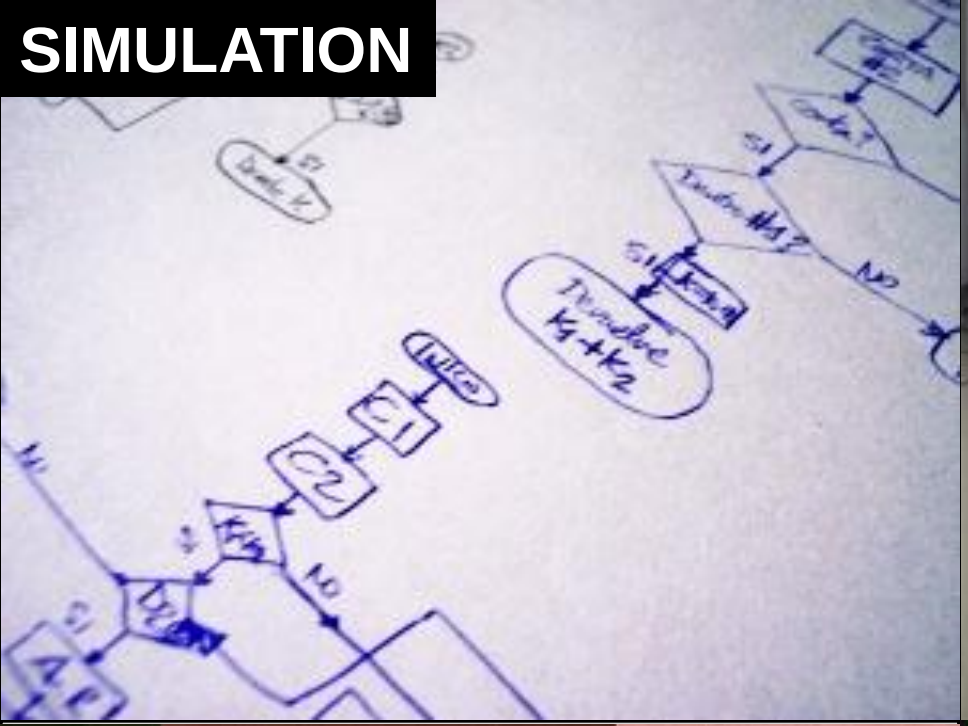
Simulation Surgeon, Solider, Spy

Roger Smith, PhD
Chief Technology Officer
Florida Hospital
Nicholson Center for Surgical Advancement

roger.smith@flhosp.org

Approved for Public Release.

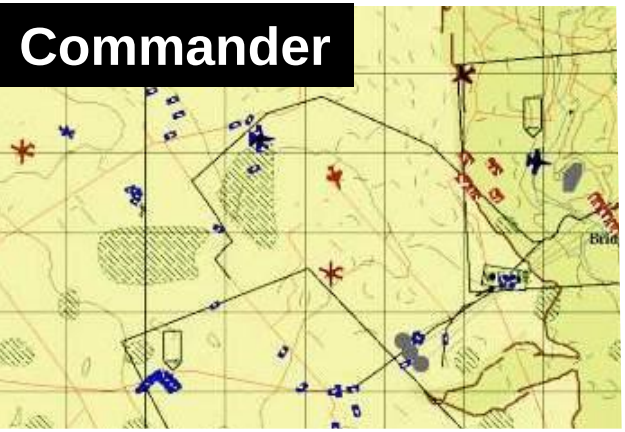

SIMULATION

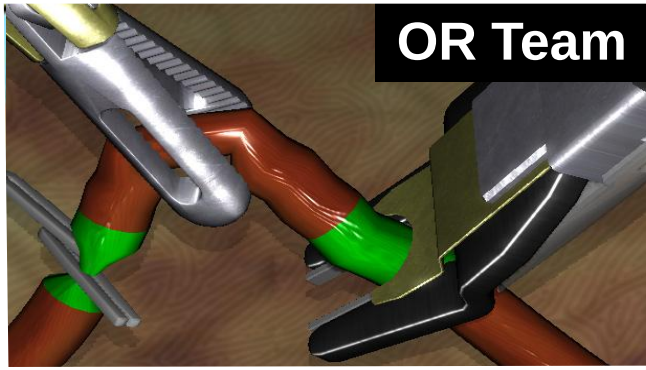

SURGEON


SOLDIER


SPY

Cross-Domain Principles



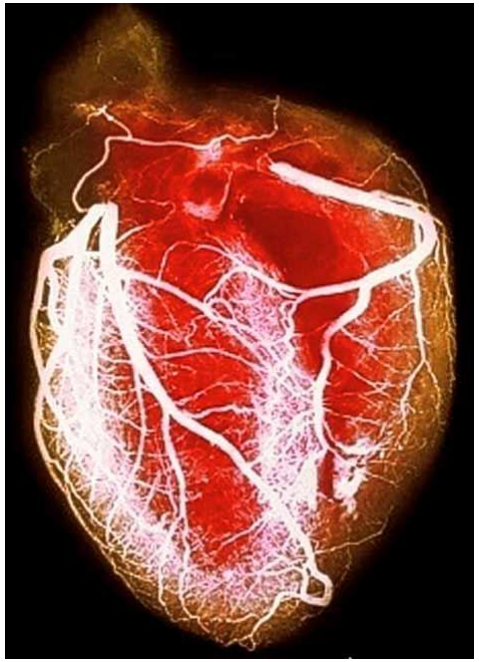


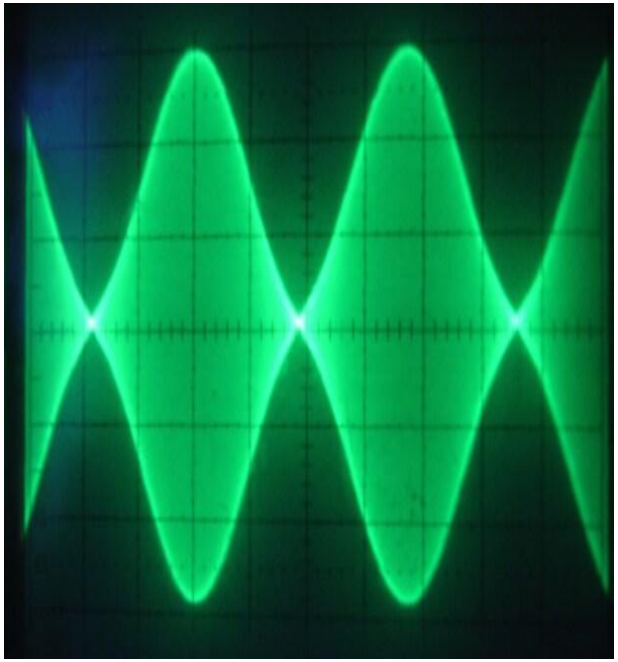
Modeling the World

Hard Objects
tanks, helos, ships

Human Body
living
tissue

Energy Signals
rf, eo, ir





90 Mental Models … for Investing

You've got to have *models* in your head. And you've got to array your experience - both vicarious and direct - on this latticework of models. …

What are the models? Well, the first rule is that you've got to have *multiple* models - because if you just have one or two that you're using, the nature of human psychology is such that you'll *torture* reality so that it fits your models, or at least you'll think it does. …

It's like the old saying, "To the man with only a hammer, every problem looks like a nail." But that's a perfectly disastrous way to think and a perfectly disastrous way to operate in the world. …

And the models have to come from multiple disciplines - because all the wisdom of the world is not to be found in one little academic department. …

You may say, "My God, this is already getting way too tough." But, fortunately, it *isn't* that tough - because 80 or 90 important models will carry about 90% of the freight in making you a worldly - wise person. And, of those, only a mere handful really carry very heavy freight.

Charlie Munger
Berkshire Hathaway
(Warren Buffett's Partner)

90 Mental Models

- Mathematics
- Statistics
- Physics
- Logic
- Queuing
- Human Behavior
- Economics
- Social Relationships
- CFD
- Finite Element

- Finite State Machine
- Markov Chain
- Continuous vs. Discrete
- Sim Languages & Tools
- Notations (ER, UML)

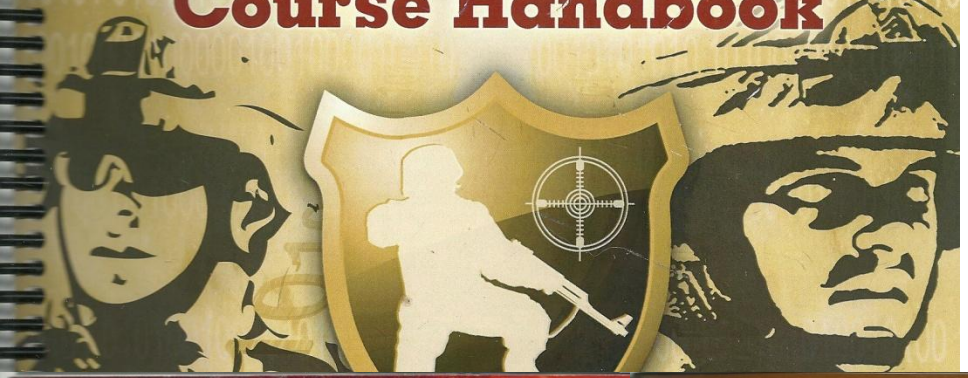
Holy Grail:

MODELS OF MODELING?

MILITARY SIMULATION

SERIOUS GAME TECHNOLOGY

Course Handbook



Digital Worlds, Virtual Reality, Training, Analysis, Interaoperability, Entertainment

MASTERING SIMULATION

The Past, Present, and Future

DIGITAL WORLDS, VIRTUAL REALITY, PREDICTION, ANALYSIS, TRAINING, INTEROPERABILIT

SIMULATION FOUNDATIONS

UNLOCKING THE PAST, PRESENT & FUTURE POWER OF SIMULATION TECHNOLOGY

1-DAY SEMINAR

PRESENTED BY

SIMULATION BASED AQUISITION

Course Handbook

A Foundation in the Technology, Processes, and History of Simulation

The First Critical Step in Creating a Virtual World

PRINCIPLES OF MODELING

For Leaders, Architects, and Engineers of the Digital World

Pritsker's Modeling Principles

- Conceptualizing a model requires system knowledge, engineering judgment, and model-building tools.
- The secret to being a good modeler is the ability to remodel.
- The modeling process is evolutionary because the act of modeling reveals important information piecemeal.
- The problem or problem statement is the primary controlling element in model-based problem solving.
- In modeling combined systems, the continuous aspects of the problem should be considered first. The discrete aspects of the model should then be developed.
- A model should be evaluated according to its usefulness. From an absolute perspective, a model is neither good or bad, nor is it neutral.
- The purpose of simulation modeling is knowledge and understanding, not models.

Source: Pritsker, A. (2000). *Papers, Experiences, Perspectives*. Systems Publishing Corp.

DES Program Structure

Start

Main

1. Invoke Initialization
2. Invoke Timing
3. Invoke Event Handler

Initialization

1. Set clock
2. Set state variables
3. Load event list

Timing

1. Select next event
2. Advance sim clock

Event Handlers

1. Update state variables
2. Increment counters
3. Generate future events

Mathematics

1. Statistical Distributions
2. Mathematical Operations

Finished?

NO

YES

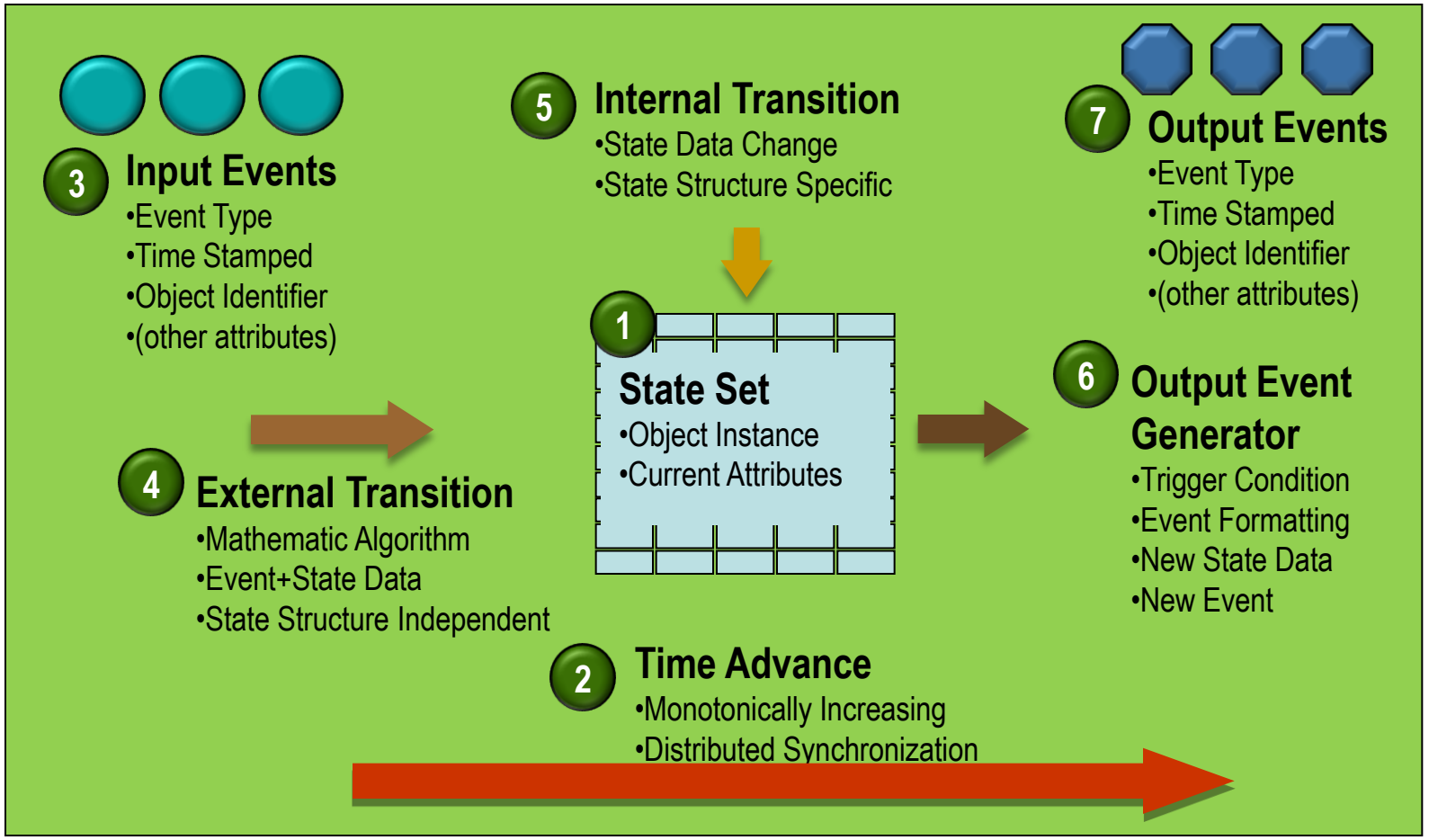
Reports

1. Compute interest data
2. Write reports

Stop

Source: Law, A & Kelton, W. (1991). *Simulation Modeling and Analysis*. McGraw Hill.

DEVS Model Structure



Source: Zeigler, Praehofer, Kim. (2000). *Theory of Modeling and Simulation*. Academic Press.

Kiviat Modeling Approach

Purpose of the modeling project.

Problem Statement

Static state of objects.

Physical Model

Relationships between objects.

Logical Model

Possible actions.

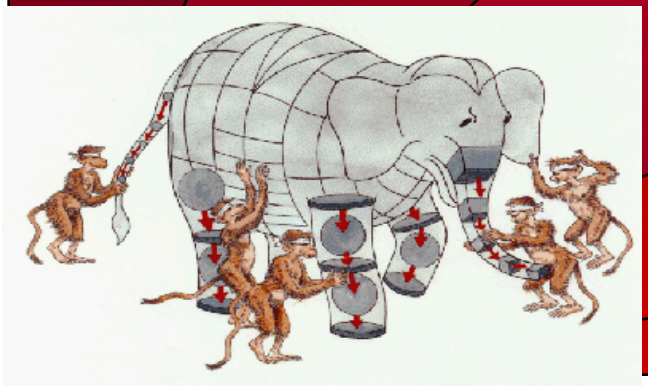
Dynamic Model

Criteria for taking action.

Decision Process Model

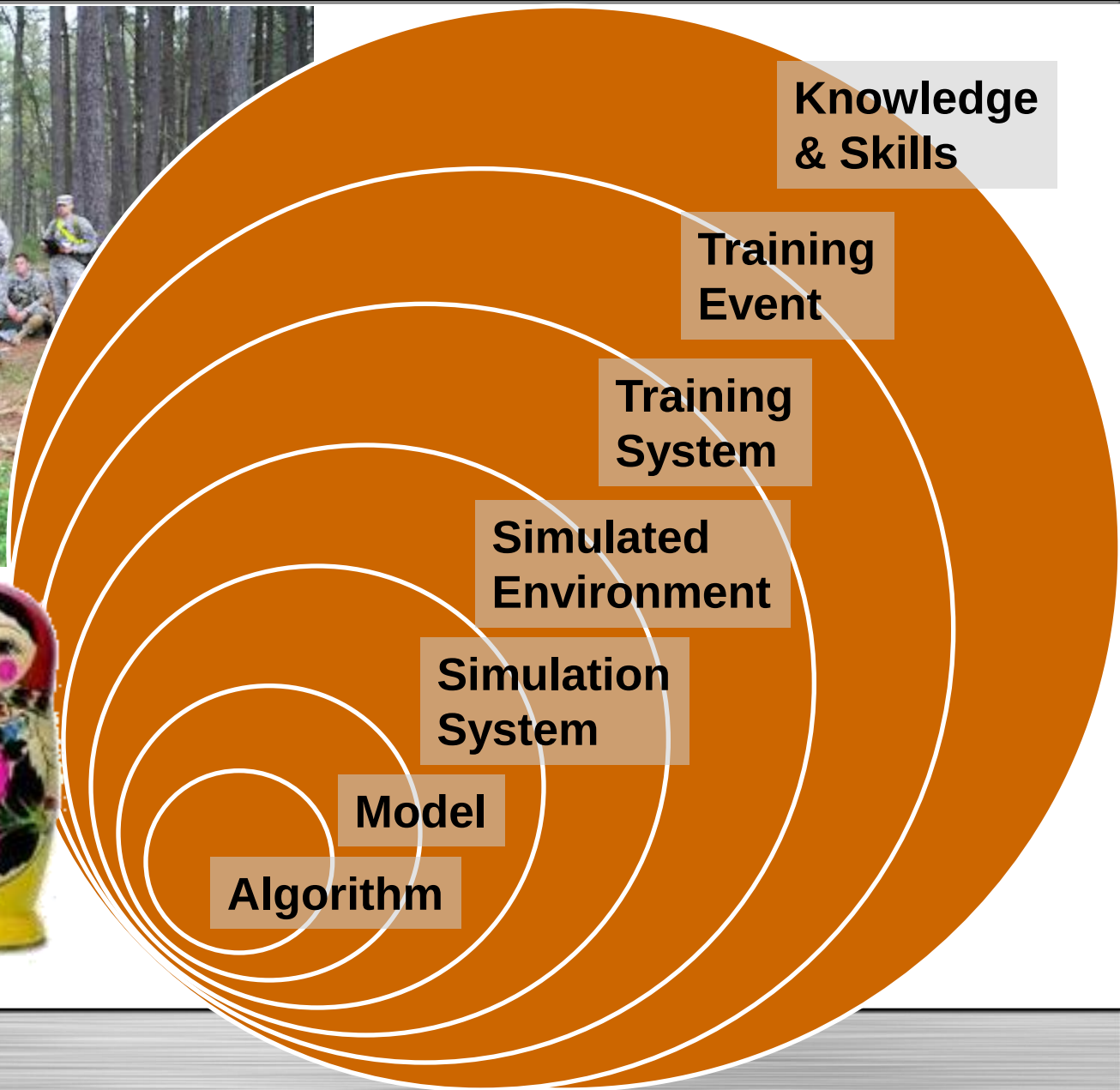
Limiting effects.

Control System Model

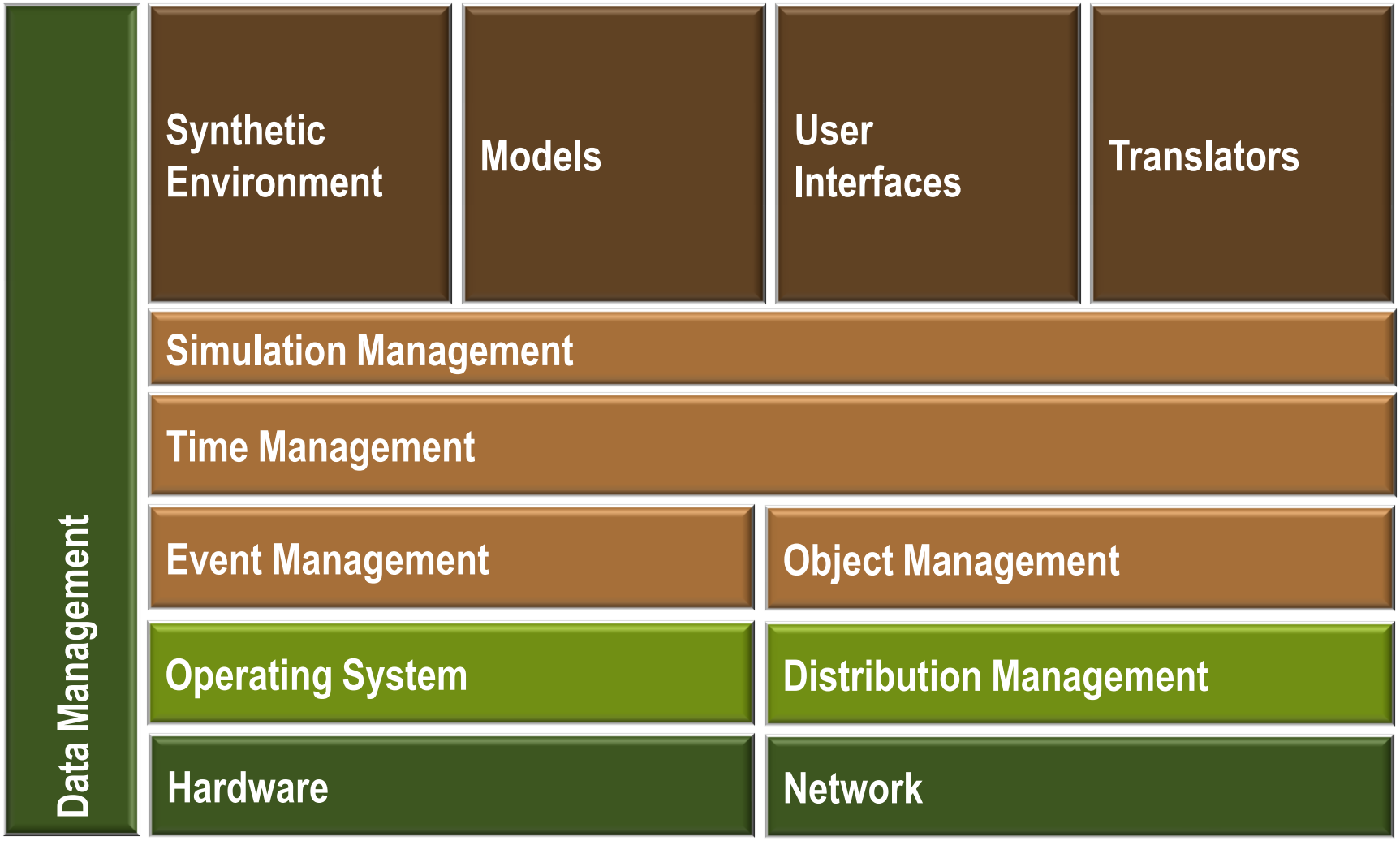


Source: Kiviat, P. (1998). *Interview with Ernie Page for ACM SIGSIM Distinguished Lectureship*. http://www.acm.org/sigsim.

The Bigger Picture: Algorithm to Knowledge



Interactive Simulation Architecture



Source: Smith, R. (2006). *Military Simulation Techniques and Technology,* DiSTI Course Workbook.

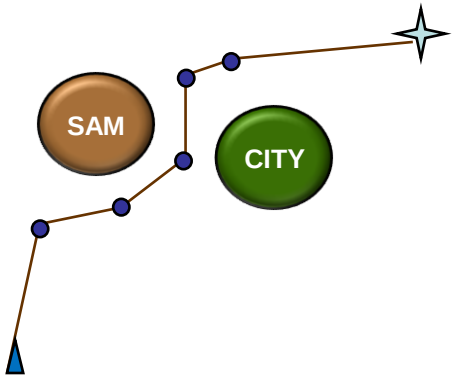
Modeling Approaches

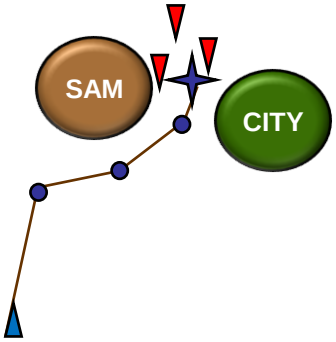
- None – Omit Feature and Behavior from the Simulation
- Geometry – Size and placement of organ
- Stochastic – Probability of Injury, Mean Time Between Failure
- Logical – Tissue Properties, Body System
- Physics – Force, Mass, Friction, Vector Tracing
- Artificial Intelligence – Human Decision & Perception

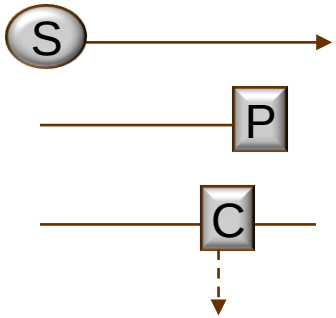
Source: Smith, R. (2007). "Military Modeling", *Handbook of Dynamic Systems Modeling*, CRC Press.

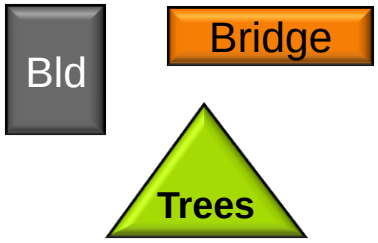
Event Categories

Planned	Reactive	Management	Environment
Movement Path Search Pattern Battle Planning Intel Analysis	Evade Enemy Fire Weapons Detect Enemy Apply Attrition	Start Pause Checkpoint Rate Change	Crater Terrain Destroy Bridge Burn Forest Collapse Building

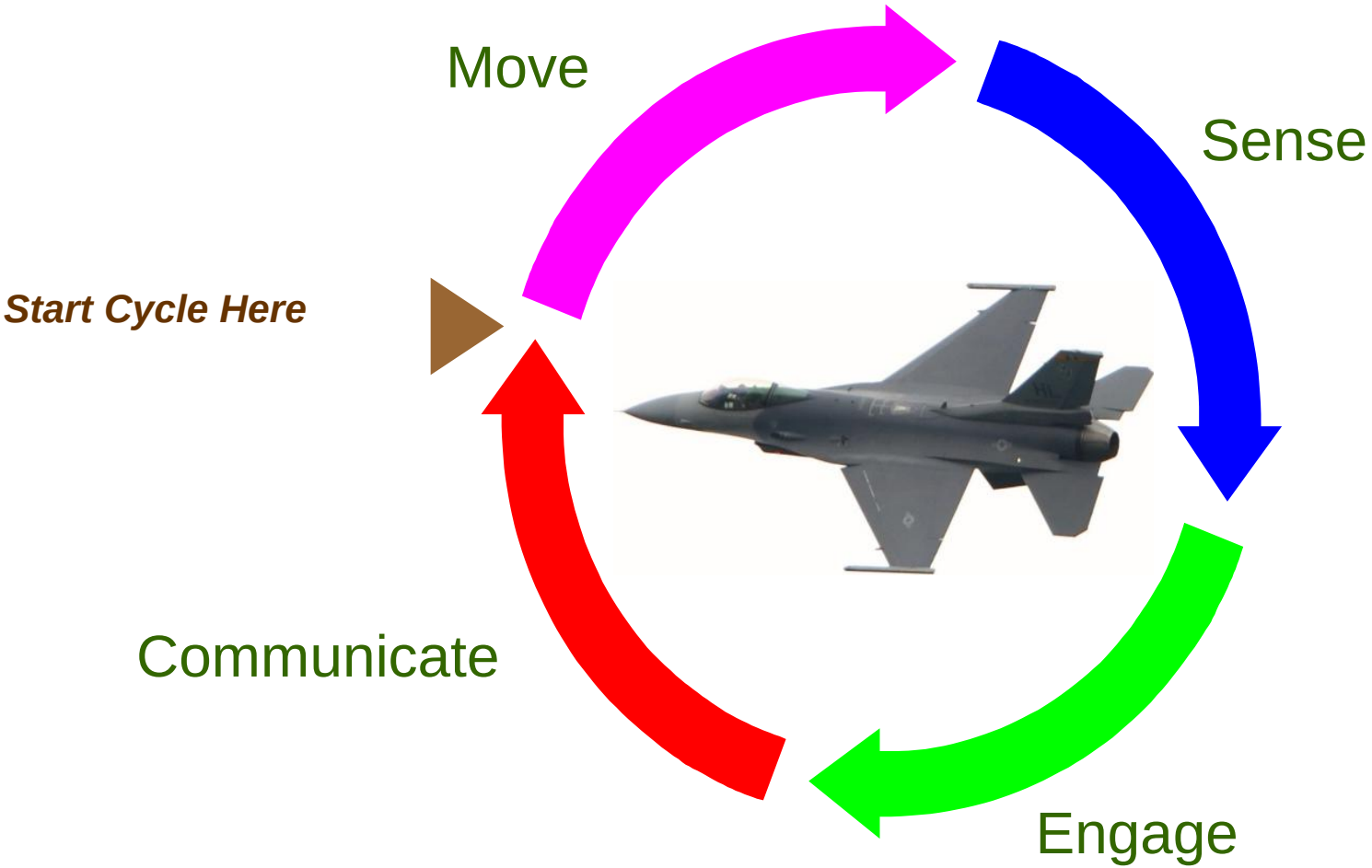








Physical Modeling Cycle



Source: Smith, R. (2002). *Military Simulation Techniques & Technology*. DiSTI Course Manual.

Battlespace Abstract Model

Performance Modifiers

Maneuver

Perception

Environment

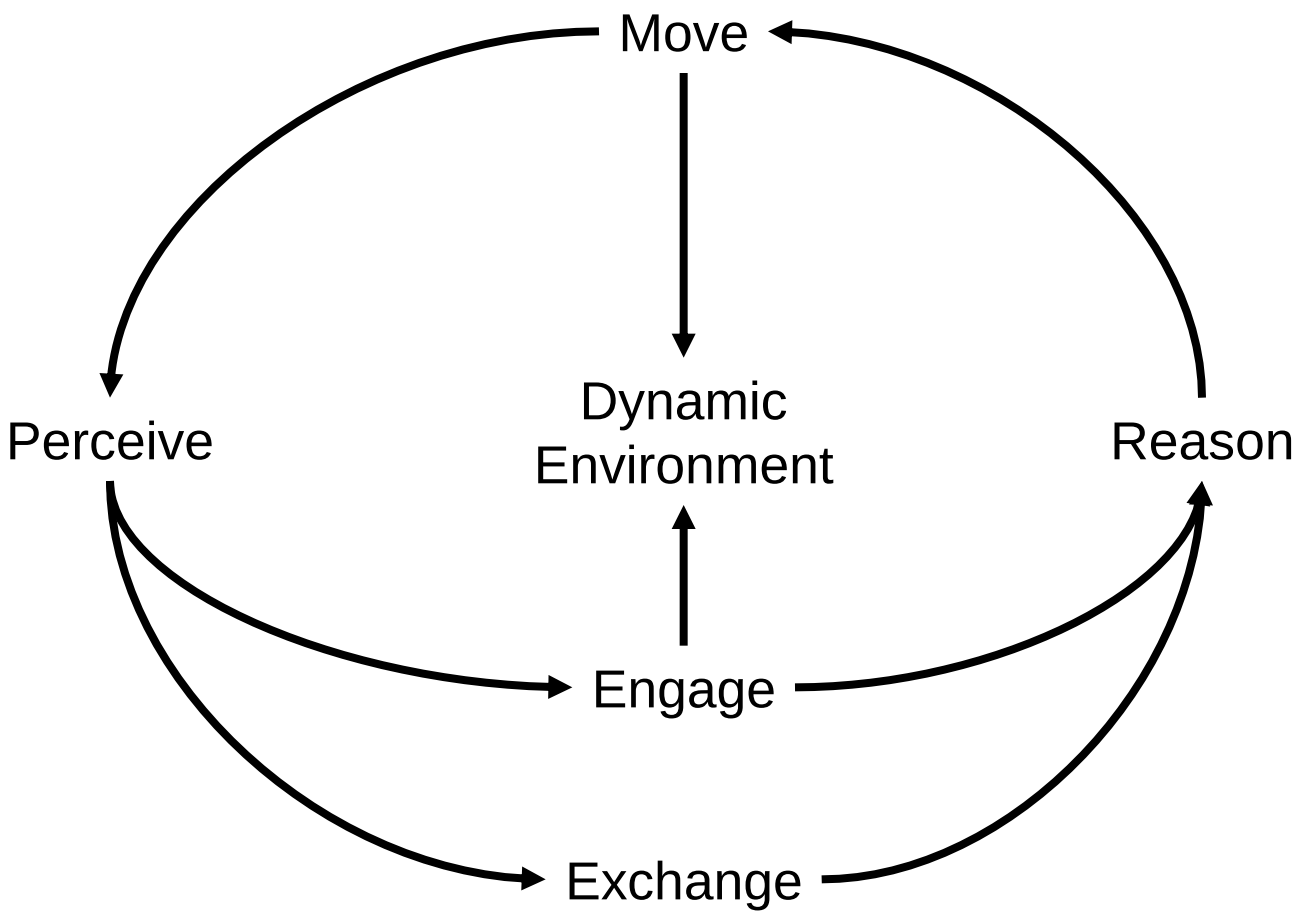
Mission Function

Communication

Decision Making

Source: Smith, R. (2006). *Military Simulation & Serious Games*. Modelbenders Press.

Battlespace Abstract Model 2



Source: Smith, R. (2007). "Military Modeling", *Handbook of Dynamic Systems Modeling*, CRC Press.

Surgical Simulation Components

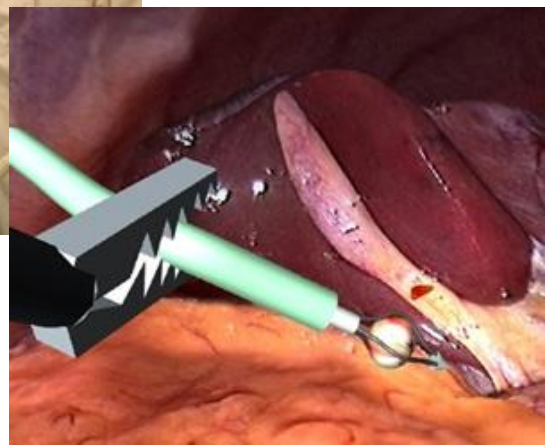
Model Generation

Clinical Expertise

Vascular Structures

Bleeding Simulation

Tissue Parameters



Tissue Cutting

Organ Texturing

Tissue Deformation

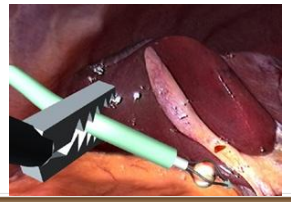
Haptic Interface

Collision Detection

Immersive OR

Fluid Simulation

Surgical Simulation Architecture



Synthetic Environment
-Body
-Fluids
- Pharma

Models
-Tissue Dynamics
-Fluid Flow
-Body Response

User Interfaces
-Instruments
-Video
- Monitors

Translators
-Surgeon
-Team
-Anesthetist

Simulation Management

Time Management

Event Management

Object Management

Operating System

Distribution Management

Hardware

Network

Data Management

Source: Smith, R. (2006). *Military Simulation Techniques and Technology*. DiSTI Course Workbook.

Code, Code, Code

AWSIM

```
for(i=1 ; i <= NUMS ; ++i)
 {
x1 = myPoints[ mySprings[i].i ].x;          y1 =
myPoints[ mySprings[i].i ].y;
x2 = myPoints[ mySprings[i].j ].x;
myPoints[ mySprings[i].j ].y;
r12d = sqrt ( (x1 - x2) *(x1 - x2)  +  (y
);                          // square
// root  of the distance
if(r12d != 0)
 {
vx12 = myPoints[ mySprings[i].i ].vx
mySprings[i].j ].vx;
vy12 = myPoints[ mySprings[i].i ].vy
mySprings[i].j ].vy;
f = (r12d -  mySprings[i].length) * KS
x2) + vy12 * (y1 - y2)) * KD / r12d;
```

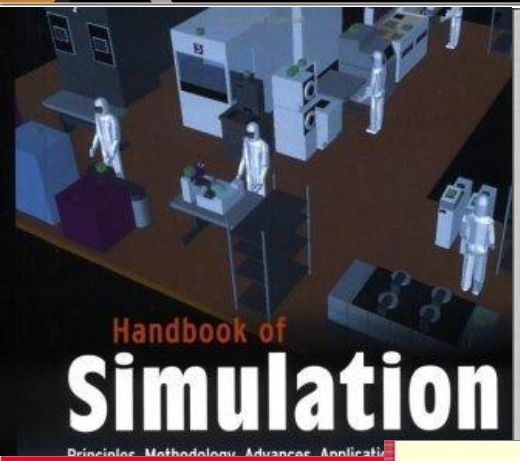
TACSIM

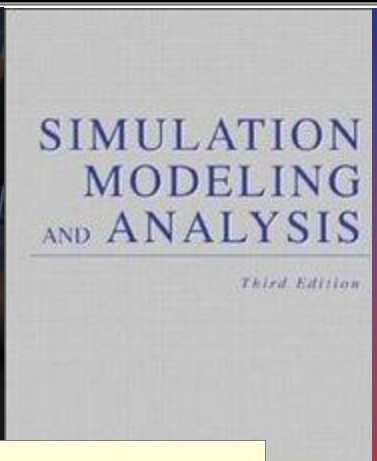
```
while(x<getmaxx()){
setfillstyle(SOLID_FILL,0);
bar(x,y,x+bmp.width,y+bmp
x++;
draw_bitmap(&bmp,x,y);
}
```

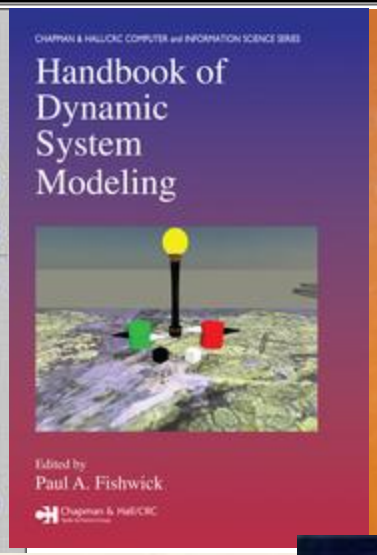
Quake

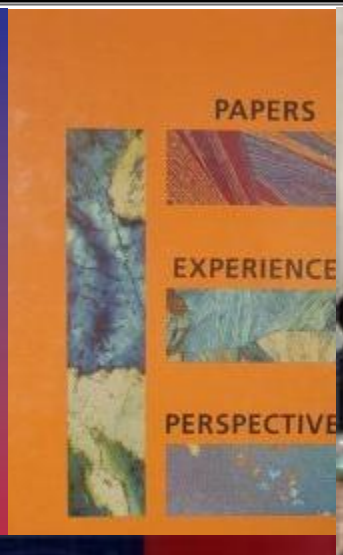
```
 for (i=0; i<NUM_ITER; i++)
 {
   // Transfer the block N times and simulate
corruption
   lostBlockCount = 0;
   for (j=0; j<N; j++)
     if (rand_val() <= PR_BAD)
       lostBlockCount++;

   // Are all blocks lost or did some make it through?
   if (lostBlockCount == N)
     lostDataCount++;
   else
     goodDataCount++;
 }
```

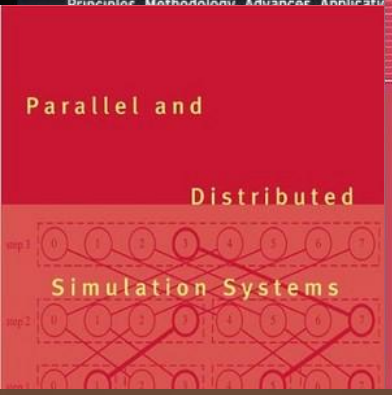
Books, Books, Books

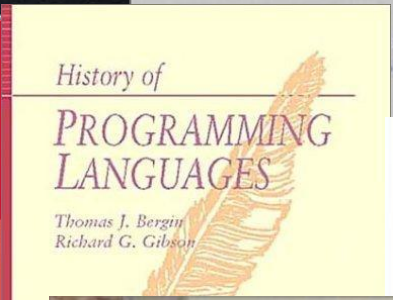


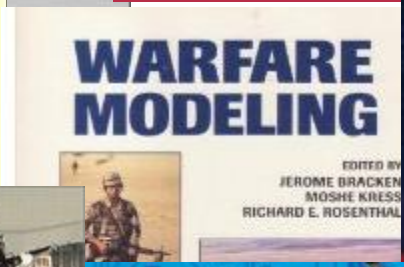


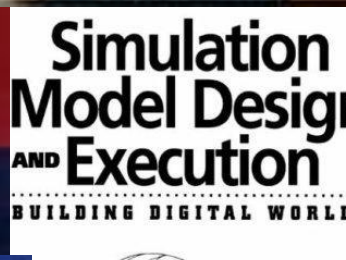


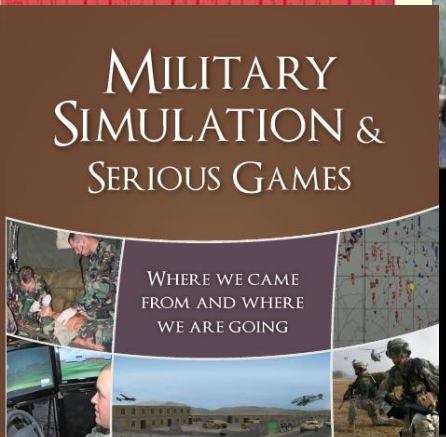


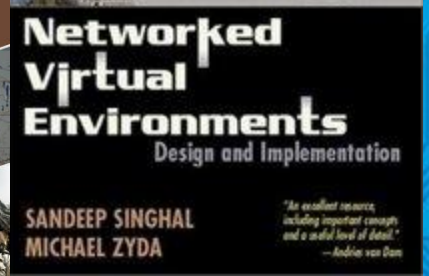


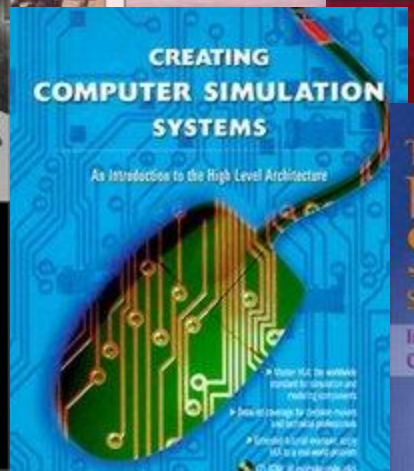


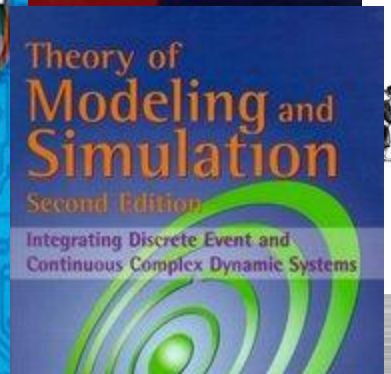


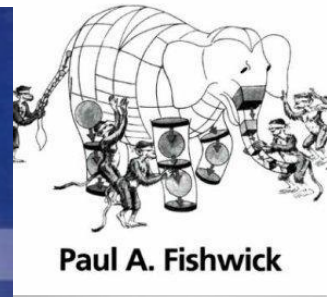












Advice for the Next Generation

- **Just do it**
  - … Design, build, run your own models
- **Generalize**
  - … Look for general principles
- **Read books and code**
  - … Learn beyond your own experience
- **Question other people**
  - … How have they modeled?
- **Branch out**
  - … psychology, system dynamics, medicine, economics

Download the Presentation

http://www.modelbenders.com/

- Technical Papers
  - Presentations