Planning and Executing Fast-Track Projects

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Planning and Executing Fast Track Projects

Outline

- Fast Track Project Case Study: The Lockheed Martin Launch Vehicle
- Techniques for Planning Fast Track Projects
  - PERT Simulation
  - The Critical Chain
  - Systems Dynamics Simulation
  - The VDT/SimVision Project Design Approach
- Appendix
  - Trajectory of Ongoing Project Design Research
Fast-Track Project Case Study: Lockheed Martin Launch Vehicle

- **Goal:** Shrink time-to-market for LMLV by 80% vs. Trident missile!
- **Highly Concurrent:** many interdependent activities must be scheduled concurrently
- **Key components** will be outsourced to minimize cost
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Organization of Avionics PDT
Planning and Executing Fast Track Projects

Converting Strategy into Action

Activity Workflow for Avionics PDT

- Project Manager (1)
- Offshelf SubTeam (ST) (5)
- Cables ST (3)
- Flight Boxes ST (15)
- ElectronicParts ST (6)
- Packaging ST (1.5)

Define Requirements
- Vehicle Avionics Concept
- New Engineering (Cables)
- Reengineering Experiences

Developing Sub-contracts
- Range Requirements
- Physical Mockup

Teaming Agreements
- Procurement

System Integration and Test
- Build and Test Flight Units
- Paint and Physical Mockup

Cables SubTeam (3 FTE)
- Detailed Cable Drw.
- Fabricate and Test Cables

Avionics SubTeam (6 FTE)
- Building and Test Flight Units
- Apply Existing Applications

Flight Boxes ST (15 FTE)
- Build and Test Flight Units

Electronic Parts SubTeam (6 FTE)
- Detailed Cable Drw.
- Fabricate and Test Cables

Packaging ST (1.5 FTE)
- Printed Wiring Board Design
- Printed Wiring Assembly
- Enclosure Design
- Top Assembly

Identify Parts Required
- Search for Vendors
- Prepare Documentation
- Procurement Support

Activity (Total Hours)

Predecessor - Successor relationship

- Offshelf SubTeam (5 FTE)
- Cables SubTeam (3 FTE)
- Flight Boxes ST (15 FTE)
- Electronic Parts SubTeam (6 FTE)
- Packaging ST (1.5 FTE)

- Project Manager (1)
- Offshelf SubTeam (ST) (5)
- Cables ST (3)
- Flight Boxes ST (15)
- ElectronicParts ST (6)
- Packaging ST (1.5)
Case Study Results:

*Lockheed Martin Launch Vehicle*

- LMLV1 launched in mid-April 1996 – almost **4 months later** than planned
- Launch vehicle “departed controlled flight” and **had to be detonated** by AF safety officer
- Analysis of telemetry data indicated most likely cause of failure to be a **misrouted cable** that shorted out!
Analysis Tools Can Enable “Project Design”

- **Conceptual Design**
- **Detailed Design and Execution**
- **Closeout & Learning**

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- **Level of Influence**
- **Expenditure of Funds**
- **Outcome Predictions**
- **Analysis Tools**
- **Outcome Knowledge**
Fast Track Projects Are Information-Intensive

Product

High performance, complex product has high level of inter-dependency between its subsystems

Process

Fast-track schedule triggers unplanned coordination and rework for project organization

Organization

Project team must process large amount of information under extremely tight time constraints
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The Challenge of Fast-Track Projects: “Concurrent Engineering” Incurs Large Overheads

CPM View of Fast-Track Project work—Overlapped Activities

Reality of fast-track project work!

Increased Coordination
Increased Rework
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PERT Simulation

- Assume each activity has a variable duration that is described by a probability distribution (Gamma) as follows:

- Perform a large number of PERT simulations (~1,000)
  - Independently sample each activity’s duration
  - Perform a standard CPM analysis, using the sampled duration for each activity
  - Use multiple (~1,000) CPM analyses to compute probability distributions of project duration and activity criticality
What Would PERT Simulation Have Told Lockheed Managers?

- “There is uncertainty in project completion time”

- “Some near-critical activities may become critical”
  - Fast-track projects usually have multiple near-critical paths
  - A “criticality index” is computed for each activity, equal to the % of simulation trials in which it was critical
Pros & Cons of PERT Simulation for Fast-Track Projects

Pros:
- Shows how uncertainty in task durations affects uncertainty of project completion date
  - A straightforward extension of CPM approach and tools

Cons:
- Assumes that activity durations vary independently
  - Does not model fundamental causes of variation in activity durations (e.g., poor designs, key skill deficits, bad weather, ...)
  - Does not reflect that fact that positive or negative risk factors ("knights and villains") will impact multiple activities
  - Gives managers no guidance about where/how to intervene
- Assumes no effects of executing activities in parallel vs. in sequence
  - Provides no insights about the hidden cost of more aggressive fast-tracking (concurrent task scheduling)
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Critical Chain* Concepts—1

- Remove hidden safety from task estimates

- Eliminate multitasking

* Sources: Eliyahu Goldratt, “The Critical Chain,” and Scitor Corporation Web Site)
Critical Chain* Concepts—2

- Plan backward from required completion date
- Calculate the Critical Chain (the resource constrained critical path)

* Source: Eliyahu Goldratt, Scitor Corporation Web Site
Critical Chain* Concepts—3

- Insert Project Buffer at end of critical chain; and insert Feeding Buffer at end of all non-critical chains

* Source: Eliyahu Goldratt, Scitor Corporation Web Site

Track consumption of buffers during project
What Could Critical Chain Analysis Have Told Lockheed Managers?

- **During the Planning Stage**
  - “Start some project activities earlier!”
  - Earlier start time may not have been feasible.

- **During the Execution Stage**
  - “Cable team project and feeding buffers are being consumed by activity overruns!”
  - Analysis could have alerted managers earlier in the project to bring in extra cable resources.
of Critical Chain for Fast-track Projects

- Highlights latest starts
- Shows impact of eliminating multi-tasking
- Tracks impact of activity delays on buffers
- Does not relate size of buffer in Feeder Chain or Critical Chain to degree of complexity or interdependence of activities in that chain
- Does not predict relative schedule risks of particular activities or chains in advance—vs. “task criticality” in PERT Simulation
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System Dynamics Approaches

- Model projects as “stocks and flows” of work, resources, information, motivation, etc.
- Express relationships between variables as arbitrarily simple or complex finite difference equations

What Would a System Dynamics Model Have Told Lockheed Managers

- Showed impacts of **positive and negative feedback loops on performance**
- Show impacts of **delayed feedback loops**—(oscillation)
- Could provide insights about overall schedule risks due to fast-tracking this project
- Unlikely to have identified specific problems in this case

*Source: “The Rework Cycle: Why Projects Are Mismanaged” by Kenneth Cooper, PMNet*
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Pros & Cons of System Dynamics for Fast-Track Projects

Pros

- System Dynamics is a broadly applicable simulation language
  - SD has been applied to problems as diverse as business supply chains (e.g., “The Beer Game”) and natural ecosystems (e.g., sustainability of fisheries, forests, …)

Cons

- System Dynamics is a broadly applicable simulation language
  - No built-in objects or behaviors to model projects in detail
  - Insights it can provide about projects tend to be generic and high level (e.g., rework example)
  - “Stocks & flows” architecture is ideally suited for modeling flows of goods & info in ecosystems or supply chains
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VDT Project Design Case Study: *Lockheed Martin Launch Vehicle*

**Project Design Approach**

- **Model** planned fast-track work process and proposed organization realistically

- **Simulate** organization executing work process to predict schedule/quality risks

- **Compare** predicted performance vs. plan, and “intervene” to mitigate risks

- **Iterate** to find “optimal” project design
LMLV Project Avionics Team: VDT/SimVision Model

- Start
- New Engineering
- Vehicle Avionics Concept
- Reengineering Experiences
- Apply Existing Applications
- Re-engineering Experiences
- Experiences
- Define Interfaces
- Detailed Cable Drawings
- Fabricate and Test Cables
- Identify Parts Required
- Search for Vendors
- Prepare Documentation
- Procurement Support
- Production Enhancements
- Build and Test Flight Units
- System Integration & Test
- Project Management
- Avionics PM

Scenario 1 Properties
- General
- Organization
- Probabilities
- Simulation Settings
- Centralization: Medium
- Formalization: Low
- Team Experience: Medium
- Matrix Strength: High
LMLV Project: Actor Backlogs

Actor Backlog
Lockheed Avionics - Scenario-1 - Baseline

- Avionics Project Manager
- Cables Sub-team
- Electronic Parts Sub-team
- Flight Box Sub-team
- Off Shelf Sub Team
LMLV Project: Process Quality Risks

Activity Communication Risk
Lockheed Avionics - Scenario-1 - Baseline

- Fabricate and Test Cables
- Define Interfaces
- Detailed Cable Drawings
- Vehicle Interconnect Layout
- Vehicle Avionics Concept
- Project Management
- Developing Subcontracts
- New Engineering
- Teaming Agreements
- System Integration & Test

missed communications / total communications

- 0 to 0.25
- 0.25 to 0.5
- 0.5 to 0.75
- 0.75 to 1.0
Project Design Guides Managerial Interventions

“What-if Analysis” of LMLV Avionics Team

<table>
<thead>
<tr>
<th>Intervention</th>
<th>Better</th>
<th>Worse</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase Cable Subteam staffing from 3-5 engineers</td>
<td>9%</td>
<td>0%</td>
</tr>
<tr>
<td>Replace 3 Cable Subteam members with 3 more experienced engineers</td>
<td>0%</td>
<td>5%</td>
</tr>
</tbody>
</table>

- Cost
- Duration
- Except's
Lockheed Martin Launch Vehicle: Project Design Results

- Simulated organization executing work process to predict schedule and quality risks
  - VDT/\textit{SimVision} predicted launch date delay to within a few days, one year ahead!
  - VDT/\textit{SimVision} identified cable team quality risk that ultimately caused LMLV to fail!
- Predicted performance impact of two potential managerial interventions (although these results were not used)
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But Project Participants also Coordinate. And they Generate & Handle Exceptions

Project Participants Perform Assigned Tasks

“Exception”

(Jay Galbraith, 1974)
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Info. Volume is Derived from Project Tasks: Direct Work, Communications, Rework
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**Team Information Processing Capacity is Derived From:**

- # Actors
- Skill Set
- Experience
- Structure
- Policies

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**Actor Properties**

**Name**: Design PM

**Role**: SL

**Skill**
- Design Coordination: High
- Architectural: Medium
- Biotechnology: Low
- Mechanical: Low

**Centralization**: High

**Formalization**: Low

**Team Experience**: Medium

**Matrix Strength**: High

**Scenario-1 Properties**
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VDT/SimVision Information Processing Model:
Team IP Capacity >= Task IP Demand?
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Predictions from VDT/SimVision Project Design Approach

Model

Simulation Results

Activity Cost Breakdown
\texttt{Asic2p1 - Scenario-1}

- FloorPlanning
- FullChipSynth
- Synth_B1RTL
- Write_B1RTL
- Design Coordination
- Sim Gates
- Gen Test Suite
- Verify_B1RTL
- Develop Specification
- Verify RTL

- Work
- Rework
- Coordination
- Decision Wait
Steps in VDT/SimVision Project Design

- Identify client’s key business issues and risks
- Develop Flexibility Matrix and trade-offs

**Model “Baseline Case”**
- Lay out 5-10 key business milestones per project
- Identify and sequence 5-10 activities per milestone
- Lay out organization:
  - structure, positions, capacity, skills, decision making policies
- Assign each task to **one responsible position**

- “Flight-simulate” Baseline Case
  - Diagnose backlogs, schedule and quality risks
  - Explore potential interventions to mitigate risks

- Choose a project design that is likely to succeed
# Level of Effort for Project/Program (Re)Design

<table>
<thead>
<tr>
<th>Elements of Fast-Track Program Design and Redesign</th>
<th>Client Effort (FTE-days)</th>
<th>Analyst Effort (FTE-days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gather data from client about business objectives, milestones, tasks, costs, staffing, known risks, etc.</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Build “straw-man” as-planned, baseline model</td>
<td>0</td>
<td>1-2</td>
</tr>
<tr>
<td>Discuss and refine model</td>
<td>0.5</td>
<td>1-2</td>
</tr>
<tr>
<td>Diagnose risks with baseline case</td>
<td>0.25</td>
<td>0.5</td>
</tr>
<tr>
<td>Evaluate multiple potential interventions</td>
<td>0.25</td>
<td>0.5</td>
</tr>
<tr>
<td>Produce recommendations and report</td>
<td>0</td>
<td>1.0</td>
</tr>
<tr>
<td><strong>Ongoing Redesign (Tracking) per cycle</strong></td>
<td><strong>0.5</strong></td>
<td><strong>1.0</strong></td>
</tr>
</tbody>
</table>
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VDT Fast-Track Project Design: Examples

- Reduce time to market for complex manufacturing facilities
- Facilitate roll-out of new wireless telecom infrastructure across multiple regions
- Develop best practices template to accelerate factory start-ups
- Identify and correct subcontractor management problem that would have delayed project 4 mo.
- Help to meet ship milestone date required to close sale with large customer
- Align goals and accelerate rollout of innovative consumer product by 3 months
- Identify and mitigate critical quality risks to accelerate rollout of new server product
- Help to define scope, schedule and organization for strategic IT projects
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✓ & ✖ of VDT/SimVision for Fast-Track Projects

✓ VDT/SimVision uniquely highlights impact of fast-track work process on cost, schedule and process quality

✓ VDT/SimVision shows impacts of differences in participants skills & experience on project outcomes

✓ Small models and graphical inputs/outputs engage executives in project design process

✗ Models only organizational risks—not technical or market risks (these risks require separate “scenarios”)

✗ VDT organizational model assumes hierarchical exception handling
Analysis Tools Can Support “Fast-Track Project Design”

- PERT Simulation
- Critical Chain
- System Dynamics
- Virtual Design Team
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Appendix

- Trajectory of Ongoing Project Design Research
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Trajectory of Past VDT Project Design Research

- More Impact of IT/Communication technologies
- More Impact of Social Processes
- More Innovative Work Processes
- More Flexible Organizations

- 95-99: Thomsen Salazar-Kish
- 96-99: Fridsma/Cheng
- 97-00: Miller
- 99-02: Lambert Buettner

- 90-94: Cohen/Christiansen
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Ongoing Stanford Project Design Research

Direct Costs

Institutional Costs

Coordination Costs

21st Century “Global Change” Projects

* Effects of Institutional Complexity

Complex, Fast-Track “Engineering Projects”

* Effects of Coordination complexity

$, ¥, €, …
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