ESD.36J System & Project Management

System Project Management

and

Product Development Processes

Instructor(s)

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Lecture 11

10/9/2003
Introduction

- Project Preparation and Planning
  - Importance of Upfront Preparation
    - Contents of Program Management Plan
- Product Development Processes (PDP)
  - Waterfall Model
  - Spiral Model

Acknowledgments: Prof. Ed Crawley
  Prof. Steve Eppinger
  Dr. Joyce Warmkessel
  Dr. Darian Unger
ESD.36 Framework

Doing the right job

Project Preparation

Project Planning

Project Execution

Project Adaptation

Doing the job right
Preparation versus Planning

- “Preparation” address the who, what and why issues
  - Who are the major stakeholders?
  - Why we are doing the project?
  - What do the stakeholders expect in exchange for their participation (“value”)?
- Time frame for “Preparation” is prior to project initiation
- “Planning” is the “how” the project will be conducted
Management Leverage is Greatest Early
Preparation Actions

- Identify Stakeholders
- State End-User Needs
- Determine Project Mission & Timing
- Identify Project Scope
- Identify Project Interfaces
- Address Make/Buy
- Identify Constraints
- Determine Organization Structure
- Line up Resources

Identify program processes

Planning
Planning Actions

- Populate Organizational Structure
- Develop Product Structure
- Develop Program Schedule
- Determine Risk Management Approach
- Define Team boundaries and responsibilities
- Define Communication Plan
- Put in place system for Information Management
- Define Performance Measures & Metrics
- Define Assessment & Control Approach

Executable Program Plan
Program Management Plan Topics

- Summary - program description and major objectives
- Assumptions & constraints
- Deliverables
- Work breakdown structure
- Major milestones with associated exit criteria
- Staffing & training plan
- Spending/budget profile
- Project organization
- External interfaces
- Program plans: list with summary description
- Product documentation tree
Other Lower Level Plans

- Control plans
  - Schedule/budget
  - Requirements
  - Configuration
  - Technical Parameters
  - Interface
- Risk Management
- Subcontract Management
- Contract Management
- Reviews and Audits
- Quality Assurance
- Safety
- Reliability
- Problem resolution
- Information Management
Four Basic Tensions (Trade-offs) in Product/System Development

One of the main jobs of the program manager (and architect) is to identify the principle tensions and resolve them.

Ref: Maier/Rechtin
Factors that Influence the Program Plan

Development
Approach
- New Product
- Update
- Platform Product
- Platform development

Program Structure
- Single organization
- Prime with subs/suppliers
- Federation of associates

Product Strategy
- New technology
- Significant reuse
- Integration of existing “subsystems”
- Platform based

Execution
- Does “culture” or customer require specific execution approach (V, spiral etc)
Characteristics of PDP

Always involves at least:
- Marketing
- Design
- Manufacturing

Challenges of the PDP
1. Tradeoffs
2. Dynamics
3. Details
4. Time Pressure
5. Economics

“A PDP is the unique sequence of steps or activities, which an enterprise employs to conceive, design, and commercialize a product”

Ulrich and Eppinger
Conceive, Design, Implement

The Environment: technological, economic, political, social, nature

- Mission
- Requirements
- Constraints

Creativity
Architecting
Trade Studies

Conceive
Create

"Process Information"

Design
Choose

Modeling Simulation
Experiments
Design Techniques
Optimization (MDO)

Iterate

The Enterprise
Manufacturing
Assembly
Integration

The System

"Turn Information to Matter"

1

The Enterprise

The System

Customer Stakeholder User

Architect Designer System Engineer

SRR

Beginning of Lifecycle

Conceive

Design

Implement
Operate, Upgrade, Liquidate

The Environment: technological, economic, political, social, nature

The System
- The System
- Architect Designer System Engineer
- System ID behavior prediction
- control usage
- degrade
- EOL

The Enterprise
- The Enterprise
- Operate
- Upgrade
- Liquidate

The System
- Customer Stakeholder User
- System ID behavior prediction
- control usage
- degrade
- EOL

Architect Designer System Engineer
- End of Lifecycle

Operate, Upgrade, Liquidate
Generic PDP Process

Need Assessment
- Internal and external needs.
- Future needs

Concept Evaluation
- Formulate and Evaluate Concept Alternatives

Define Requirements
- Translate Customer Wants and Needs into Engineering Requirements.
- Top down System to Components.
- System to System Requirements

Design
- Trade-off Studies
- Materials, Geometries
- Tooling, Detailed Specifications.
- Manufacturing Techniques

Develop
- Prototypes,
- Build and Integrate
- Subsystem Test

Test
- Verify, Validate and Qualify

Implement
- Design Completion.
- Transition to Operations.
- Lessons Learned
Roles in PDP*

Key Differences in PDP

- Number of phases (often a superficial difference)
- Phase exit criteria (and degree of formality)
- Requirement “enforcement”
- Reviews
- Prototyping
- Testing and Validation
- Timing for committing capital
- Degree of “customer” selling and interference
- Degree of explicit/implicit iteration (waterfall or not)
- Timing and degree of supplier involvement
PDP In the SMALL v. In the LARGE

Product:
- **SIMPLE**
  - Countable interfaces
  - Parts identifiable

Process:
- **STATIC**
  - Goals & resources constant

Organization:
- **SMALL**
  - Team at a table

- **COMPLEX**
  - Very many interfaces
  - Parts abstracted

- **EVOLVING**
  - Goals & resources changing

- **LARGE**
  - Big team

Other Factors: clean slate vs legacy components; single product vs platform; collocated vs distributed team; team in enterprise vs supplier involvement

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Example: Global Telecommunications Services Development Process

- Multi-national telecommunications company
- “Document-based” development environment
- 100+ documents involved in complex new IP product
- 15+ internal organizations
  - technical, billing, product, service, etc.
- Redundant information and duplicated efforts
- Too many projects
- Frustrating and long development cycle

We have the process on paper – but we don’t live it.

Ref: Eppinger
Telecommunications Development: The Planned Process

- Four-Phase Development Process
- 150 Documents in DSM Model

Business Req’ts → System Req’ts → Network Plan → Eng’g Specs

Concept Approval

PLANNING AND SPECIFICATIONS

Specification Approval

DETAILED DESIGN AND BUILD

Op. → Cust. Service → Implem. & Billing → Eng’g

Launch Approval

OPERATE

CONCEPT

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Telecommunications Development: The Actual Process

Critical Problem:
Ongoing Iterations after Specifications Phase

CONCEPT

Business Req’ts

System Req’ts

Network Plan

Eng’g Specs

PLANNING AND SPECIFICATIONS

Eng’g

DETAILED DESIGN AND BUILD

Implem. & Billing

Ops.

Cust. Service

OPERATE

Launch Approval

Concept Approval
Telecommunications Development: An Improved Process

**Solution:**
- Planned Iterations in Specs Phase
- X-Functional Resources in Specs
- Formal Spec Approval Gate
- Enables Parallel Design Efforts

**Specification Approval Gate is Critical:**
- Frozen product requirements
- Frozen technical specifications
- Project plan for detailed design
- Financial analysis

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Phased vs. Spiral PD Processes

Phased, Staged, or Waterfall PD Process
(dominant for over 30 years)

- Product Planning
- Product Definition
- System-Level Design
- Detail Design
- Integrate and Test
- Product Launch

Spiral PD Process
(primarily used in software development)

- Product Planning
- Define, Design, Build, Test, Integrate
- Define, Design, Build, Test, Integrate
- Define, Design, Build, Test, Integrate
- Product Launch

Process Design Questions:
- How many spirals should be planned?
- Which phases should be in each spiral?
- When to conduct gate reviews?
Stage Gate PD Process

Planning

Concept Design

System-Level Design

Detailed Design

Integration & Test

Release

Cross-Phase Iterations (unplanned)

Within-Phase Iterations (planned)

Reviews

Spiral PD Process

Adapted from:


Spiral PD Process (Simplified)
Spiral PD Process

- Planning
- Concept Design
- System-Level Design
- Detailed Design
- Integration & Test
- Release

Time

Reviews

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Design-to-Schedule, Design-to-Budget PD Processes

Planning → Concept Design → Sys-Level Design

<table>
<thead>
<tr>
<th>Priority Level</th>
<th>Task Details</th>
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<tbody>
<tr>
<td>High Priority</td>
<td>Detailed design, test</td>
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<tr>
<td>Medium-High</td>
<td>Detailed design, test</td>
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<tr>
<td>Medium-Low</td>
<td>Detailed design, test</td>
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<tr>
<td>Low Priority</td>
<td>Detailed design, test</td>
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</tbody>
</table>

Run out of time or budget here
Other PD Processes

- Evolutionary delivery
- Evolutionary prototyping
- Extreme programming (software only)
- Modified stage gates
- Set-based concurrent engineering
- Short-term solutions, i.e. acquisitions

(Hybrid) Case Study: Xerox

- Hardware (DC 460-ST) and software (Endeavor)
- Large company and steady platform (variant) products
- Iterations
  - TTM process technically a stage gate but w/some important exceptions
    - Software subprocess
    - Internal experiments and waivers
- Risk – emphasis on controlling schedule
Xerox Time-to-Market (TTM) Process

1. Define market attack plan & technology
2. Define product & deliver technology
3. Design product
4. Demonstrate product
5. Deliver product
6. Delight customers

Software Development Sub-Process
There are many possible PD processes to choose from.

- Spectrum from **staged** to **spiral** processes

PD processes should be designed to address project risks by

- Planning **iterations** in the process
  - Can be within or across phases
- Scheduling **reviews** to control the process
  - Cross-functional review
  - Generally reviews end phases (no backtracking)
Proposed PDP Design Procedure

1. Identify and prioritize the project risks.
2. Assign each risks to a specific phase.
3. Plan the necessary iteration cycles within each stage to address the assigned risks.
4. Schedule reviews at the completion of each phase.

- Phase
  - Review
  - Phase
  - Review
  - Phase
  - Review

- Risks
Key similarities between PDPs

- Attempt to meet customer needs
- Discrete phases of development
- Iteration in some form
- Existence of reviews or gates
- Attempt to control development risks
Key differences between PDPs

- Names and number of development phases
- Type of iteration
- Type of review
- Customer interface points
- Product complexity
- Risks addressed
Identification of key risks

<table>
<thead>
<tr>
<th>Category of risk</th>
<th>Level of risk</th>
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<tbody>
<tr>
<td>Technical/Performance</td>
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<tr>
<td>Market/User</td>
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<td>Budget</td>
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<tr>
<td>Schedule</td>
<td>3</td>
</tr>
</tbody>
</table>

Risk Profile

Low (Coord./Variation) - High (Unk-unks/chaotic)
Iteration parameters

- **Breadth of iterations**
  - 1: Narrow (Within 1 phase)
  - 2: Comprehensive (Across 3 or more phases)

- **Number of inter-phase loops**
  - 0: None (No iteration)
  - 1 to 4: 1 to 4 loops

- **Level of planning**
  - 1: None (Unexpected)
  - 2 to 5: Planned but not scheduled, Planned & scheduled

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Review/Gate parameters

- **Rigidity**
  - Final standard (Rigid criteria)
  - Phase check (Less rigid criteria)

- **Frequency**
  - Frequent (After each phase)
  - Sporadic (After 3 or more phases)
## Parameterized theoretical PDPs

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Waterfall/Stage-gate</th>
<th>Design to Sched/Budget</th>
<th>Evolutionary prototyping</th>
<th>Spiral</th>
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<tbody>
<tr>
<td></td>
<td>Iterations</td>
<td></td>
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<tr>
<td></td>
<td>Breadth</td>
<td>1</td>
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<td>1</td>
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<tr>
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<td>2</td>
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<td>Risk</td>
<td>Profile of key risks</td>
<td>Manages tech risk well</td>
<td>Manages sched./budget risk well</td>
<td>Manages market risk well</td>
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# Parameterized actual PDPs

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</tr>
<tr>
<td>Breadth</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>1</td>
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<tr>
<td># of inter-phase loops</td>
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<td>4</td>
<td>4</td>
<td>3</td>
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<td>Rigidity</td>
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<td>4</td>
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<td>3</td>
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<td>Risk</td>
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<tr>
<td>Profile</td>
<td></td>
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</tbody>
</table>

- **Schedule is king**
- **Market risk dominates**
- **Unknown**
- **Little market ambiguity**
“Tradeoff” in PDP design

- **Predictability**
  - Early spec definition
  - Narrow iteration
  - Frequent, rigid reviews
  - Reduces technical risk

- **Flexibility**
  - Market tests to ensure viability
  - Broad iterations
  - Loose, multi-phase reviews
  - Reduces market risk
IDEO Product Case

- What are the characteristics of the IDEO product development process?
  - ...

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Conclusions

- Preparation and Planning are important
- PDPs are “project plan templates”
- Phase-Gate versus Spiral continuum
- Hybrid forms in real company contexts
- PDP design driven by dominant risks
  - Technical, market, schedule, budget
- Key distinguishers/PDP design factors
  - Iterations: breadth, number, planned/unplanned
  - Gates: rigidity (rigor), frequency