Simulating Adaptive Project Management

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- Educational Background
  - B.S., Engineering Physics, Abilene Christian University
  - S.M., Aeronautics & Astronautics, MIT
  - S.M., Technology & Policy, MIT
  - Ph.D., Technology Management & Policy, MIT
- Work Experience
  - Lockheed Martin, Honeywell
- Research Emphases
  - Managing complex engineering projects and processes
  - System architecting, design, and development
  - Models and tools to support these efforts
- Industries
  - Aerospace, automotive, computers, software, utilities, transportation, military, government

Challenge

- Projects are composed of a set of related activities
- Traditional project management approaches and tools assume this set can be entirely determined and scheduled *a priori*
- Yet, this is usually not the case, especially in product development (PD) projects
  - ⇨ Ambiguity
  - ⇨ Iteration

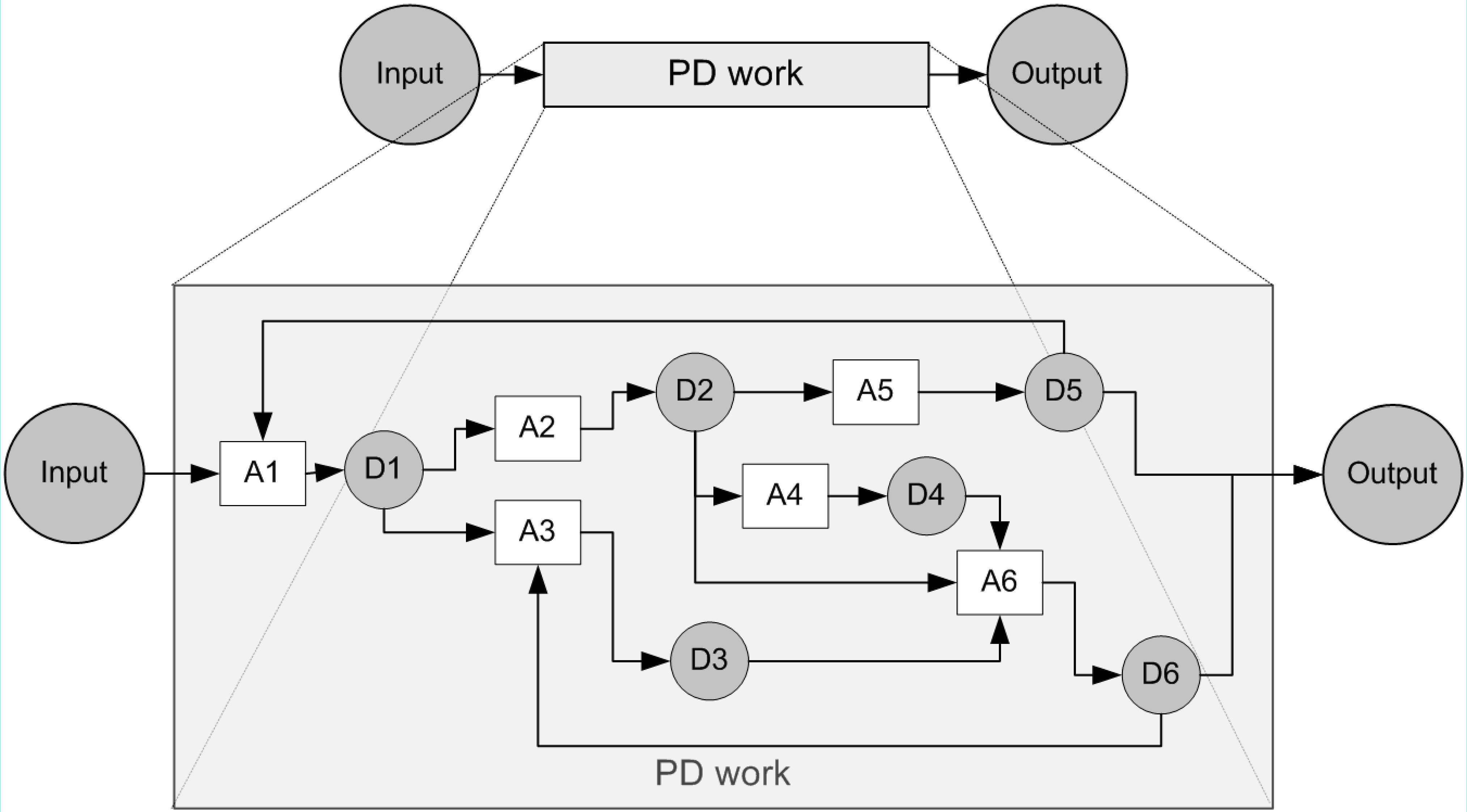
Research Approach

- Model the PD process as a *complex adaptive system*
- Define a superset (“primordial soup”) of potentially relevant activities, each with multiple *modes*
- Simple rules guide activity mode selection based on expected value, given the state of the project
- Simulate thousands of cases and observe what kinds of processes emerge

Related Literature (Examples)

- **Complex adaptive systems** (Holland)
- **Agile, Adaptive, Extreme, etc. project management** (Cockburn, Highsmith, Raymond, etc.)
- **Options-based project management** (Huchzermeier and Loch, 2001)
- **Uncertainty in projects** (Loch *et al.*, 2006)
- **Process grammars and spaces** (Chung *et al.*, 2002)
- **PD process modeling**
  - Many models: activity networks, iteration (Browning & Ramasesh, 2007)
  - Activity decomposition (von Hipple, 1990)
  - Signposting (Clarkson & Hamilton, 2000)
  - Process architecture (Browning & Eppinger, 2002)
- **Earned value management** (e.g., Fleming and Koppelman, 2000)
- **Risk Value Method** (Browning *et al.*, 2002)
- **SysTest VVT project** (Hoppe *et al.*, 2004)

Decomposing PD Work



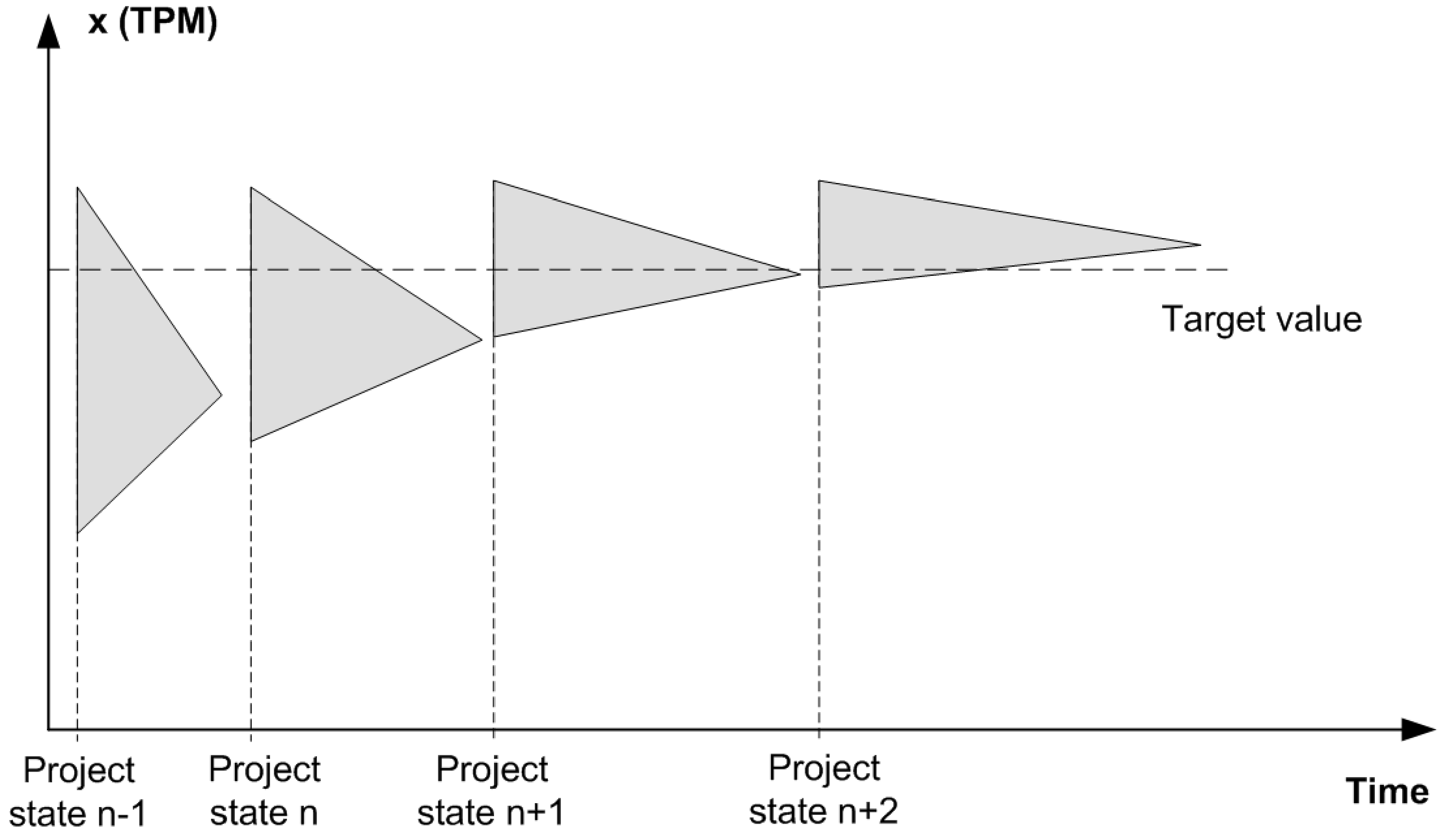
Key Motivations (1-3)

1. A key purpose of PD process modeling can be to help a project manager understand the feasible "design space" for his or her project—i.e., the process space.
2. Iteration is a managerial decision, and it will be directed when it provides the path of greatest added value to a project.
3. Product state (and value) can be represented as a vector of attributes, each measured by one or more TPMs.

Key Motivations (4-6)

4. The execution of activities creates information that revises TPMs and thereby adjusts the state (and value) of a project.

TPM Revision



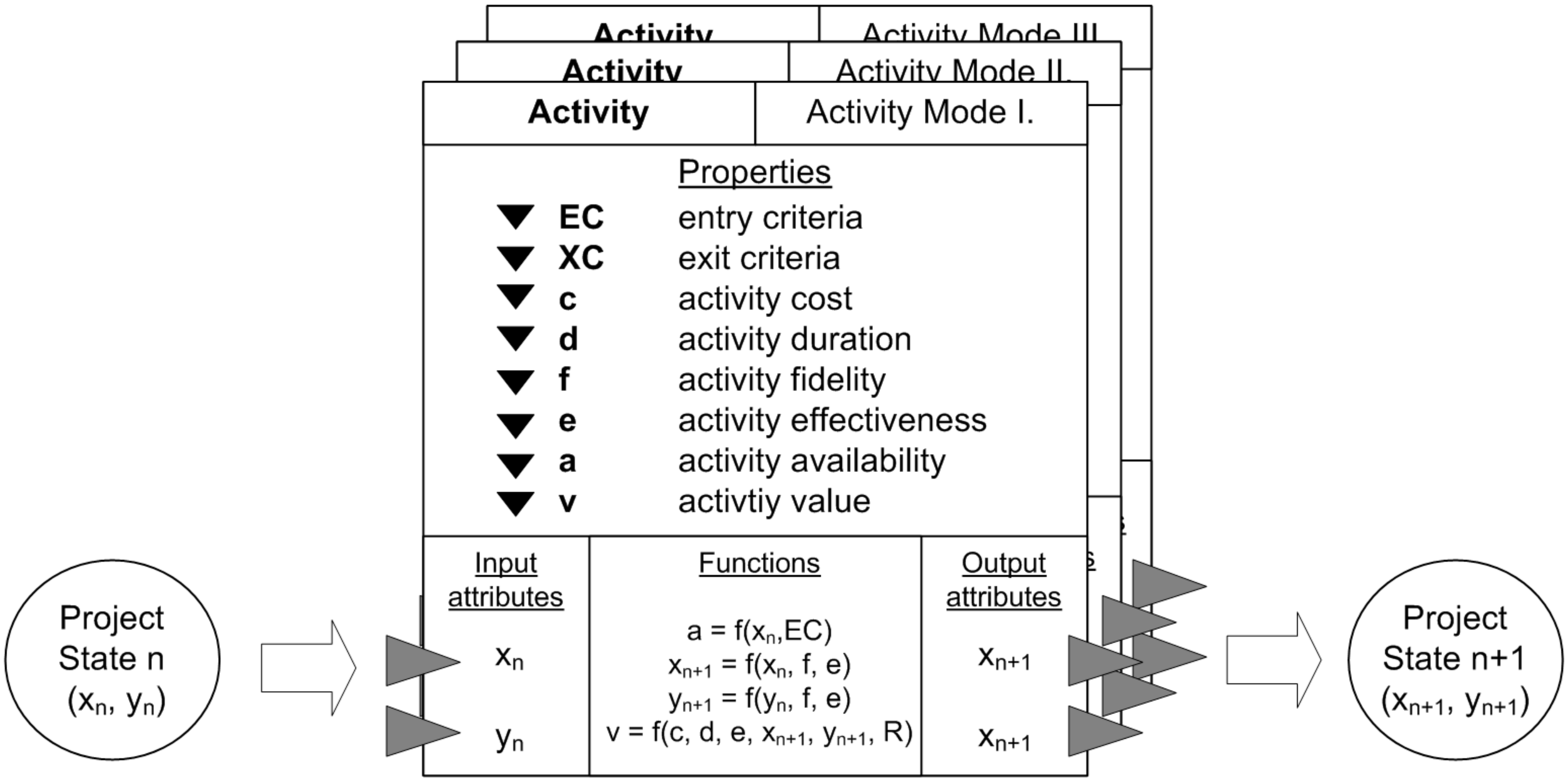
Key Motivations (4-6)

4. The execution of activities creates information that revises TPMs and thereby adjusts the state (and value) of a project.
5. Project control entails:
   - Synchronization of internal and external data regarding the state of the project
   - Use of those data in making decisions on project changes.
6. Adaptability is facilitated by advance knowledge of the potential activities and their relationships. These are specified during the planning phase. Hence, the activities are able to be quickly and effectively rearranged and re-evaluated over the course of a project.

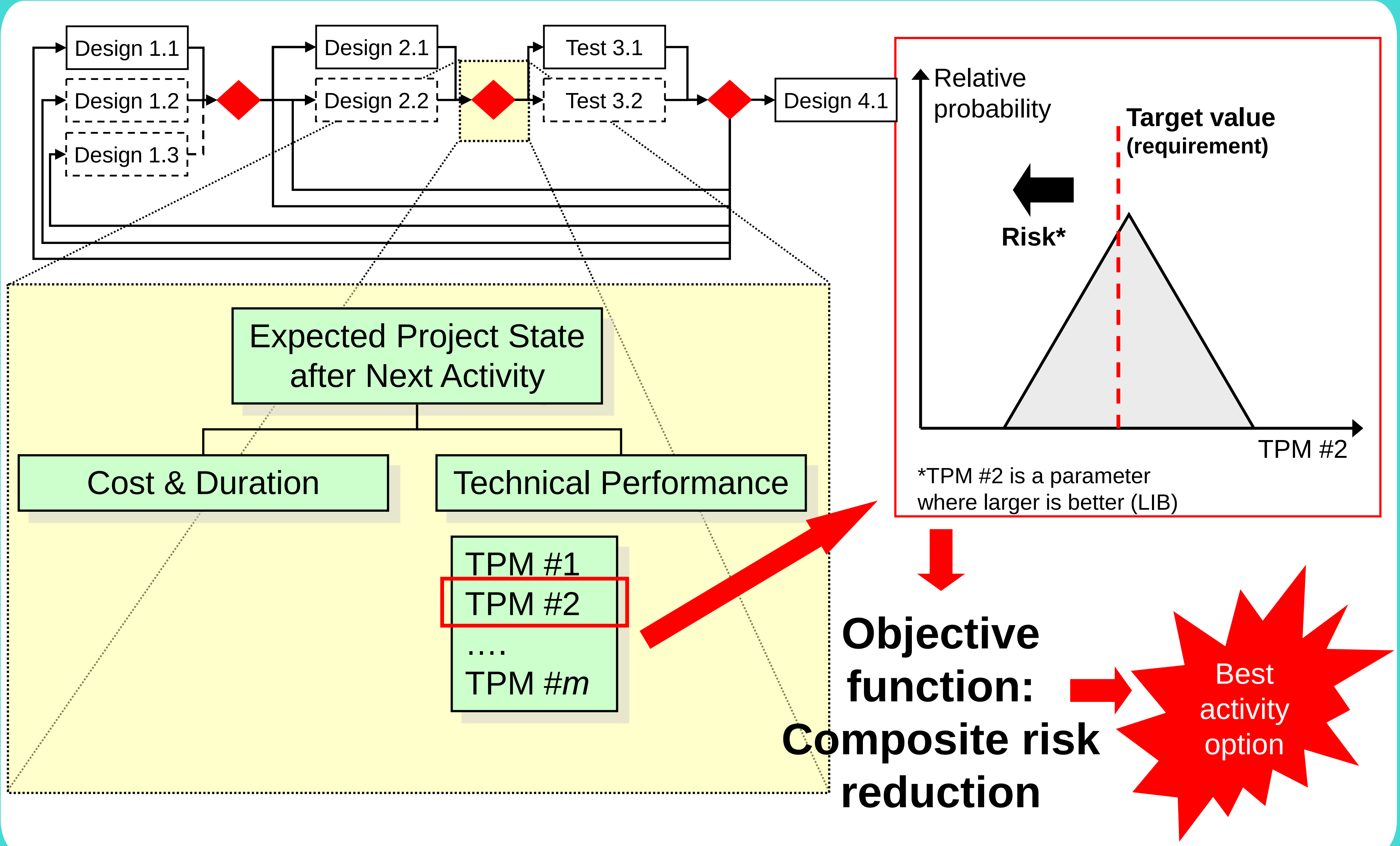
Activity Modes

- Usually only “full-scope” activity modes are shown in company processes
- In planning & scheduling, these activities are not scaled down to solve specific, smaller-scope problems: e.g., failures found during testing
- Example activity modes:
  - Modes with varied levels of cost, speed, and fidelity (low, medium, high)
  - Modes with similar purposes but alternative procedures or methods, resulting in different effectiveness in certain situations
  - Rework modes that focus on correcting typical design failures

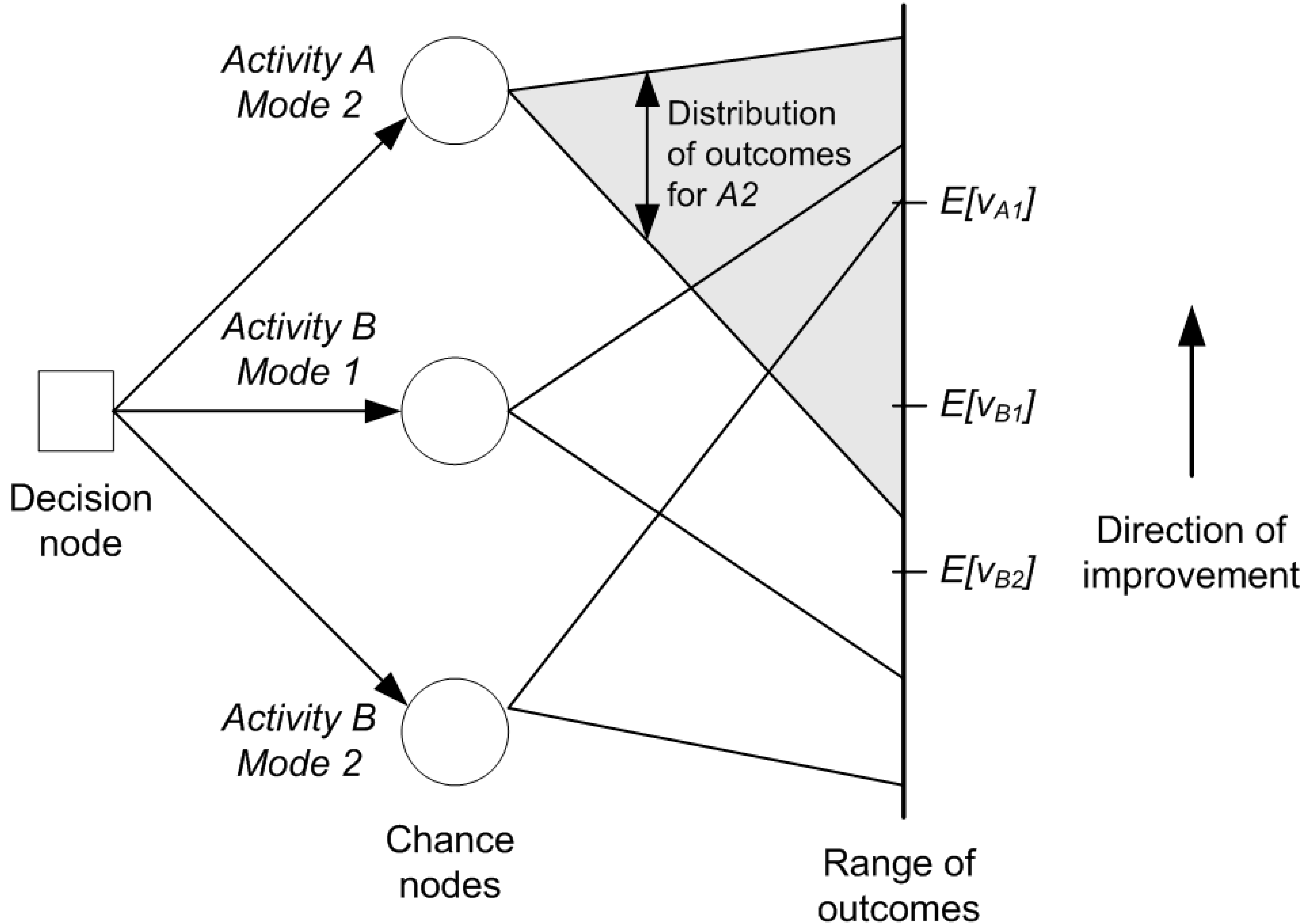
Activity Mode Attributes



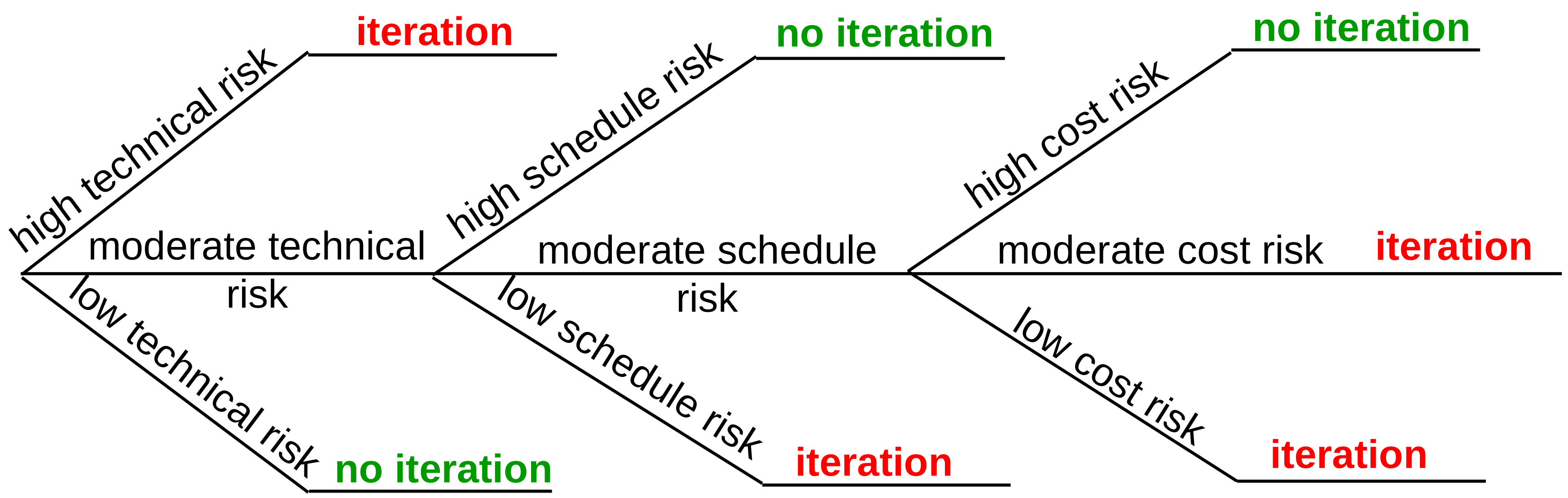
Decision Making



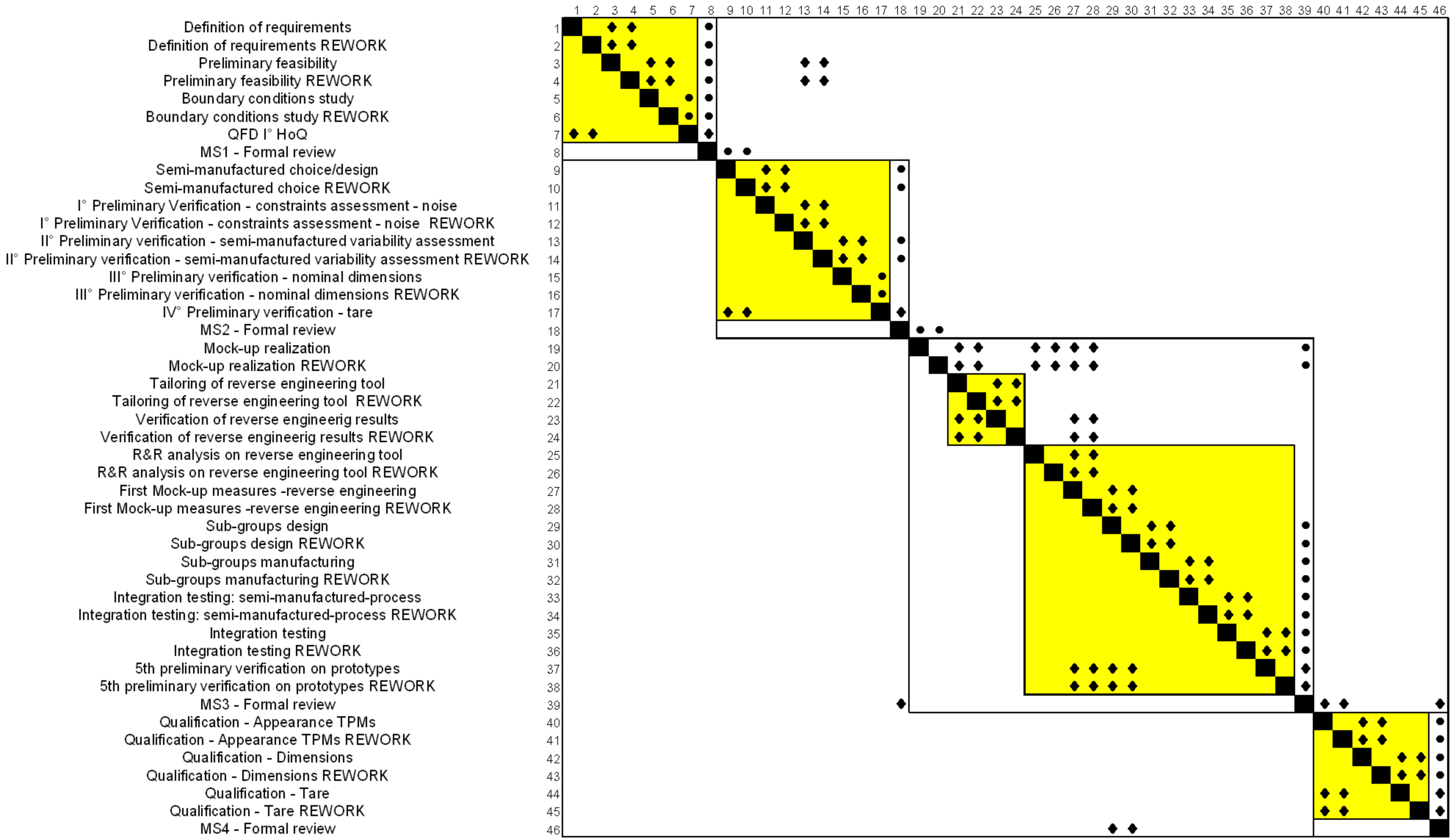
Decision Framework



Example: Iteration Decisions

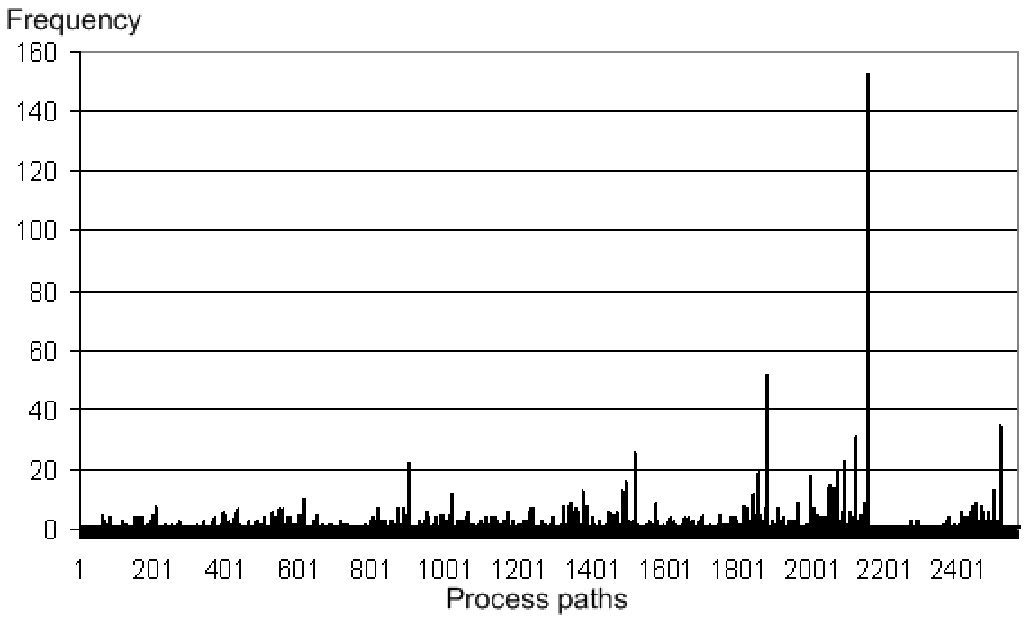


Example Application at TetraPak



Example Results and Insights 1

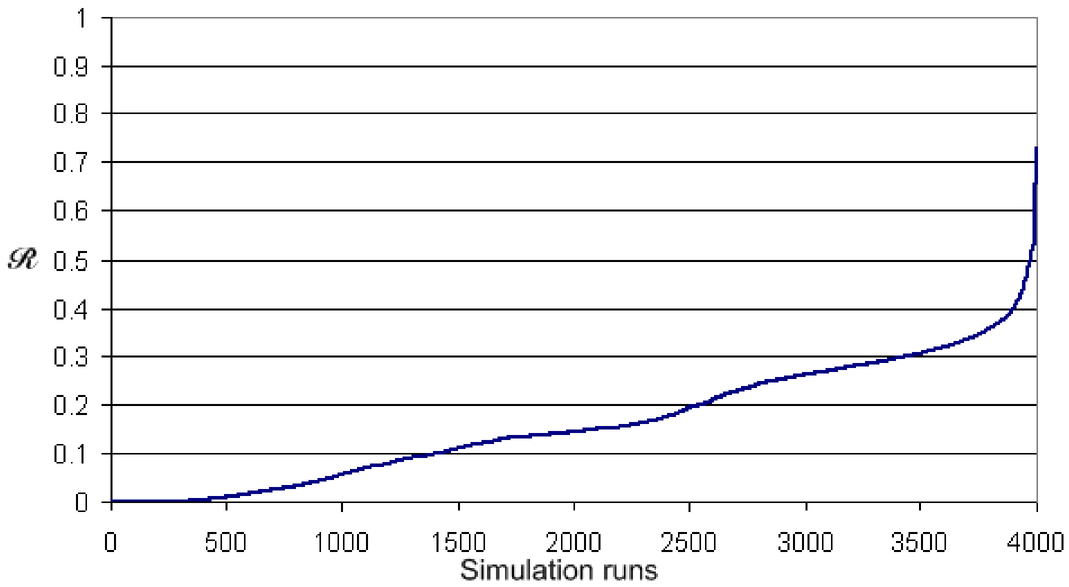
- 4000 simulation runs; 2550 unique paths
- Single most likely path occurred 153 times (3.8%)



- Insights:
  - ⇨ Plans based on a single path will be challenged to guide projects effectively
  - ⇨ Greater variety of potential outcomes increases value (options theory)

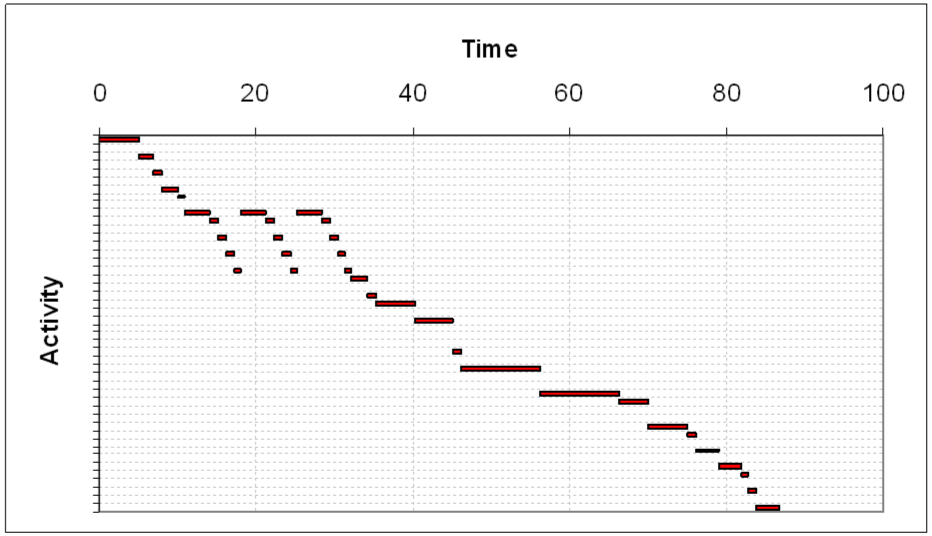
Example Results and Insights 2

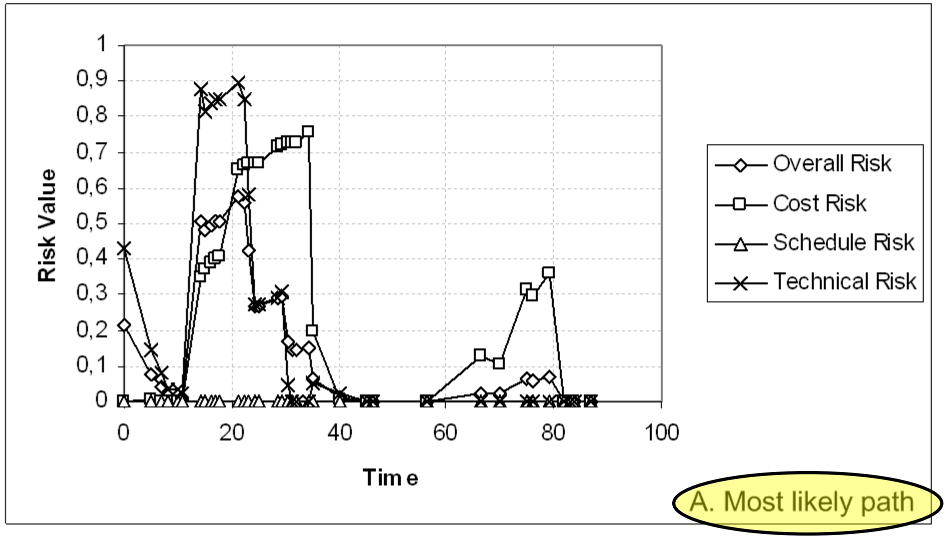
- Result: 64.7% of the processes (paths) reduced the overall project risk to a "low" level ($\mathscr{R} \leq 0.2$)



- Insight: Paths unlikely to lead to success can be identified, and projects finding themselves on them can be abandoned

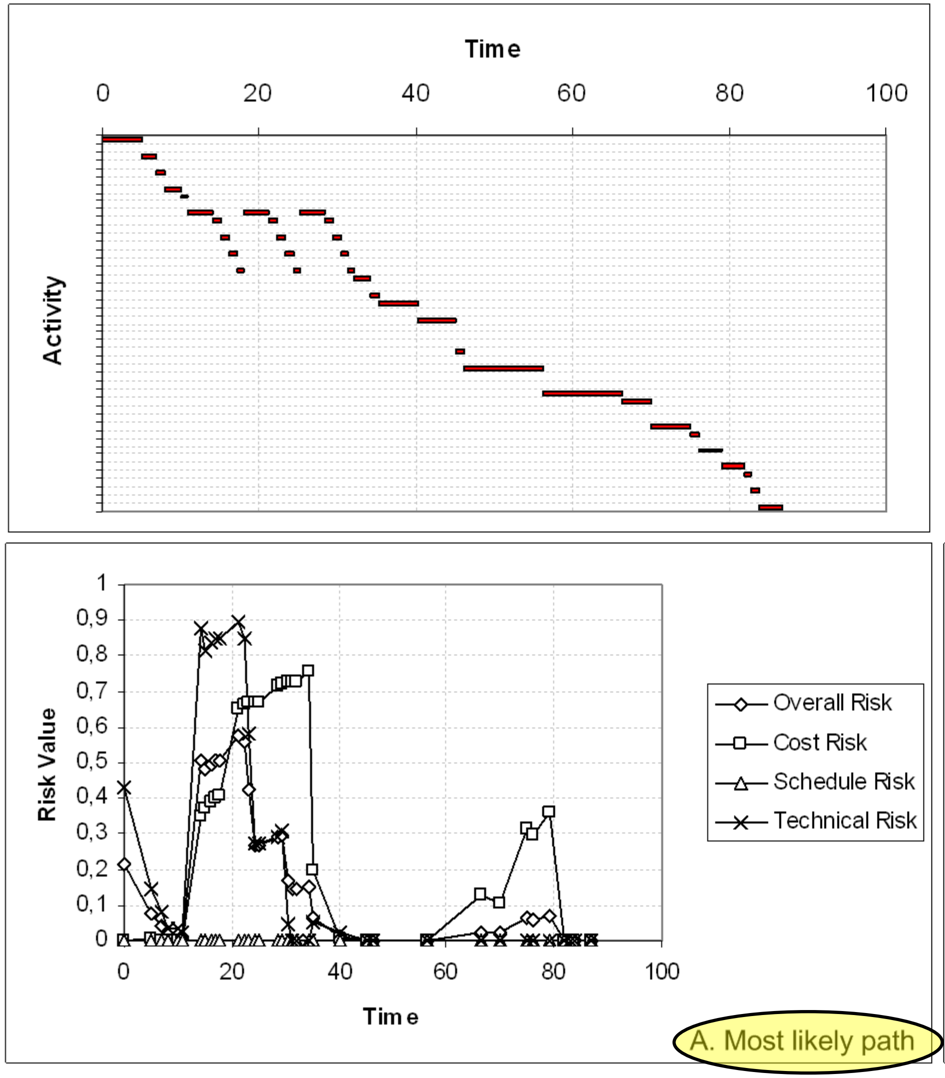
Example Results 3

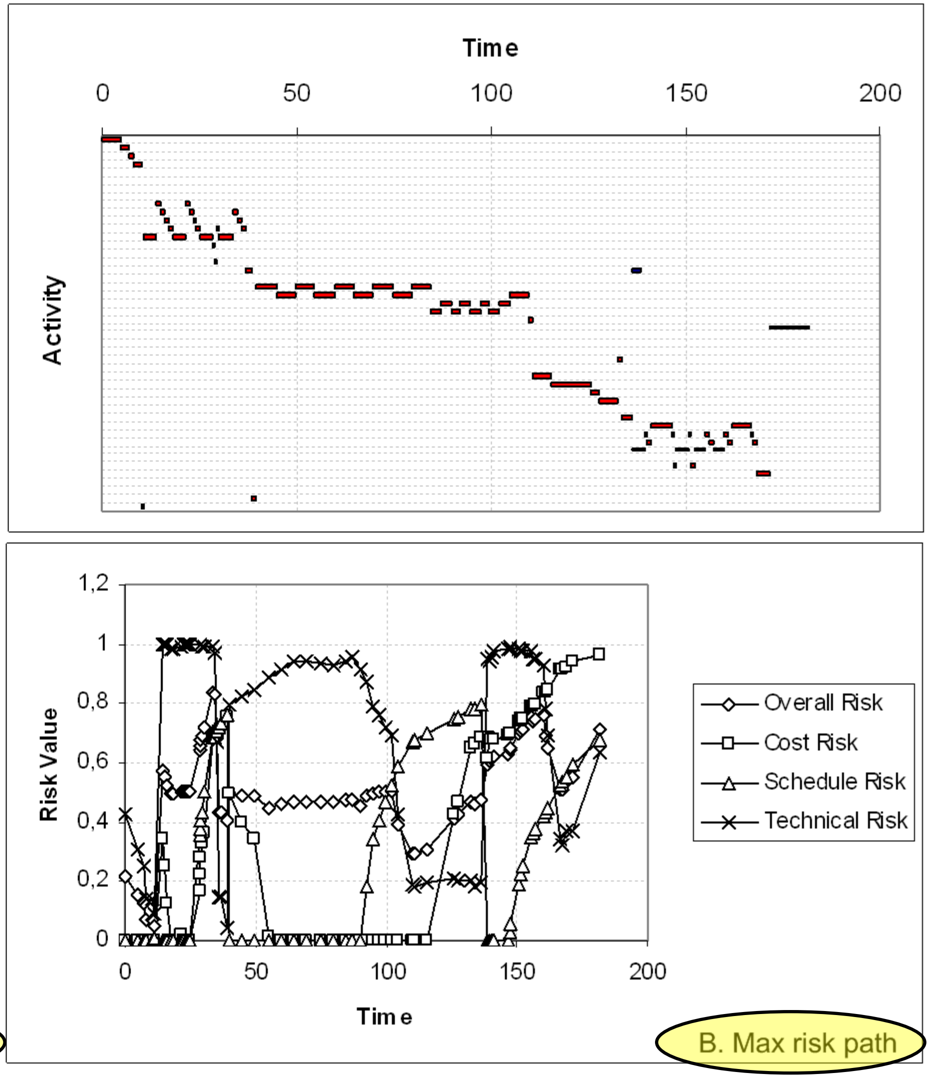




Early, “cheap” iterations

Example Results 3





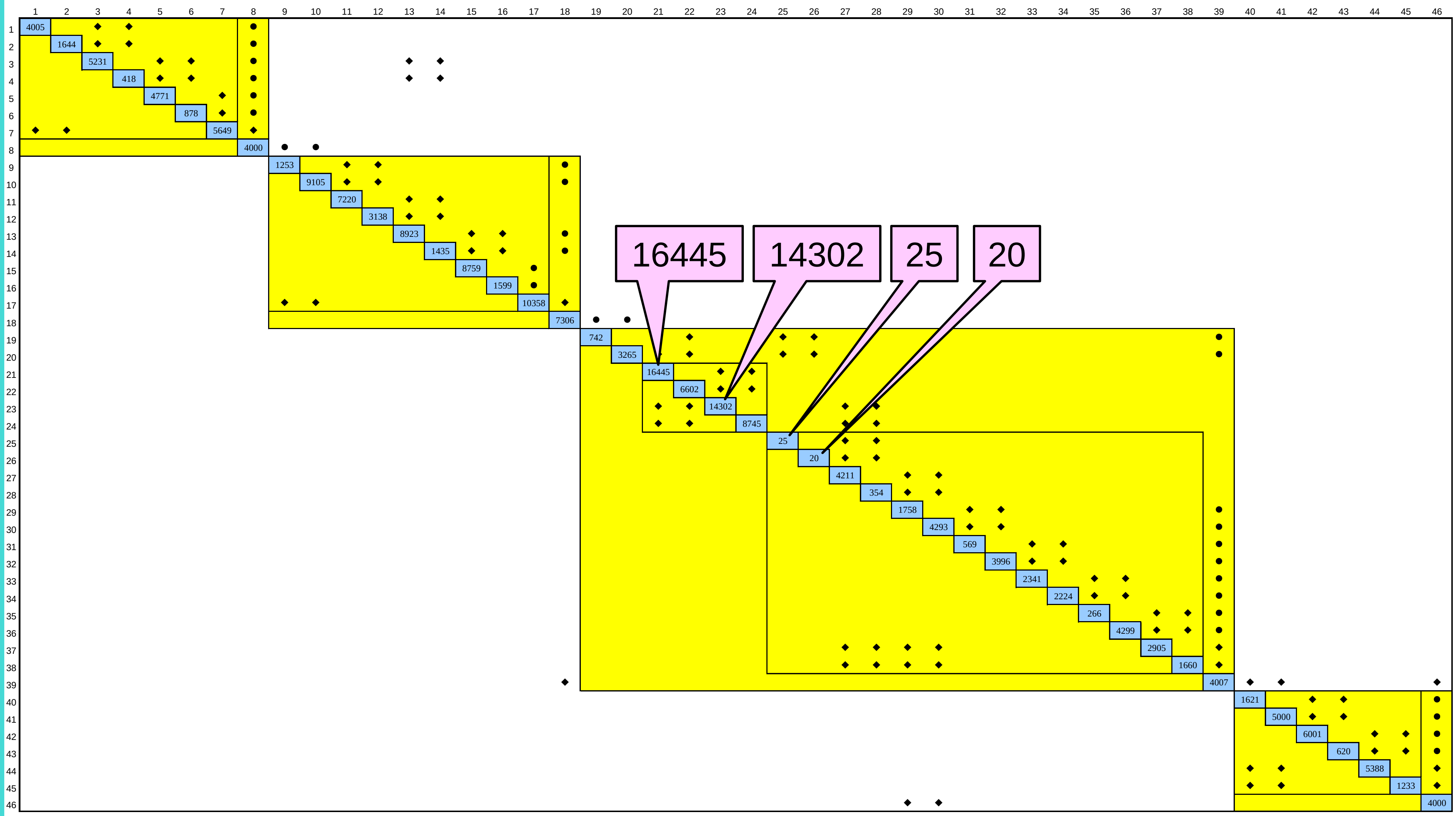
Early, “cheap” iterations

Late, expensive iterations

Example Results and Insights 3

- 97.5% of paths had at least one iteration
- Most successful paths had iterations
- Timing and scope of iterations more important than amount of iteration

Example Results 4: Activity Mode Frequency



Example Insights 4

- Since this project included two modes for most activities, it is interesting to note where either the regular mode (e.g., 19, 31, and 35) or the rework mode (4, 28, 43) was selected infrequently
- Do activity mode frequencies provide an indication of their current value to the project?
  - ⇨ They have a much lower probability of adding value to the project
  - ⇨ But, a better question: Are they on high- or low-value paths?
- Less-frequently-valuable modes may be redesigned by prescribing different technologies, methods, and/or personnel that change the mode's attributes
  - ⇨ Do such changes increase the mode's probability of adding value?
- High-value PD processes may require not fewer activity options (as suggested by Lean) but more

Example Results and Insights 5

- Result: non-obvious activity modes chosen for initial pass and rework
  - E.g., rework mode for initial pass
  - E.g., “full” mode for rework
- Insight: There is value in being able to delay the selection of the activity mode until the last possible moment
  - Option value
  - Cf. Toyota PD system: set-based design of processes (Sobek et al., 1999)

Other Areas To Explore

- Effects of front-loading uncertainty reduction (Thomke & Fujimoto, 2000)
- Predicting the value of potential new modes (e.g., investments in new technologies)
- Effects of changing target values (deadlines, budgets, and requirements) and impacts of missing them
- Locally optimal paths?

Summary

- We model the PD process as a complex adaptive system, hoping to account better for both uncertainty and ambiguity
- Activities self-organize to form potential process paths
- We provide a framework for structuring an *adaptive* approach to project planning and control that continuously rebalances cost, schedule, and performance relative to goals—to maximize value as a project unfolds
- We explore the resulting *process space* (cf. design space)
- Viewing PD projects in this way provides interesting insights for improved planning and control

Conclusions

- The framework helps reduce “unk unks” by identifying unforeseen interactions among foreseen activities
- Perhaps the greatest benefit lies in recognizing the advantages of decreasing the time required for project management decision loops
- Paradoxically, by <u>increasing the structure</u> in and understanding of a broader set of potential activities, the project manager is able to observe, orient, decide, and act (OODA) faster and with <u>greater agility and effectiveness</u>
- Drawbacks in practice:
  - ⇨ Requires additional investments in planning (cf. set-based design)
  - ⇨ Entails a different paradigm for project planning and management (valuing flexibility and adaptability vs. control to an *a priori* plan)

For More Information

- Paper available at web site (URL below)

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