Lecture 10: Prototypes

Prototyping

- Role of prototyping in the design process
- Selecting the correct prototyping strategy
- Linkage with design strategy: early or late concept lock

- Assignment
  - You need to develop the right prototypes
  - Need to justify why you are doing the prototype you are doing

Prototyping as a management tool

- Improve efficiency of the PDP
- Increased learning
  - provides a more certain metric about the quality of the product
  - feed back problems to the functional and product teams
- Communication
  - becomes a common metric or language for all functional groups
- A metric for how well the design process is going

Prototypes as a risk mitigation strategy

- Certain characteristics of the product are high risk items.
- Risk = probability of failure * cost of failure
- Prototypes move the measure of probability from an uncertain value (.50) to a certain value (1 or 0).
- Key question:
  - How much are you willing to pay to reduce the uncertainty around failure

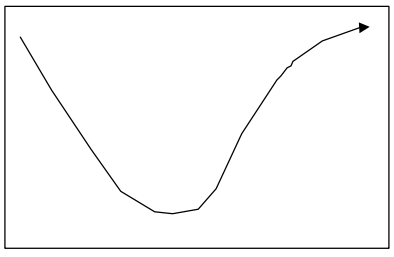
Prototyping as a Real Option

- By the option to avoid a problem later on
- The option may or may not be ultimately valuable
- The greater the uncertainty (the higher the cost), the more valuable the option is

Three Stages of Prototyping

- Concept
  - aesthetics
  - shape
- Function/Engineering
  - performance
- Production
  - producibility

Concept -> Eng. -> Production



Customer prototypes
What does the customer think

IPPD 3/9/00 Prototypes

- Industrial design - “look and feel”
  - Renderings - sketch
  - Sketch models - quick 3-D sketch
  - Foam models - models that have the look and feel but no functionality
  - Functional prototypes - models that have look feel and key functionality

Functional Prototypes
Does it function correctly

IPPD 3/9/00 Prototypes

- Virtual
  - Crash simulation
  - VSA
- Physical
  - Crash test samples
  - Breadboards

- Piece Part
  - simulate individual part behavior
  - durability tests on intermediate shafts
- System
  - simulate how the whole system works together
  - i.e., road handling

Verification / Conformance testing
does it function
Robustness / representative testing
does it function under
stress
process variation
time

Production Prototypes
Can you produce it efficiently

- Made using production equipment
- Used to highlight risk of expensive assemblies
- Very expensive because tooling is expensive

Supplier problems

- Often suppliers making prototypes are different from those making the final tooling
- Pros
  - turn-around time is shorter for prototypes
  - “quality” of prototypes is better
- Cons
  - no learning by final suppliers
  - no teaching by final suppliers

Two prototype types

- Prototype as master model
  - high quality as possible
  - built to validate the design
  - production tries to mimic quality in prototype
- Prototype as problem detector
  - built with production equipment
  - built to validate the design under production conditions

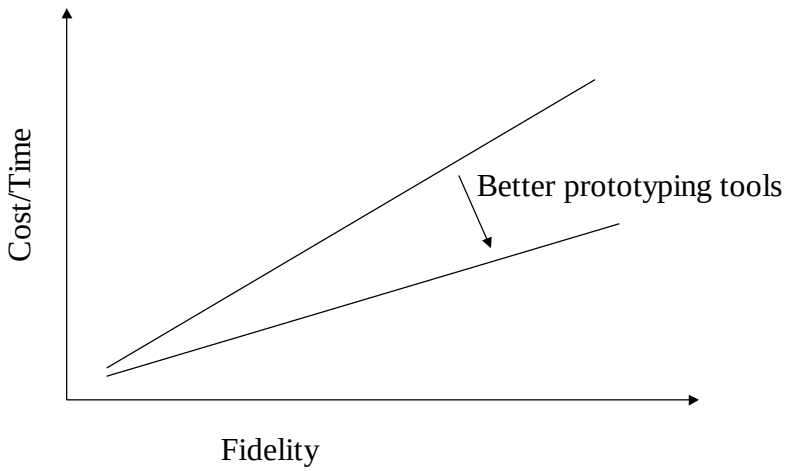
Prototype Metrics

- Fidelity
  - How accurately does the prototype represent the
    - function
    - look
    - production intent
- Time
  - Drives learning cycles
  - "This is representative of the design 10 weeks ago but so many changes have happened, it is invalid"
- Cost

Prototype fidelity

- Examples
  - Sterolithography - good at look, medium at function, bad at production intent, fast to produce, medium expense
  - soft tooling - good at look, medium at function, medium at production intent, slow to produce, expensive

Prototyping improvements



Best practice characteristics

- Proper level of prototyping picked
  - lowest cost/shortest time prototype that will answer the questions
- Production intent as early as possible
- Timing
  - do not overlap prototype cycles
  - time with design reviews
- Propagate learning through the organization

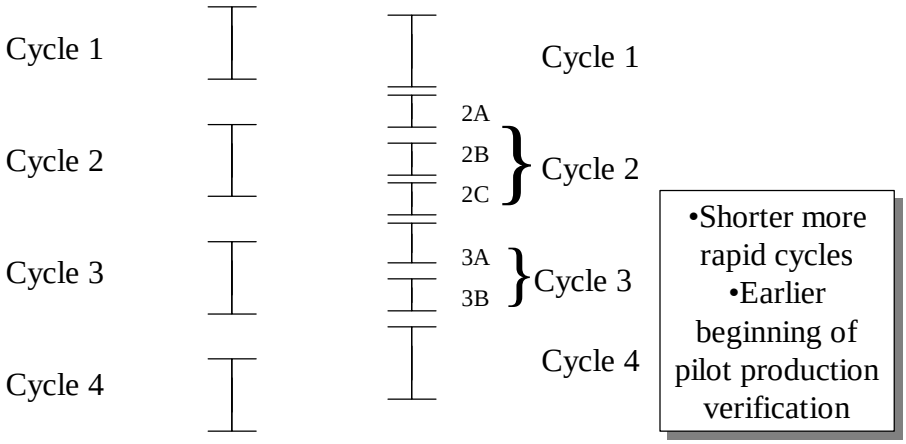
Who should be involved

- Middle prototypes (functional) are
  - primarily for engineering
  - contain significant information for manufacturing
- Who should build it
  - Outsourced/Vendor
    - good: range of capability
    - bad: learning
  - Model shop
    - good: internal learning
    - bad: manufacturing intent
  - Plant

Future of prototyping

- Rapid prototyping technologies
  - part printing
  - printing tooling
  - problems
    - the material characteristics are different
    - expensive
    - still time consuming
- Rapid cutting technologies
  - high speed machining
  - high speed CNC path generation
  - make parts and tools out of final materials

Periodic Prototyping



Types of prototypes

IPPD 3/9/00 Prototypes

Types of prototype	Role	Benefits	Problems
Scale model	• Drag/fluid models	• inexpensive	• scale up effects • see the system • time consuming
Engineering	• System performance	• Focus on performance • Shorter lead times	• Don't reflect producibility • Requires specialized skills
Conceptual	• Look/feel	• Show the ID of the product	• No indication of performance
Production	• producibility	• Shows production problems	• Very expensive • Unable to change product types
Mechanical Elements	• Performance of sub-system	•	• Doesn't capture the system
Computer based	• Performance / rapid iteration	• Cheep • Good for comparisons	• Don't reflect *actual* performance • accepted after time • Ghosts • Not trusted

Prototype strategies

IPPD 3/9/00 Prototypes

Strategy	benefits	problems
Big gain vs. continual improvement	•	•
Early production prototypes	• Detect problems earlier • Design in electrons	• If there is a change prototypes invalidate designs
Postpone production	• Lower cost • Design in metal	• Unexpected problems
Suppliers make protos	• better learning	• loose control of the learning
Small changes "seat changes"	• Easier to find difference and fine tune	• Locking out other possible configurations
Delay second	• Don't commit to design	• Don't have the benefit of learning
Representation	• captures production (early detection)	• changes to design is hard
Conformace (proto as master)	• Captures the design intent/explre design	• hard to manufacture
Two different	• Explore more concepts	• Inability to isolate fine tuning

Questions

- What strategy would you use in New Zealand
- Are the problems BMW is facing the same as New Zealand
  - what are the similarities
  - what are the differences

Key points

- Prototypes are “investments” that whose return is information and uncertainty reduction. In addition it finds problems that couldn’t be detected
  - tradeoffs/performance can’t be predicted with simple models
    - non-linear, highly constrained, highly coupled problems
    - function is not quantifiable “ride” “fee” “look”
- Change in competitive field changes the design/prototyping strategies
  - time, $, quality goals
  - push into more “non-hardware” work
- Used to validate designs when the cost of getting it wrong is very high
- Prototypes are on the critical path -- shorten prototype time, shorten design time
- Integral to the design process
- Prototypes are used to reduce uncertainty
- Design-test-refine cycle

Lecture 11: Tools and methods

- Newbold, R. C. Project Management in the Fast Lane: Applying the theory of constraints The St. Lucie Press/APICS Series on Constraints Management 1998 31-39, 79-89

- What are the difference between critical chain and other scheduling.
- What are the benefits
- What is required to execute the projects in this mode?