simulator of a data integrated supply chain environment supported by a complete range of online collaboration tools is currently being field tested and may be demonstrated at this symposium. It is available to researchers online throughout the world to develop their understanding of supply chain collaboration and networked resources management at [www.athabascau.ca/scm](http://www.athabascau.ca/scm) or [www.sccori.com](http://www.sccori.com)

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## **The Tyranny of Small Steps – An Archetypical Behaviour in Resource management**

A new archetypical behaviour has been observed. The archetypical behaviour, whereby an overarching decision is undermined by small step changes on a finer resolution level is discovered to be very frequent. The small steps must be smaller than the observation resolution of the overarching system in order to be in-stoppable. The archetypical behaviour is active in many long term political conflicts where a situation appears to be slowly deteriorating over long time, apparently with no means to stop it. It is also present in situations where several administrative levels are acting on the same object, such as resource planning and permissions by local and super-regional authorities. Examples are urban encroachment on surrounding land or the slow diffusion by one population into a territory of another.

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**Dynamics of Learning by Doing Under  
Constraints: Analysis of the Tipping Point**

The central notion in learning curve theory is that accumulating experience leads to improved performance, or “learning by doing.” The concept occupies a central role in many strands of strategy and organization theory and forms the basis for such ideas as the specialization of labor, organizational learning, knowledge transfer, and core competences of the firm. Traditional learning curve theory considers the productive activity of interest, such as the manufacture of airframes, in isolation from other demands for critical resource inputs, such as direct labor hours. In contrast, many learning situations are characterized by a competition for the learner’s time between a new skill to be learned and an old, proven means of accomplishing tasks. The learner’s time is a limited resource. The learner faces the challenge of allocating this resource to meet the demand for certain output objectives while simultaneously trying to learn how to do things a new and possibly better way.

The purpose of this paper is to extend learning curve theory by embedding the learner in a context in which he or she must achieve certain output objectives. Building on the basic notion that accumulating experience leads to improved productivity, I formulate and analyze a two-loop system dynamics model that incorporates a constraint to achieve a specified level of output as well as the forgetting or deterioration of knowledge. I use simulation analysis to demonstrate a mode of behavior in which learning begins and then stalls and another mode in which learning dominates so that the new skill becomes the preferred manner of doing. I characterize the tipping point that distinguishes these two modes. The discussion highlights key implications for managing implementation efforts and organizational change.