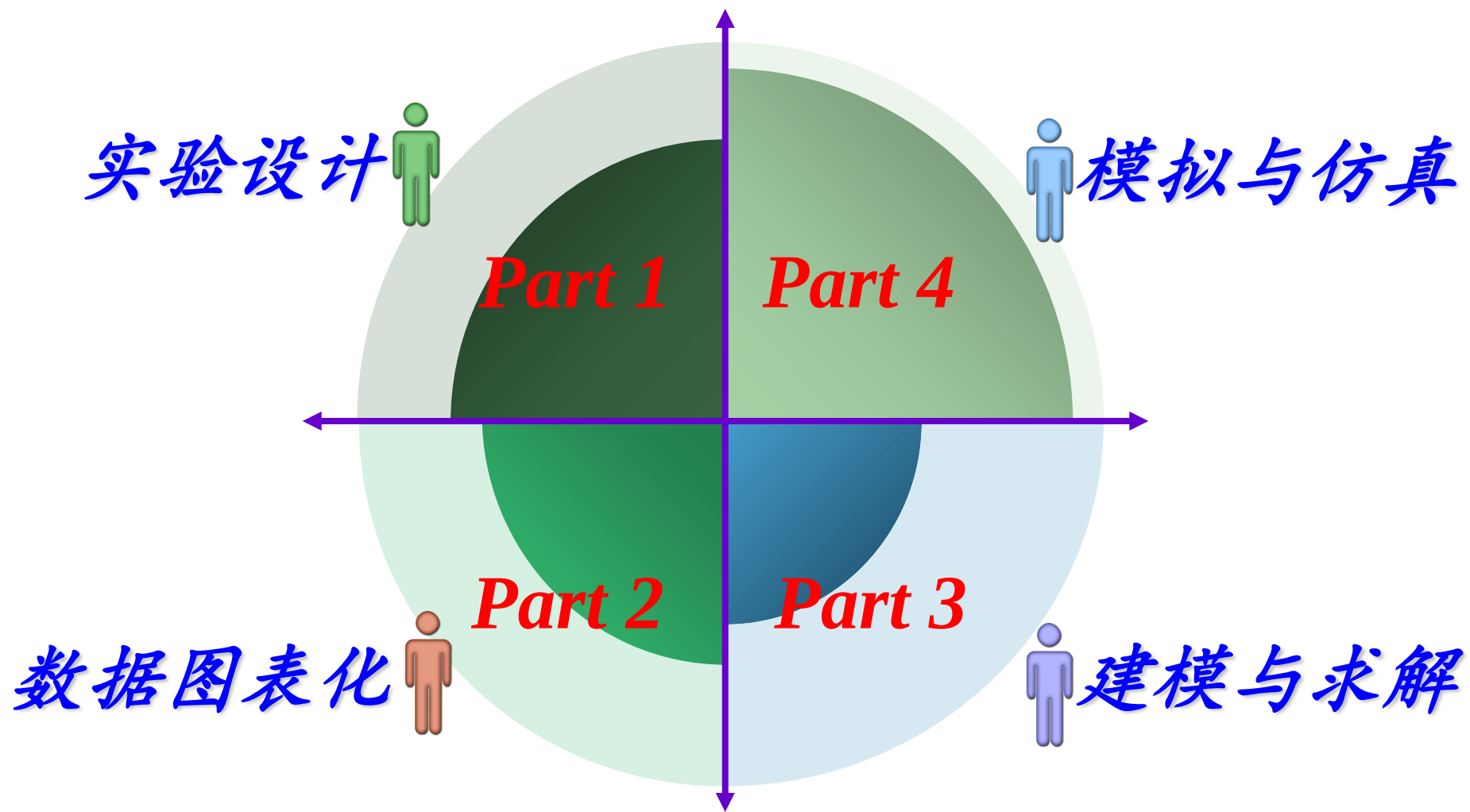




课程流程





系统动力学 (System Dynamics) 概述

1

系统动力学出现于1956年,创始人
为美国麻省理工学院(MIT)的Jay
W. Forrester教授





系统动力学 (System Dynamics) 概述

2

1961年Forrester发表的“工业动力学”(Industry Dynamics)是系统动力学的经典著作

3

此后,系统动力学应用范围日益扩大,几乎遍及各个学科领域,逐渐形成比较成熟的新学科——系统动力学



系统动力学概述

4

系统动力学是一门分析与研究信息反馈系统的学科,也是一门认识系统问题和解决系统问题的交叉综合学科

5

从系统方法论来说,系统动力学是结构的方法、功能的方法、历史的方法的统一

6

它基于系统论,吸收了控制论、信息论的精髓,是一门综合了自然科学和社会科学的横向学科



系统动力学概述

7

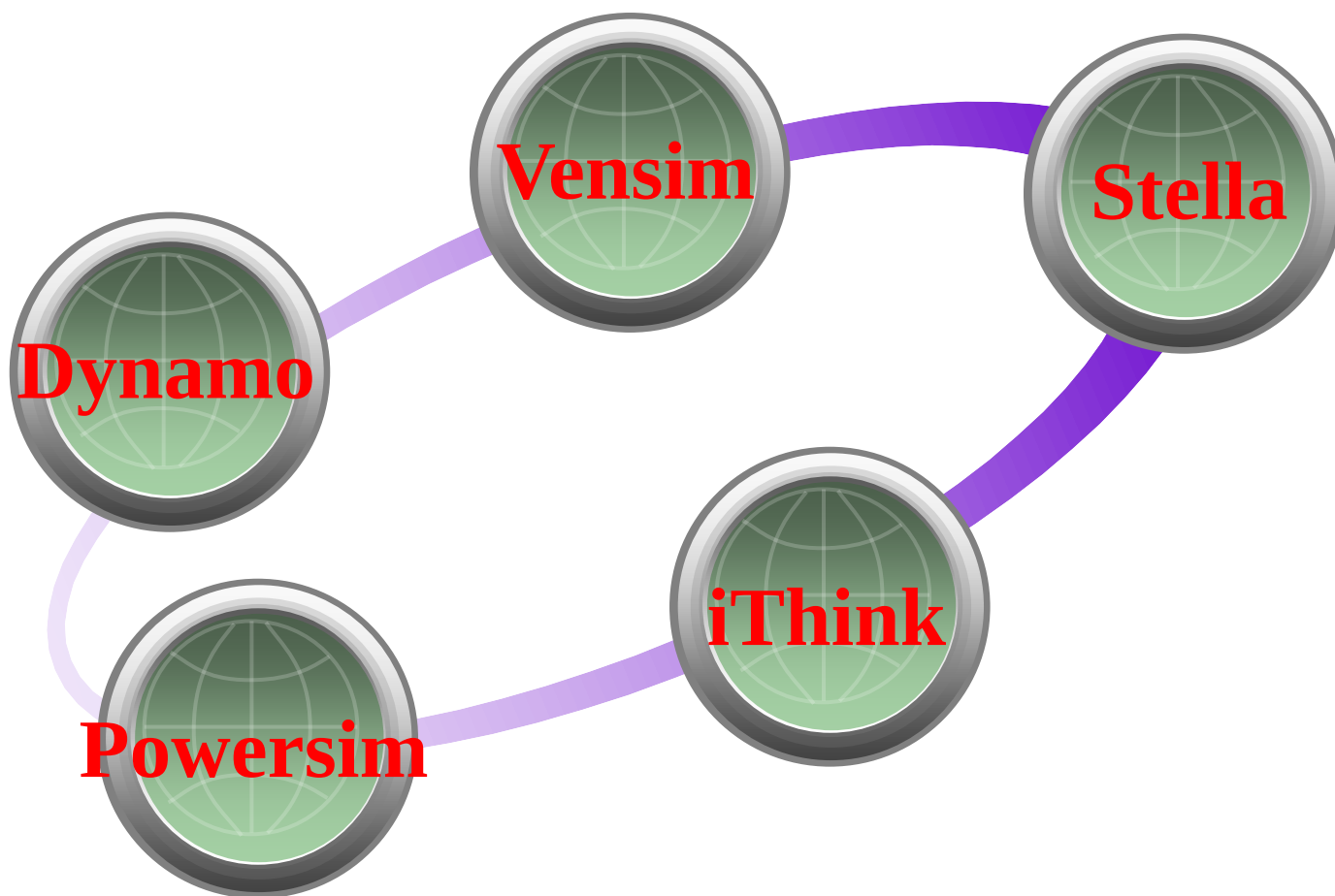
系统动力学是一种利用系统结构、各环节的因果关系和反馈回路以建立模型，并通过仿真方法来求解系统性能的一种理论。

8

由于它涉及到微分方程或差分方程求解、控制理论应用、经济技术分析以及计算机软件等多种学科，因而属于跨学科的新型理论和方法。



常见系统动力学软件





<http://vensim.com/>

<http://www.powersim.com/>

<http://www.iseesystems.com/>

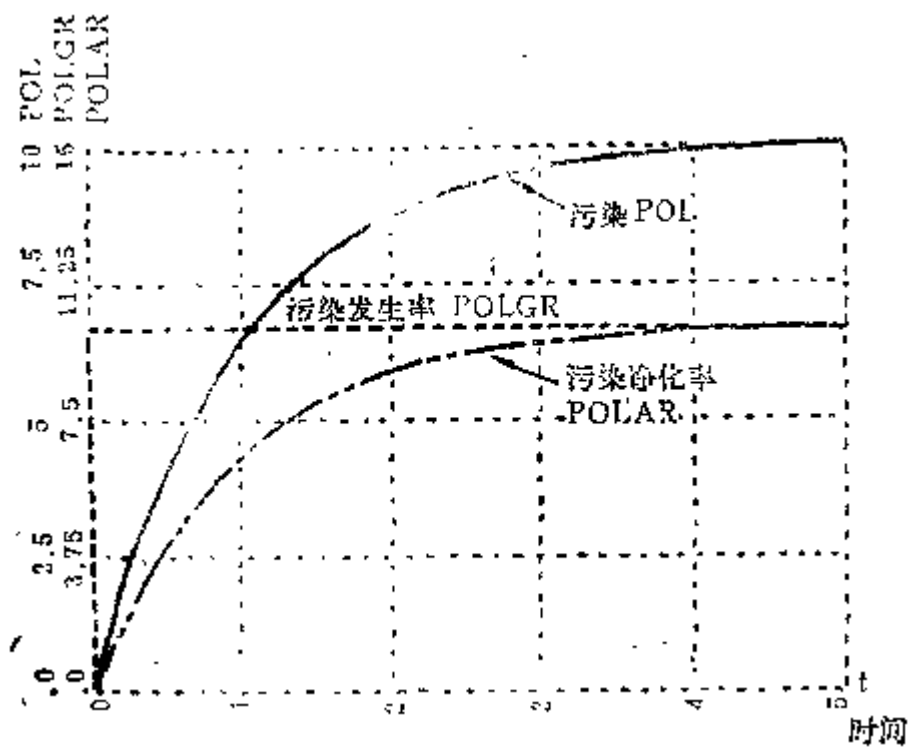
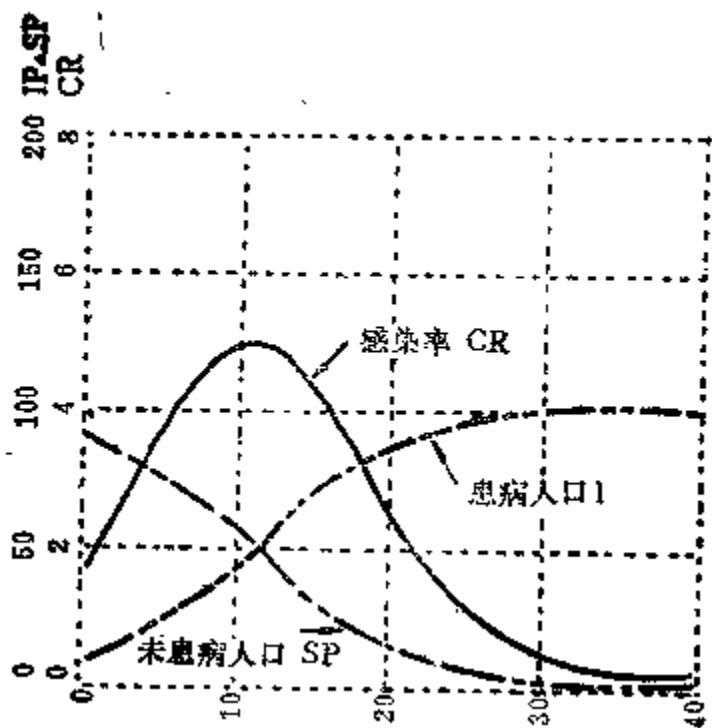
<http://www.maplesoft.com/products/maplesim/>

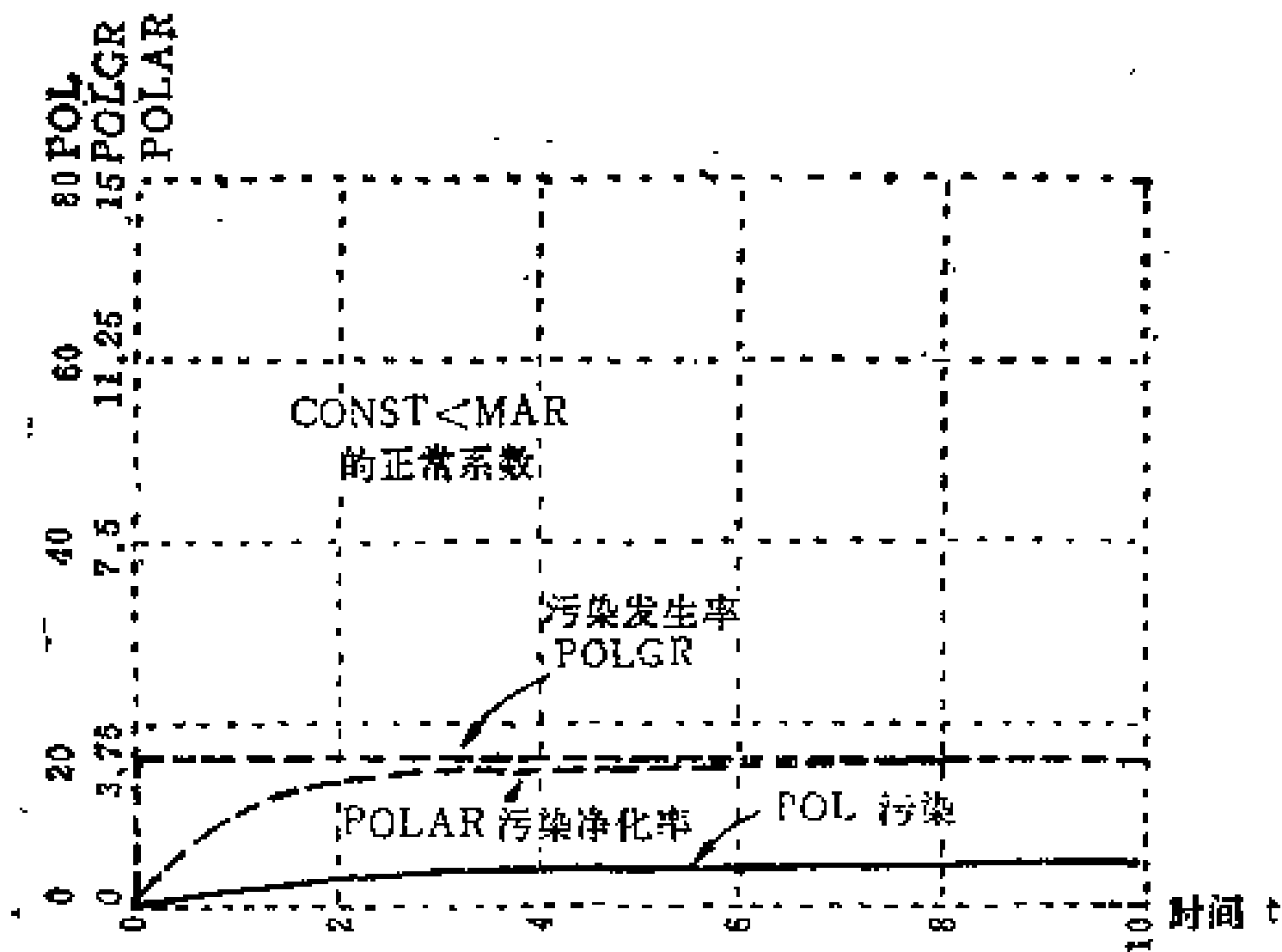


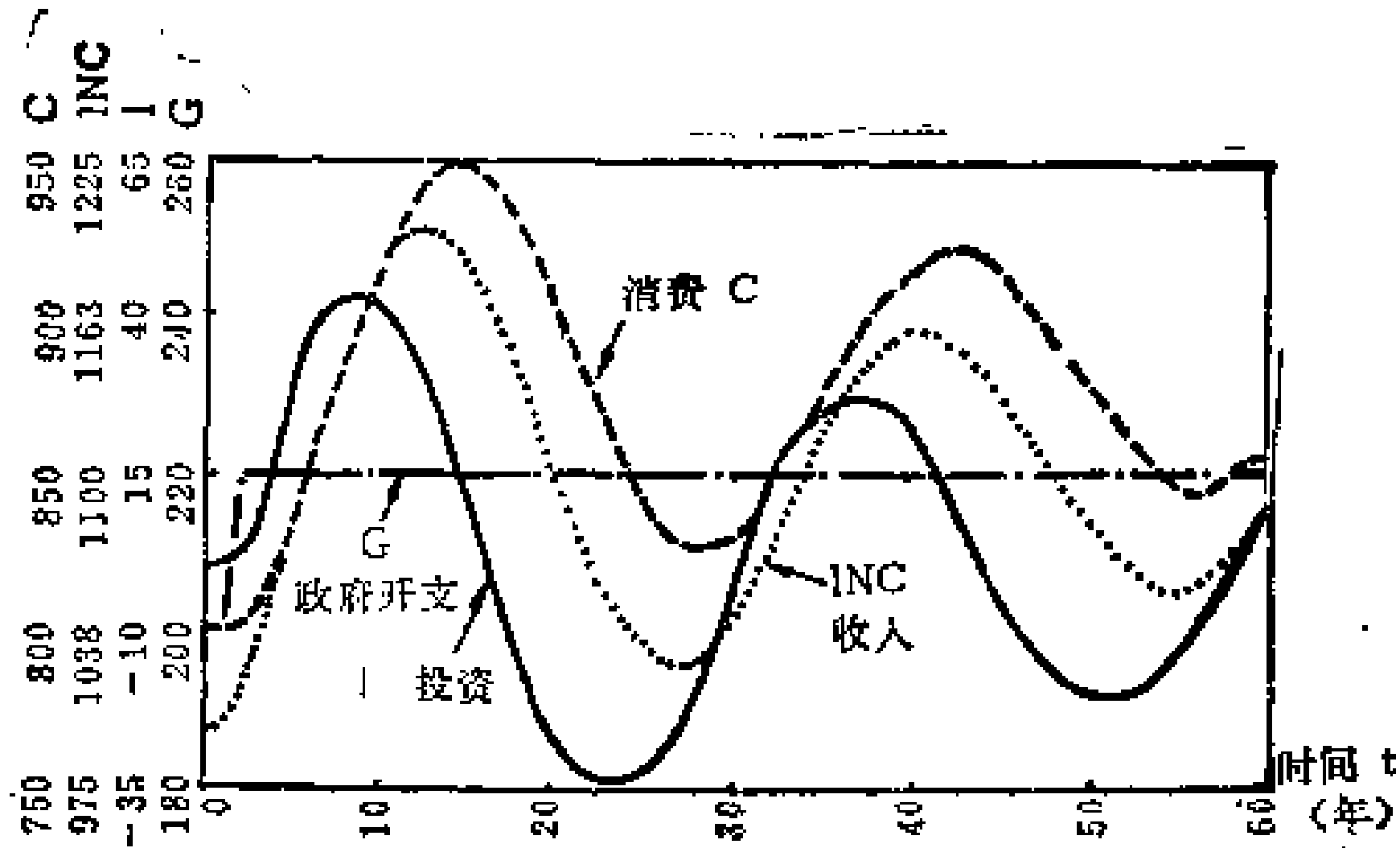
Dynamo



- 名称来自 Dynamic Model,由 MIT 的企业动力学研究小组研究开发,用以进行系统动力学建模及仿真的程序语言
- 自1958 年问世以来,曾经出现过Dynamo II, II/F,III,III/F,GAMING Dynamo,Mini Dynamo 等版本.其中DYSMAP 所提供的功能与旧有的Dynamo 相似,但可支持离散事件之模拟
- Pugh-Roberts 于1987 年将 Dynamo 加以改进成为Professional Dynamo,可提供简单的编辑,编译,模拟,结果浏览及储存功能.仿真结果能以图形及表列显示
- 在结构化,图形化以及易用性等方面,Dynamo 远不如Vensim, Stella,iThink,PowerSim
- 使用者需要具备一定的计算机编程基础









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Web Simulation

On-line simulations by MAS Consulting

Renewable Energy



[Renewable Energy](#); Simulation of solar power

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Campaign on Studio products

Introducing the Web Solution from MAS Consulting; we have a campaign on Studio products.

[More >>](#)

Collaboration Partner - MAS Consulting

MAS Consulting is a collaboration partner that provide web simulations for Studio models.

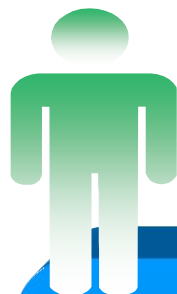
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Powersim



Powersim为1980年代中期,由挪威政府赞助开发.目前最新版本10.0



界面与 Stella类似,可将组件自工具栏拖放至图板.也提供模型显示,组件与模型管理等相关功能



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Powersim Studio 10 Products

Powersim Software has simulation tools that cover all needs for building simulations, running in-depth analyses or distributing solutions.

The tools build upon well-known methods and are widely used by satisfied customers all over the world.

Studio Modeling tools

- Build models
- Distribution
- Connectivity
- Risk / Optimization



Price listMore >>

Studio Developer Suite

- Develop custom-made solutions
- Distribute on the Internet or on a Server



Price listMore >>

Studio End-user tools

- Present models made in Preimum
- Import new data
- Export scenarios



Price listMore >>

Studio Academic

- Build models
- Auto unit control
- Presentations
- Risk / Optimization

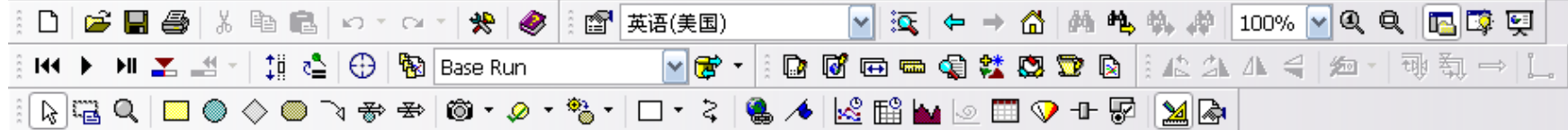


Price listMore >>

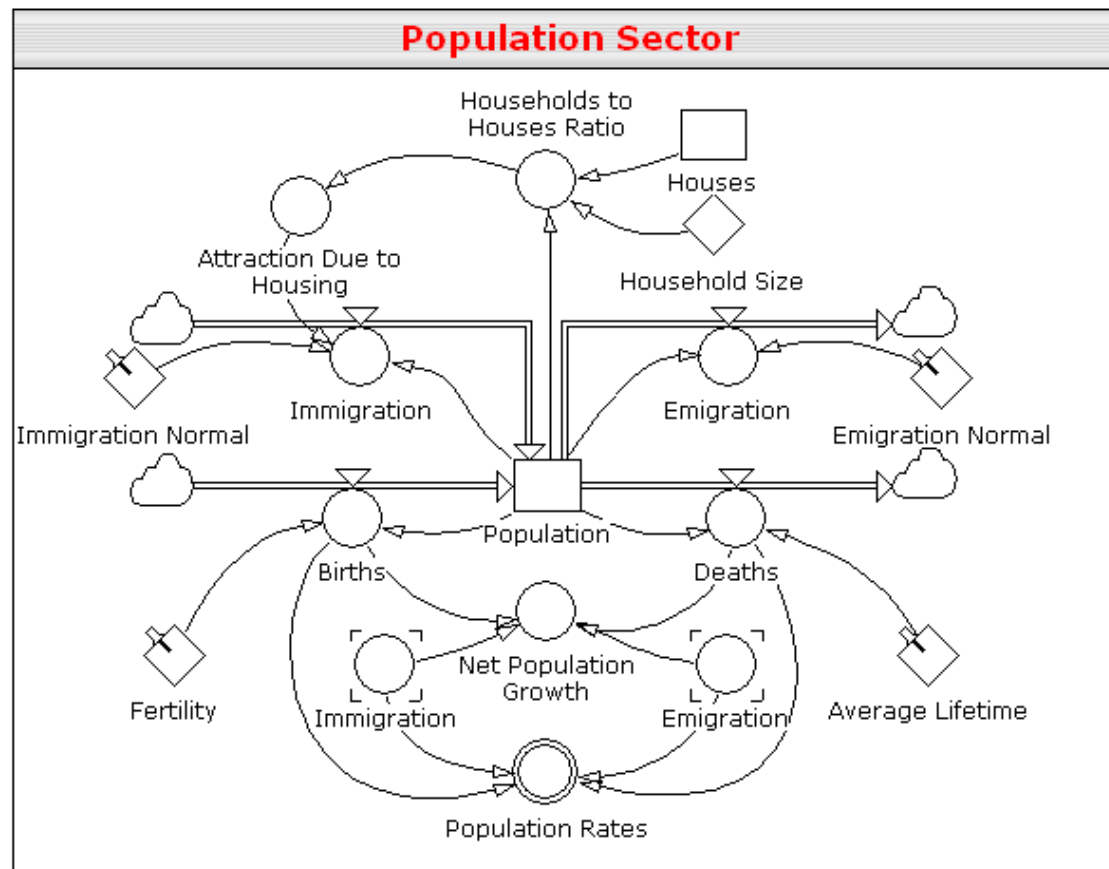
Powersim

Powersim Studio 7 Express [C:\Program Files\Powersim Studio 7.5\Samples\Samples\population.sip] - Shared Diagrams

File Edit View Insert Format Diagram Layout Simulation Project Window Help



- Project 'population'
- Population Model
 - Main Simulation
 - Equations
 - Connections
 - Analysis Variables
 - Events
 - Private Diagrams
 - Shared Diagrams
 - Local Ranges
 - Local Units
 - Runs
 - Global Ranges
 - Global Units





Vensim

Vensim®

VENTANA
systems, inc.

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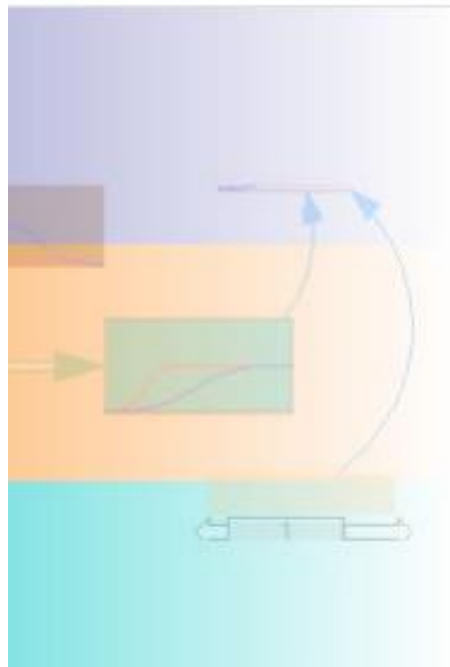
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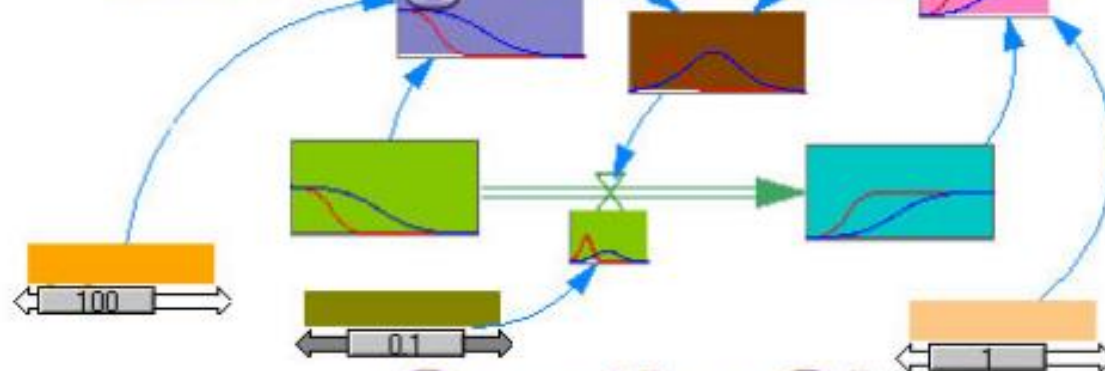
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Seeing Simulation



with SyntheSim



Vensim

Vensim是由美国 Ventana Systems公司开发的可视化模拟与分析软件.Vensim提供了一种简易而具有弹性的方式建模.

使用Vensim建立动态模型,只需用图形化的箭头连接各式变量,并将各变量之间的关系以适当方式写入模型,由此确立各变量之间的因果关系.

透过建模过程,可了解变量间的因果关系与回路,并可通过程序中的特殊功能了解各变量的输入与输出间的关系,便于使用者了解模型架构,并修改和完善模型内容.



Vensim 各版本的比較

Feature	PLE	PLE Plus	Pro	DSS	Read
SyntheSim	•	•	•	•	•
Ability to cut feedback links on the fly in SyntheSim mode	•	•	•	•	
Sketch Editor with Undo/Redo	•	•	•	•	
Causal Loop Diagrams	•	•	•	•	•
Stock and Flow Diagrams	•	•	•	•	•
Tree Diagrams	•	•	•	•	•
Document Tool	•	•	•	•	•
Loop Identification	•	•	•	•	•
Equation Editor	•	•	•	•	
Built-in Functions	•	•	•	•	
Units Check	•	•	•	•	
Causal Tracing®	•	•	•	•	•
Reality Check®	•	•	•	•	•
Simulation	•	•	•	•	•
Graphs	•	•	•	•	•
Tabular Output (Tables)	•	•	•	•	•
Run Comparison (between two simulations)	•	•	•	•	•
On-line Help	•	•	•	•	
Multiple Views (pages or sectors of a model)	•	•	•	•	•
Input and Output Sketch Objects	•	•	•	•	•
Gaming		•	•	•	•
Sensitivity Simulations (Monte Carlo)		•	•	•	•
External Data Import/Export (spreadsheet etc.)		•	•	•	•
Live Data Connections		•	•	•	•
Discrete Event Functions			•	•	•
Editable Sketch Toolsets			•	•	
Hide Sketch Elements			•	•	•
Simulation Control Dialog			•	•	



Vensim 各版本的比較 (續)

Feature	PLE	PLE Plus	Pro	DSS	Read
Partial Model Simulation			.	.	
User-configurable Tools			.	.	
Histograms			.	.	.
Password Protection			.	.	.
Model Calibration (optimization)			.	.	.
Policy Optimization			.	.	.
Kalman Filtering			.	.	
Subscripts (Arrays) - up to 8 dimensions			.	.	.
Bar Graphs			.	.	.
Gantt Charts			.	.	.
Summary Statistics			.	.	.
Text Editor			.	.	
User defined Macros			.	.	.
ODBC Capabilities				.	.
Packaged Applications (Venapps, flight simulators)				.	.
Graphical Venapp Builder				.	
Dynamic Data Exchange				.	
External Functions				.	.
Compiled Models (C language)				.	.
DLL Configuration				.	.



Stella & iThink



isee systems is dedicated to increasing understanding of our world through modeling and simulation software



Stella & iThink

Stella Professional

Model, simulate, and analyze even the most complex systems



iThink

Create complex models and engaging interfaces





Stella & iThink

提供拖放式的图形界面. 除可用程序语言描述模型外, 还可将模型组件(存量, 流率, 辅助变量及连结)自工具栏拖放到图板上, 以此方式建立模型

简介

Stella是Structure Thinking Experimental Learning Laboratory with Animation之缩写, 为图形导向型的系统动力学模型软件

在显示仿真结果方面, Stella除了图形及表格外, 还可以通过动画显示仿真结果



Stella & iThink

iThink与 Stella同属一个公司所开发,也具有相同的图形化使用界面

简介

Stella还提供了图形化控制组件,如输入框,开关,转盘等,使用者通过控件将参数输入模型,再通过动画显示仿真结果

但 iThink 的定位是商业或其他组织(如物流系统,监评机构);而 Stella 则主要面向科研和教育系统.因此在有些模块和所提供的例子方面稍有差异



Stella & iThink---Products

STELLA PROFESSIONAL

THE NEXT GENERATION MODELING EXPERIENCE



About Stella Professional

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Stella Pro 1.0.3



STELLA PROFESSIONAL

SOFTWARE VERSION: 1.0.3

Registered to:
tnd xyz



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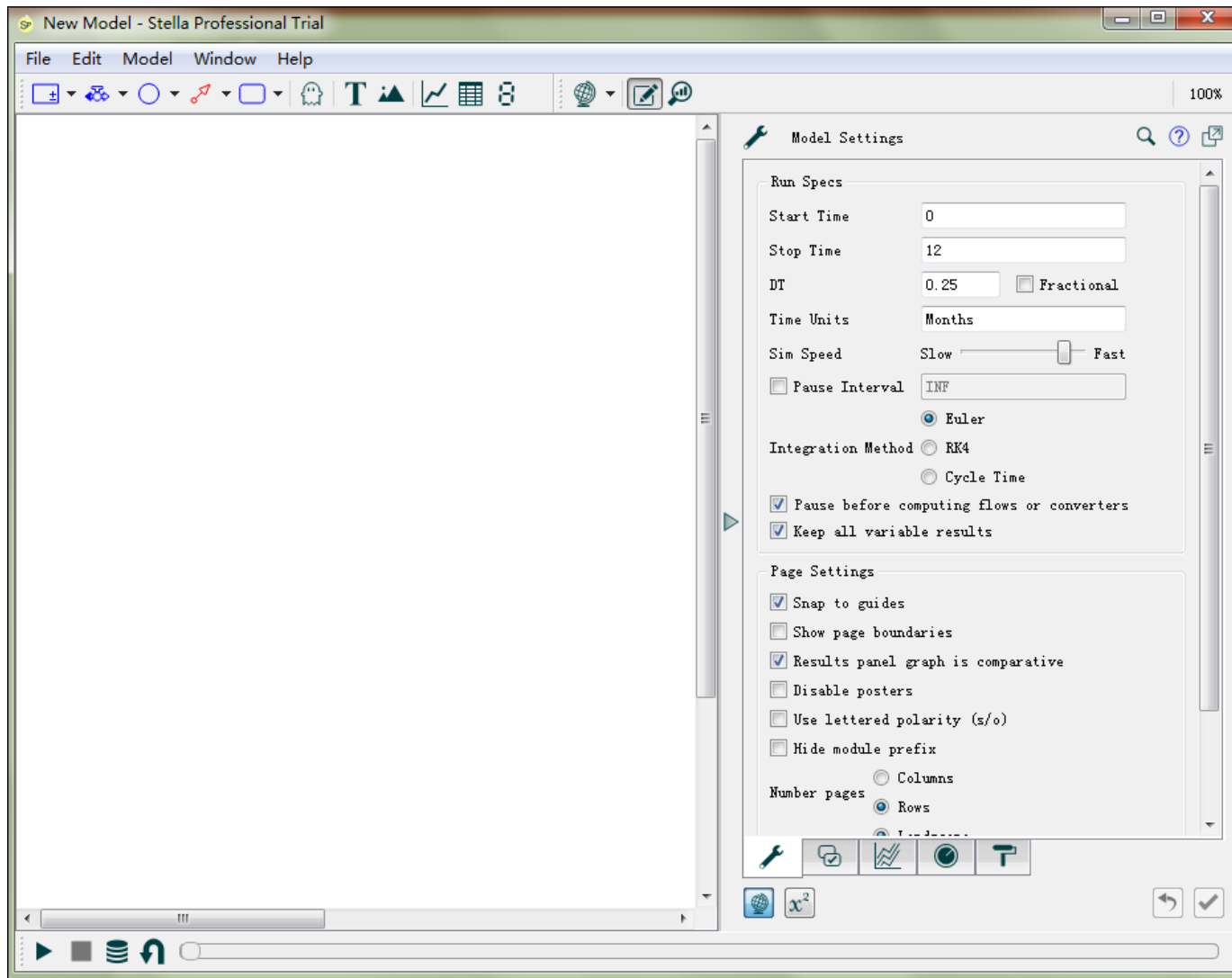
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Registration number:
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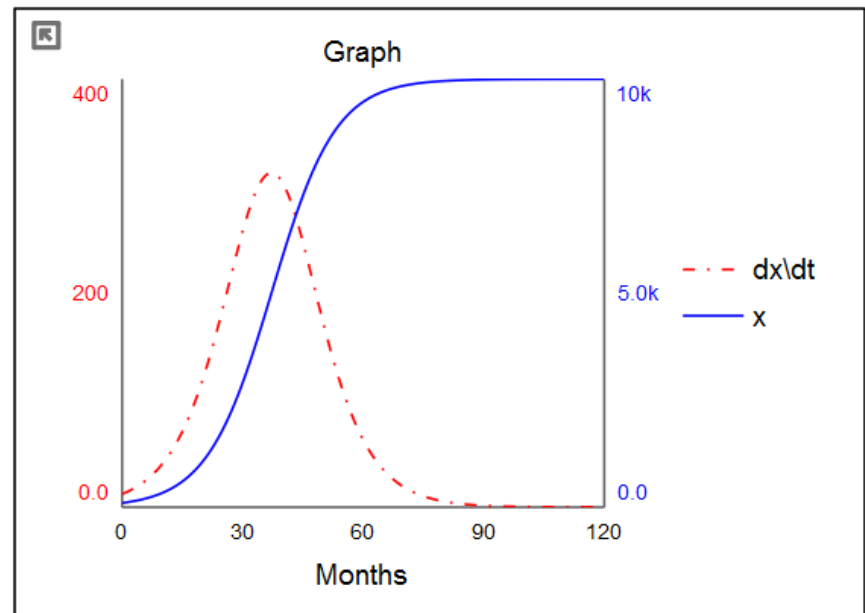
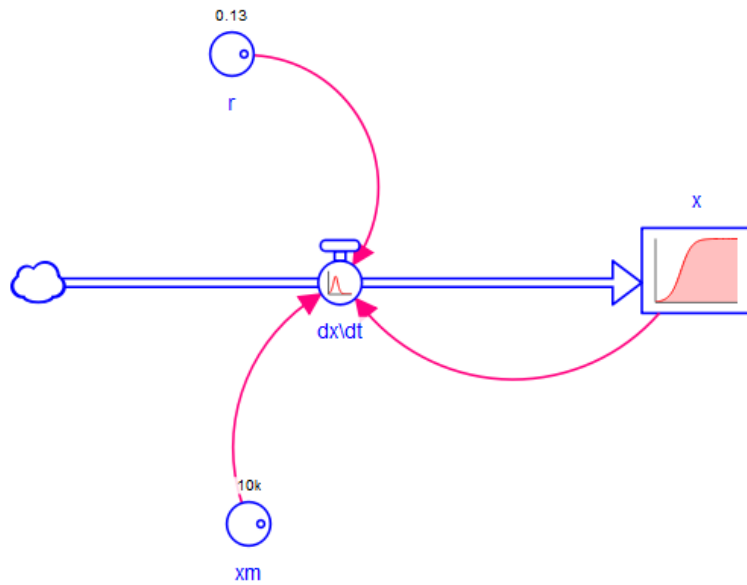


Stella Pro 1.0.3





Stella Pro 1.0.3





MapleSim



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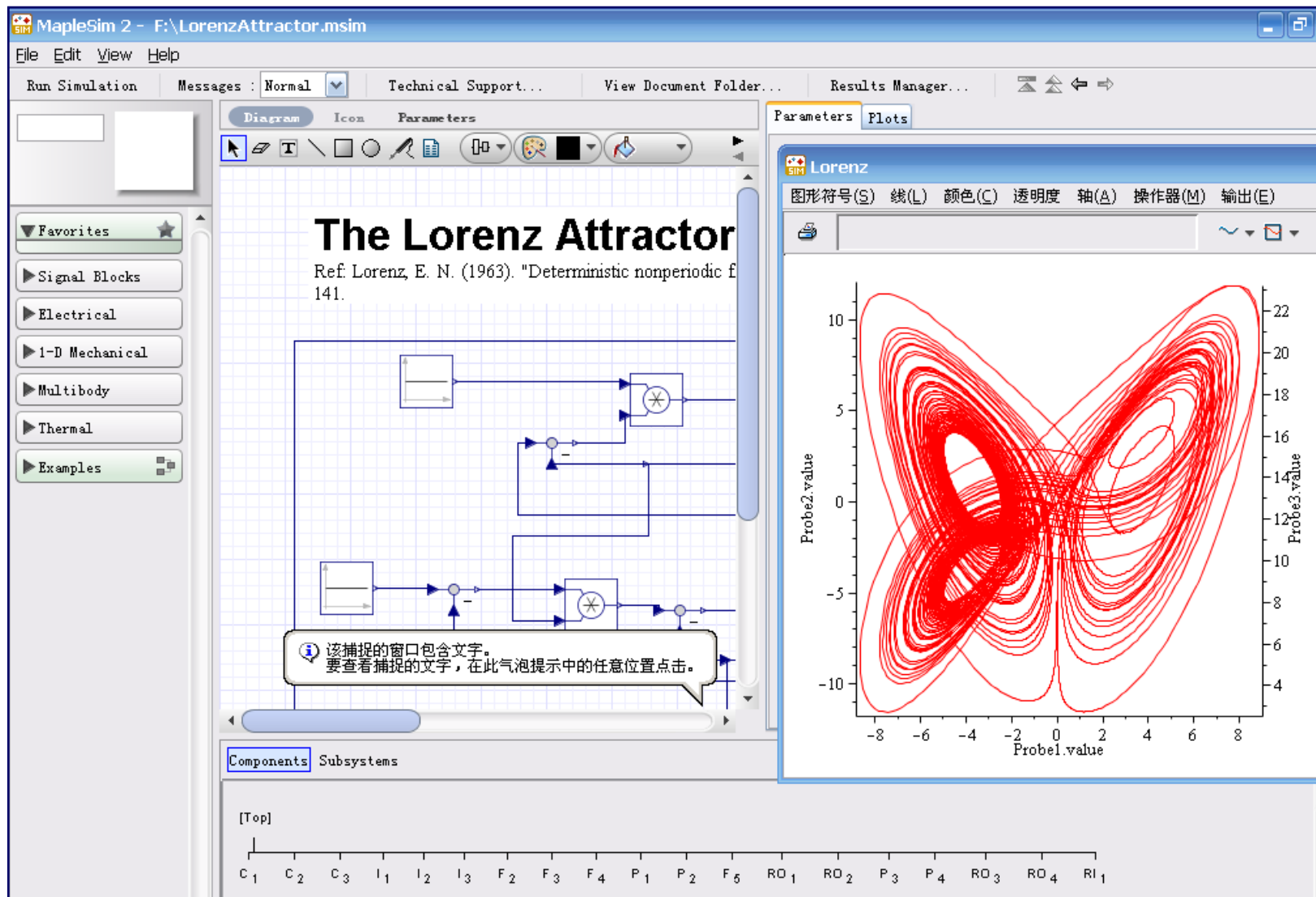
Advanced System-Level Modeling

With MapleSim, dramatically reduce model development time,
provide greater insight into system behavior, and produce fast,
high-fidelity simulations.



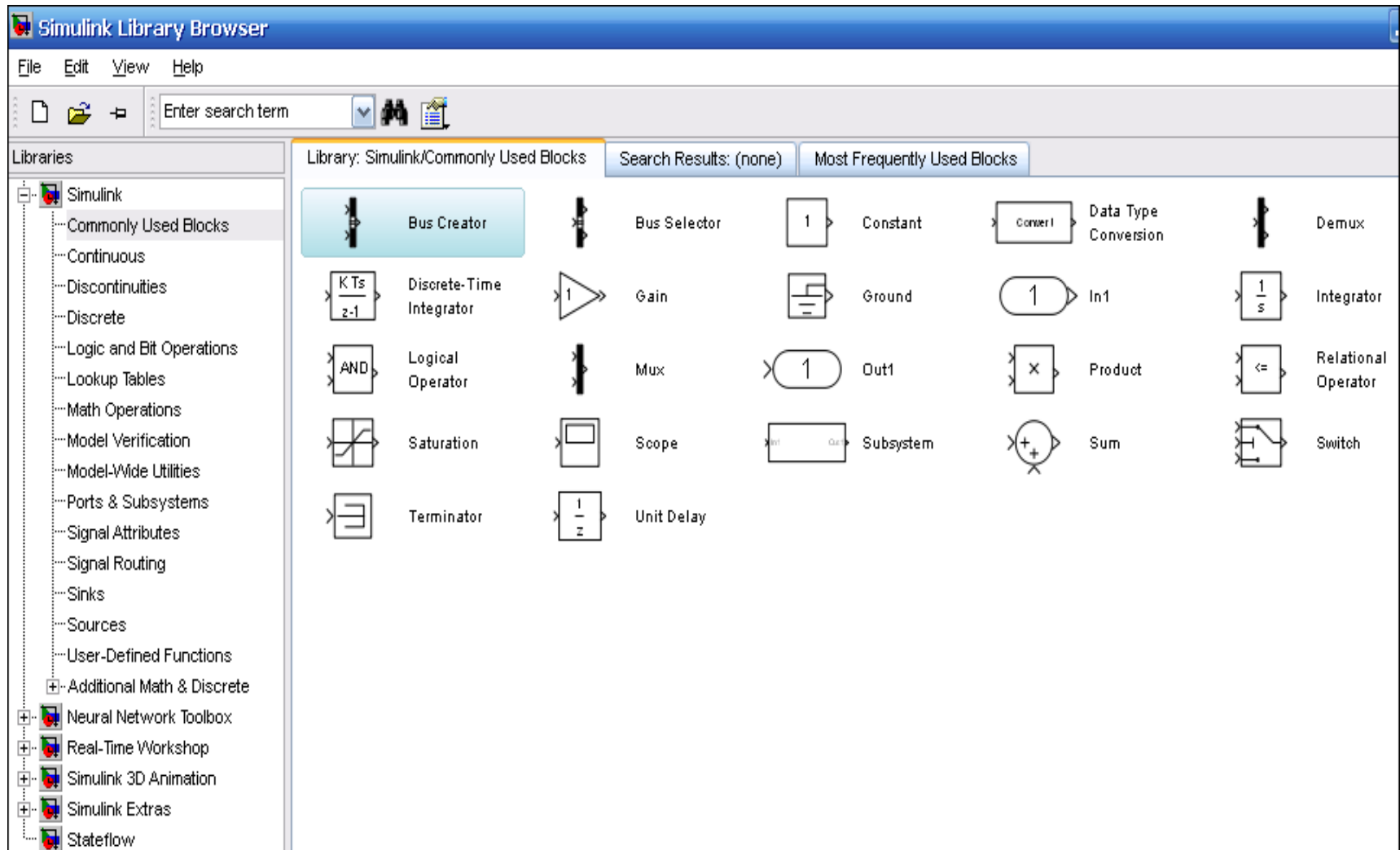


MapleSim



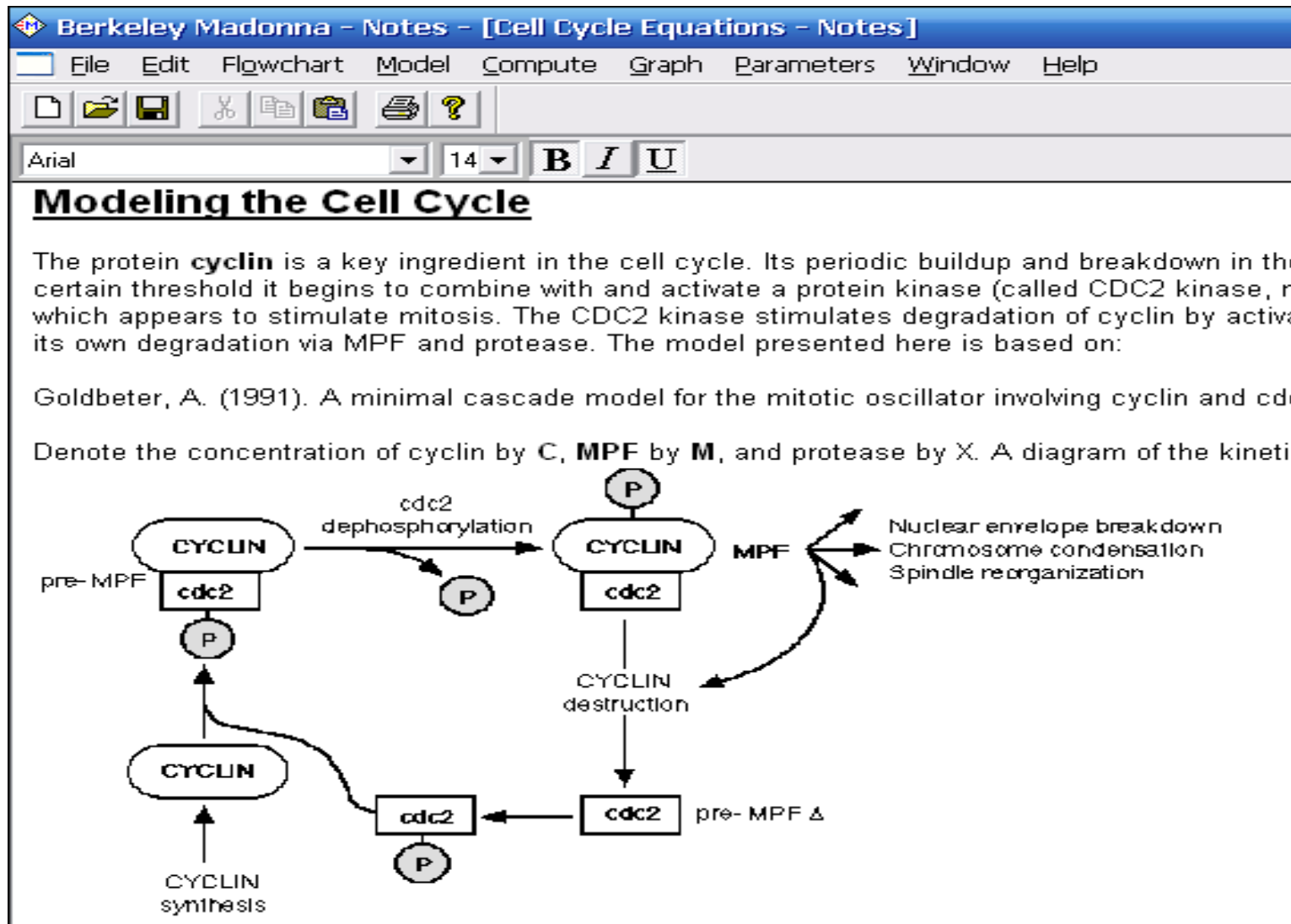


Matlab/Simulink





Berkeley Madonna

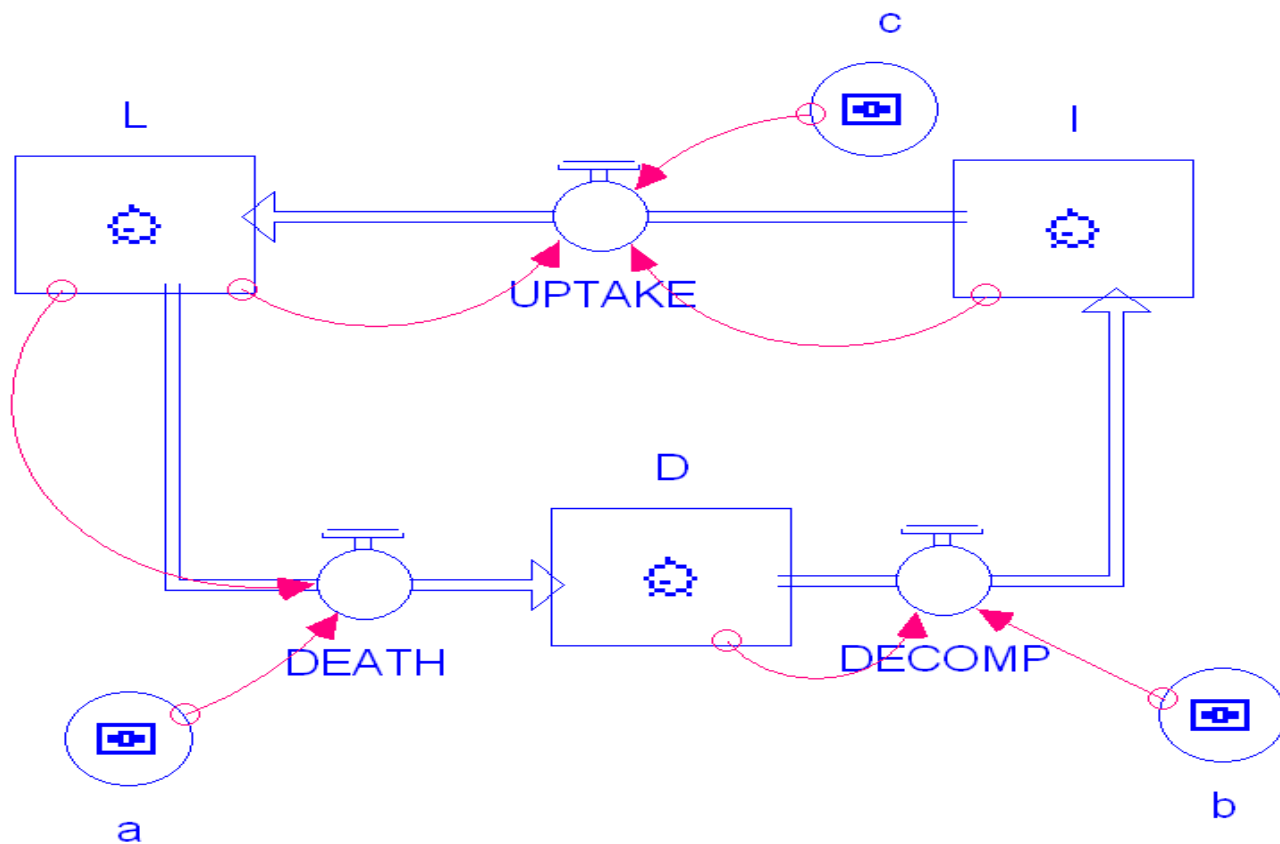




系统动力学与 环境和生态系统 建模例子

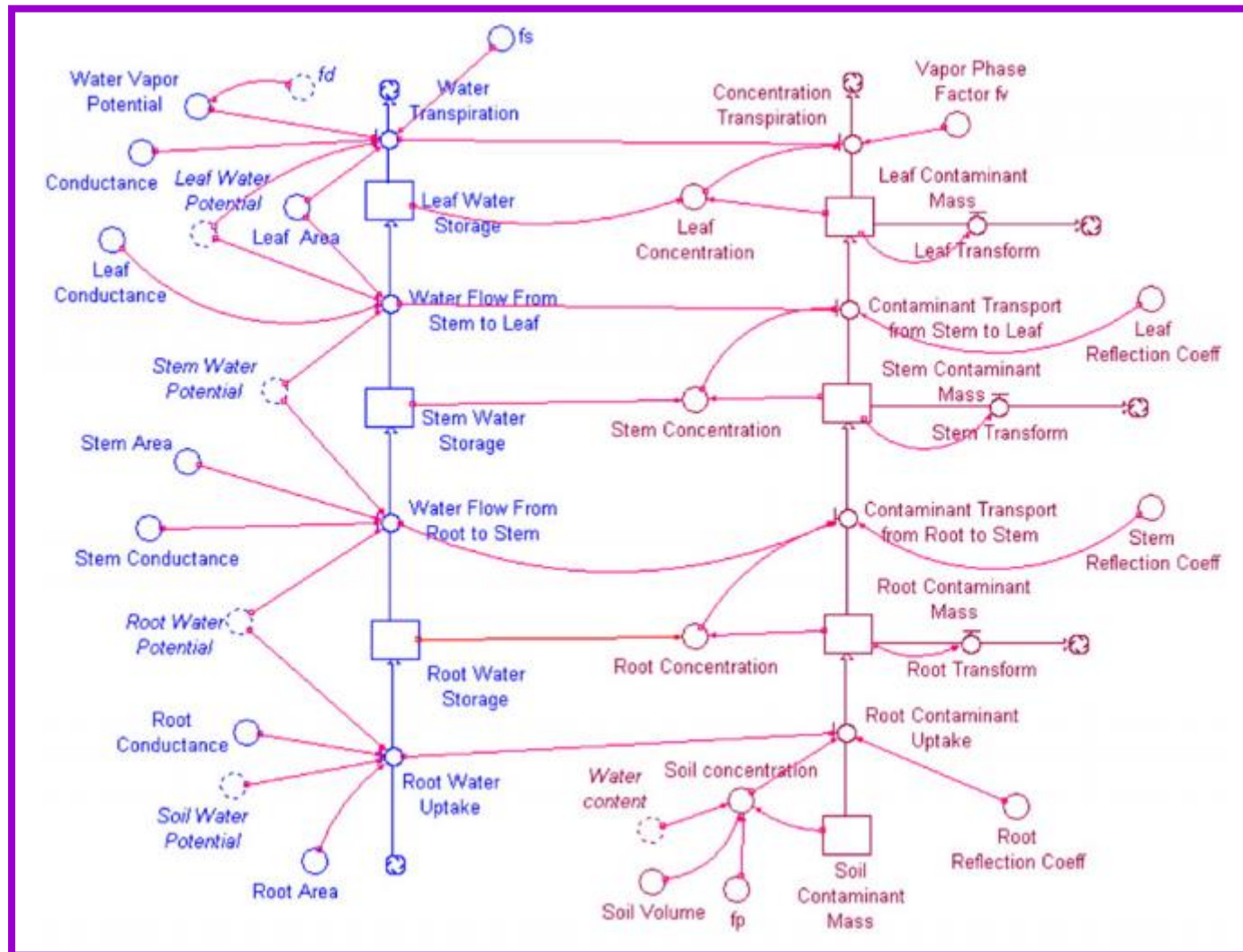


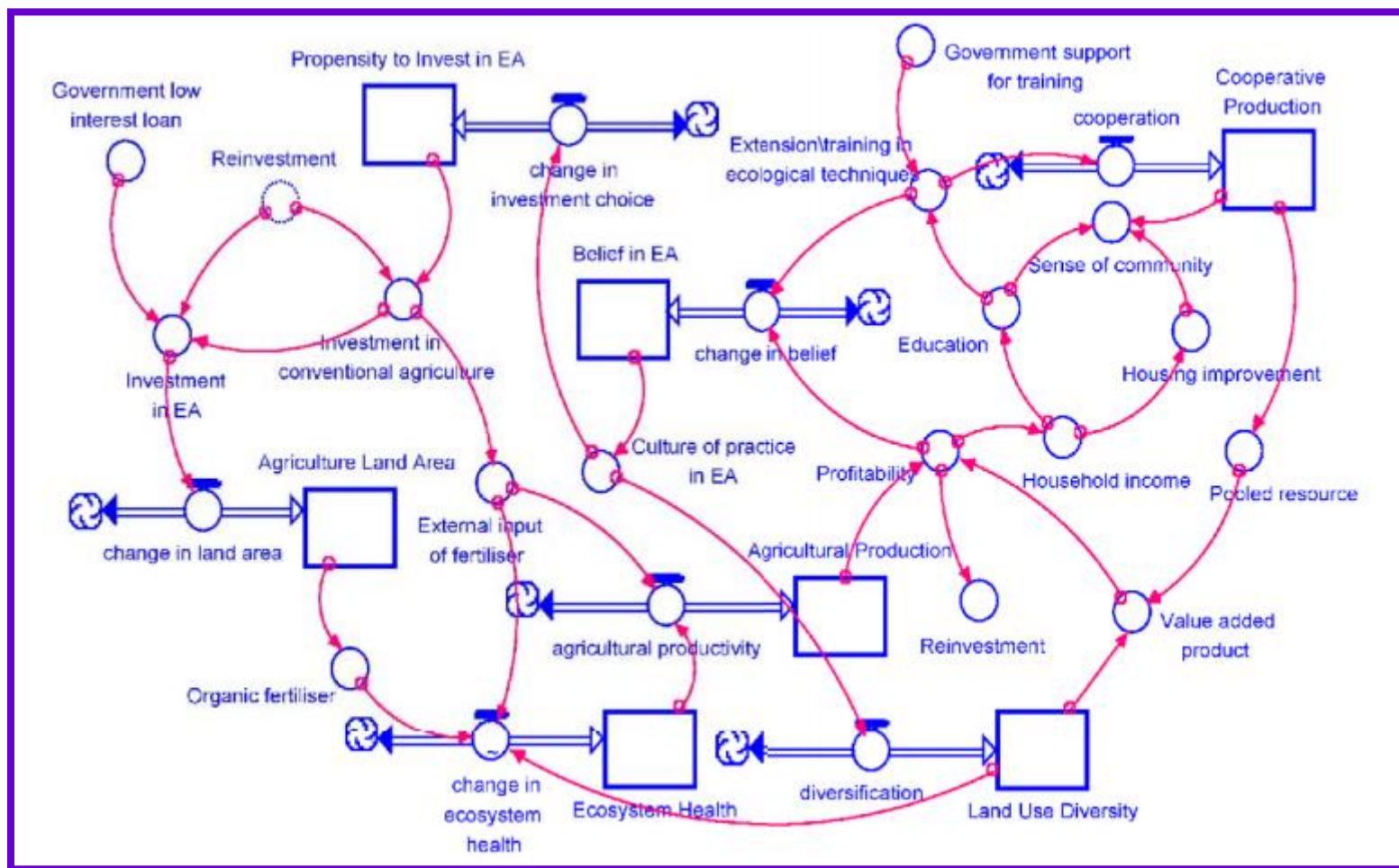
例1：生态系统中磷的迁移转化模型





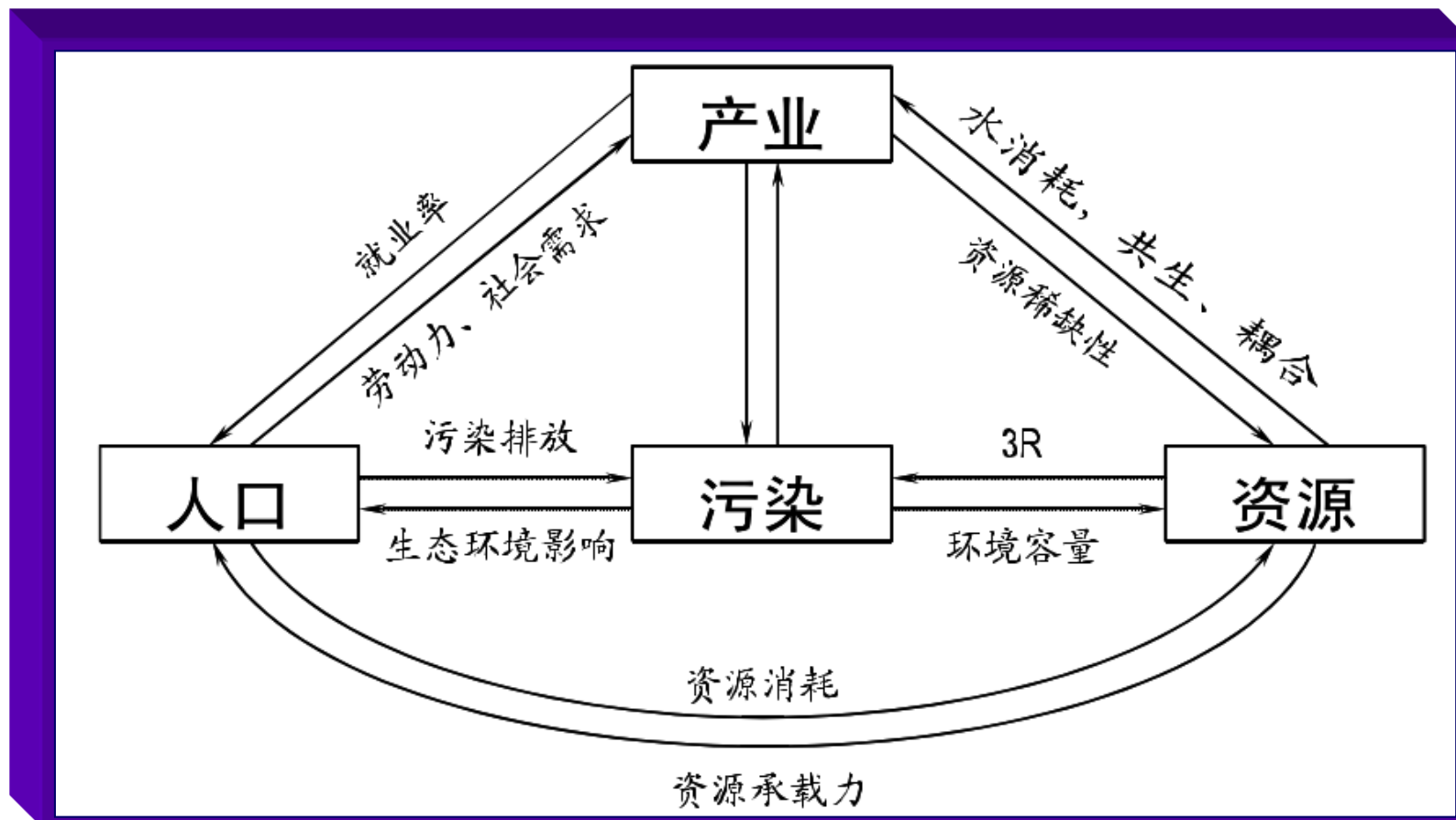
例2: The Dynamic Model for Uptake and Translocation of Contaminants from a Soil-Plant Ecosystem (UTCSP)







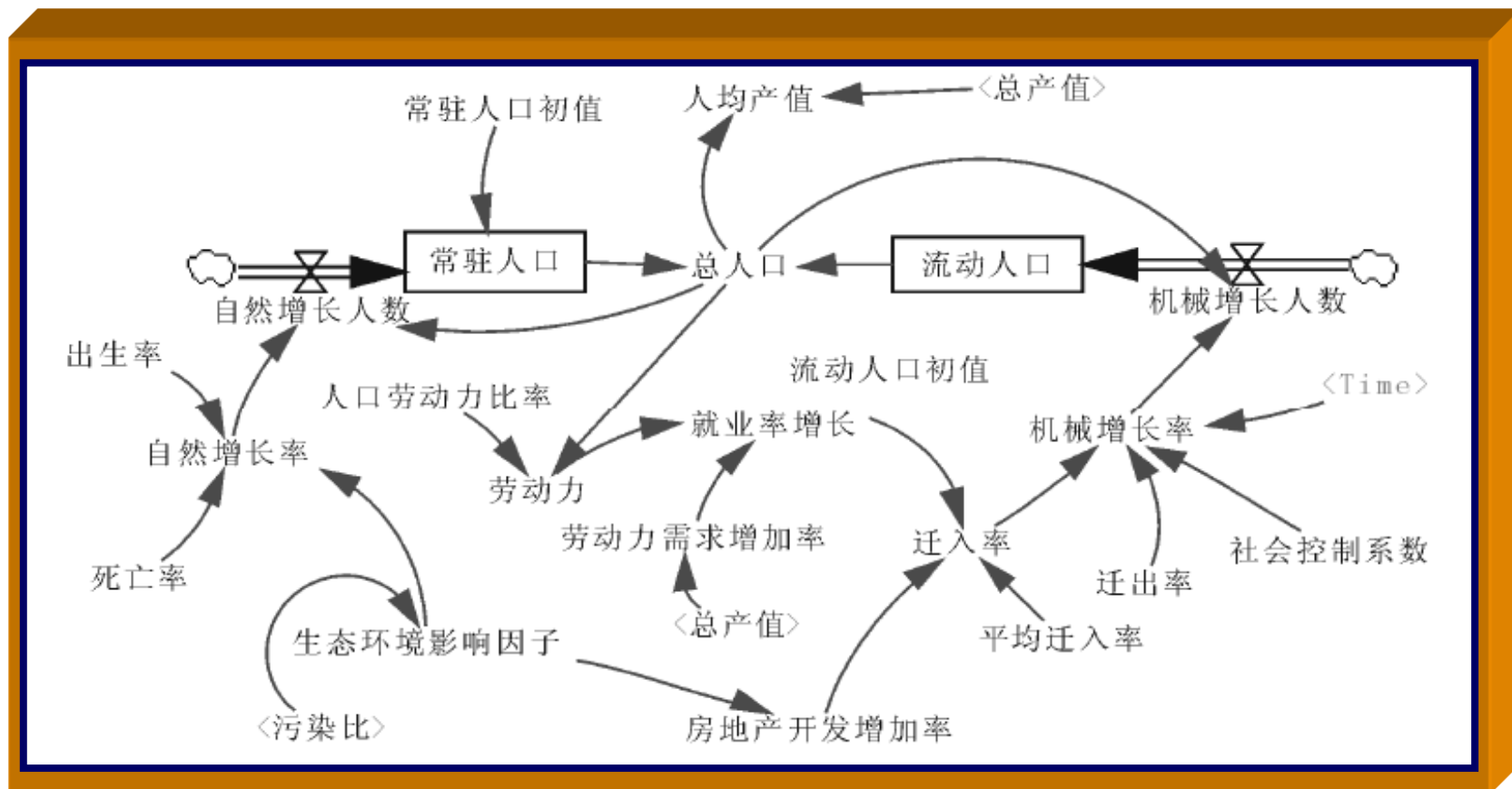
例4：基于系统动力学的区域规划环境影响评价



经济开发区社会经济、资源和环境子系统反馈关系图

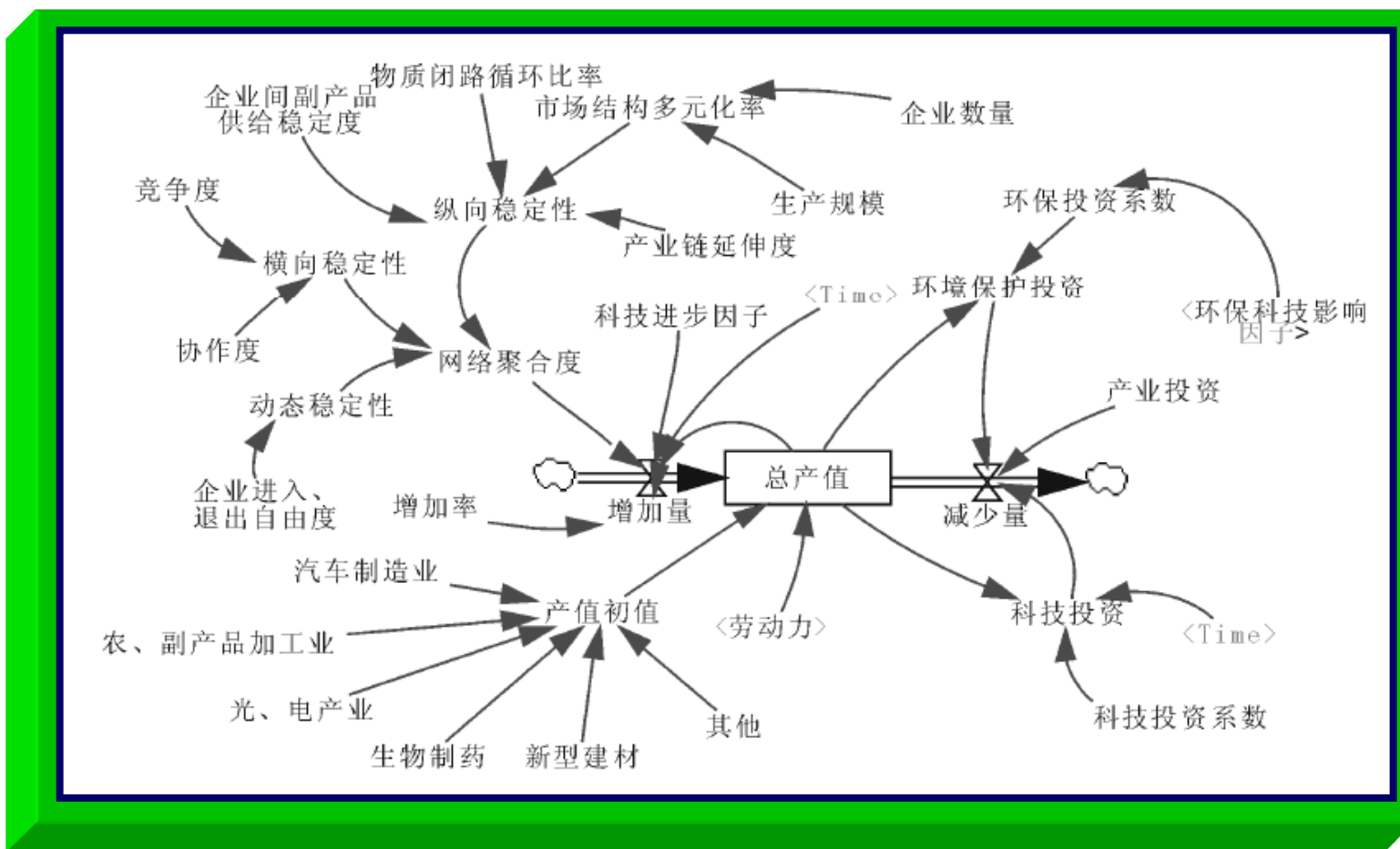


社会经济子系统1：人口子系统模型结构图



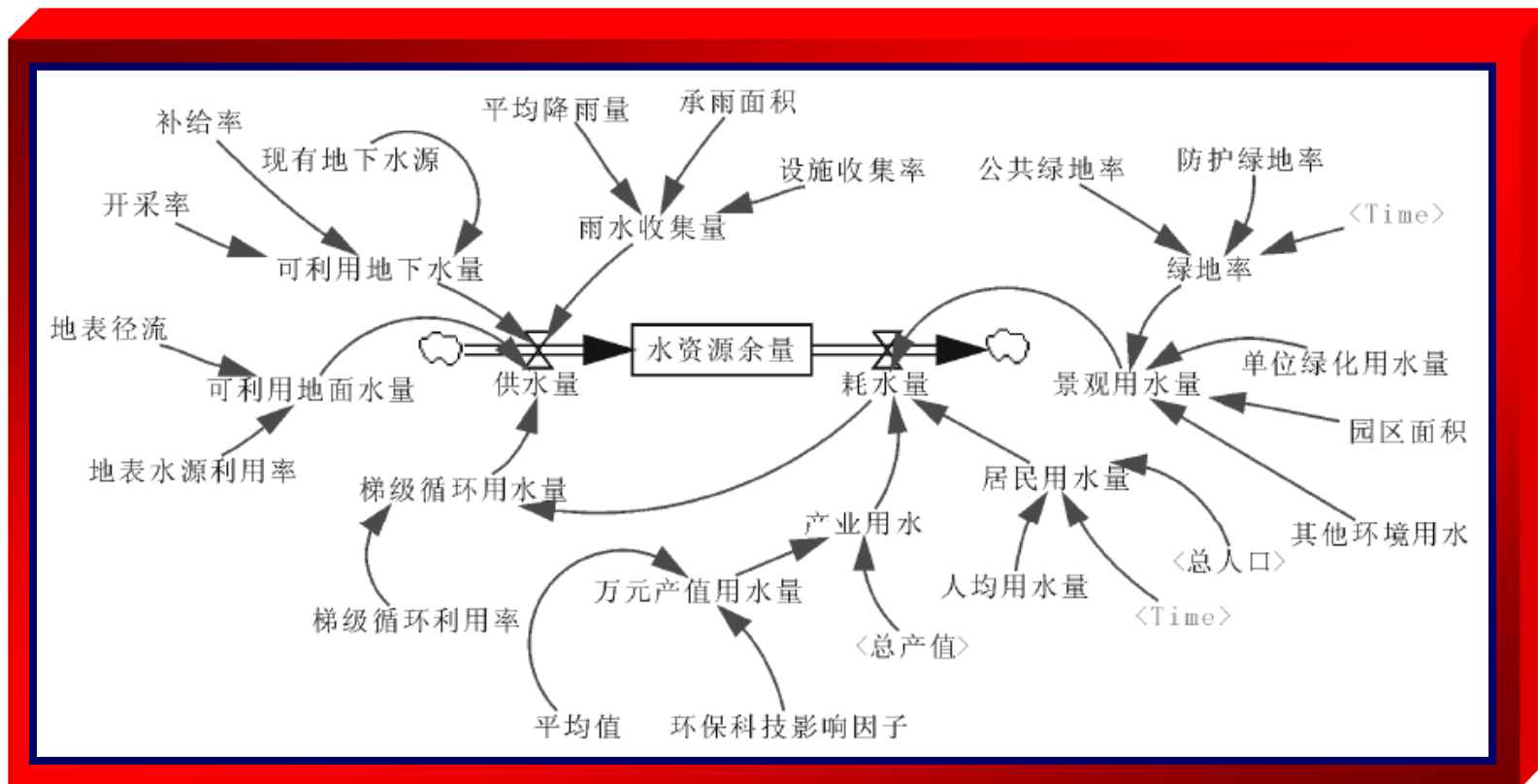


社会经济子系统2：经济子系统模型结构图



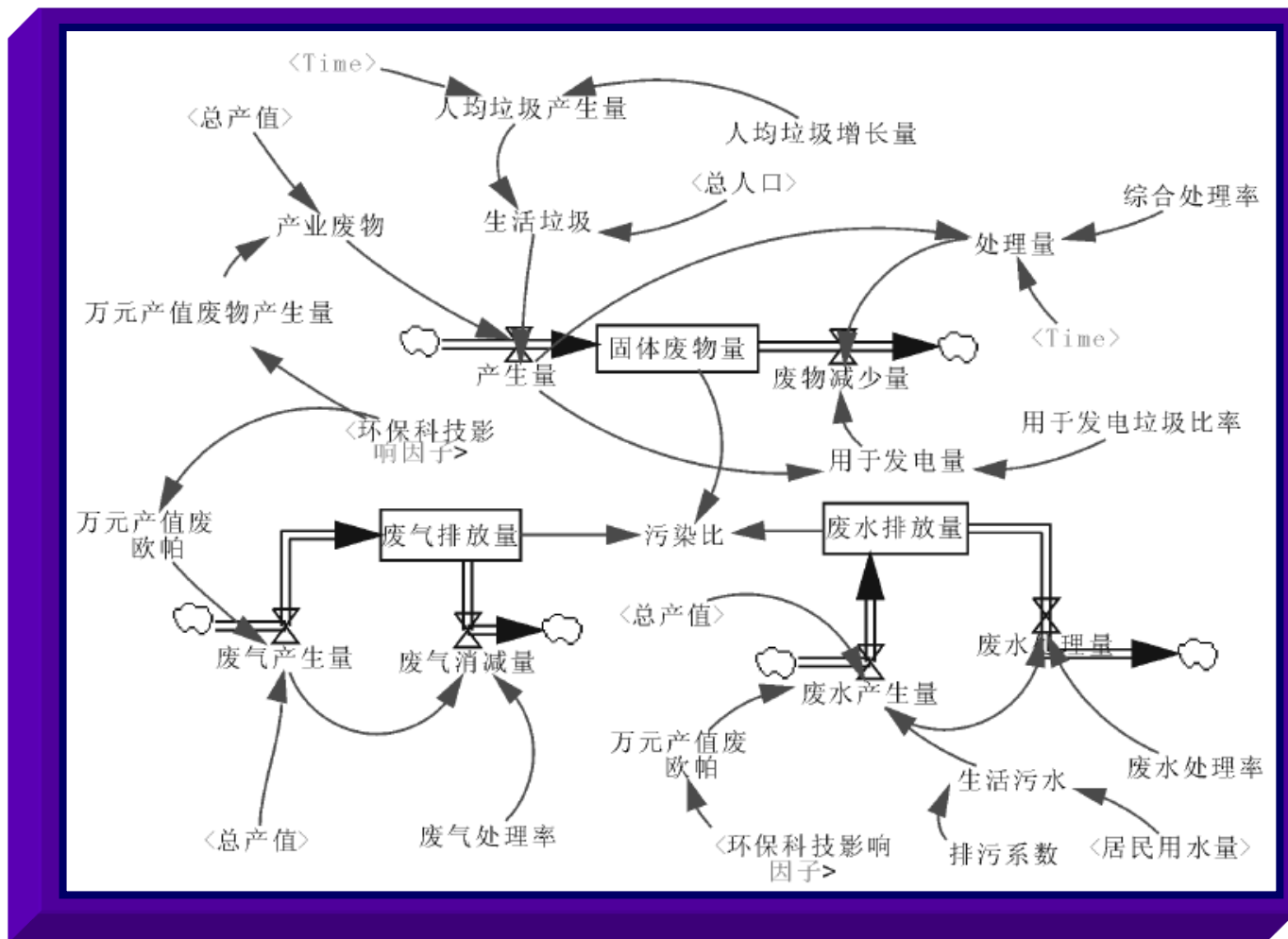


资源子系统:开发区水资源子系统模型结构图





环境子系统:开发区环境子系统模型结构图



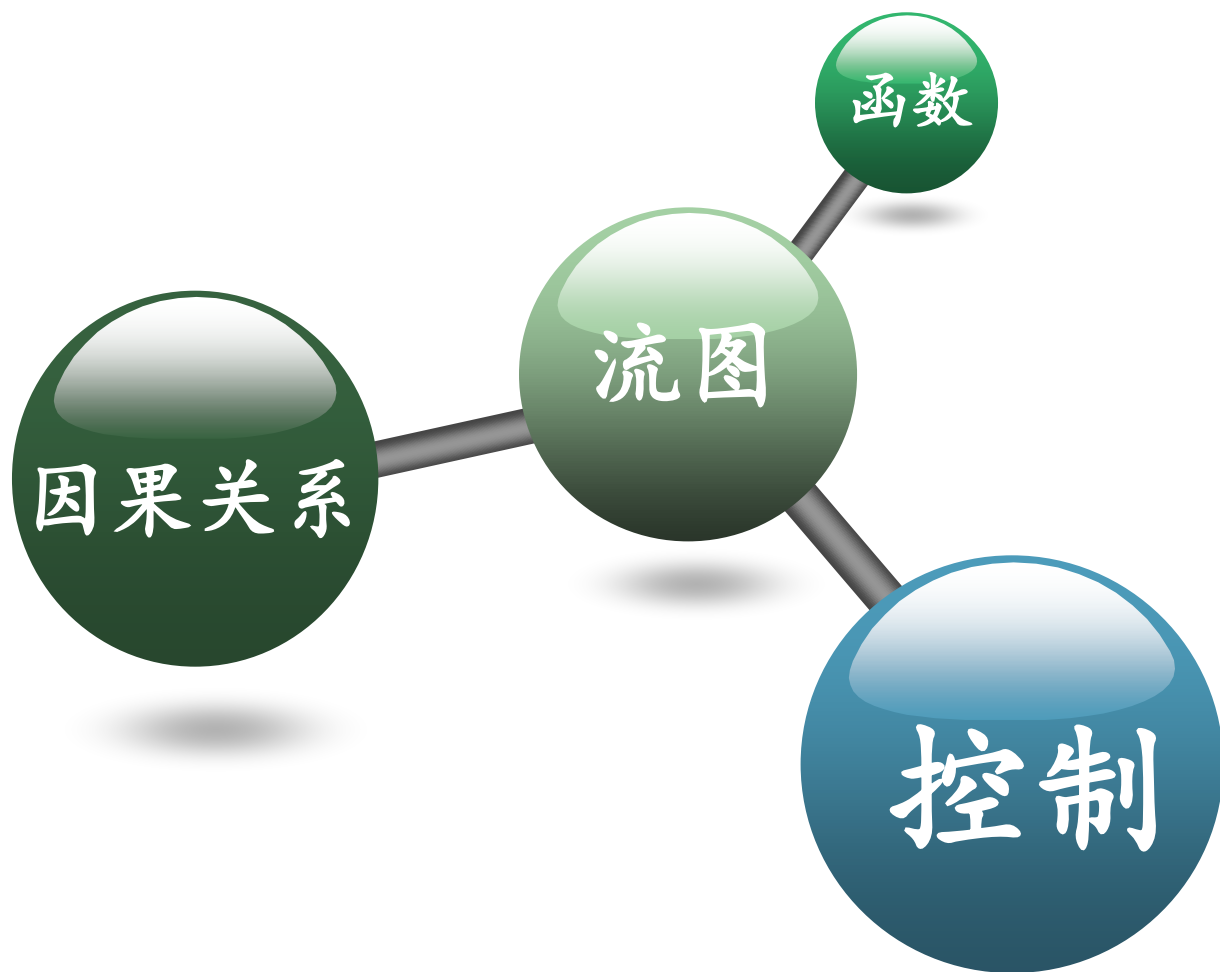


其他模拟仿真软件

**MapleSim; Matlab/Simulink;
Berkeley Madonna; Arena;
AnyLogic; Swarm;
Extend(Sim); GPSS/H;
Hyperformix Workbench;
Microsaint; SimApp; LCA;
Simscrip III; Goldsim;
Simul 8; Simile; Ecolego;
Simcreator; Automod;
Flexsim; Promodel;**

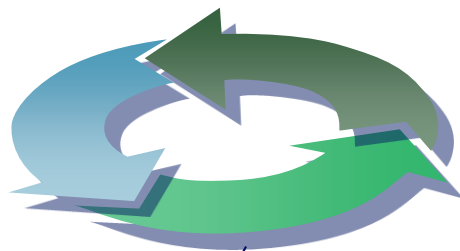


系统动力学建模的主要概念





(1) 因果关系和反馈环



1

系统由各个子系统或系统要素构成. 系统要素之间存在着某种数学关系或逻辑关系, 可概括为要素之间的因果关系. 正是这种要素之间的因果关系最终形成了系统的性能或行为特性

2

因果关系是进行系统分析的关键, 也是系统动力学建模的基础. 利用因果关系图, 可以对系统的结构, 功能和相互关系作出定性的描述

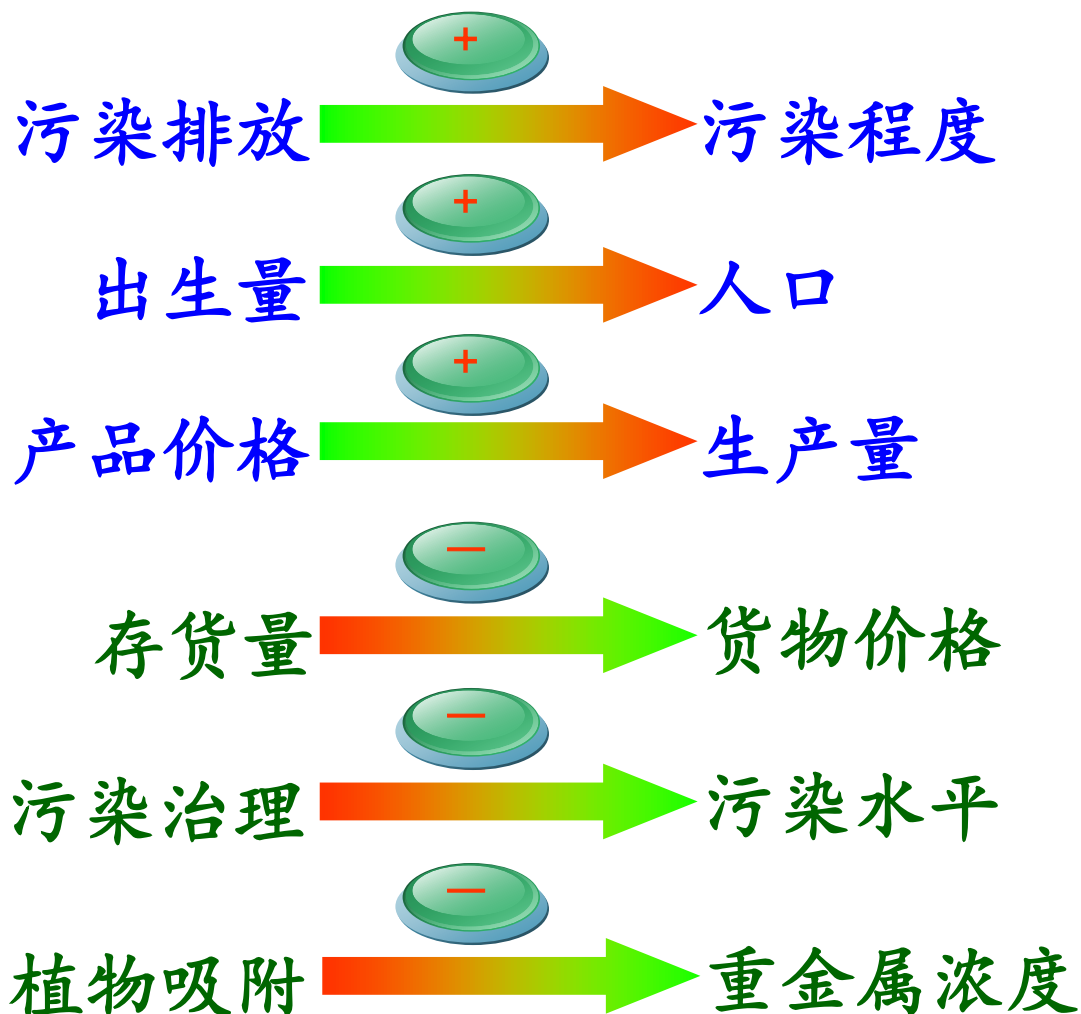
3

因果关系有正负之分. 因果链彼此联结而形成的封闭环路结构称为因果反馈环. 因果关系和反馈环可形象地描述实际系统中错综复杂的关系



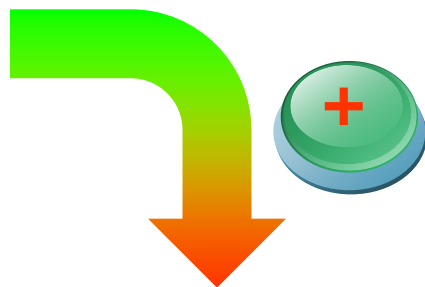
常见的因果关系（正负因果链）

树大招风
滴水穿石
因噎废食
见异思迁





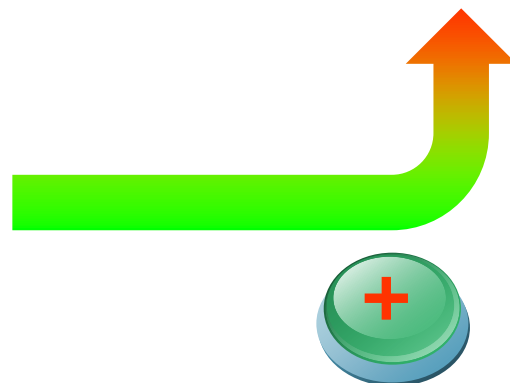
羡慕



恨

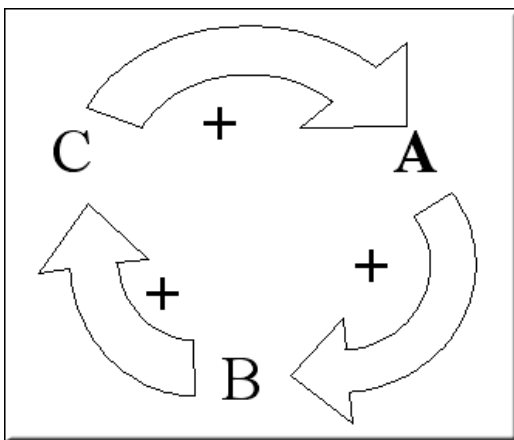


嫉妒

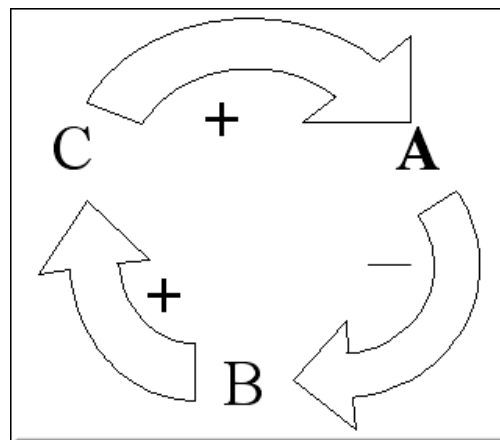




常见的反馈形式



正反馈



负反馈

正反馈

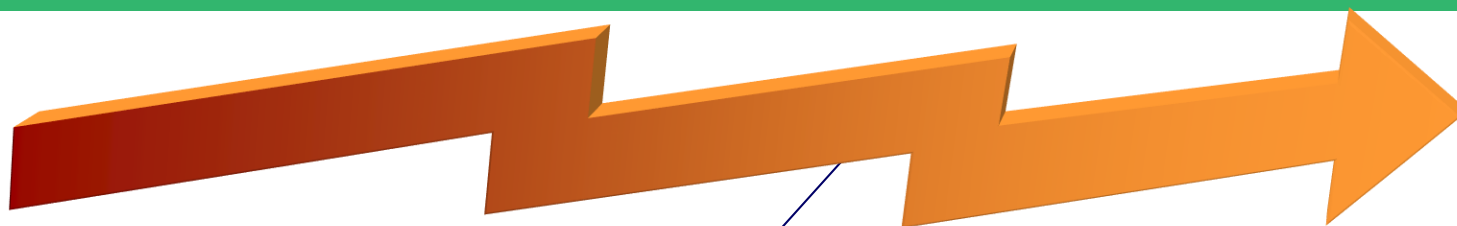
当回路中不存在负因果链, 或偶数的负因果链, 便是正反馈回路

负反馈

当回路中存在奇数的负因果链时, 此反馈回路为负反馈回路



(2) 流图

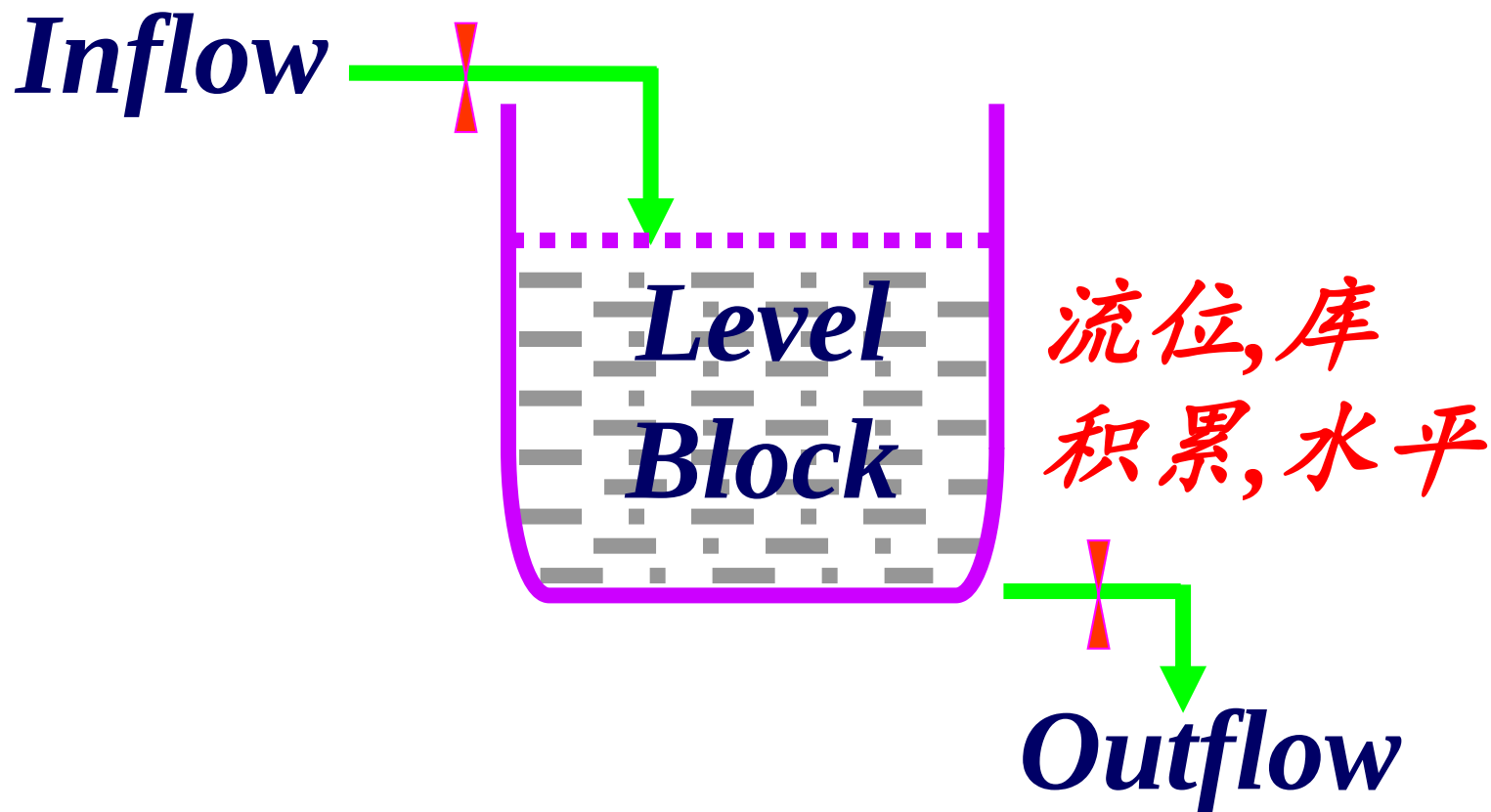


1

为进一步明确系统各元素之间的数量关系,便于建立相应的数学方程,按照系统动力学的约定,需将因果关系转化为系统动力学流图

2

系统动力学把连续的物质流和信息流作为系统处理的主要对象.物质流从具有无限容量的”源”流入系统,在系统各方程,函数和信息流的控制下,流经系统的各个环节,形成流位(库,积累)与流率,及其随时间变化的规律



液位变量（库、积累）反映的是系统运行过程的积累。其当前值是前一个时间点上的初始值与单位时间流入率与流出率之净差值的乘积。



$$Volume_t = Volume_{t-\Delta t} + (Inflow - Outflow)\Delta t$$

$$Volume_t - Volume_{t-\Delta t} = (Inflow - Outflow)\Delta t$$

$$\frac{Volume_t - Volume_{t-\Delta t}}{\Delta t} = Inflow - Outflow$$

$$\frac{dV}{dt} = Inflow - Outflow$$



流率是流位（库）被影响时的变化率

率是库的一阶导数，即单位时间库的变化量

率是库的一阶导数，即单位时间库的变化量