

# TechnoBusiness Forum -- 2005

*Open Innovation*

*-- Enterprise Transformation --*

*Interactive Modeling of Research Projects*



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# Interactive Modeling of Research Projects

## ■ Introduction

- ✓ *Modeling R&D – why and how*

- ✓ *Application to forest products R&D*

## ■ Interactive demonstration

- ✓ *Model of R&D for a forest products company*

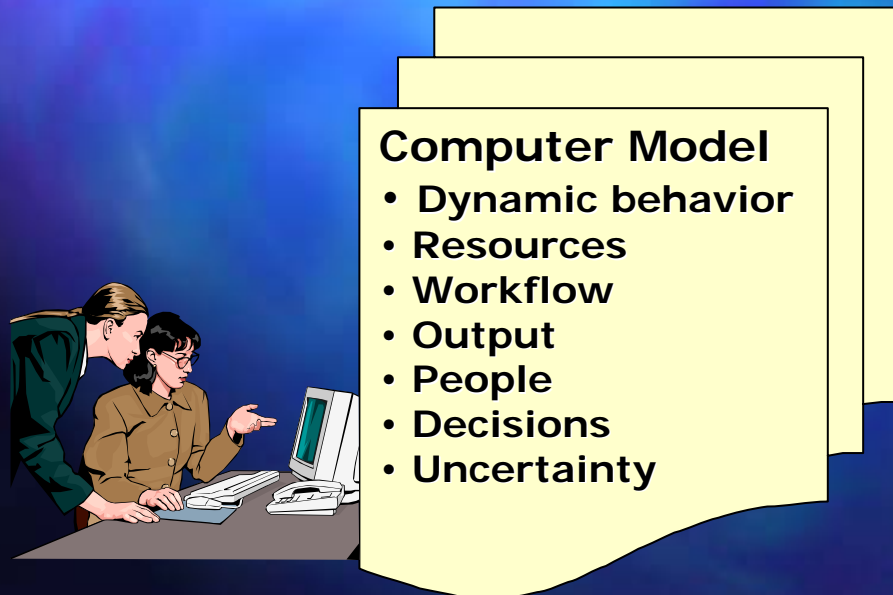
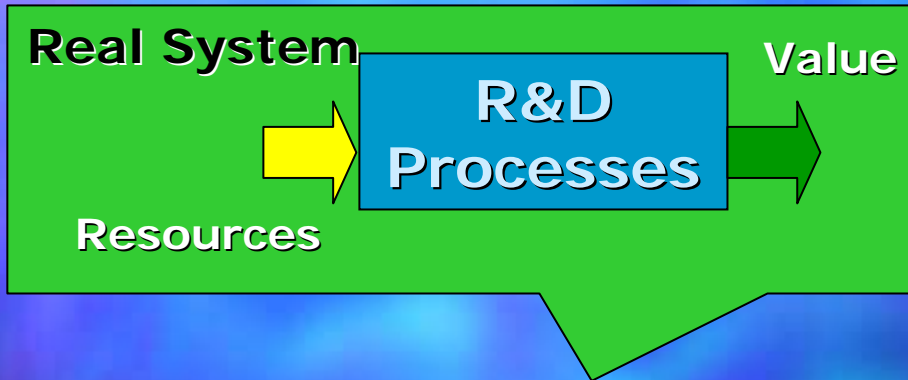
## ■ Q&A and next steps

- ✓ *How would this benefit you?*

# R&D World

- Goal is to improve effectiveness of R&D, especially related to value creation
- Uses organizational simulation methods
  - ✓ *Business process flow and decision logic*
  - ✓ *Uncertainty*
  - ✓ *Enterprise behavior and performance over time*
- Uses investment valuation approaches
  - ✓ *Economic analysis*
  - ✓ *Decision-making under uncertainty*

# Using R&D World

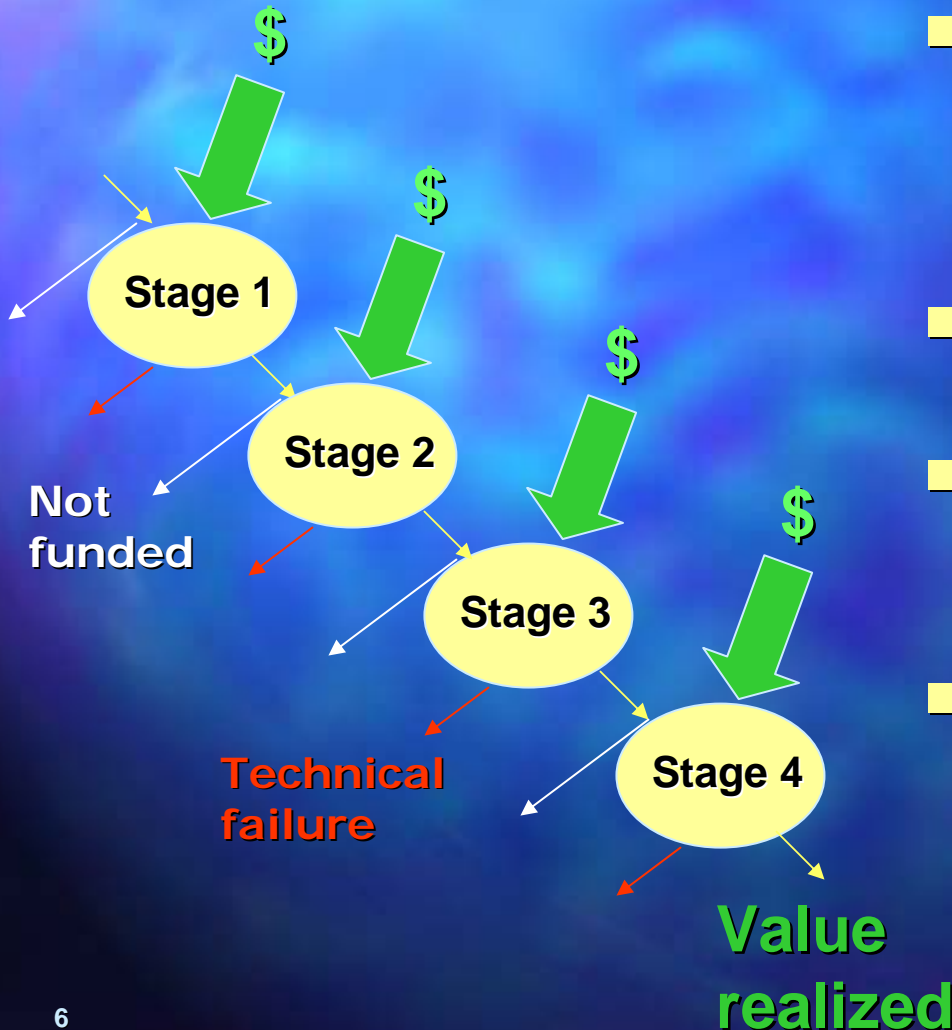


- Modeling and data gathering
  - ✓ *Understanding your R&D system better*
- Quantitative insight via controlled experiments
  - ✓ *Attach numbers to effects with statistics*
- What-if analysis
  - ✓ *Make changes to your R&D system and see the effect – without using the real system*

# Forest Products R&D Model

- Strawman models developed for forest products R&D
  - ✓ *Company R&D model*
  - ✓ *Consortium R&D model*
- Emphasis in today's session on company model
- Concept demonstration

# R&D Value Creation Framework



- Value is derived from financial returns of deployed products or systems
- Value is realized downstream
- Upstream estimates of value are uncertain/dynamic
- Multi-stage investment structure mitigates risk via flexibility

# Forest Products R&D Value Creation

- **Stages**
  - ✓ *0 Opportunity Identification*
  - ✓ *1 Opportunity Analysis*
  - ✓ *2A Feasibility Analysis*
  - ✓ *2B Feasibility Validation*
  - ✓ *3 Business Proposal Development*
  - ✓ *4 Commercial Implementation (Startup)*
- **Decision points between stages (stage-gates)**
- **Only new product R&D modeled (not technical support projects)**

# Data Used for Model

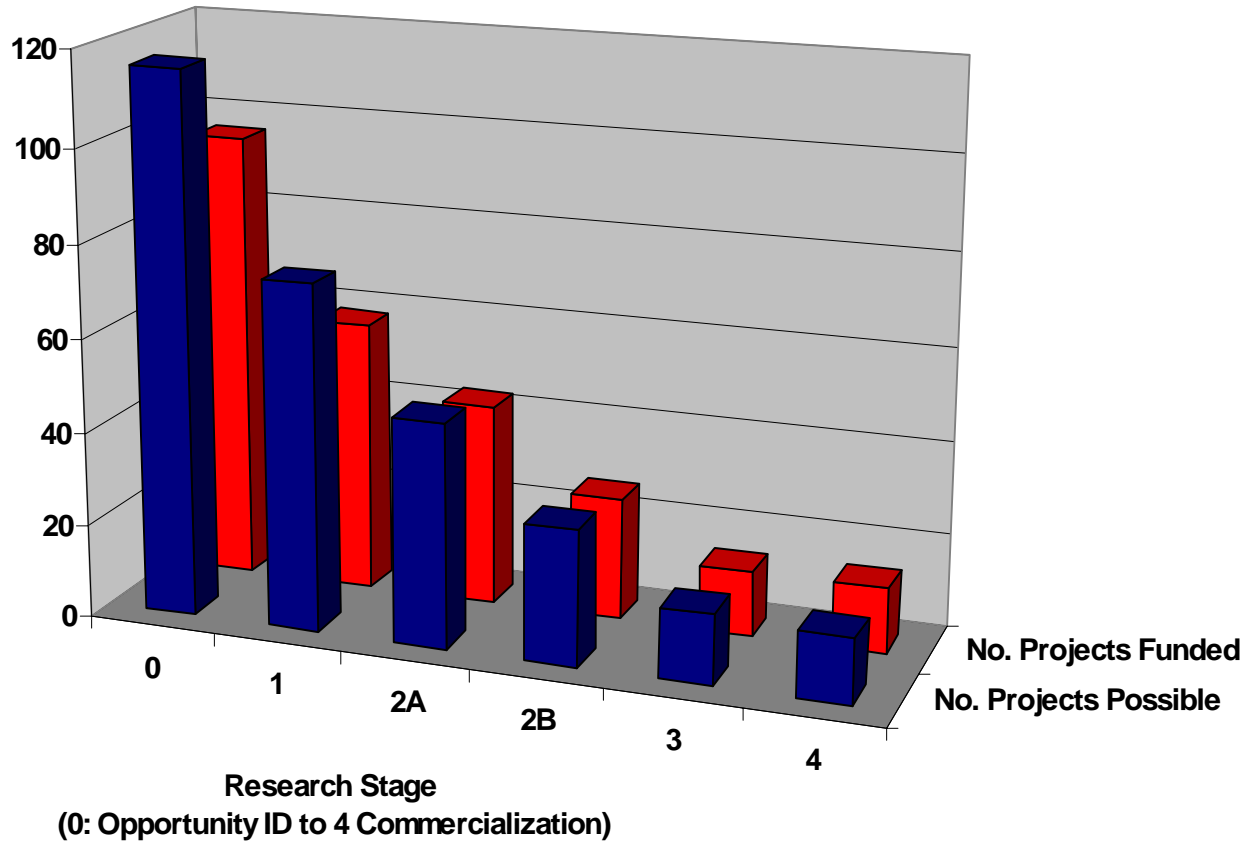
- For each stage
  - ✓ *Number of projects funded*
  - ✓ *Average project budgets at each stage*
  - ✓ *Rates of technical failure*
  - ✓ *Duration*
- For R&D system
  - ✓ *Annual budget*
  - ✓ *Free cash flow (i.e., value of commercialized projects)*

# Dynamic/Uncertain Model Data

- For each stage
  - ✓ *Average project requesting funding, but varies each year*
  - ✓ *Average project budget requests, but varies by project*
  - ✓ *Rates of technical failure can be modified*
  - ✓ *Project duration at a stage can be modified*
  - ✓ *Estimated free cash flow of a project varies over time (volatility)*
- For R&D system
  - ✓ *Annual R&D budget can be modified*

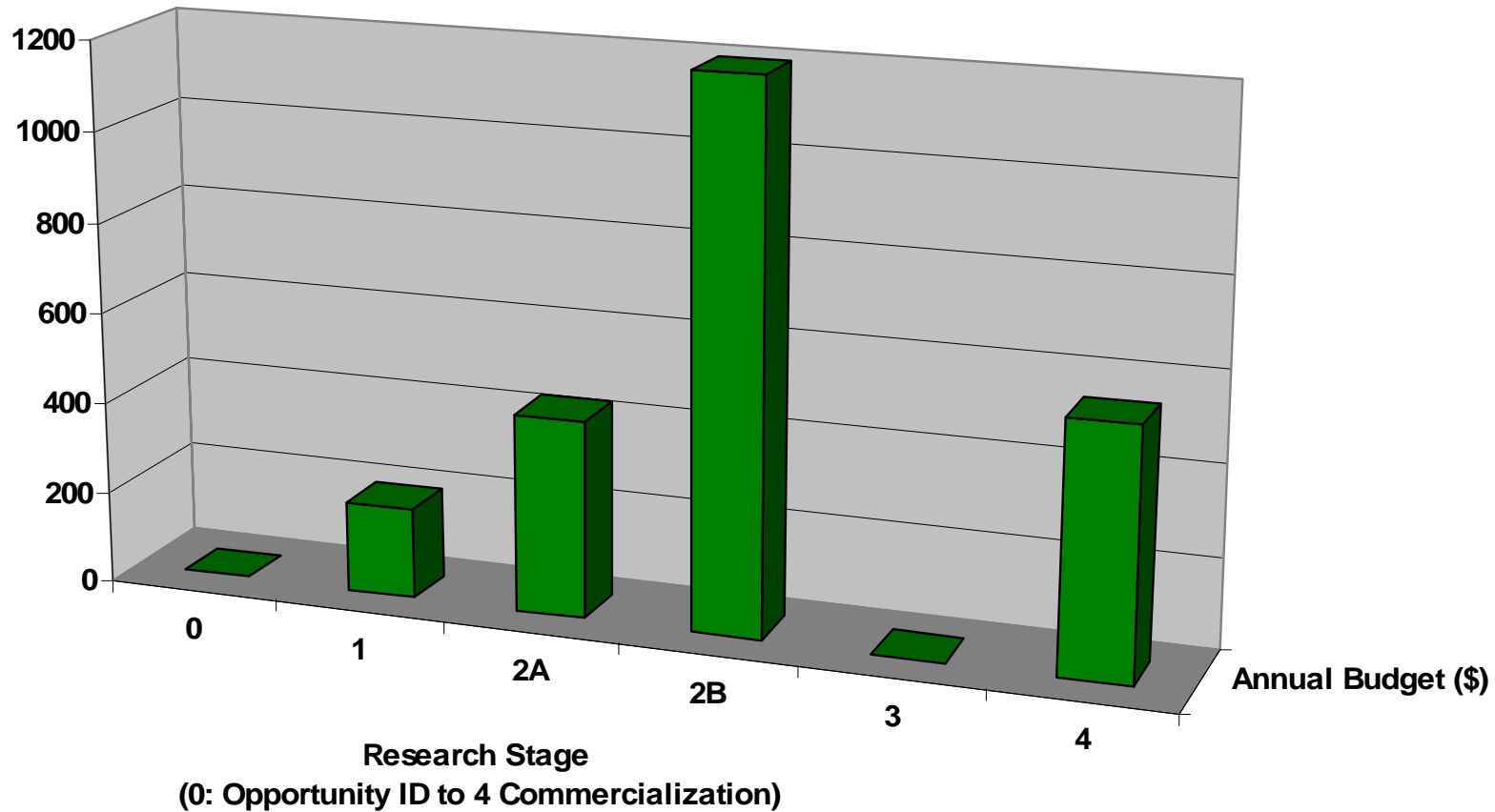
# Historical Data for Company Model

Forest Products Company R&D

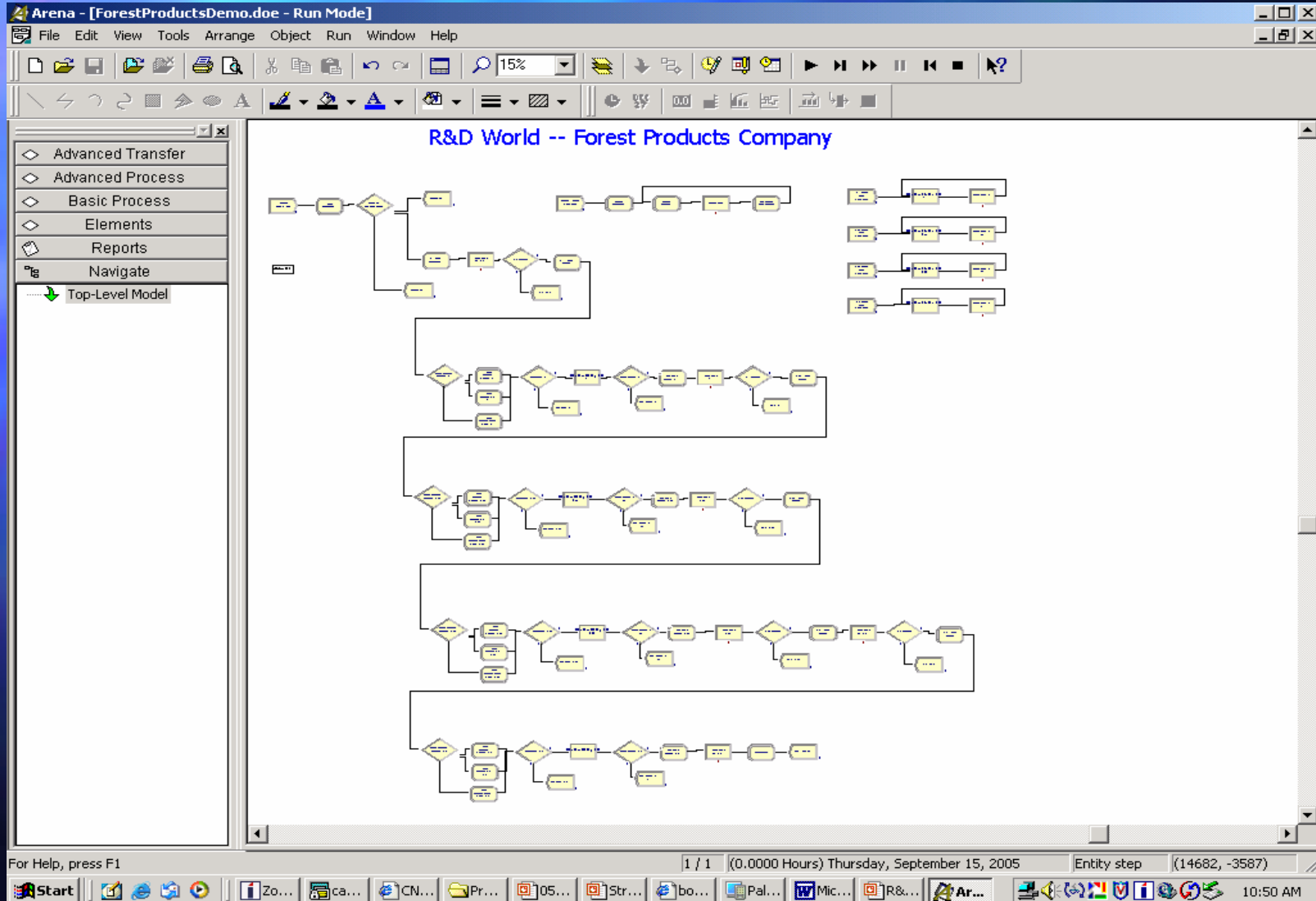


# Historical Data for Company Model

Forest Products Company R&D



# Simulation Model



# Model Description

- Workflow system paradigm
- Projects flow through the system
  - ✓ *Delays, decision points (funded or not, success or failure), R&D work*
- Projects exit the system as deployed results, or as failed/non-funded efforts
- 5 year warm-up, then 25 year steady state run
- Variables track budgets, expenditures
- Statistics can be collected to reflect
  - ✓ *Value deployed over time*
  - ✓ *Expenditures over time*
  - ✓ *Yield over time*

# Measuring Success

- Total value of deployed R&D over a time horizon (e.g., 25 years)
  - ✓ *Given an R&D budget, maximize results*
- Number of projects deployed over time horizon
  - ✓ *Given an R&D budget, maximize new offerings*
- Yield (total value deployed per dollar of R&D expended)
  - ✓ *Maximize ROI*

# What-if Analysis

- How to allocate funding across R&D stages
  - ✓ *Spend more funds upstream*
  - ✓ *Spend more funds downstream*
  - ✓ *Balance funding according to expected expenses at each stage (weighted by failure rates)*
- How do delays impact value
  - ✓ *What would it be worth to reduce delays vs. the cost of doing so*

# What-if Analysis (Cont'd)

- How to value projects for continued funding
  - ✓ *Stage-gates, net present value analysis, or real options analysis*
  - ✓ *Real options are analogous to stock options. Purchase of the next R&D stage is an option to fund future stages and eventually fund deployment of a product (i.e., exercise option to purchase asset)*
- Volatility
  - ✓ *How does the level of variability associated with estimated free cash flow affect performance*
- Level of variability in project budgets
- Level of variability in # of new projects entering stage 0 per year

# Results – Company Model

## ■ Baseline parameters

### ✓ *Funding allocation across stages*

- 0 Opportunity Identification (0%)
- 1 Opportunity Analysis (11.5%)
- 2A Feasibility Analysis (19.5%)
- 2B Feasibility Validation (49.4%)
- 3 Business Proposal Development (0%)
- 4 Commercial Implementation – Startup (19.6%)

### ✓ *Delays (no delays, all stages last one year, except 0 and 3, which are 90 days)*

### ✓ *Valuation method (stage-gate)*

### ✓ *Volatility (0.6, moderate)*

# Results (Cont'd)

- **Baseline case performance**
  - ✓ ***Total deployed value (TDV)***
    - \$1,592,166,000 over 25 years
  - ✓ ***Number of projects deployed (n)***
    - 235 over 25 years
  - ✓ ***Yield (TDV/n)***
    - 2.25
- **Stay tuned for the interactive demo to see how changes to parameters affect performance**
- **Note: These results are averaged over ten simulation replications to promote statistical significance**

# Assumptions

- Estimated free cash flow from deployed projects varies over time
  - ✓ *Random walk process whereby value either increases or decreases incrementally at each instant*
  - ✓ *Theoretically unlimited upside, downside is bounded by zero*
- Estimated free cash flow is revenue minus operating expenses (EBITDA)
- Sunk costs not considered in project evaluation
  - ✓ *Only future cash flows considered*

# Assumptions (Cont'd)

- Fixed project budgets
- Fixed annual R&D budget (no inflation effect)
- No project termination in mid stage
- No costs associated with project termination at the end of a stage (e.g., no clean-up costs)
- Human expertise and complex decision-making not modeled
- Simple value network structure
  - ✓ *Organizational learning not modeled*
  - ✓ *Synergy between R&D efforts not modeled*

## Assumptions (Cont'd)

- Market risk is modeled by volatility of estimated free cash flow
  - ✓ *Continuous change rather than dramatic shifts*
  - ✓ *Competition not explicitly modeled*
- Technical risk depends only on stage, not type of project, etc.
- Free cash flow added to total value deployed upon successful deployment
  - ✓ *Post-deployment not modeled*

# Interactive Demonstration

- Audience participation using handout
  - ✓ *Handout shows parameters to be manipulated, baseline case and restrictions on parameters*
  - ✓ *Audience members can select new values for “what-if analysis” factors (pp. 15-16)*
  - ✓ *We need some audience members to modify only one parameter, while others can modify more than one*
  - ✓ *The one-parameter modifications will be run first*
  - ✓ *Model will be run with selected sets of new factors*
  - ✓ *Discussion of results comes next*
- Questions so far?

# Interactive Demonstration

- Here we go...

# How Can This Benefit You?

- In general... data-driven decision-making
  - ✓ *Underlying, and perhaps transformative benefit*
  - ✓ *Major trend in industry (e.g., retail industry identifies most profitable customers and designs stores/systems to facilitate their business)*
- Specifically... using R&D World to help improve your R&D function

# Take-Aways from Today

- Modeling R&D with simulation
  - ✓ *Capture effect of uncertainty in and dynamics of R&D*
- Understanding effect of
  - ✓ *Budget allocation among stages*
  - ✓ *Delays*
  - ✓ *Funding/valuation methods*
  - ✓ *Variability (volatility, budget variability, etc.)*
  - ✓ *Interactions of the above*
- Current model can be augmented for more complex situations
- Capability for what-if analysis and controlled experimentation

# Potential Next Steps

- Analysis of issues discussed today in a detailed case study
- Cyclical nature of forest products industry
  - ✓ *How to position R&D efforts and funding*
  - ✓ *Is it wise to introduce new products in a down period to create new markets*
  - ✓ *Is it wise to synchronize R&D so that results come out in up periods*
- R&D portfolio management
  - ✓ *Test performance of portfolios under various scenarios*

# Next Steps (Cont'd)

## ■ Benchmarking

- ✓ *How does your company's R&D compare with industry average, or best-practice R&D?*
- ✓ *Requires input/output data*
- ✓ *Can be done anonymously with GT as broker*

## ■ Project characteristics

- ✓ *Is it better to fund a few large projects or many smaller ones*

## ■ Other ideas?

# Questions



# Reading List

- Bodner and Rouse, 2005, R&D World: Simulation-based analysis of R&D enterprises, Industrial Engineering Research Conference. [<Available at TI website>](#)
- Rouse and Boff, 2003, Value streams in science & technology: a case study of value creation and intelligent tutoring systems, *Systems Engineering*. [<Available at TI website>](#)
- Rouse and Boff, 2004, Value-centered R&D organizations: Ten principles for characterizing, assessing, and managing value, *Systems Engineering*. [<Available at TI website>](#)
- Rouse and Boff, 2005, *Organizational simulation*. New York: Wiley-Interscience.
- Trigeorgis, 1996, *Real options: managerial flexibility and strategy in resource allocation*. Cambridge, MA: The MIT Press.

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