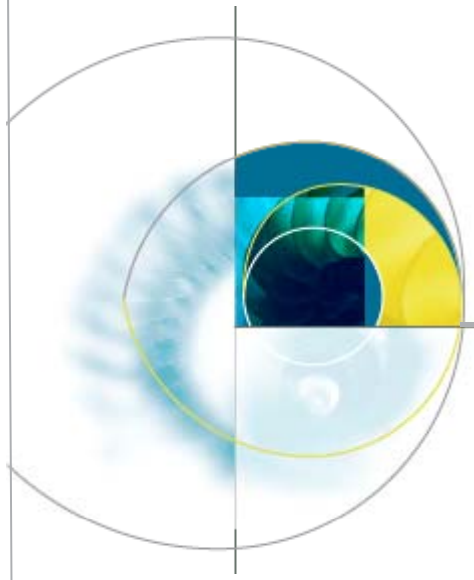


System Dynamics:

Improving Discourse in a Complex World

COMPASS: Centre of Methods and Policy Application in the Social Sciences

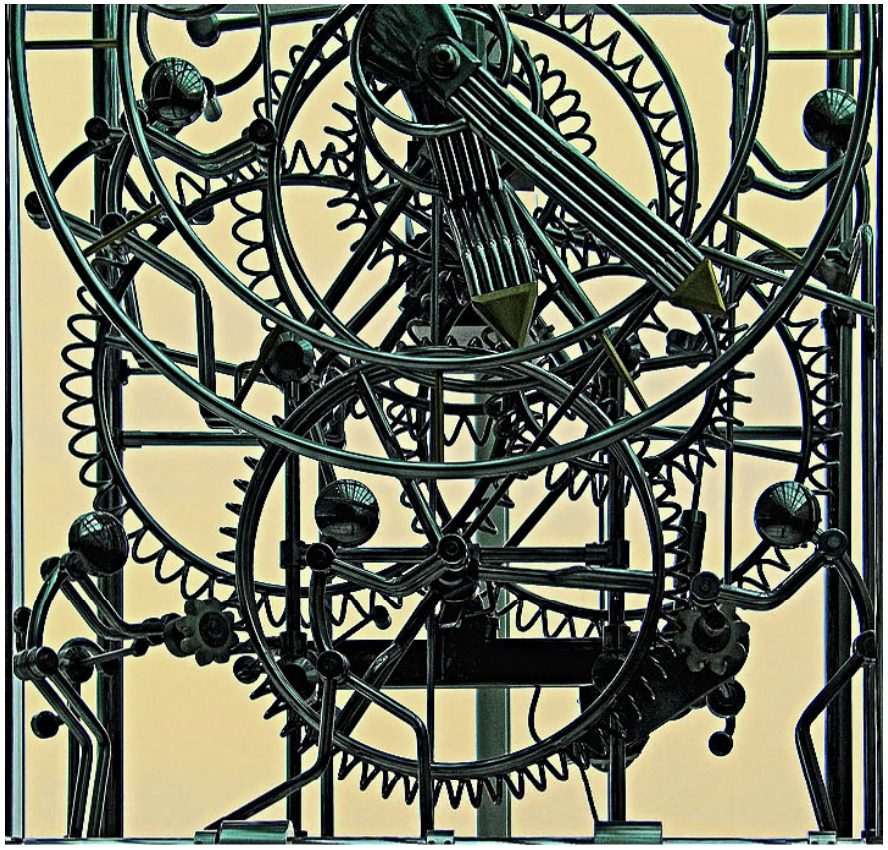
Auckland University 20th November 2009

David Rees
Synergia Ltd &
Honorary Lecturer
University of Auckland
School of Population Health

Dr. Tim Kenealy
General Practitioner & Associate
Professor of Integrated Care
University of Auckland
School of Population Health

SCHOOL OF POPULATION HEALTH
FACULTY OF MEDICAL AND HEALTH SCIENCES
THE UNIVERSITY OF AUCKLAND

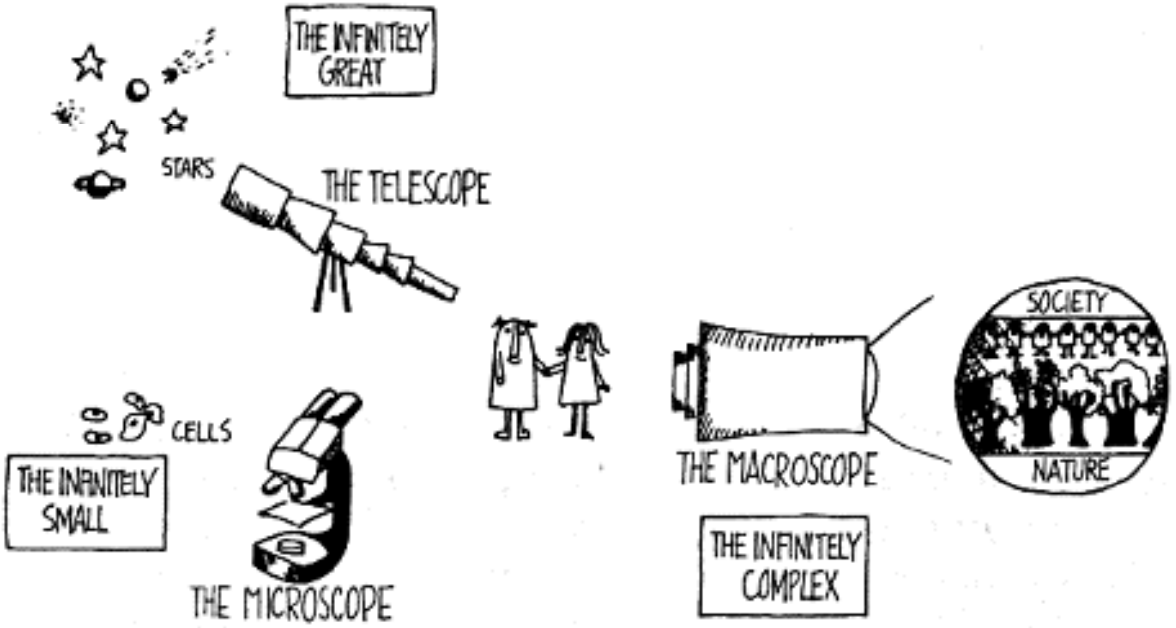
SYNERGIA



Topics for Today

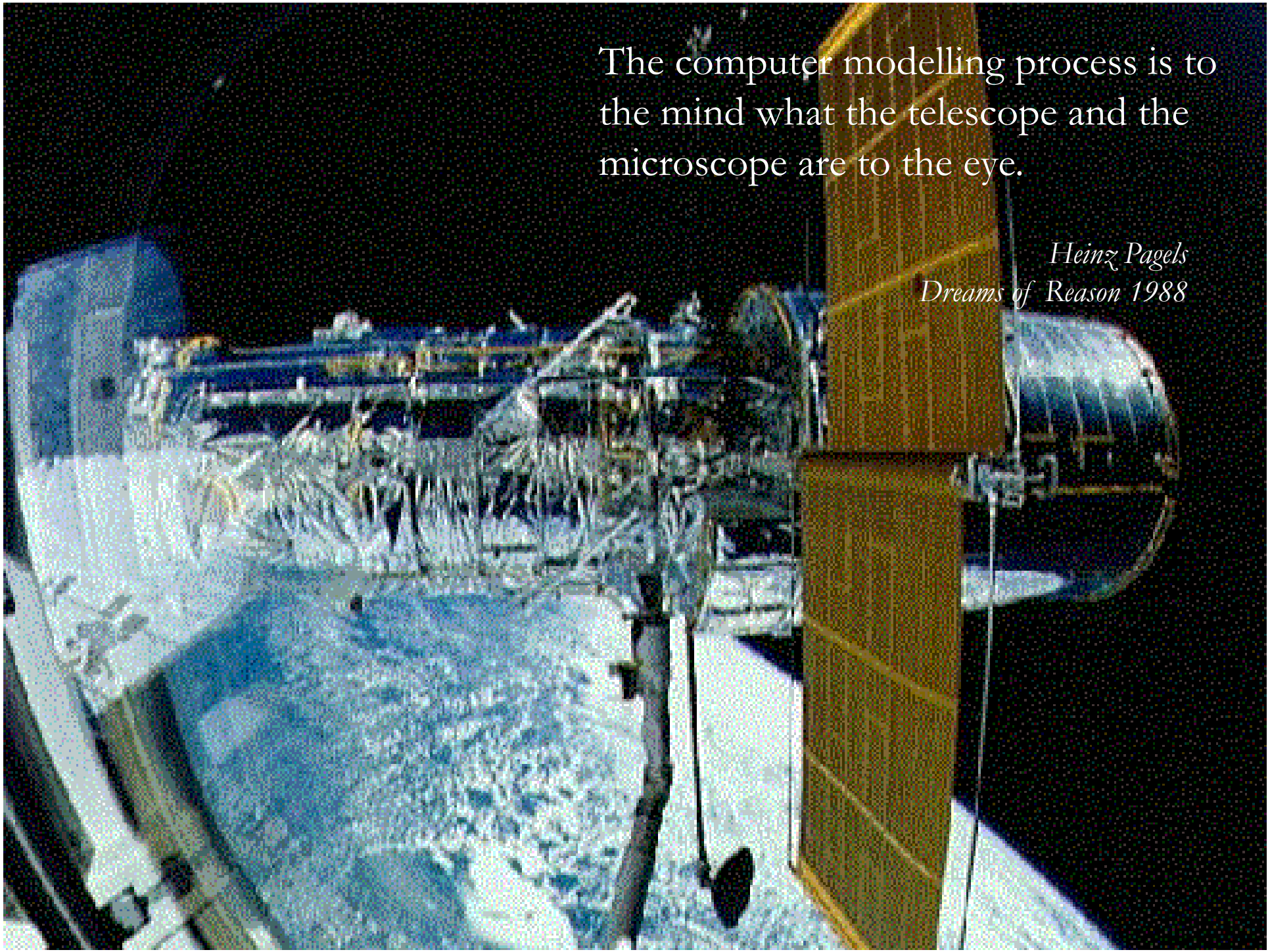
- The Purpose of Modelling: A System Dynamics Perspective
- Modelling to Enhance Learning
- Science & Public Discourse
- Examples
  - Demand for Renal Replacement Therapy (RRT)
  - CVD

What are we trying to do when we model?



"The macroscope filters details and amplifies that which links things together. It is not used to make things larger or smaller but to observe what is at once too great, too slow, and too complex for our eyes."

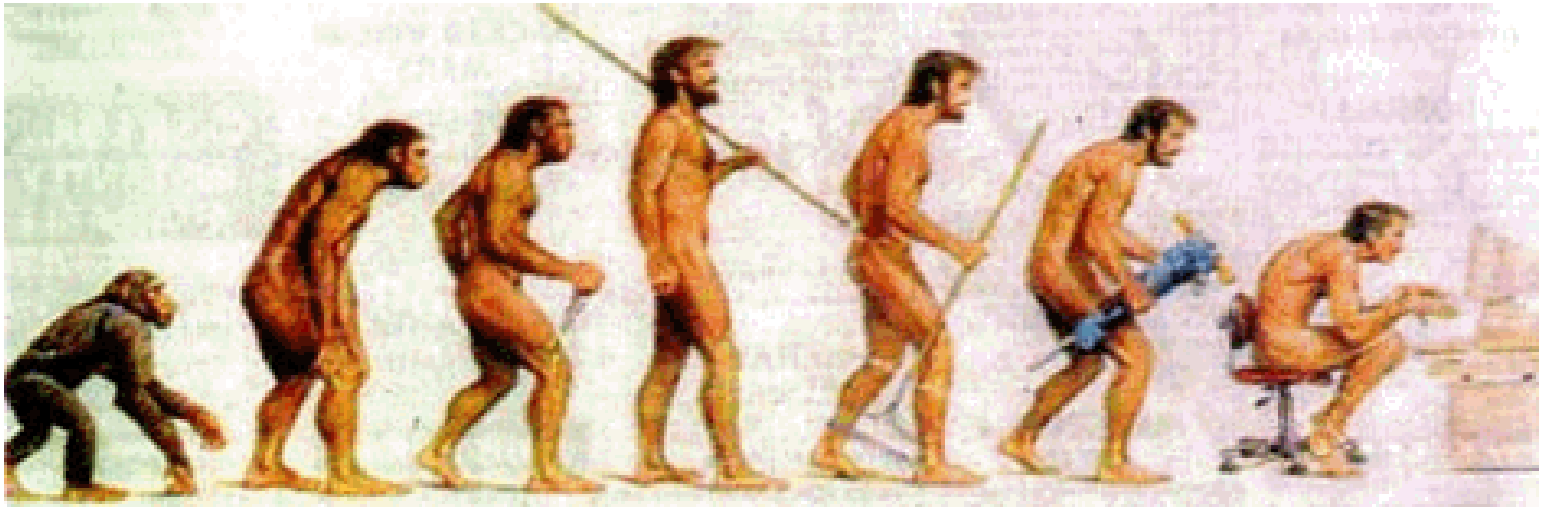
The Macroscope: A New World Scientific System
Joel de Rosnay, 1979


The computer modelling process is to the mind what the telescope and the microscope are to the eye.
Heinz Pagels
Dreams of Reason 1988

Computer Models:

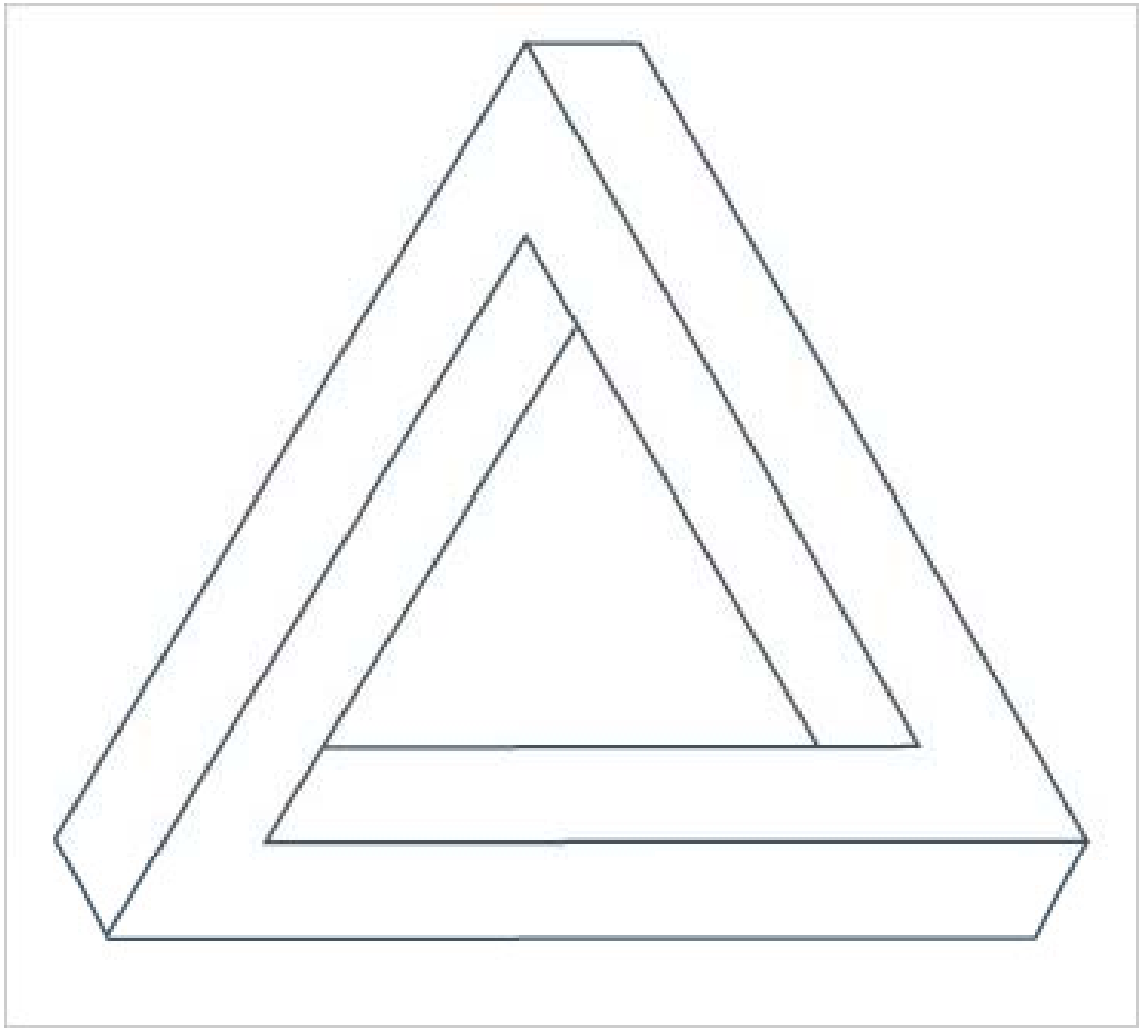
(Tools to Challenge our Thinking)

…computer models faithfully demonstrate the implications of our assumptions and information. They force us to see the implications, true or false, wise or foolish, of the assumptions we have made.
It is not so much that we want to believe everything that the computer tells us, but that we want a tool to confront us with the implications of what we think we know.

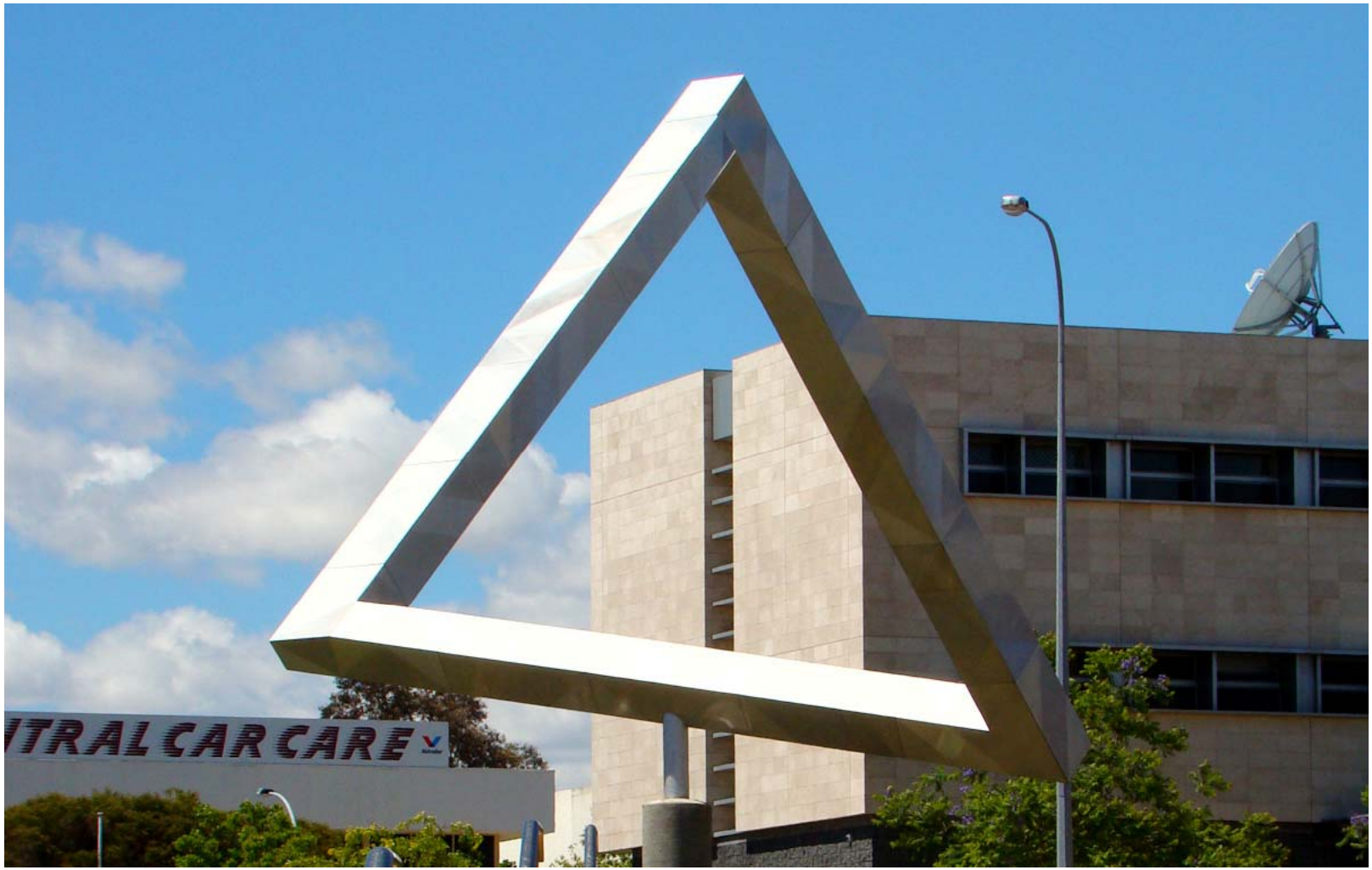


Could you make this?

(why or why not?)

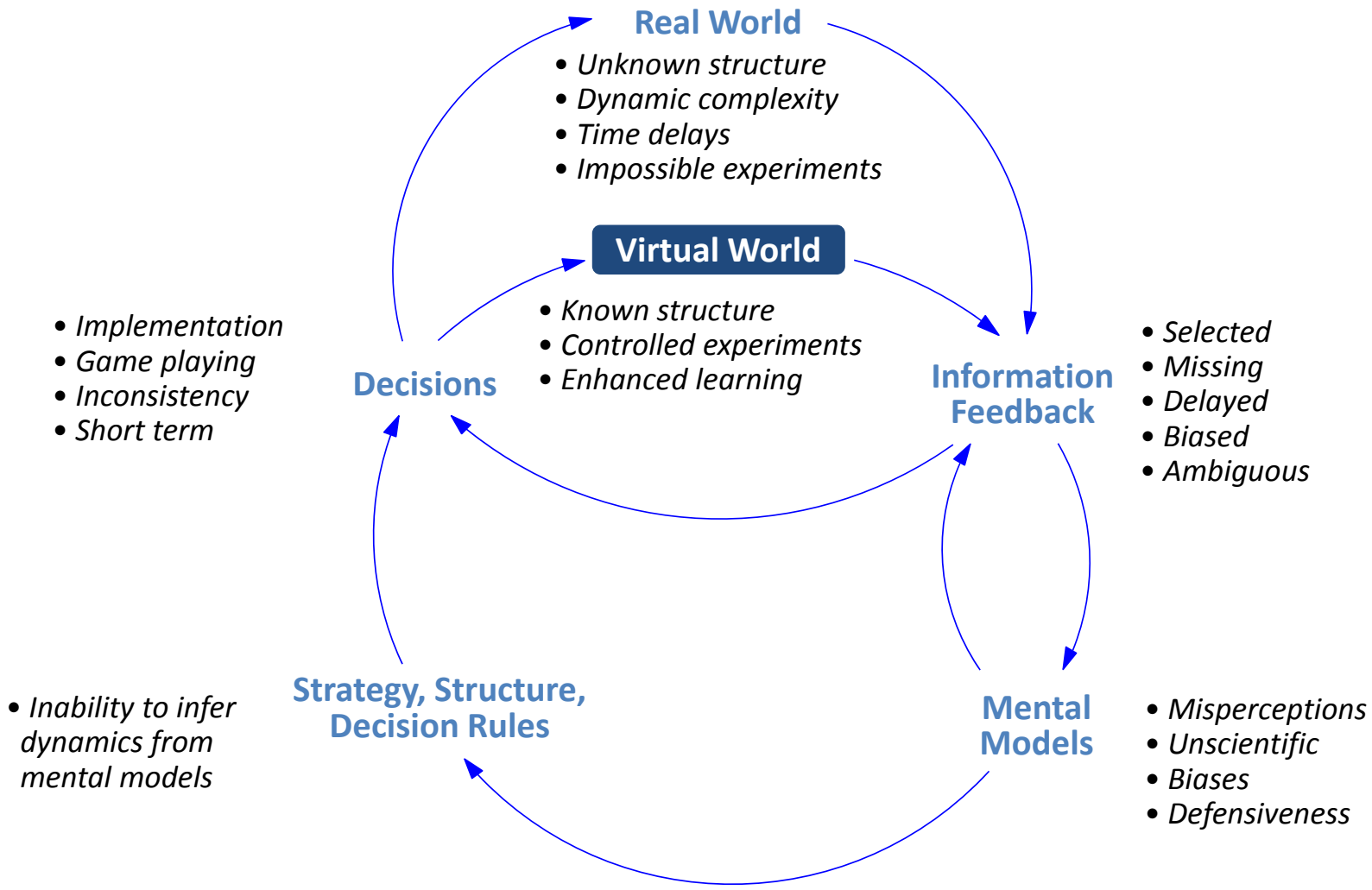


An optical illusion?



…it all depends where you stand

Learning in and About Complex Systems

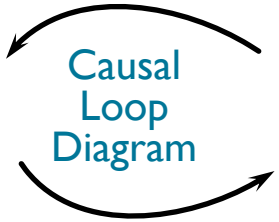


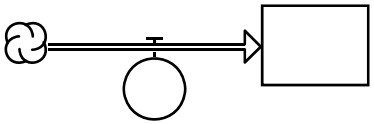
Sterman JD. Learning in and about complex systems. System Dynamics Review 1994;10(2-3):291-330.

Sterman JD. Business dynamics: systems thinking and modeling for a complex world. Boston, MA: Irwin McGraw-Hill, 2000.

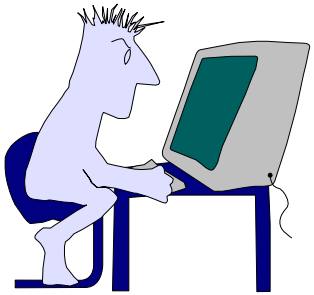
Models

Static → Dynamic





Stock & Flow
Diagram

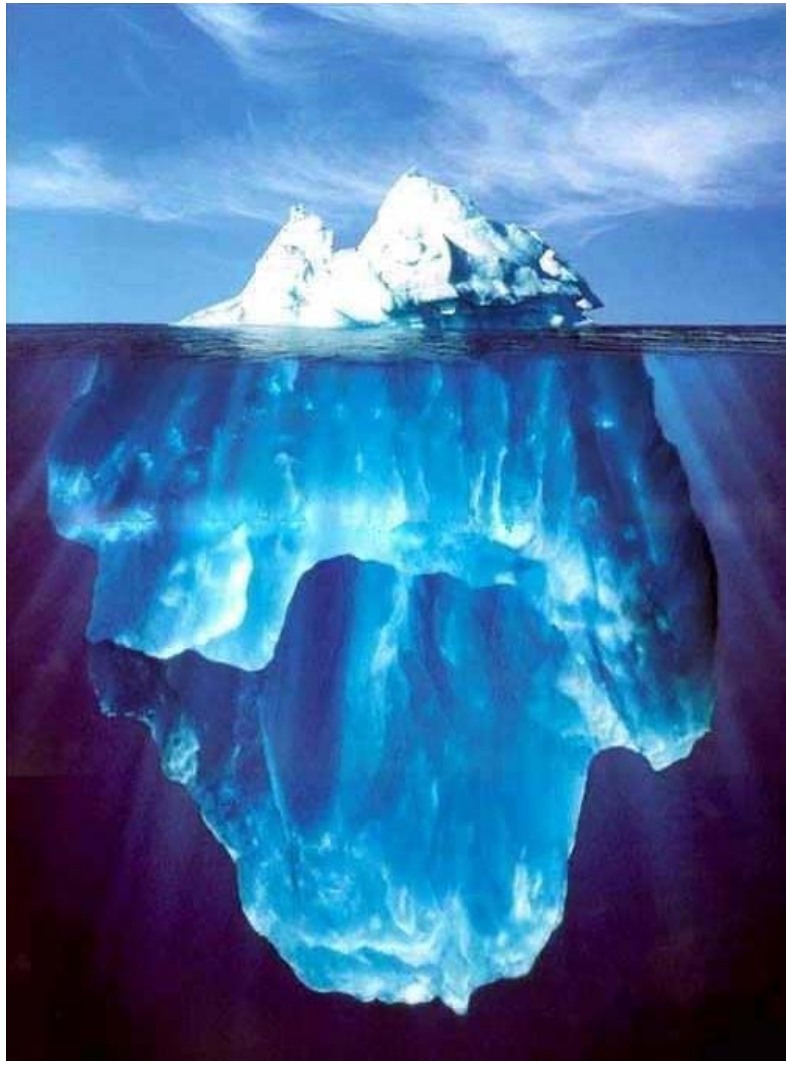


Dynamic
Computer Simulation

Mental Models → Visual Models → Simulation Models

….to see what is not immediately obvious

Increasing Leverage



EVENTS

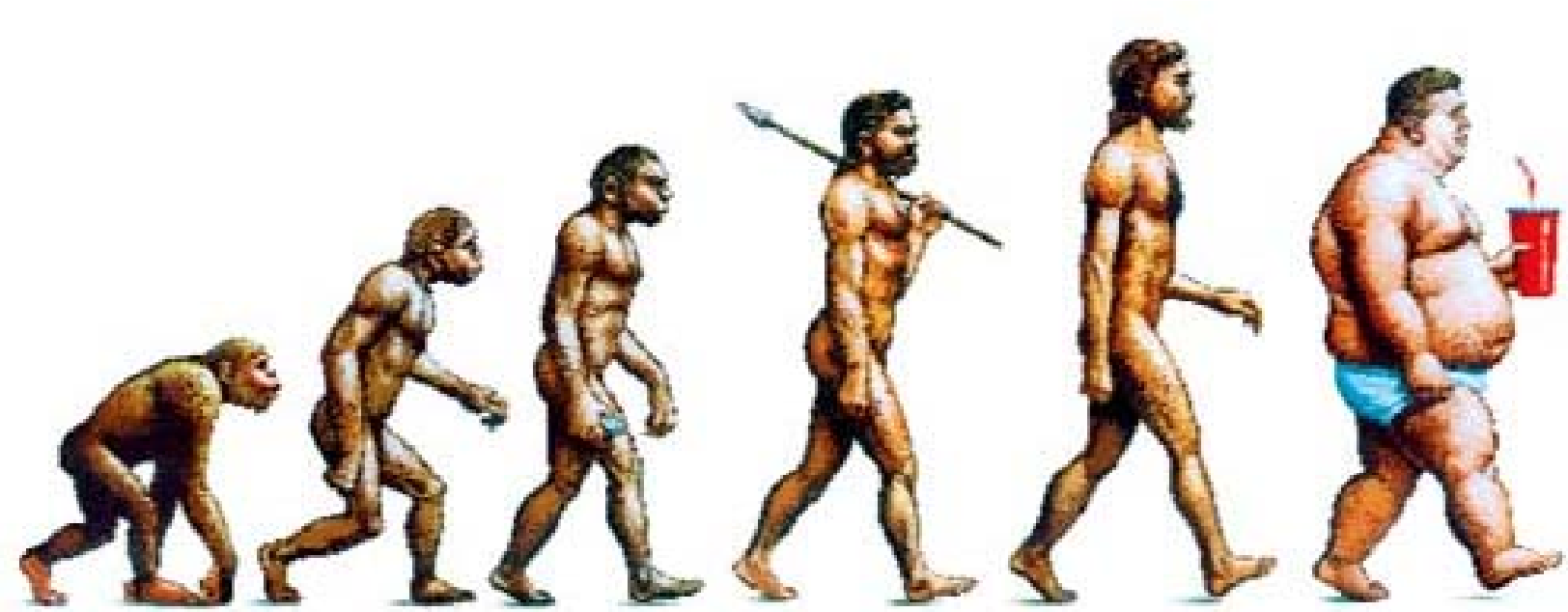
PATTERNS

STRUCTURE

MENTAL MODELS

VALUES

….and what may happen through time



The Economist
December 2006

Knowing ≠ Doing

"People are happy to add to the pharmacopoeia; they forget to swallow the medicine."

Stafford Beer, 1982

Science & Public Discourse

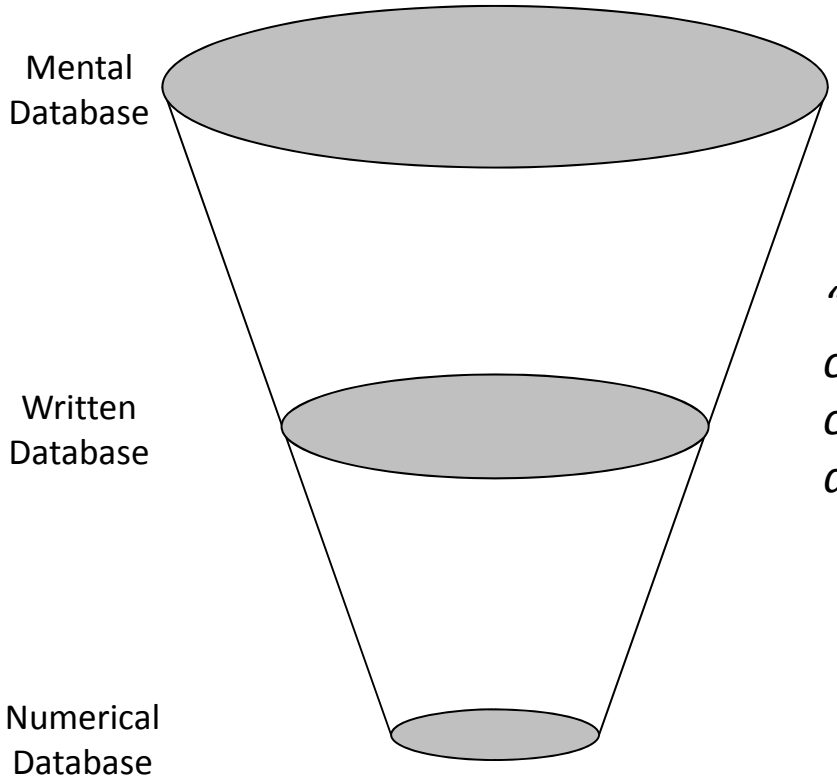
Thomas Dietz
Chair of US National Research Council Committee on Human Dimensions of Global Change
Professor of Sociology……
Michigan State University

- How can the public be engaged in a way that leads to competent deliberation using the best available science?
- How can the science be engaged while taking proper account of the limits of our knowledge and the uncertainties inherent in even the best analysis?
- How can a process make use of quantitative information while giving proper weight to qualitative information?
- How can discourse proceed in ways that are respectful of all viewpoints while encouraging learning and change on the part of individuals and groups?

"...one of the most integrative tools available to science".

From:
Van Den Belt, M. (2004). Mediated Modeling: A System Dynamics Approach to Environmental Consensus Building. London, Island Press.

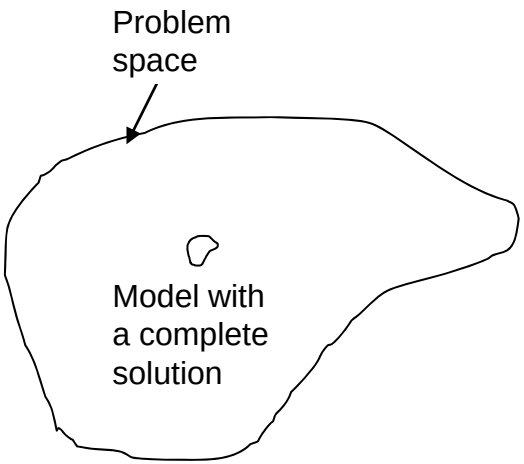
Data ≠ Numbers

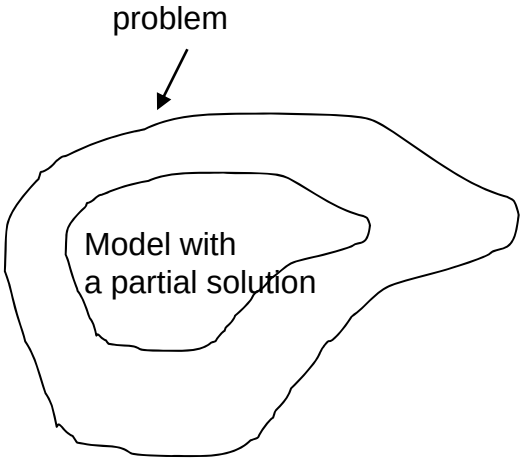


"[SD modellers]...would regard a series of conversations with mothers about their children to be as useful a source of information as a twenty-year time series on fertility data."

Meadows, D., The Unavoidable A Priori
In
Randers, J., Ed. (1980). Elements of the System Dynamics Method
Cambridge, Productivity Press.

Data ≠ Precise Numbers



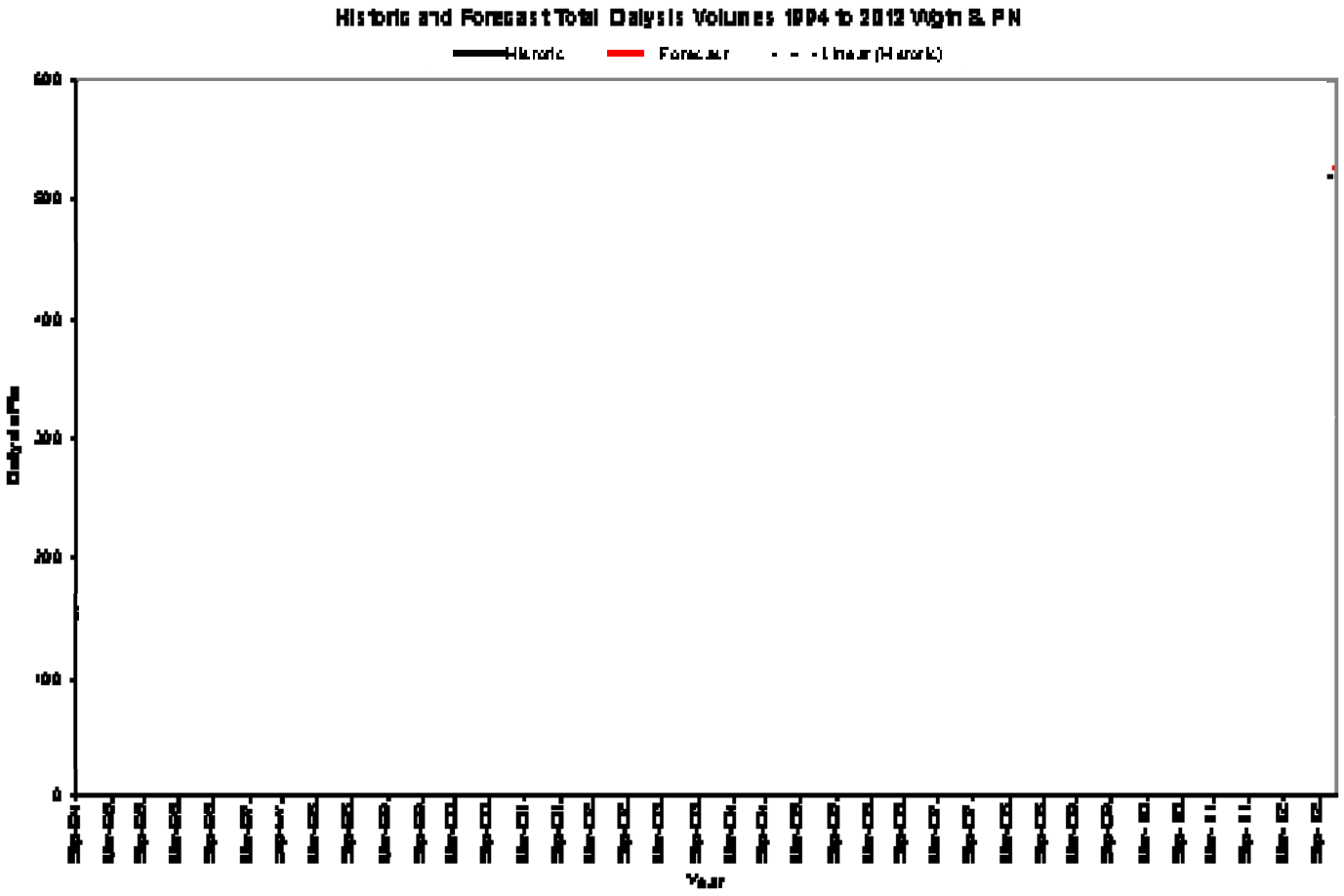


"A solution outlining cause and effect relationships might be able to provide a clue to the design of corrective roles or remedial institutions counterbalancing poor outcomes of existing causes and effects without carrying out any precise measurements."

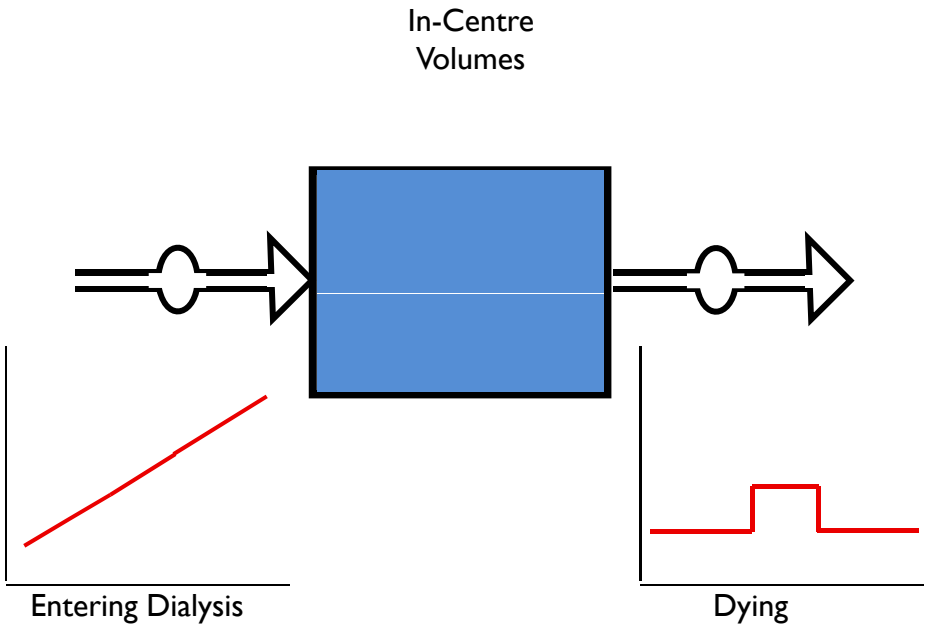
Saaed, K. (1992). "Slicing a complex problem for system dynamics modeling." Systems Dynamics Review **8(3): 251-261.**

EXAMPLE 1: REDESIGN OF RENAL SERVICES

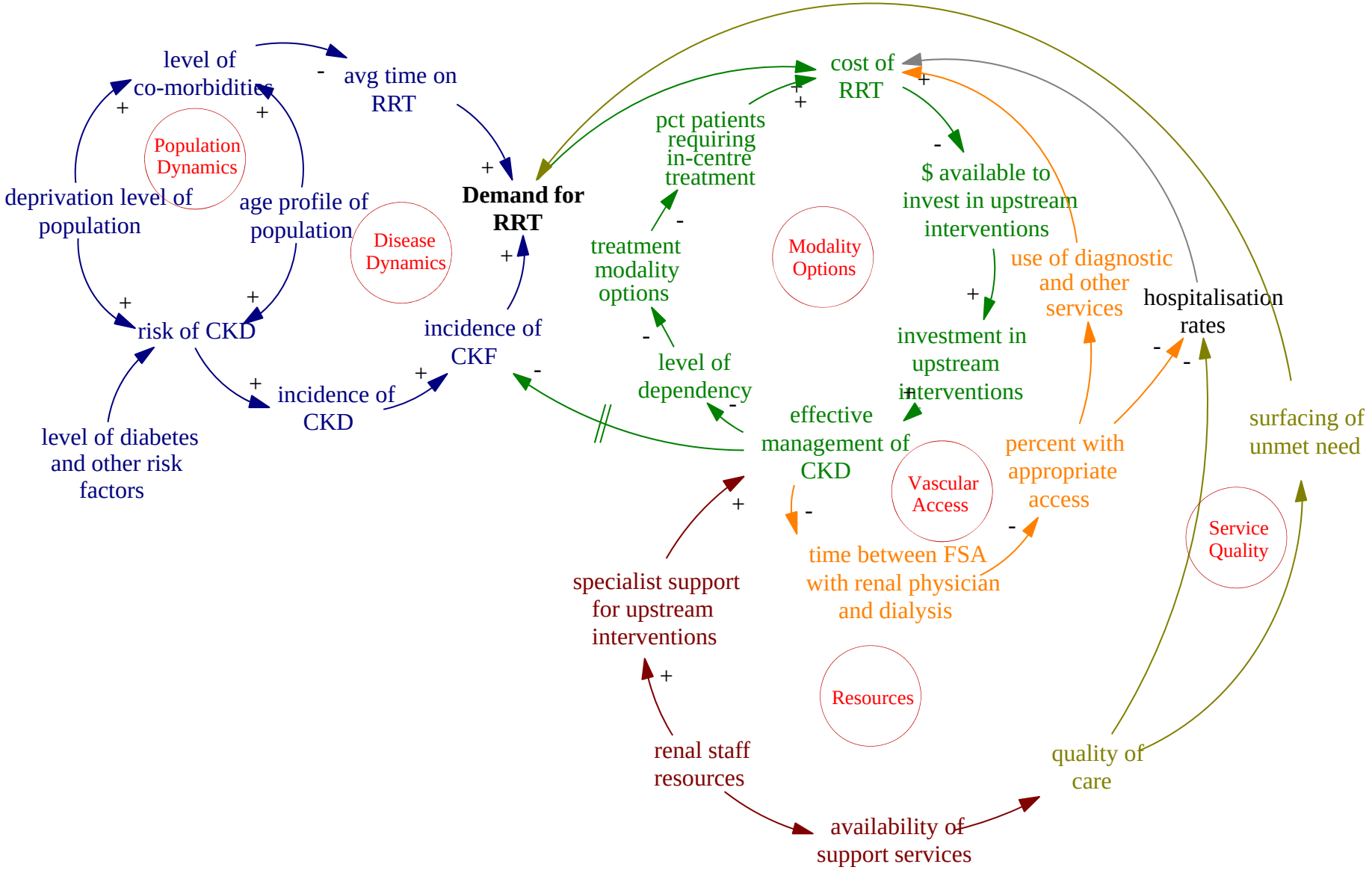
Problem #1: Rising Demand for RRT



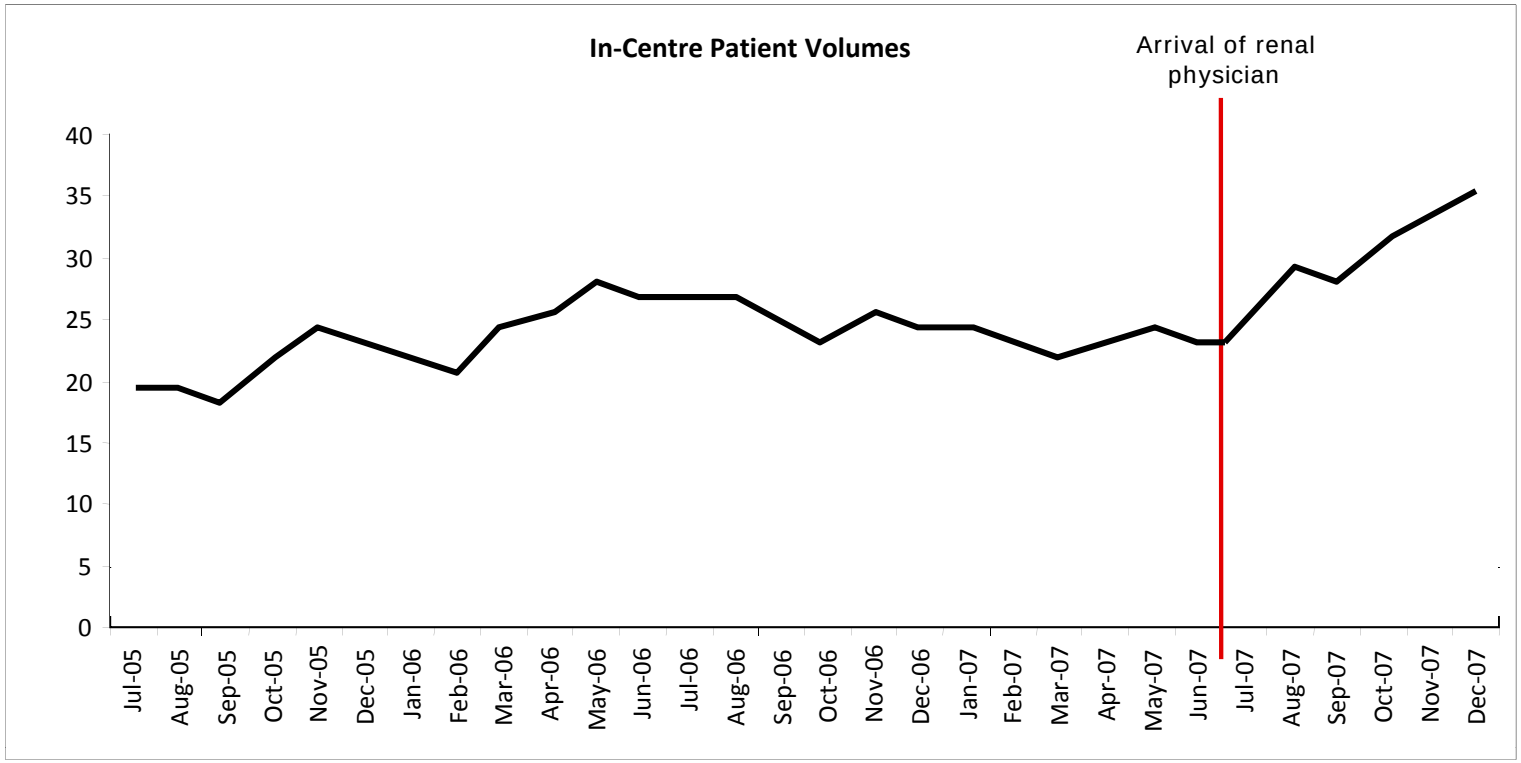
Problem #2: In-Centre Volumes



Dynamics of Renal Demand



Service Improvement Increases Demand



iThink 9.1.3 - HBDHB_Renal Model_200308.itm

File Edit View Interface Run Help

Interface Map Model Equation

WHAKAWATEATIA
HAWKE'S BAY
District Health Board

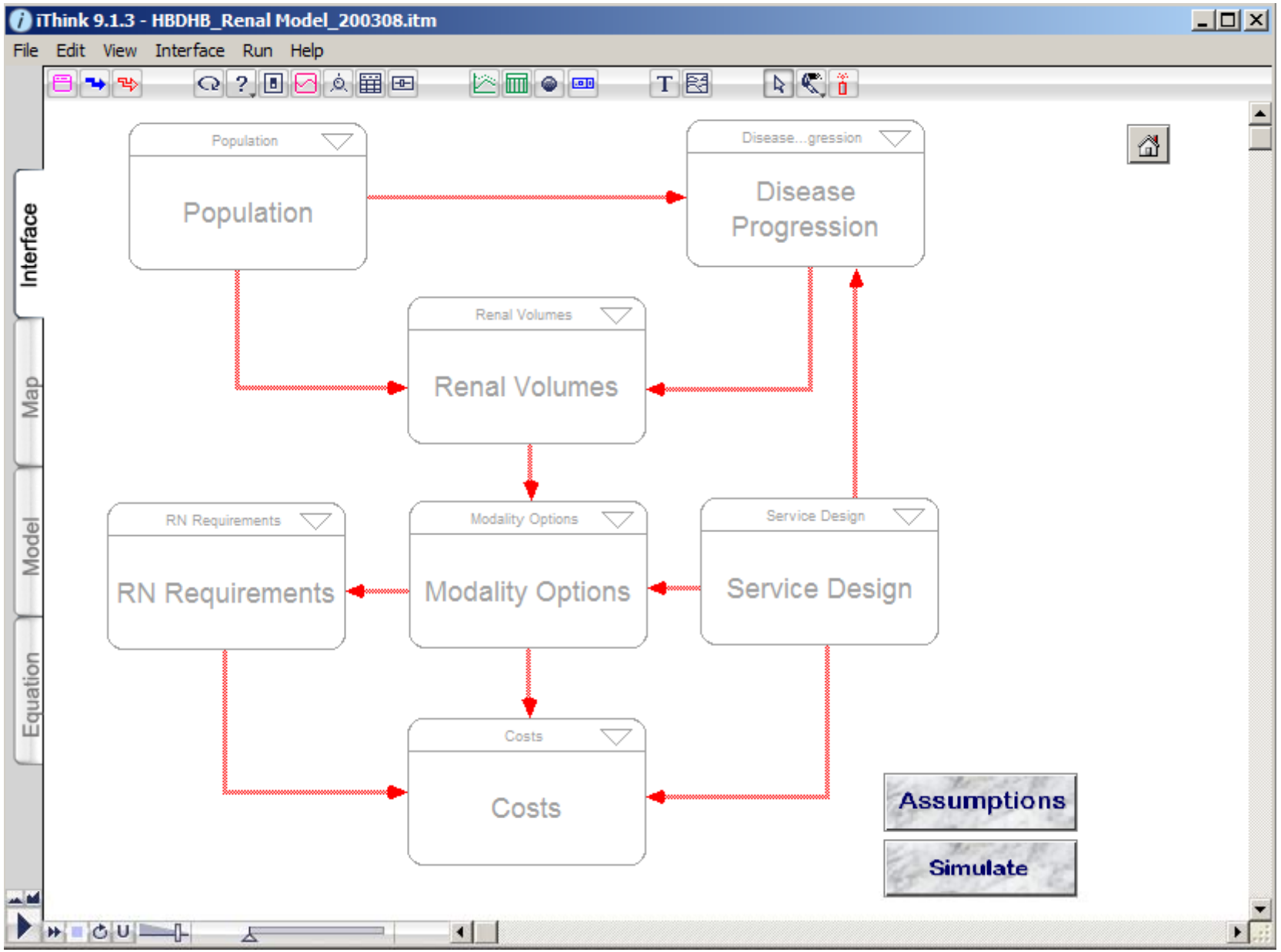
Dynamics of Demand for Renal Therapies

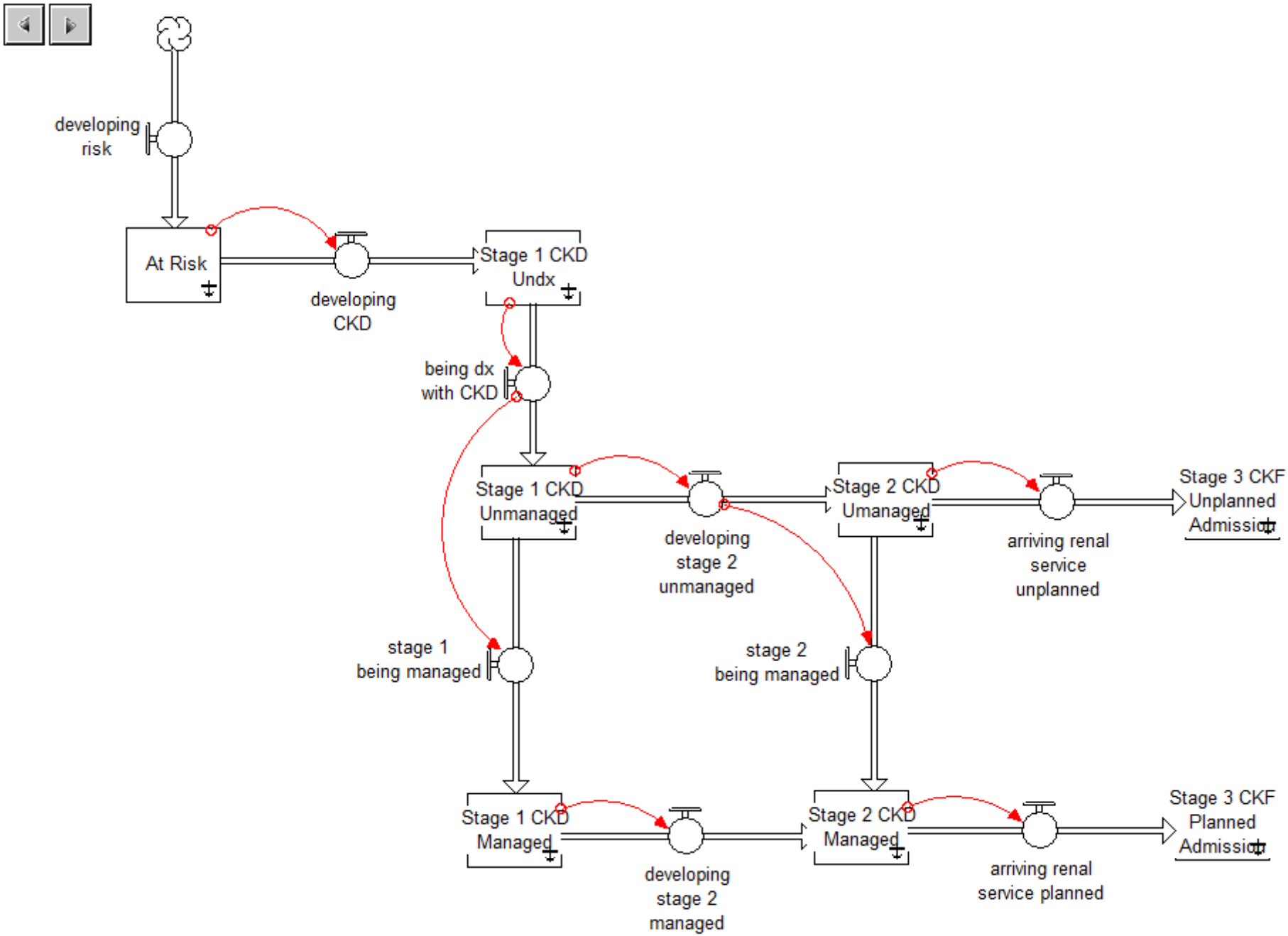
20th March 2008

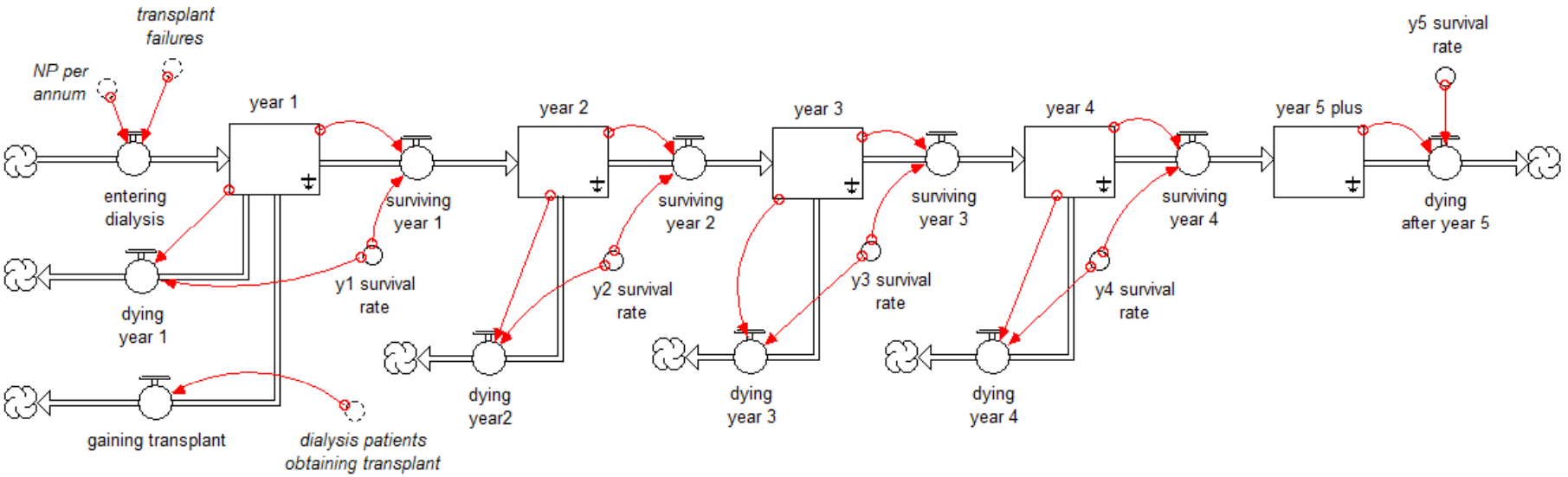
This simulation model has been put together to assist the Hawke's Bay DHB develop a plan for the sustainable development of the renal service. It's purpose is to provide an overview of the key factors that influence renal demand and provide a simulation environment in which a range of policy options and scenarios can be tested prior to agreeing and implementing any changes.

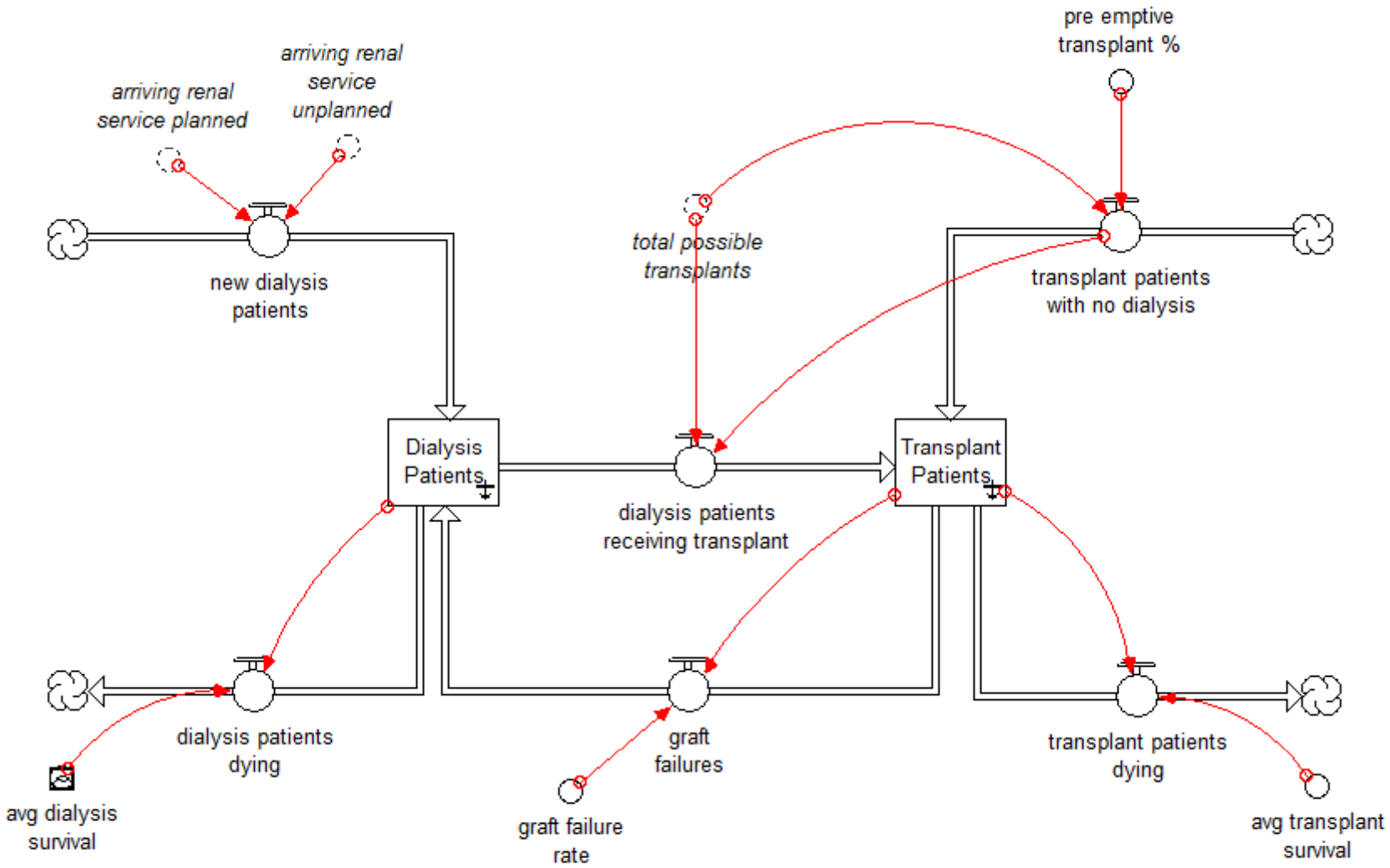
View Overview Model | Assumptions

View Detailed Model | Simulate


iThink 9.1.3 - HBDHB_Renal Model_200308.itm
File
Edit
View
Interface
Run
Help
Interface
Map
Model
Equation
Population
Population
Disease...gression
Disease Progression
Renal Volumes
Renal Volumes
RN Requirements
RN Requirements
Modality Options
Modality Options
Service Design
Service Design
Costs
Costs
Assumptions
Simulate


developing risk
At Risk
developing CKD
Stage 1 CKD Undx
being dx with CKD
Stage 1 CKD Unmanaged
developing stage 2 unmanaged
Stage 2 CKD Umanaged
arriving renal service unplanned
Stage 3 CKF Unplanned Admissio
stage 1 being managed
stage 2 being managed
Stage 1 CKD Managed
developing stage 2 managed
Stage 2 CKD Managed
arriving renal service planned
Stage 3 CKF Planned Admissio


transplant failures
NP per annum
year 1
year 2
year 3
year 4
year 5 plus
y5 survival rate
entering dialysis
surviving year 1
surviving year 2
surviving year 3
surviving year 4
dying after year 5
y1 survival rate
y2 survival rate
y3 survival rate
y4 survival rate
dying year 1
dying year2
dying year 3
dying year 4
gaining transplant
dialysis patients obtaining transplant


arriving renal service planned
arriving renal service unplanned
new dialysis patients
total possible transplants
pre emptive transplant %
transplant patients with no dialysis
Dialysis Patients
dialysis patients receiving transplant
Transplant Patients
dialysis patients dying
graft failures
transplant patients dying
avg dialysis survival
graft failure rate
avg transplant survival

iThink 9.1.3 - HBDHB_Renal Model_200308.itm

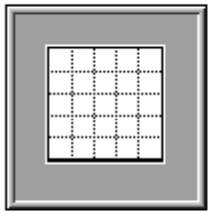
File Edit View Interface Run Help

Interface Map Model Equation

Key Assumptions

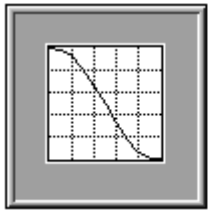
The projections produced by the model are influenced by the assumptions made about the demand for RRT and the responses that the service can make to that demand.

unmet need due to service improvements



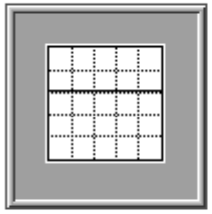
This sets the increase in patient admissions, above the base incidence rate that is likely to occur as a result of bringing the serice to Hawkes Bay and increasing clincial staffing, especialy the appointmnet of a full-time renal; physician.

of developing supported self care units



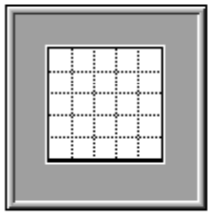
This describes the impact that the opening of supported self-care units is likely to have on the pecentage of dialysis patients requiring in-centre facilities.

avg dialysis survival



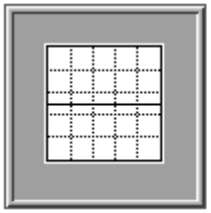
This describes the average survival, in years, of dialysis patients.

developing supported self care units



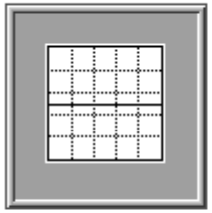
This describes the timeline for the development of supported self-care units. The default case is that it will take 5 years to bring on stream the supported self-care units needed to support the strategy for a sustainable renal service.

rate unmanaged requiring RRT



This specifies the rate at which managed patients with eGFR < 30 will rrequire RRT

rate managed requiring RRT



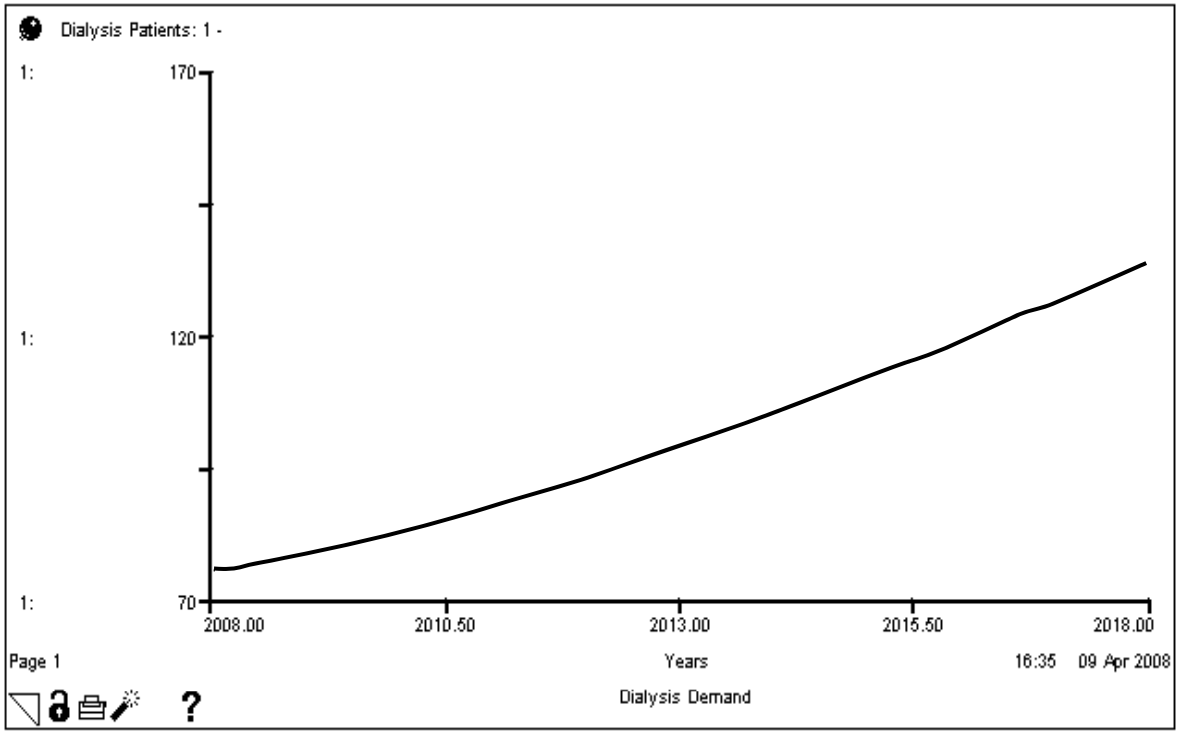
This specifies the rate at which unmanaged patients with eGFR < 30 will rrequire RRT

DU2 shifts

This adjusts the number of shifts being run in DU2. At the start of the simulation

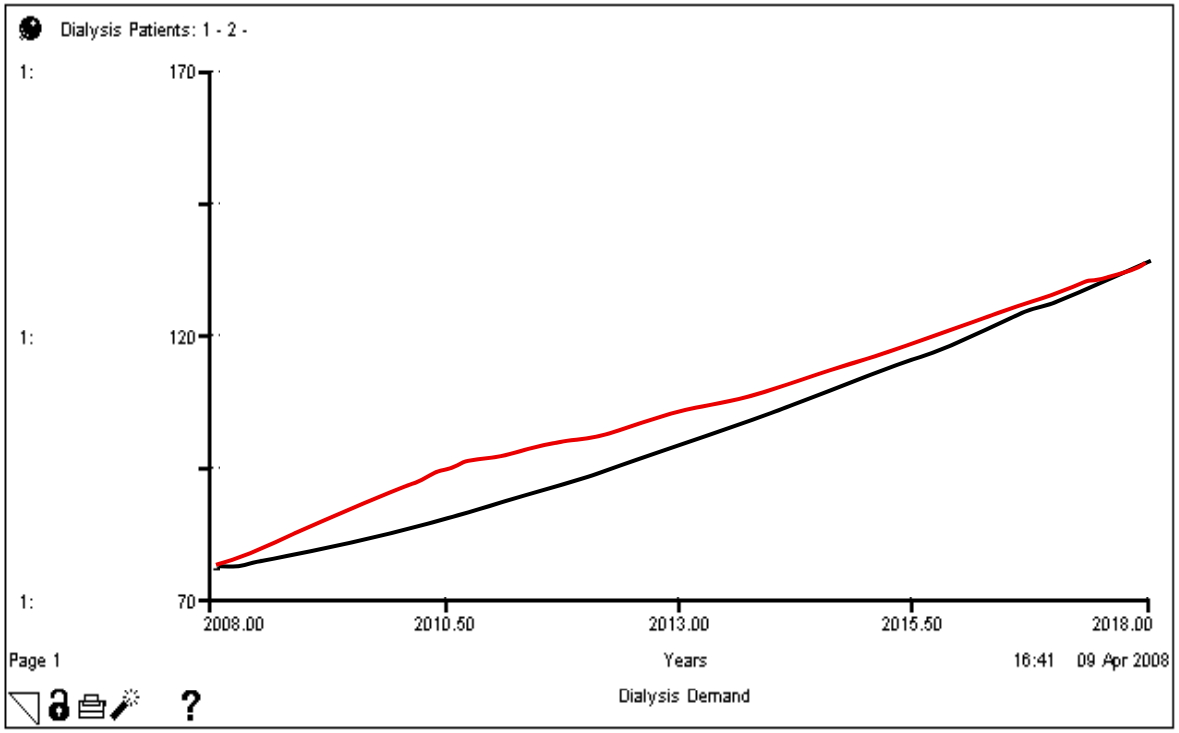
Simulate

Future Dialysis Numbers:
(Baseline Scenario)



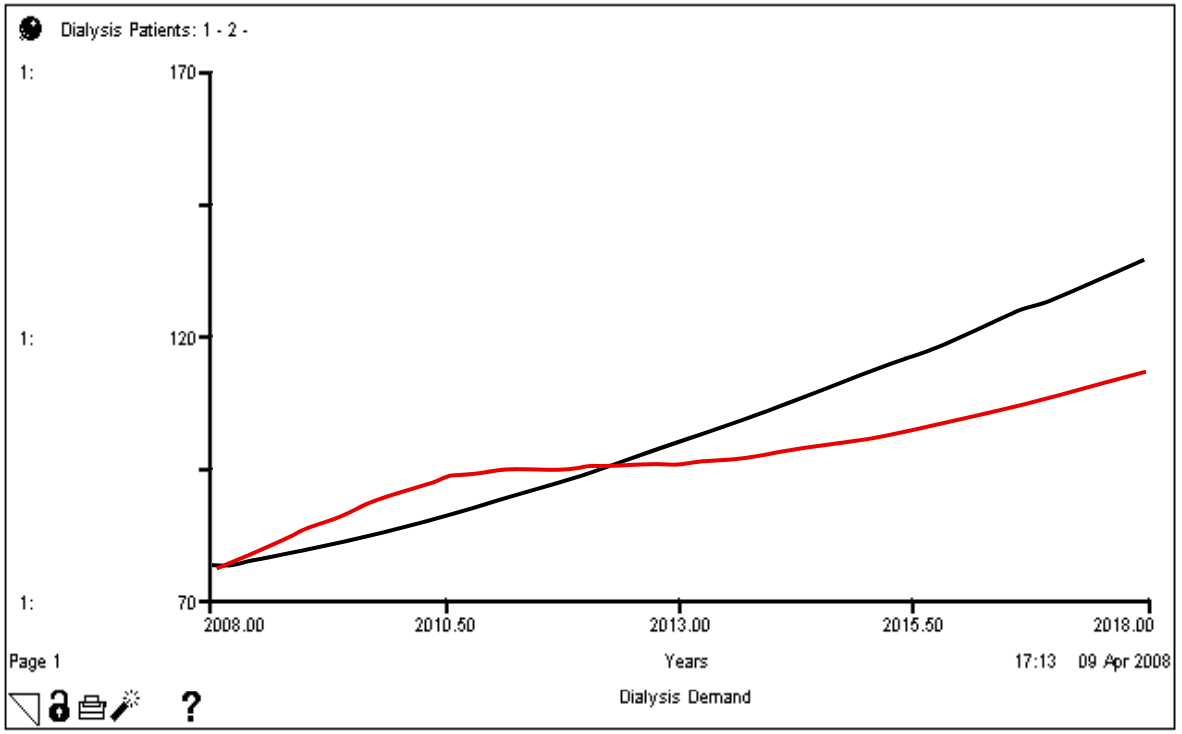
Future Dialysis Numbers:

(Surfacing Unmet Need)



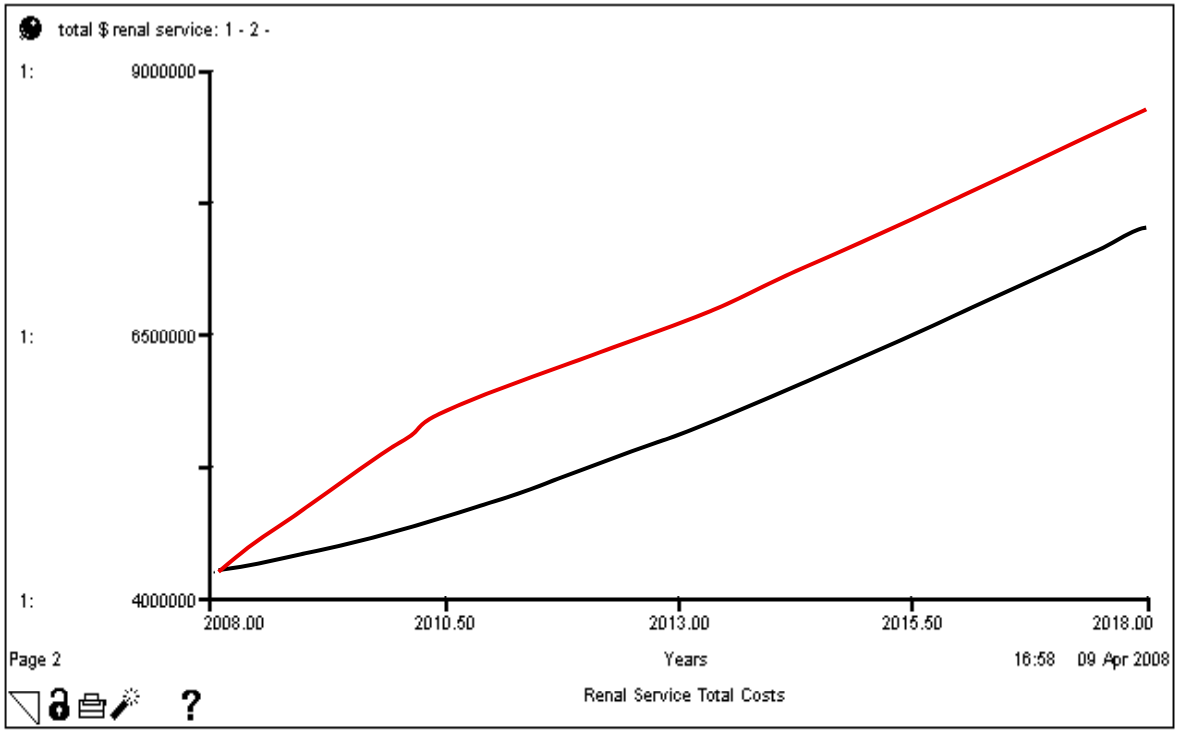
Future Dialysis Numbers:

(Best Practice Care)



Future Dialysis Costs:

(Surfacing Unmet Need & Increased Growth)

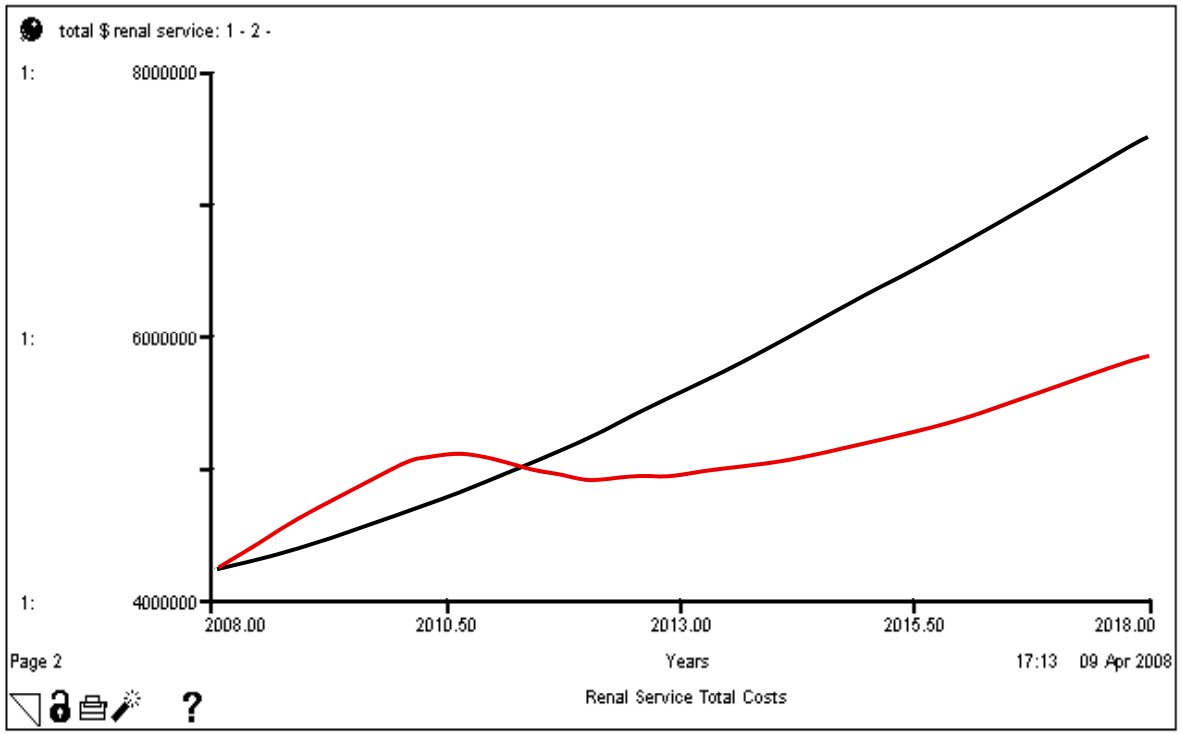


$8.7 million

$7.5 million

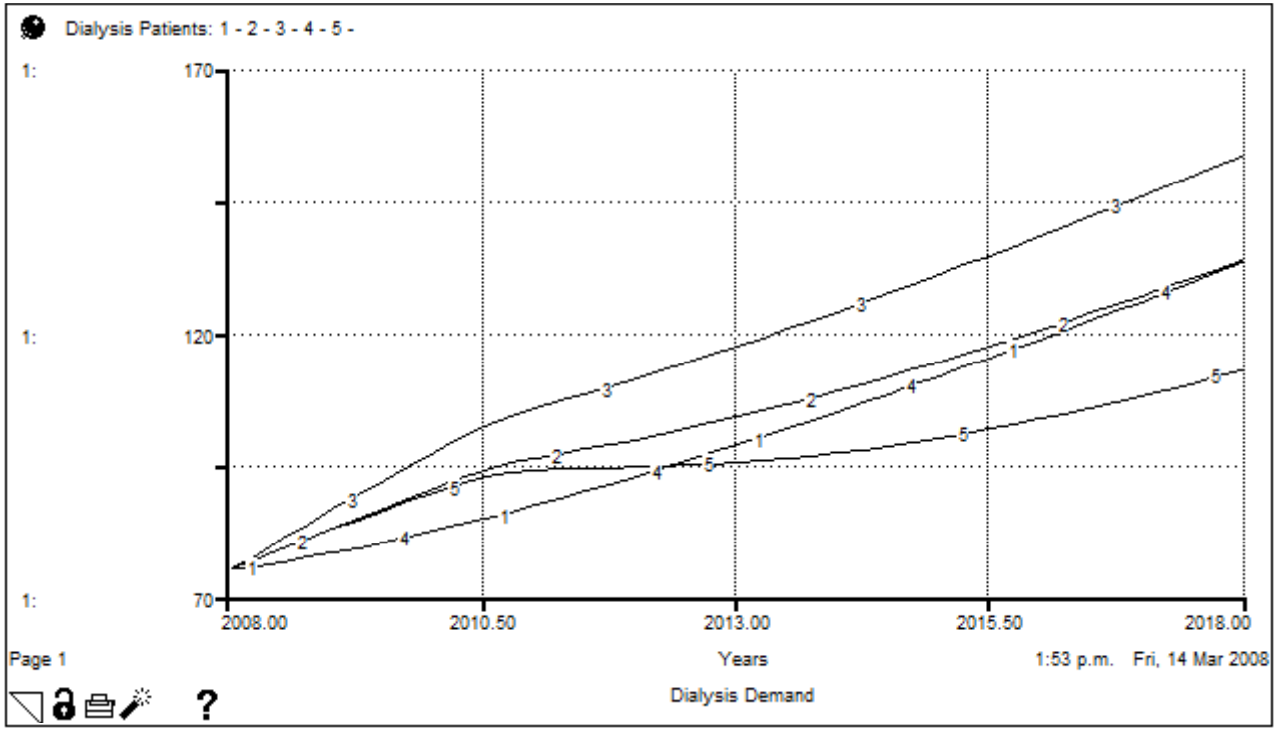
Future Dialysis Costs:

(Best Practice Care)



Plausible Futures:

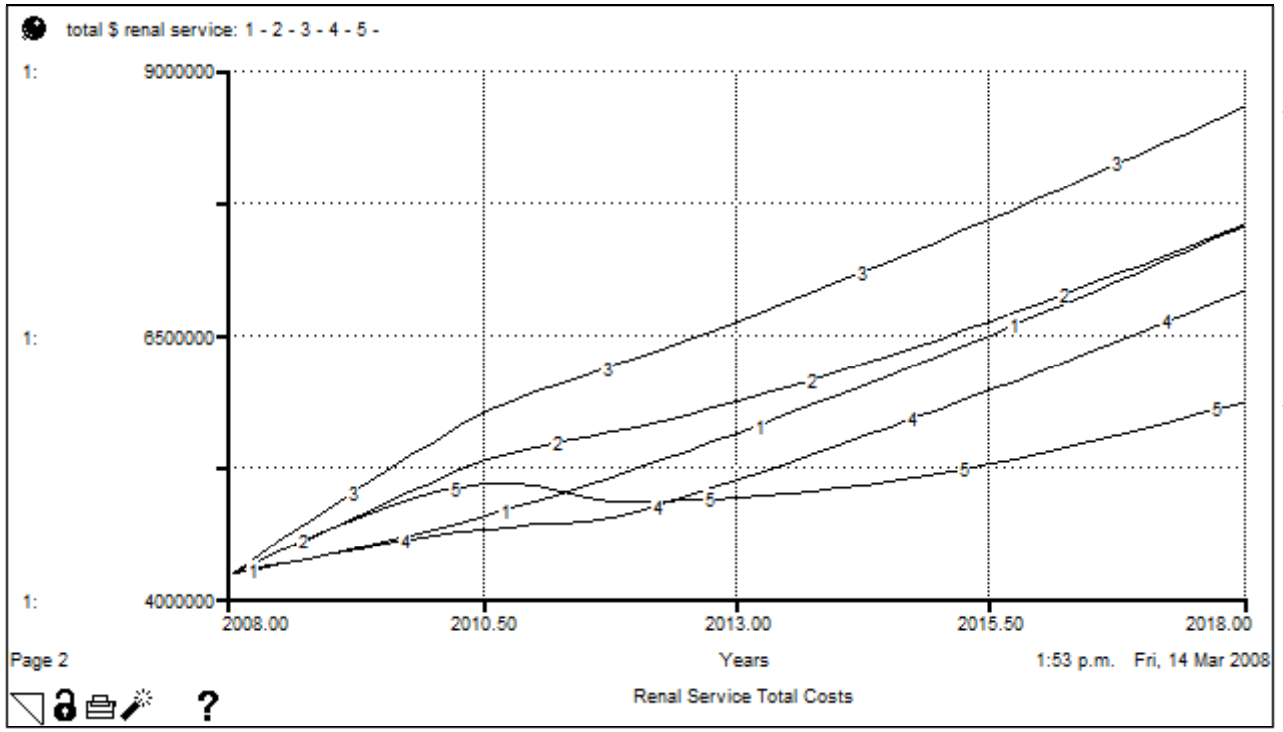
(Numbers)



154 Dialysis Patients

113 Dialysis Patients

Plausible Futures:
(Costs)



$8.7 million

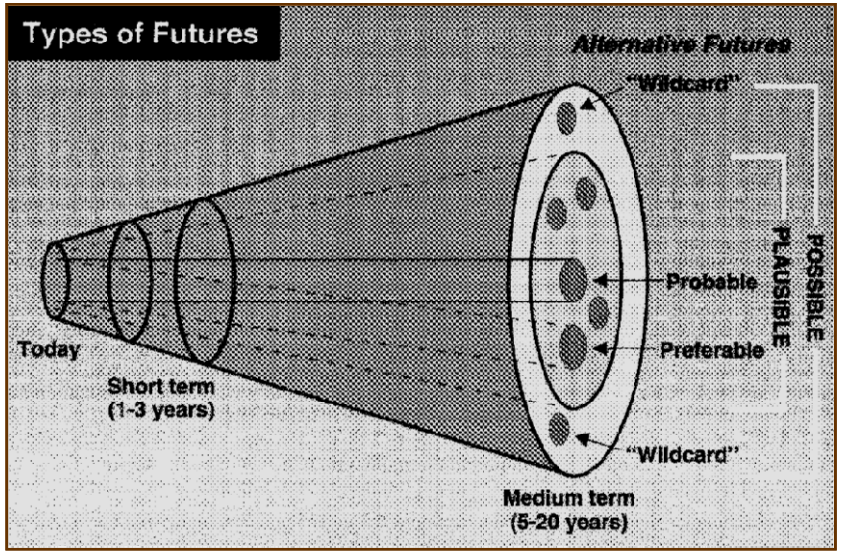
$5.8 million

Seeing Beyond Probable

(trend ≠ destiny)

"Most organizations plan around what is most likely. In so doing they reinforce what is, even though they want something very different."

-- Clement Bezold

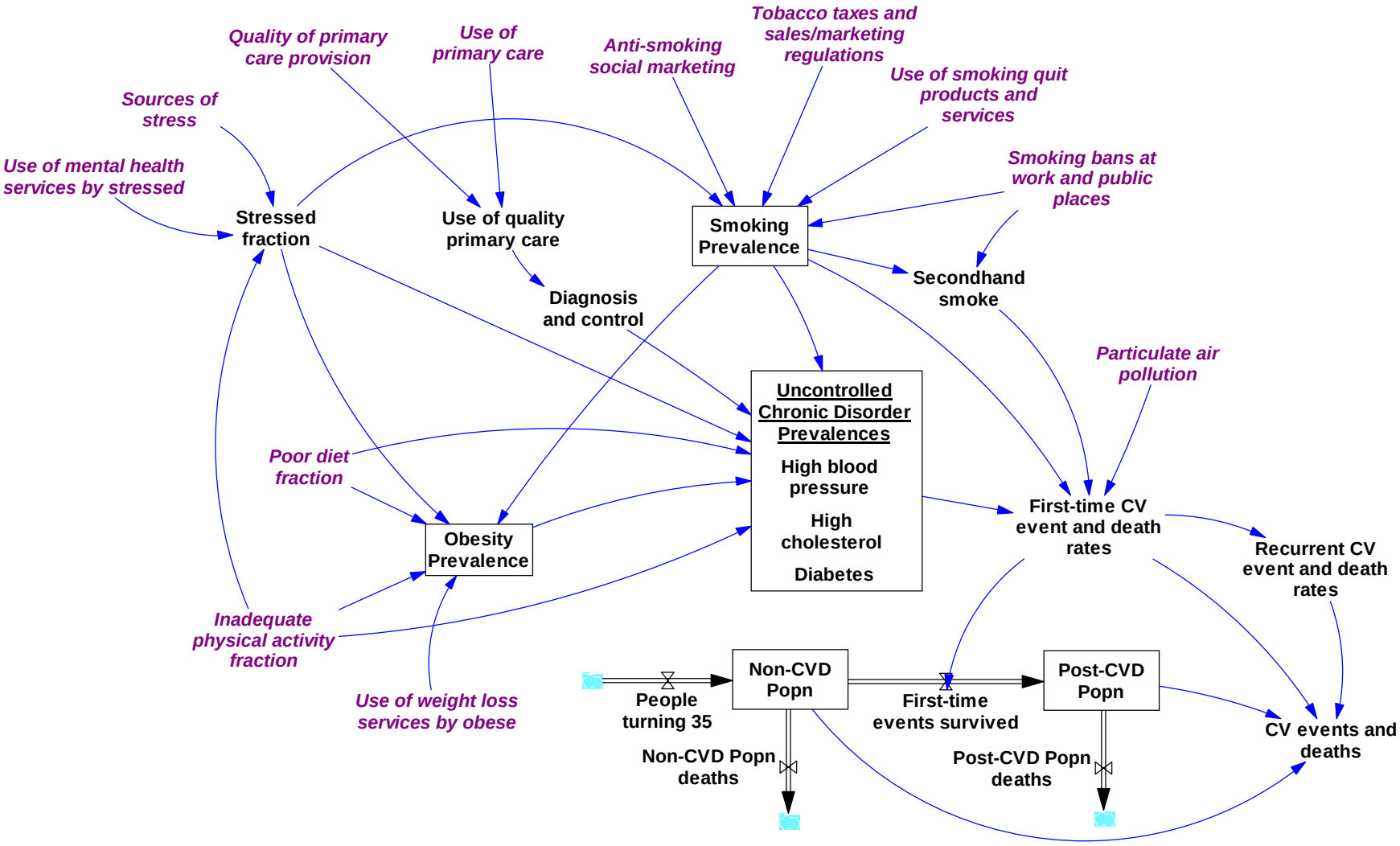


- Possible
  What may happen?
- Plausible
  What could happen?
- Probable
  What will likely happen?
- Preferable
  What do we want to have happen?

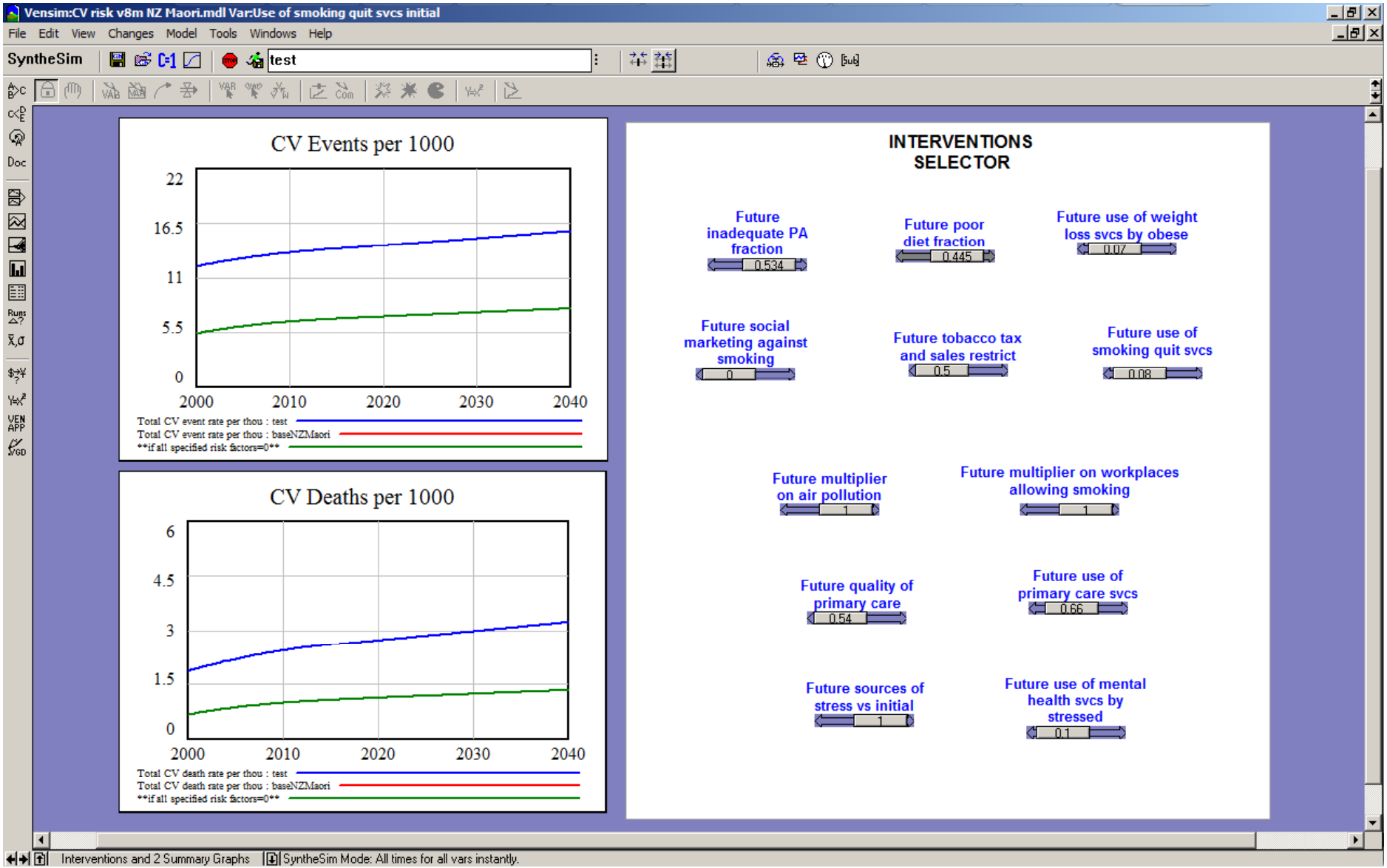
Bezold C, Hancock T. An overview of the health futures field. Geneva: WHO Health Futures Consultation; 1983 July 19-23.

EXAMPLE 2: CARDIOVASCULAR DISEASE

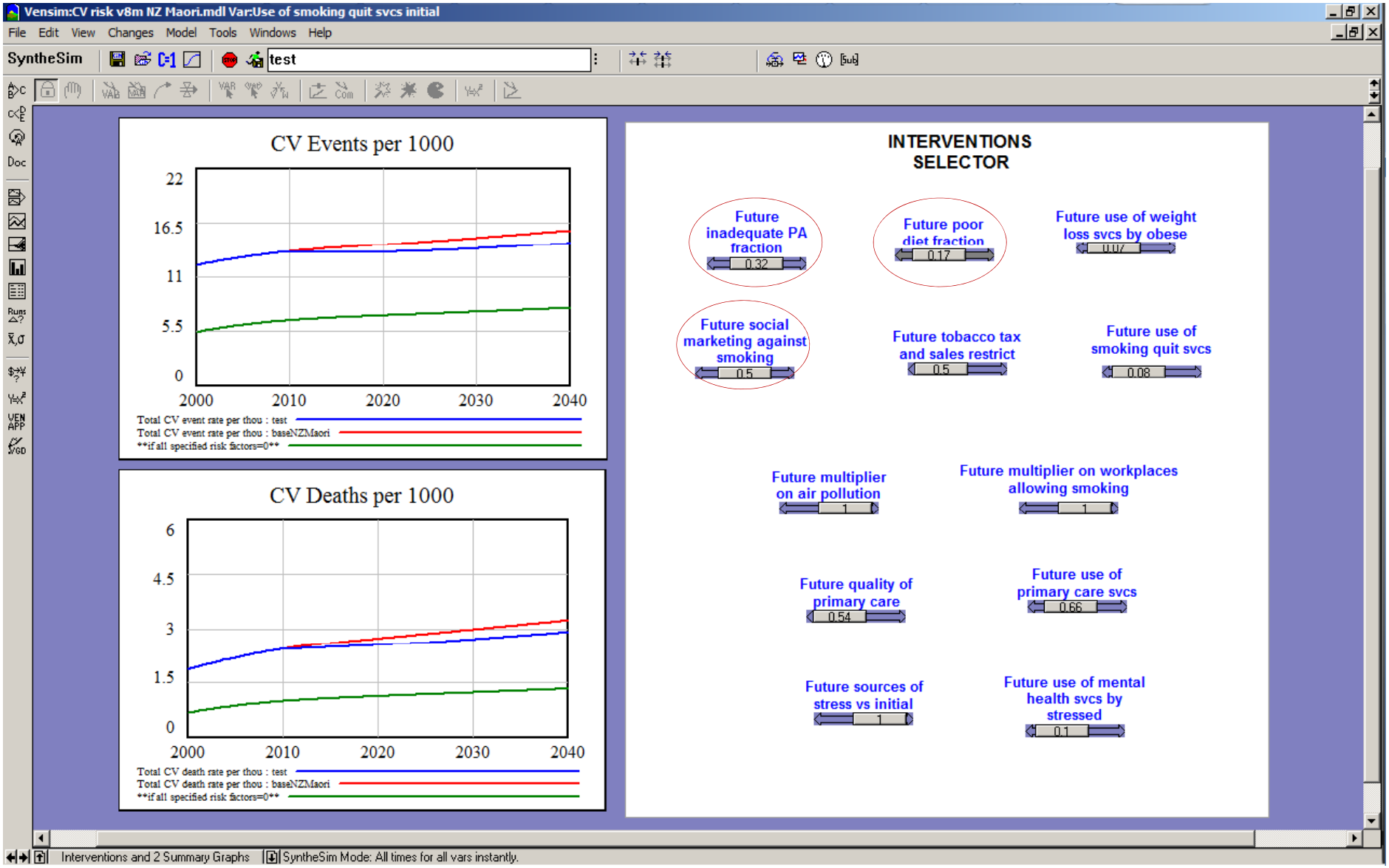
SD Model of Cardiovascular Disease:
(Concept Model)



Modelling Policy Options



Modelling Policy Options



Modelling Tasks

- Transform historical information into a reference mode
- Transform experiential information into an aggregate mental model or dynamic hypothesis
- Construct a structurally valid computer model subsuming the dynamic hypothesis
- Understand model behavior and create confidence in its behavioral validity
- Conduct experiments for policy design

Kahlid Saaed
Professor: Social Science & Policy Studies
Worcester Polytechnic Institute

Models as Teaching Tools

- The physical sciences have built up their body of knowledge through extensive use of experimentation to test and refine theory
- Whilst experimentation is central to the physical sciences it is rare in the social sciences
- System dynamics provides a means of bringing experimentation within the realm of the social sciences, enhancing social science and social policy

Kahlid Saaed
Professor: Social Science & Policy Studies
Worcester Polytechnic Institute