To Main Proceedings Document

# A Dynamic Model for Studying the Impact of Resource Estimation and Allocation Processes on R&D Performance

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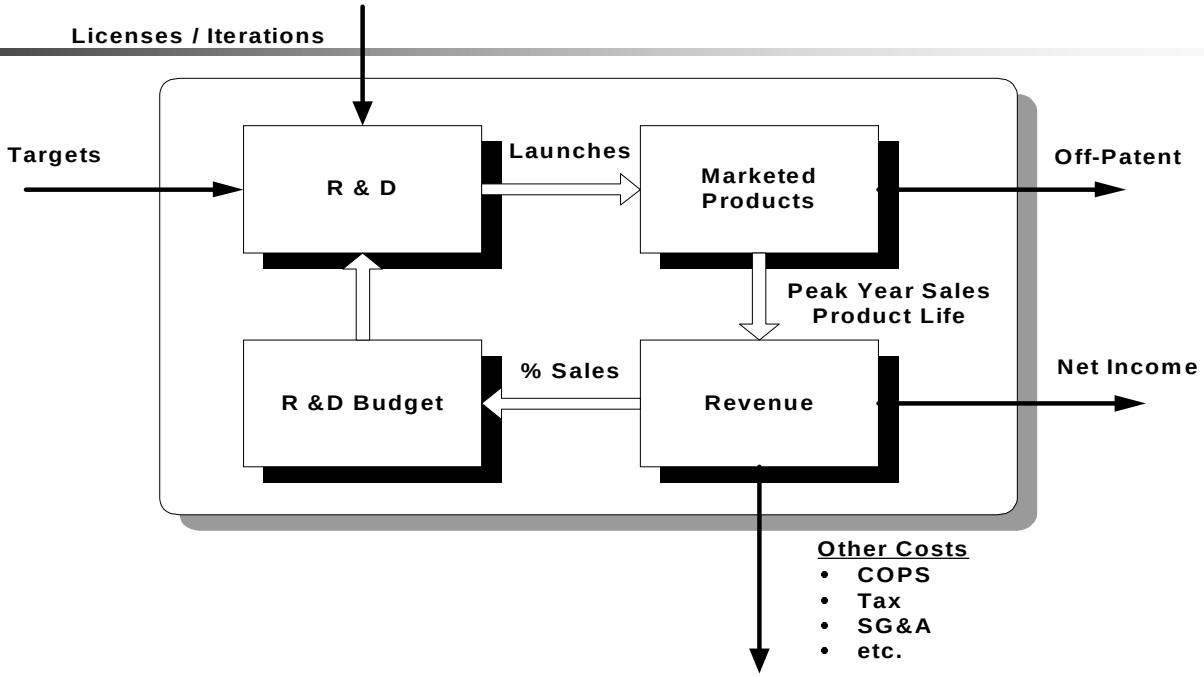
# Outline

- Problem at Lilly
- Model Boundaries and Assumptions
- Analysis and Explanation of Dynamic Behavior
- Key Learning Points

# Model Boundaries



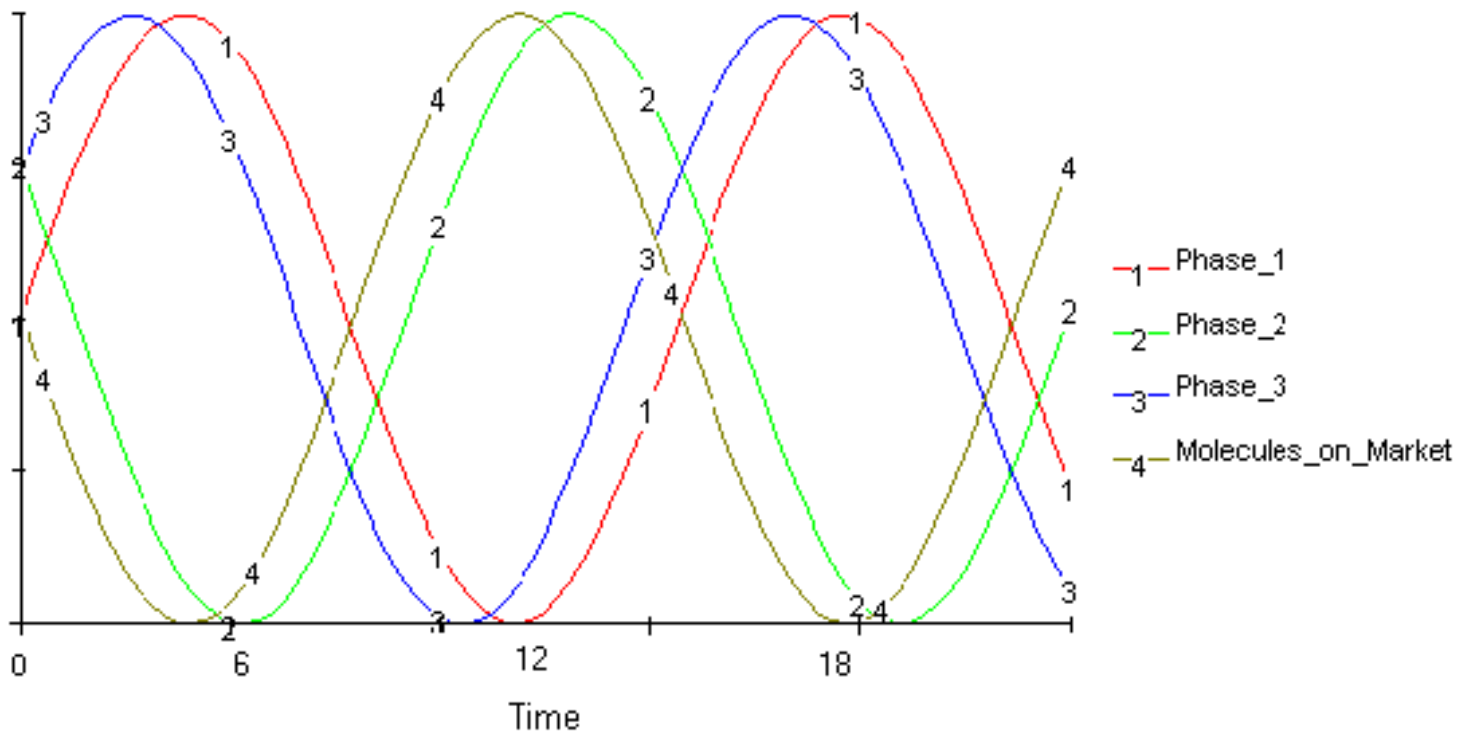

- Included
  - R&D process flow (NCE only)
  - R&D resource estimation
  - R&D resource allocation

Excluded

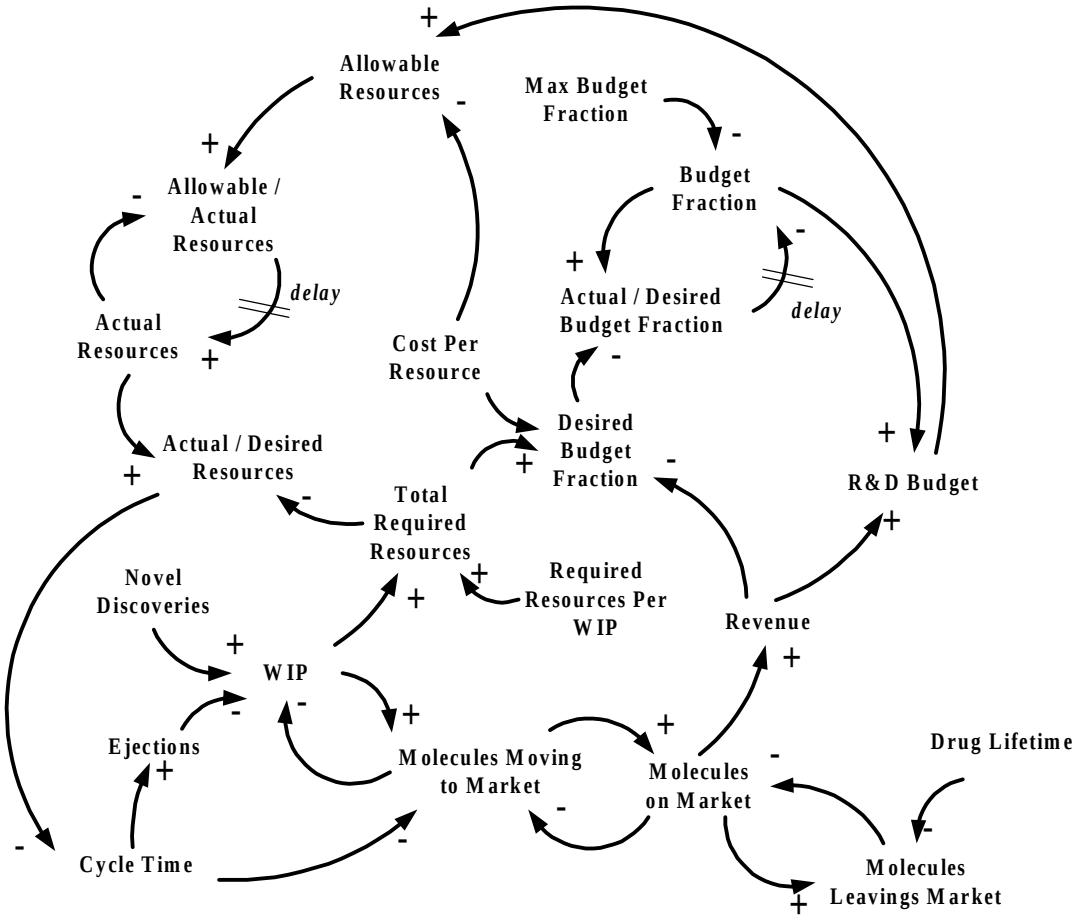
Sales and Marketing Processes

expenses, ability to influence revenue, etc.

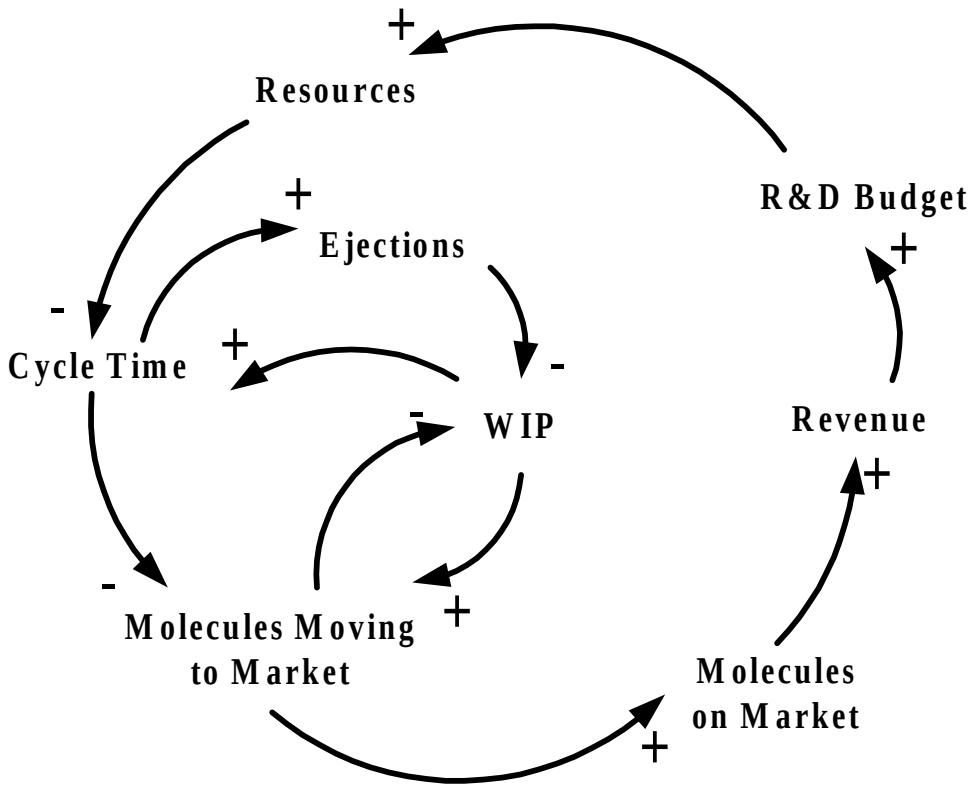
# Reference Mode



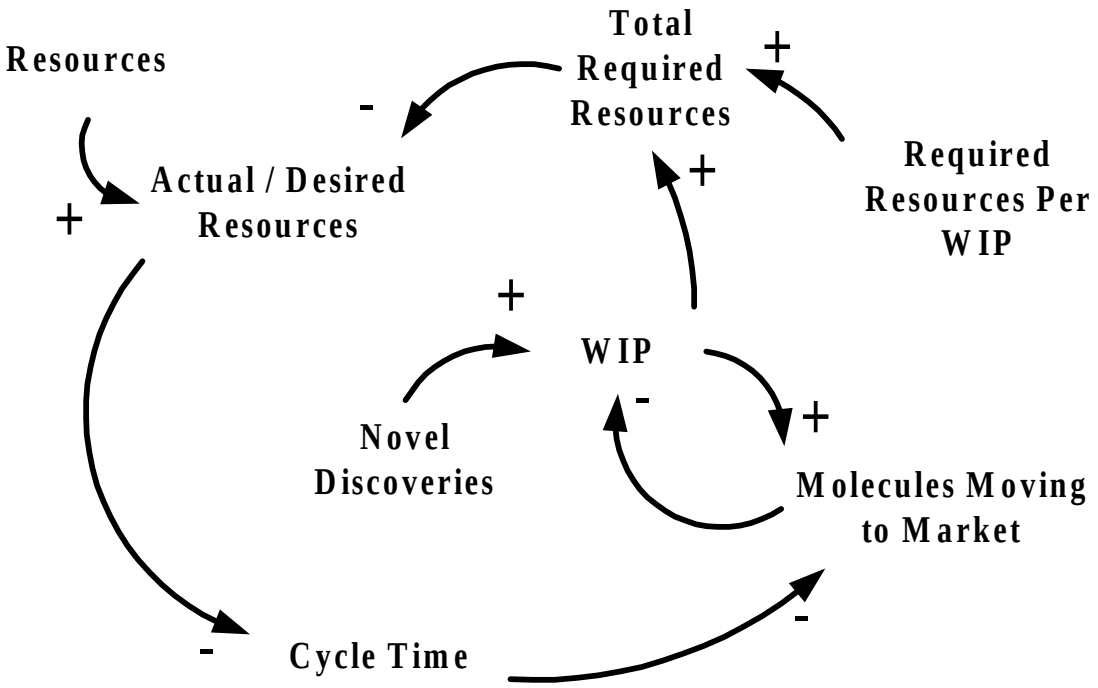
# R&D Dynamic Hypothesis



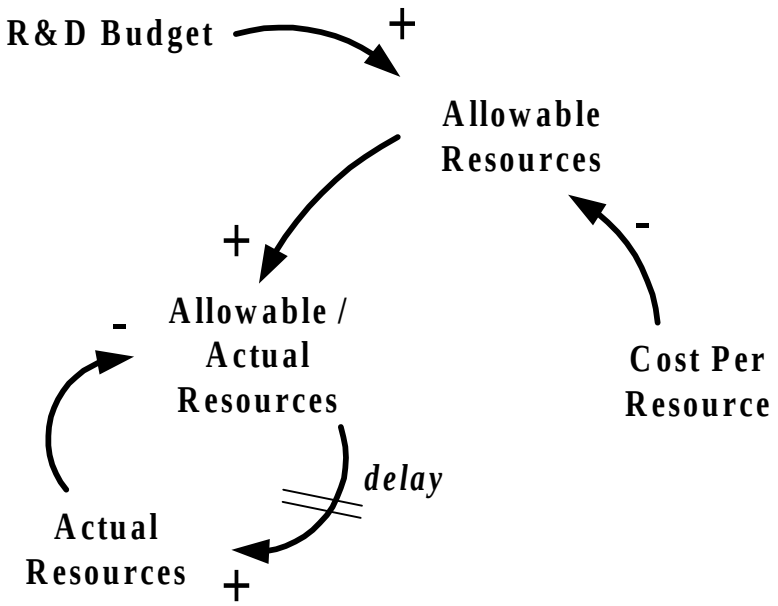
# Examples of Feedback in R&D



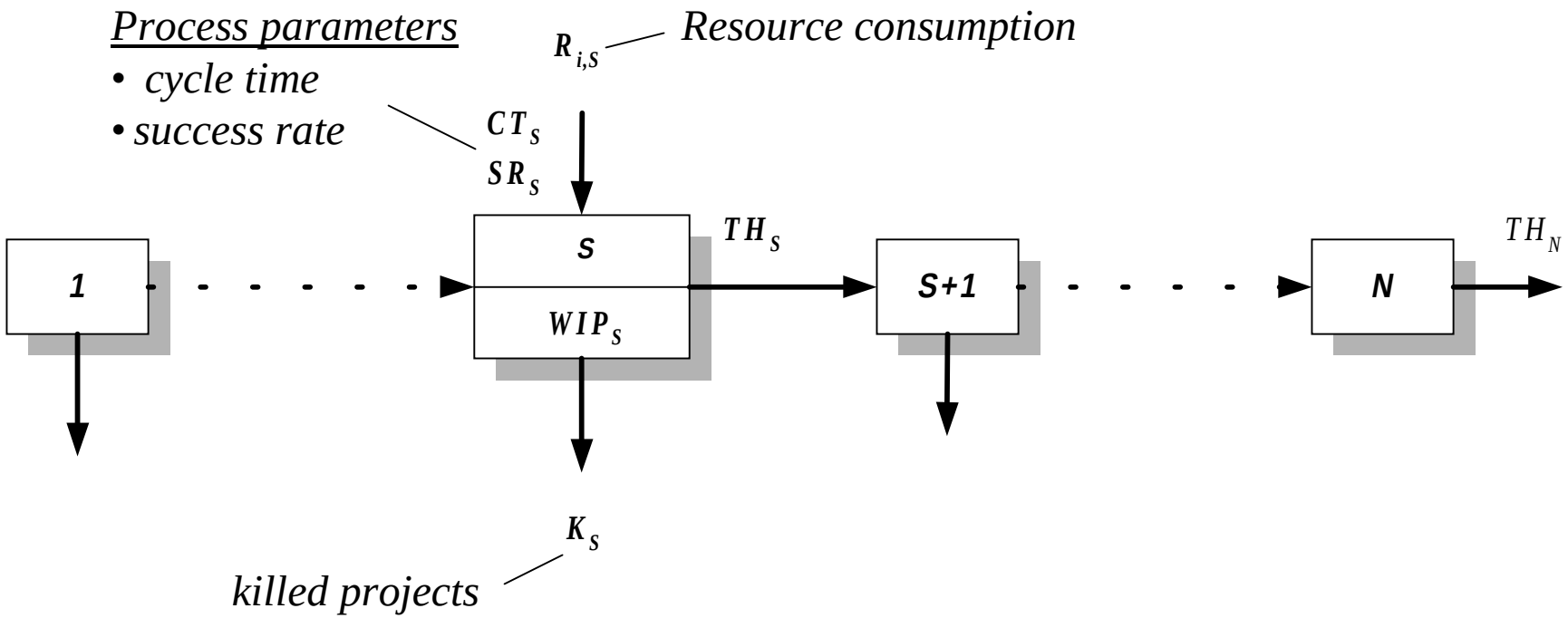
# Unintended Consequences



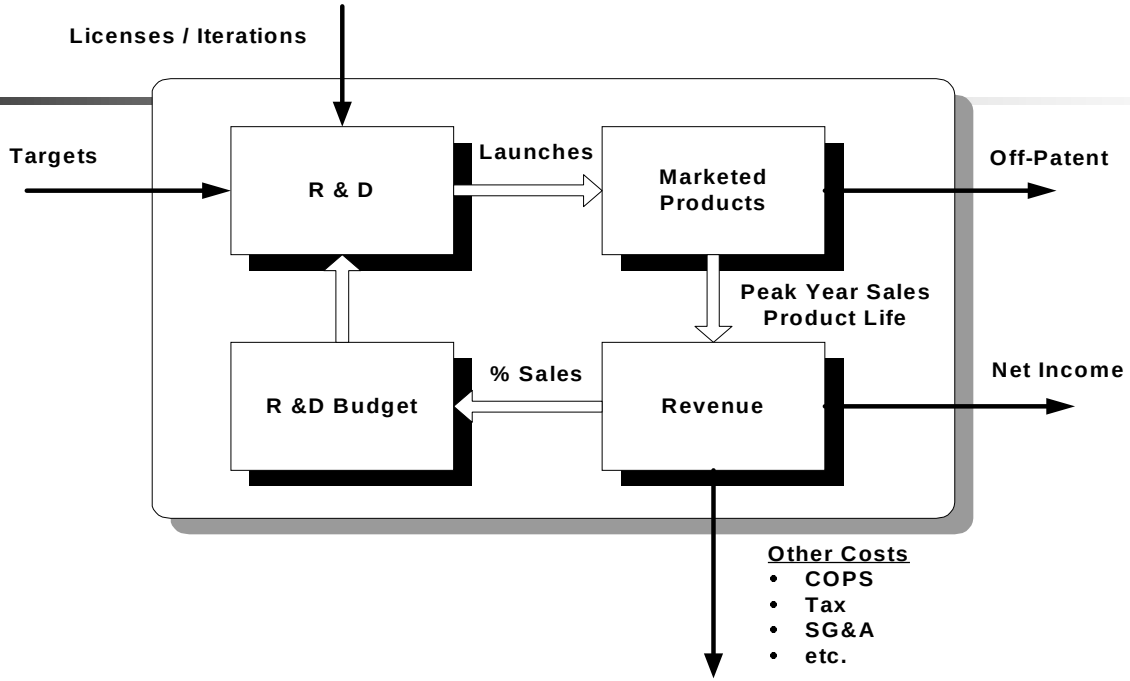
# Significant Time Delays



# General Phase Structure

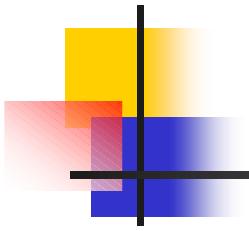


# Model Assertions



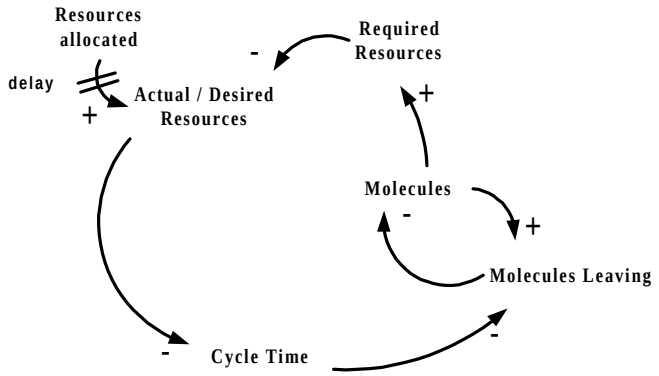

- R&D performance generated new products on market
- New products on market generate revenue
- Revenue is the source of the R&D budget
- A minimum R&D budget is required for R&D performance to reach target levels

# Results of Disturbance and Parameter Analysis



- System typically falls into one of 3 states
  - perpetual oscillation
  - transitory oscillation and system-wide collapse
  - transitory oscillation with damping

# Case 1: Why Oscillations?



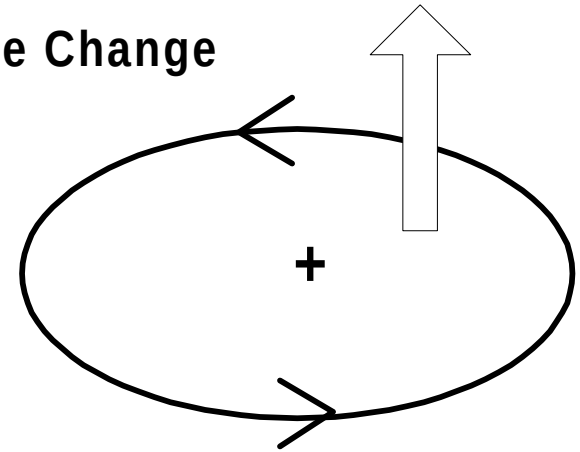

**Shifting of Dominant Feedback Loops Through Time**

**Delay in Resource Re-allocation**

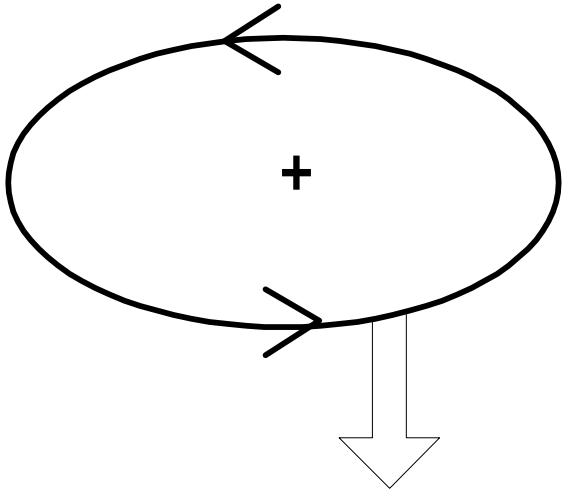
**When Molecules are Increasing, Molecules Leaving are typically decreasing**

# Two Loop States

**Molecule Change**

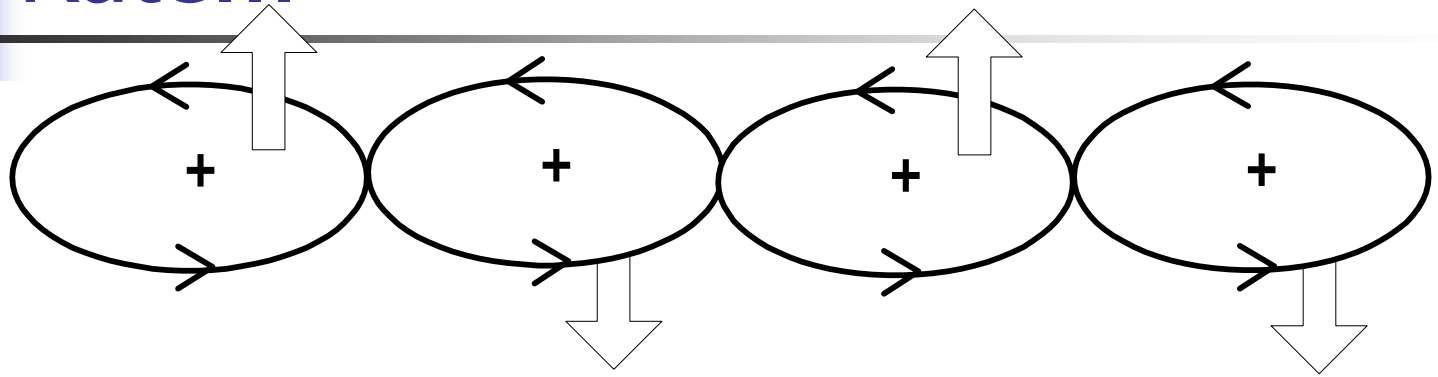



When in this state, molecules in this phase are increasing. Molecules leaving the phase are typically decreasing as cycle times increase.

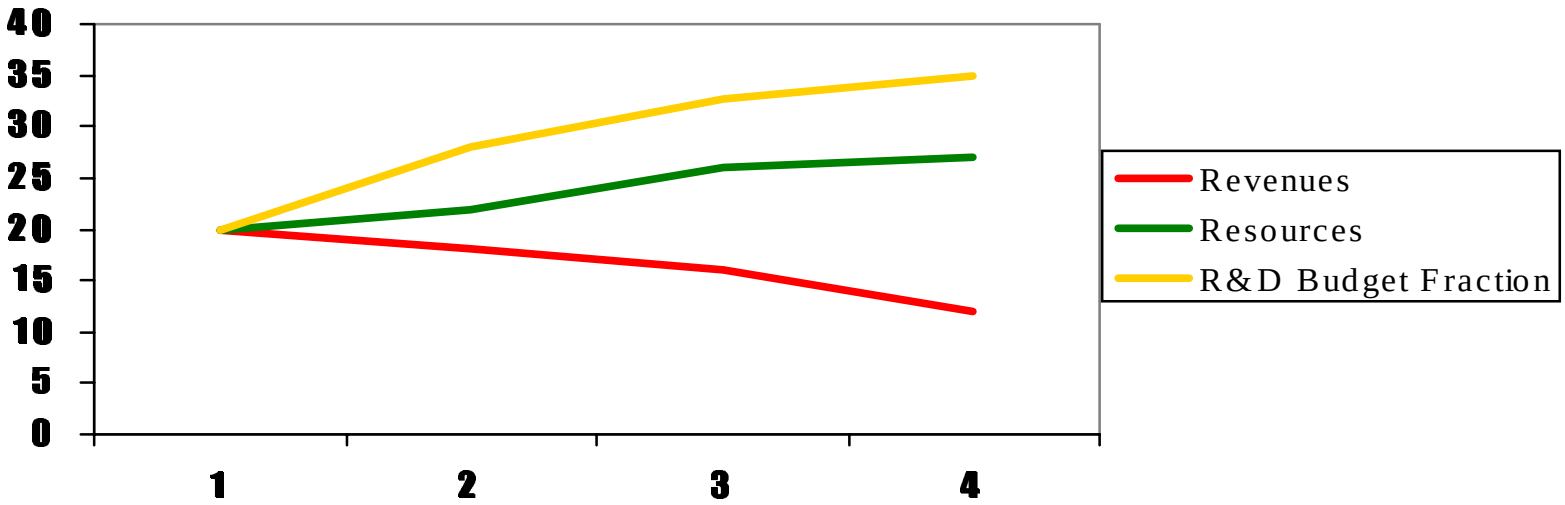



When in this state, molecules in this phase are decreasing. The amount of molecules leaving the phase are typically increasing as cycle times decrease.

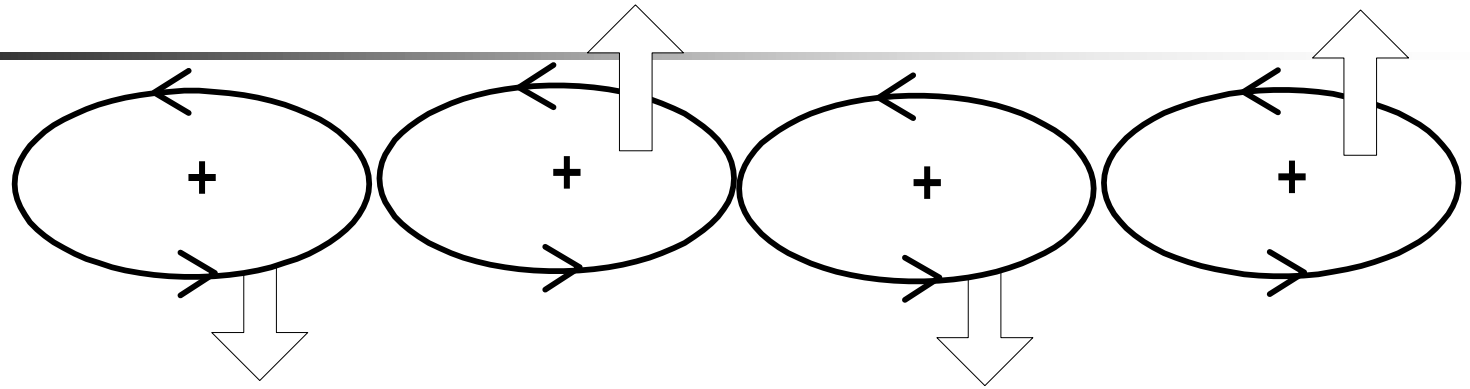
# After Initial Increase of Discovery Rate...



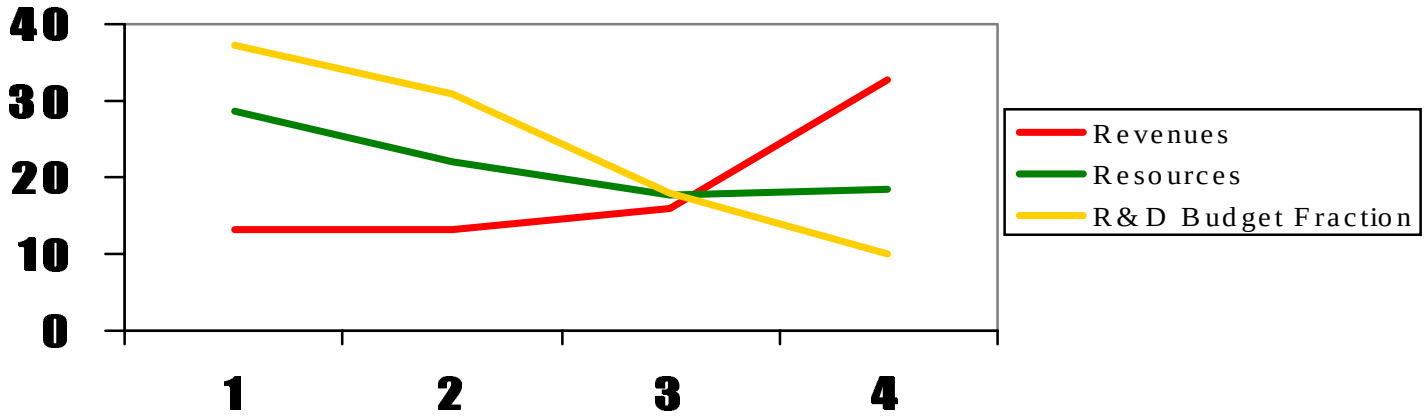

**Resources are initially inadequate, after a delay, a sufficient amount of resources become available to change the direction of the loops.**



# When Resources Are Sufficient, the Flows Change Direction...




**Resources reach adequacy, flows reverse direction. Phase 2 and Molecules on Market Rise quickly as Phase 1 and 3 empty. As this happens, large quantities of resources become available and are allocated to Phase 2. When the rate of molecules leaving 2 > those entering, the loops shift again.**



# Summary of Behavior

- In summary
  - Oscillations occur due to the inevitable time delays in resource allocation and acquisition
  - Side by Side Positive Feedback Loops create a situation of continual resource shifting

# Consequences

- Unintended Consequences.
  - In the short term, increasing discovery rate decreases profits.
- Consequences.
  - Disturbances thought to increase output can actually decrease profits as resources are tied up in transit.

# Case 2: Systemic Collapse

- System Collapse Occurs when the system crosses a threshold where it becomes unable to satisfy the needs of loops with increasing resources requirements.
- As a consequence, the directions of these loops cannot be reversed.

# Case 3: Damped Oscillations

**Resource Estimation Technique**

- Enhanced Ability to deal with Oscillations
- Summary of Characteristics
  - Quicker Positive Adjustment
  - Lowering of Cycle Times with + Resources
  - Less Negative Adjustment
- Damps Oscillations in Steady State, Reduces Oscillations in Normal Distribution

# Key Learning Points

- Due to long time horizons of effect, policies have counter-intuitive behavior in the short term.
- Ultimately increasing output requires consciousness of shifts of resources, molecules, and the budget fraction.
- Alternative Resource Estimation Techniques (Planning) can lead to robustness and the dampening of oscillations.

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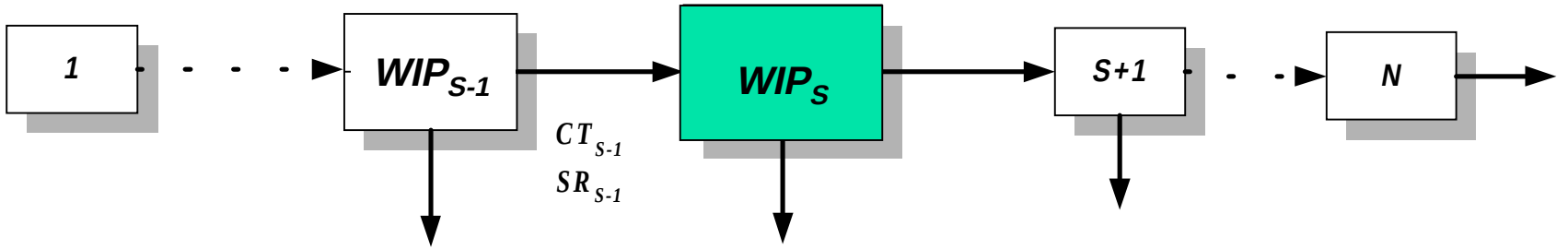
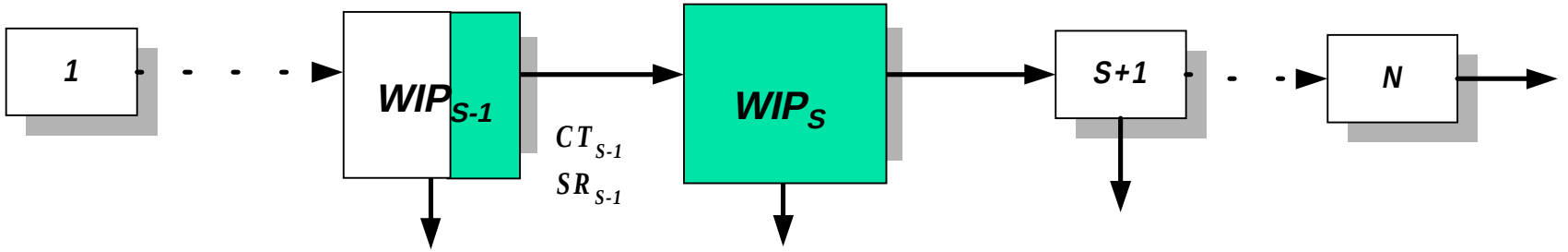
# Resource Estimation Options

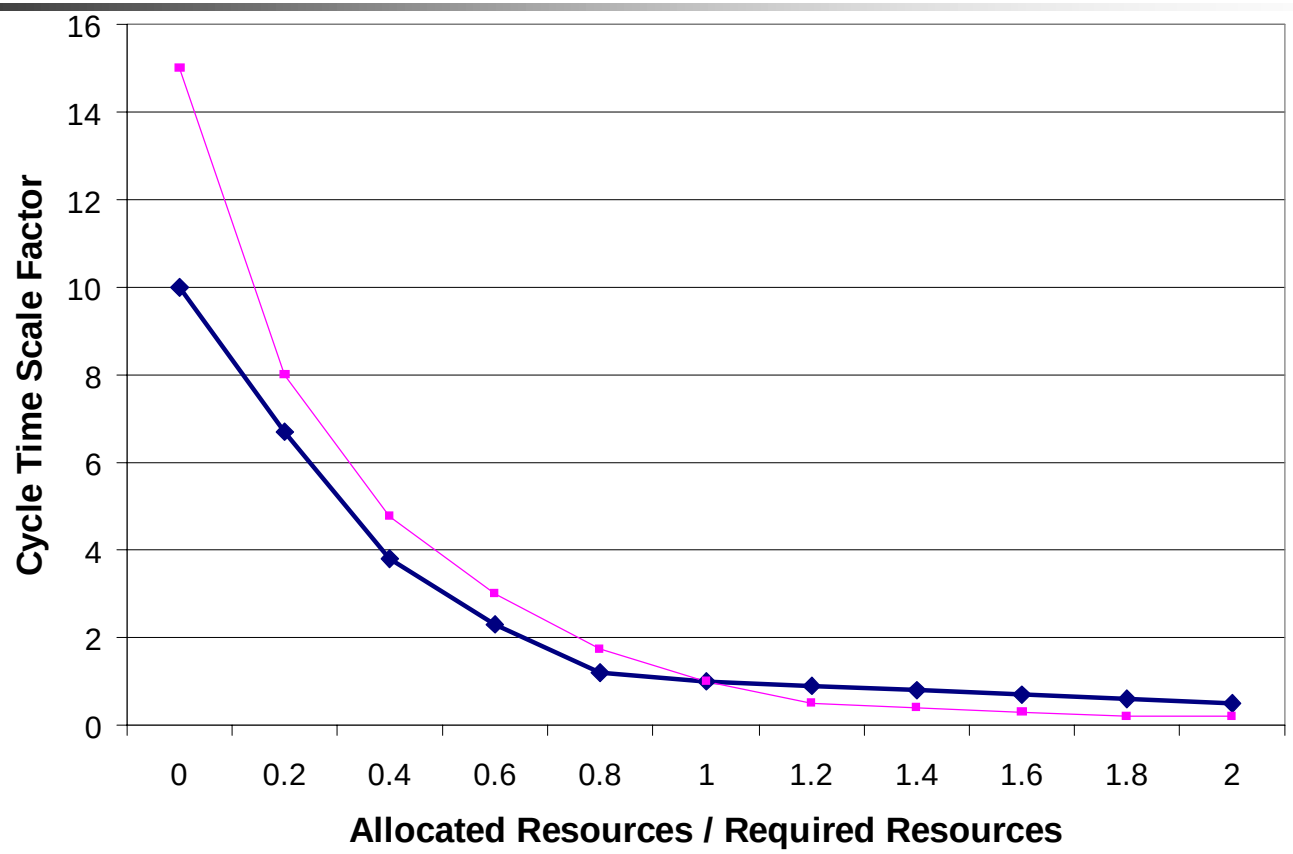
***Resource estimates base on current WIP***




***Resource estimates based on current demand plus anticipated demand over some time horizon***



# Different Effects of Resources on Cycle Time

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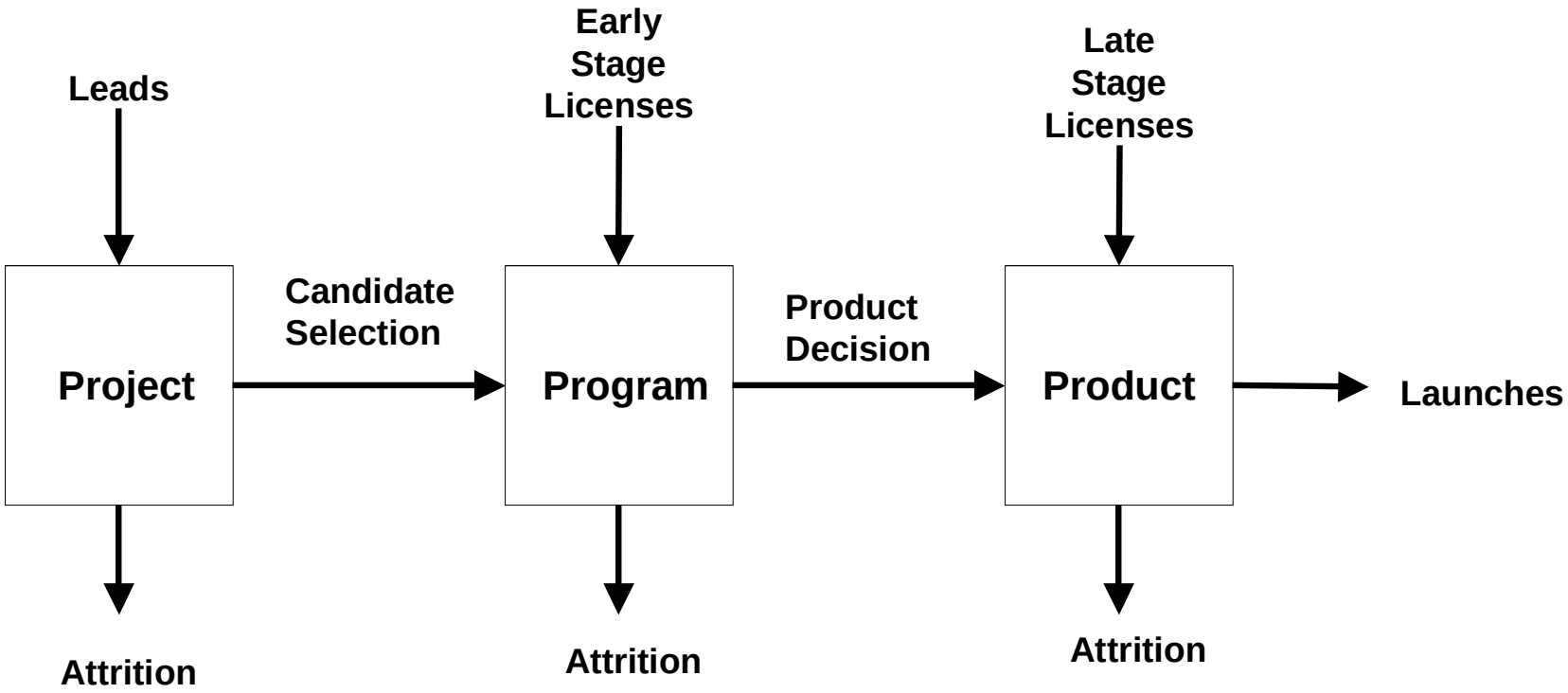
# Specific Model Flow Structure

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# Disturbance Options

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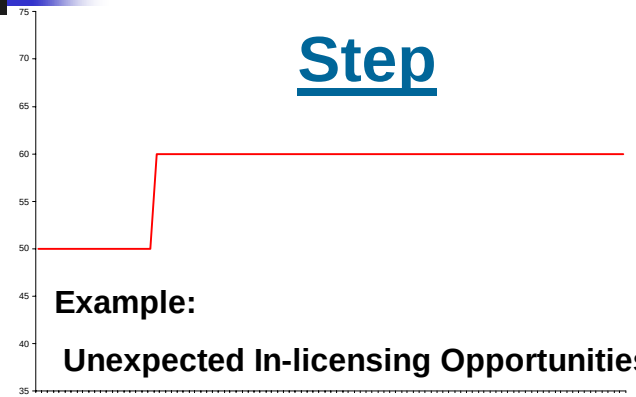
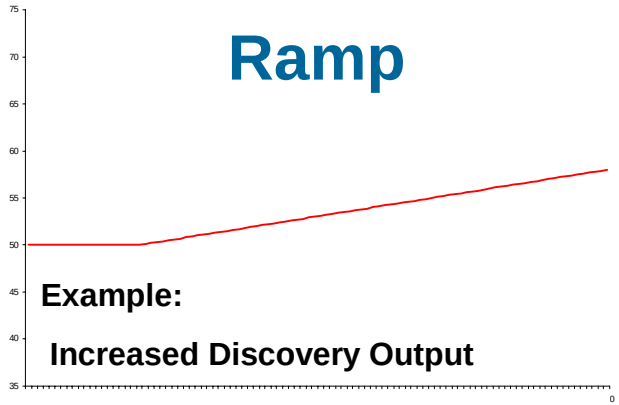
## Step




**Example:**

**Unexpected In-licensing Opportunities**

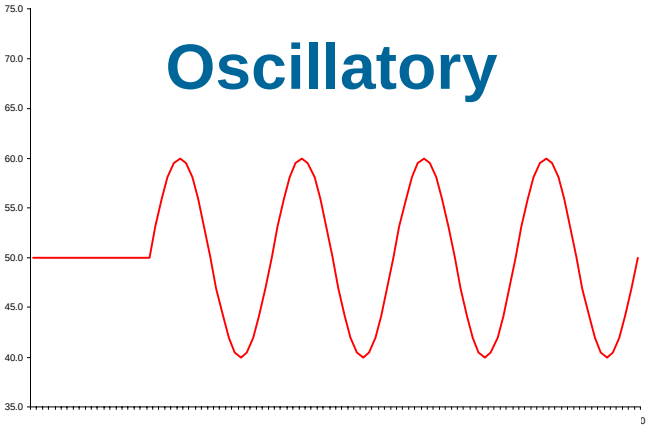
## Ramp



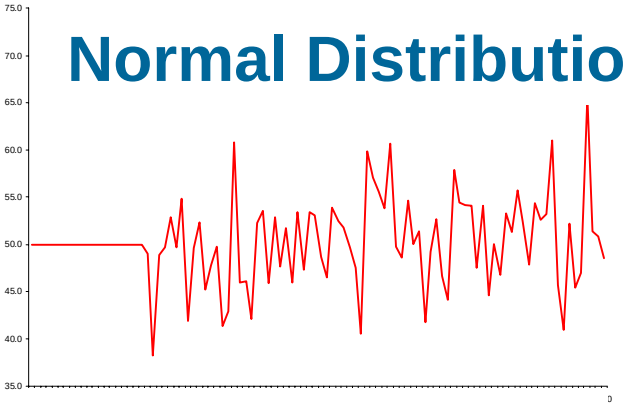

**Example:**

**Increased Discovery Output**

## Oscillatory




## Normal Distribution




**Example:**

**Reality**

# Resource Allocation

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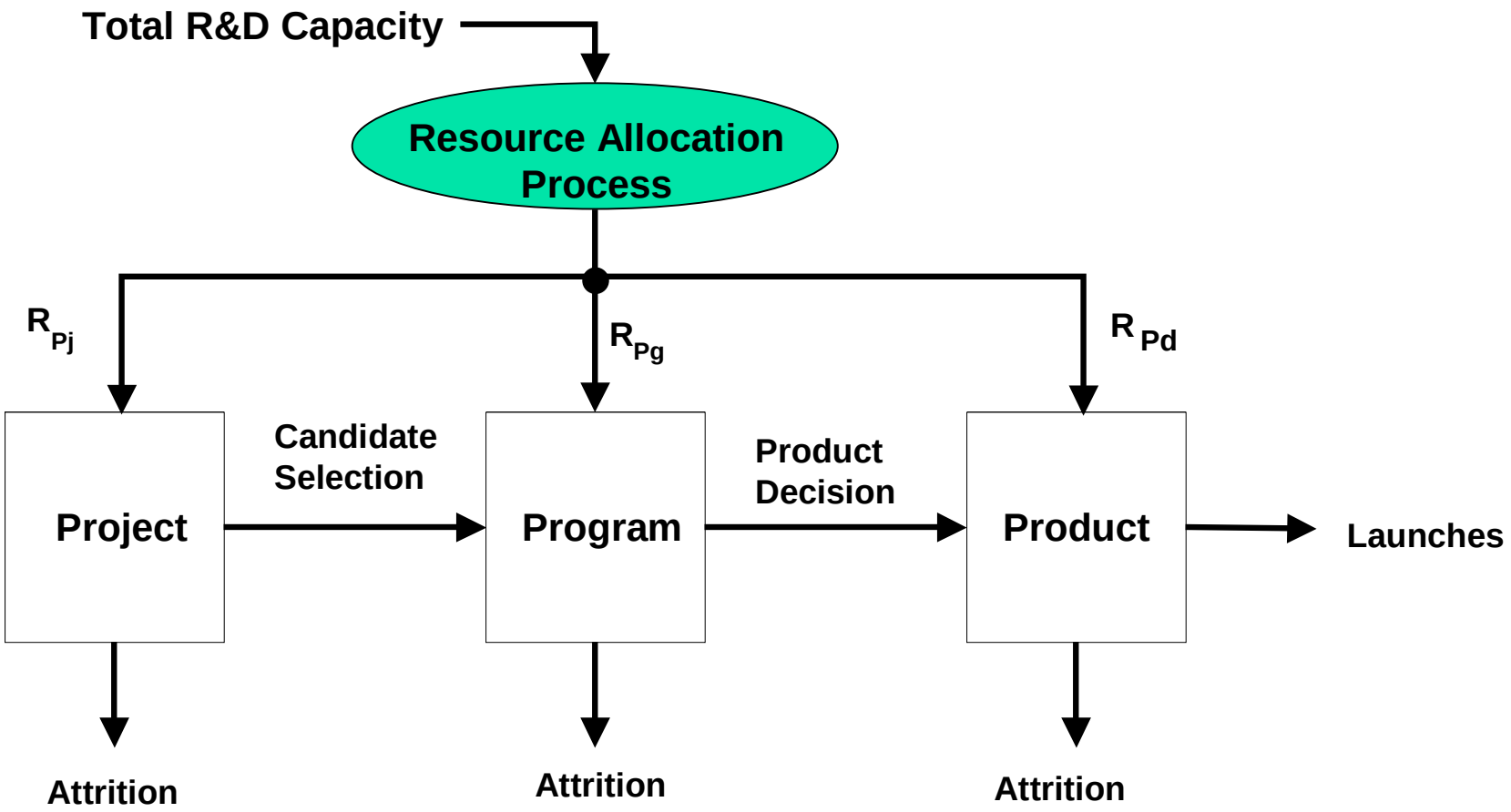
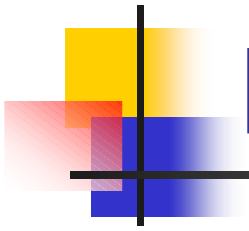
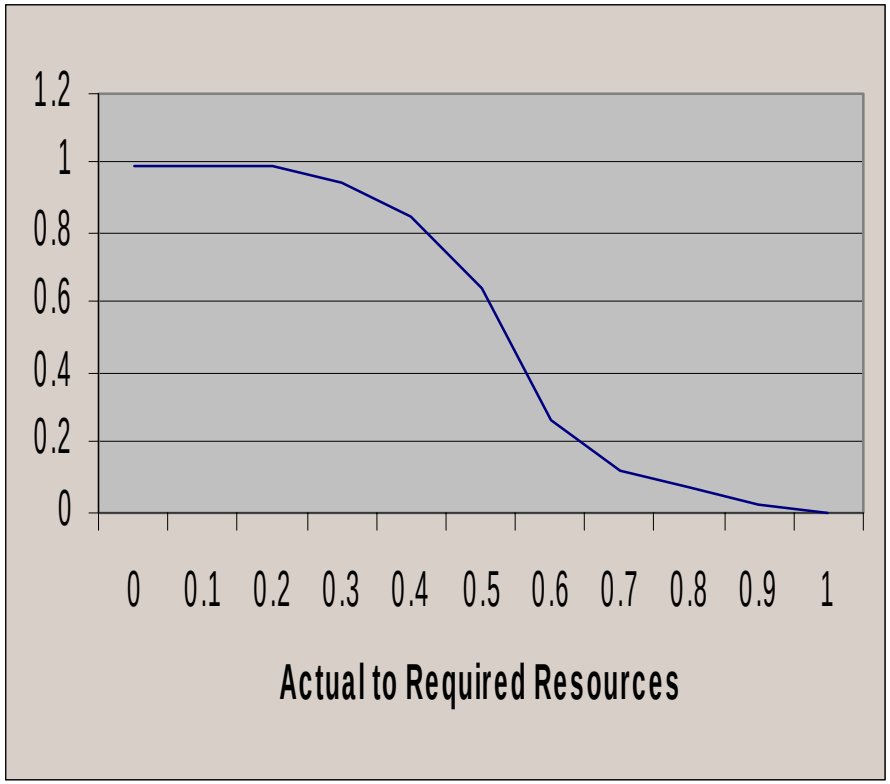


# A Specific Instance of the Model



- Resource Requirements in a Phase are based on current Phase WIPs and the associated Phase Costs / Molecule
- Allocation is proportional to relative need and occurs with delay

# Fraction of Research to Terminate

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