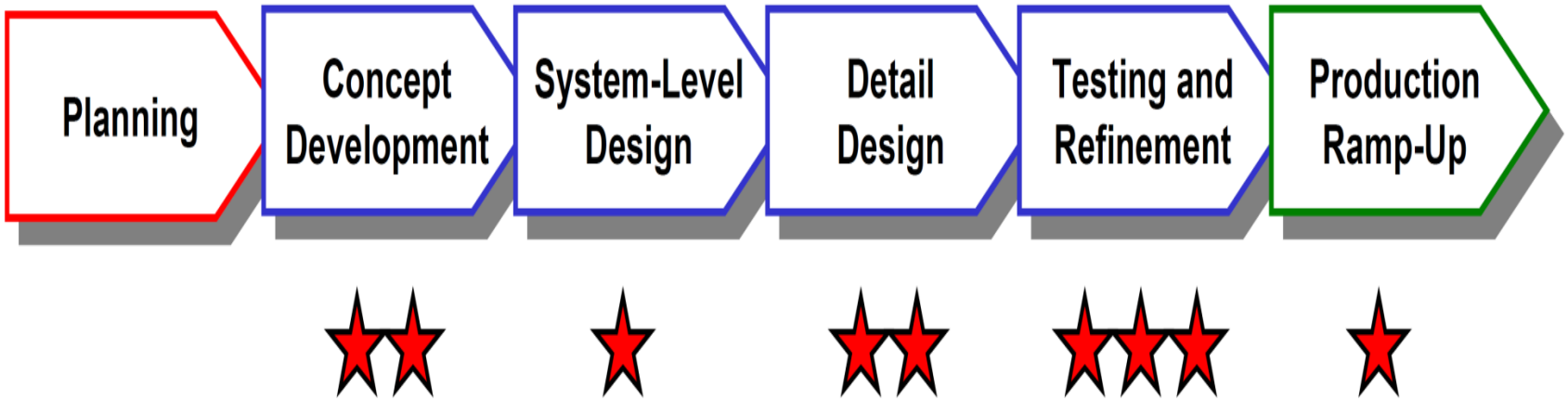
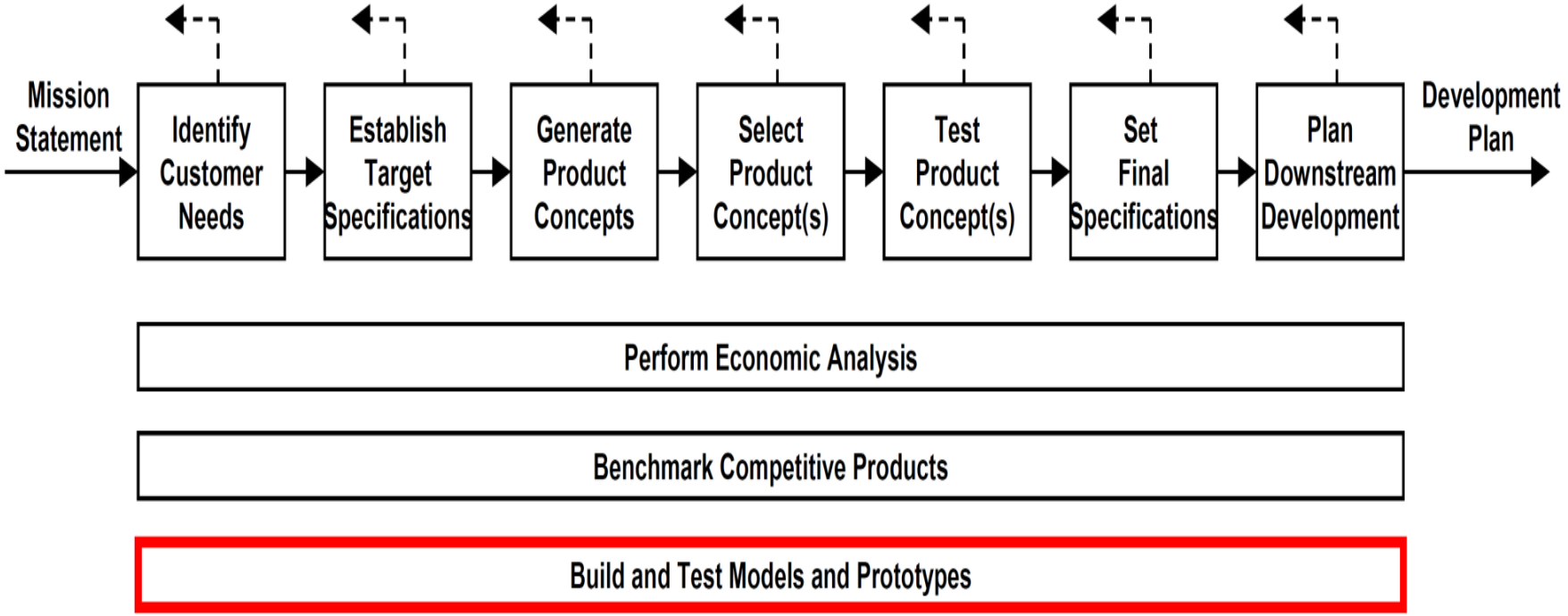
Prototyping

Product Development Process



Prototyping is done throughout the development process.

Concept Development Process



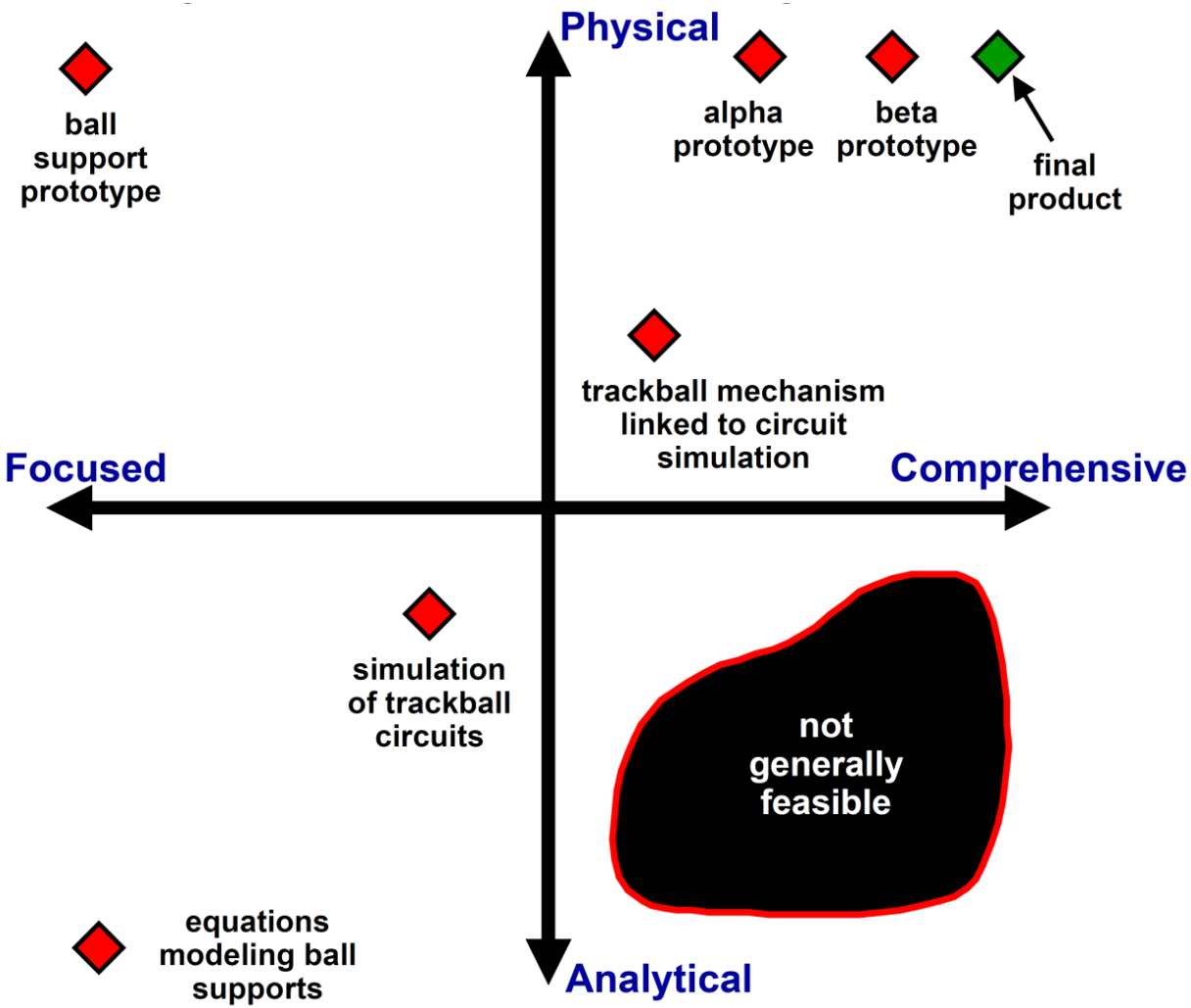
- Prototype is an approximation of the product along one or more dimensions of interest. Any entity that exhibits some aspect of product that is of interest to the development team can be viewed as prototype. It ranges from concept sketches to fully functional product.

Prototyping Example: Apple PowerBook Duo Trackball

Four Uses of Prototypes

- Learning
  - Answering questions about performance or feasibility
  - E.g., proof-of-concept model
- Communication
  - Demonstration of product for feedback
  - E.g., 3D physical models of style or function
- Integration
  - Combination of sub-systems into system model
  - E.g., alpha or beta test models
- Milestones
  - Goal for development team's schedule
  - E.g., first testable hardware

Types of Prototypes



Physical vs. Analytical Prototypes

Physical Prototypes

- Tangible approximation of the product.
- May exhibit unmodeled behaviour.
- Some behaviour may be an artifact of the approximation.
- Often best for communication.

Analytical Prototypes

- Mathematical model of the product.
- Can only exhibit behaviour arising from explicitly modelled phenomena. (However, behaviour is not always anticipated.
- Some behaviour may be an artifact of the analytical method.
- Often allow more experimental freedom than physical models.

Focused vs. Comprehensive Prototypes

Focused Prototypes

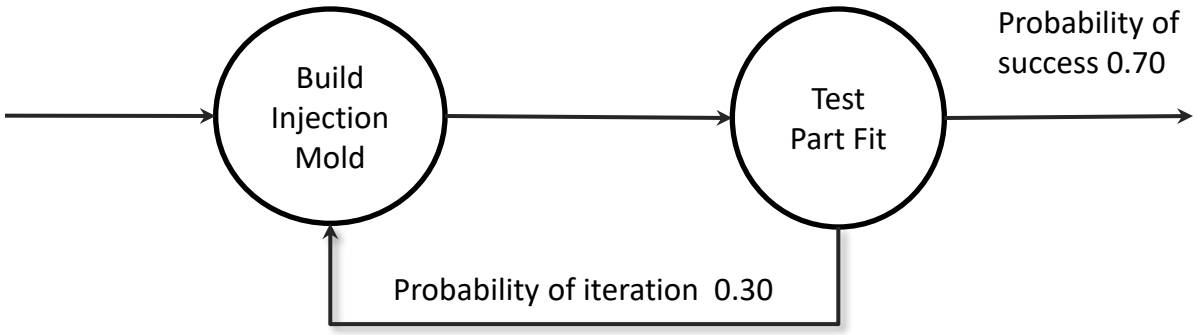
- Implement one or a few attributes of the product.
- Answer specific questions about the product design.
- Generally several are required.

Comprehensive Prototypes

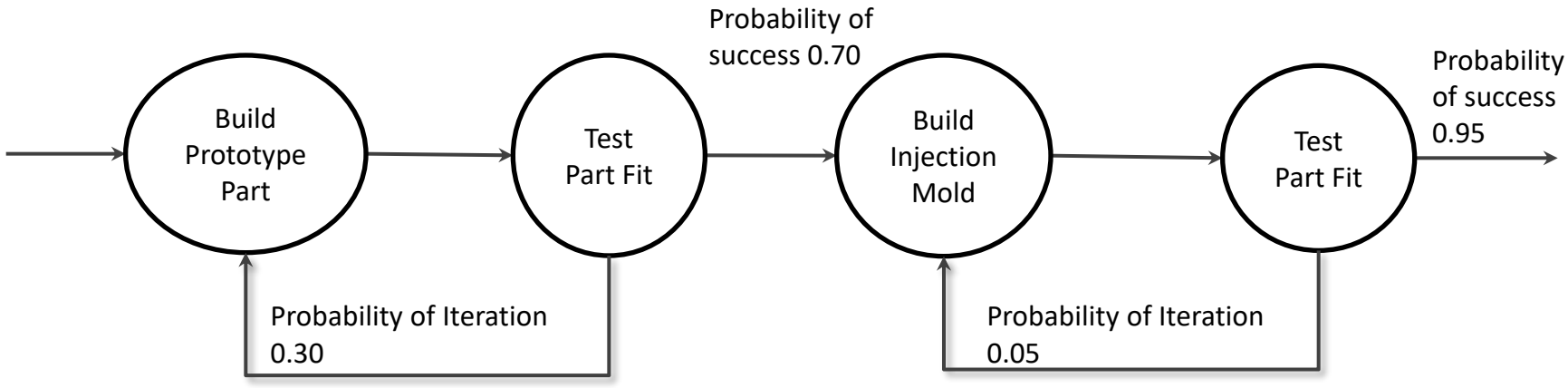
- Implement many or all attributes of the product.
- Offer opportunities for rigorous testing.
- Often best for milestones and integration.

Principles of Prototyping

- Analytical prototypes are generally more flexible than physical prototype
- Physical prototypes are required to detect un anticipated phenomena
- A prototype may reduce risk of costly iterations
- A prototype may expedite other development steps
- A prototype may restructure task dependencies

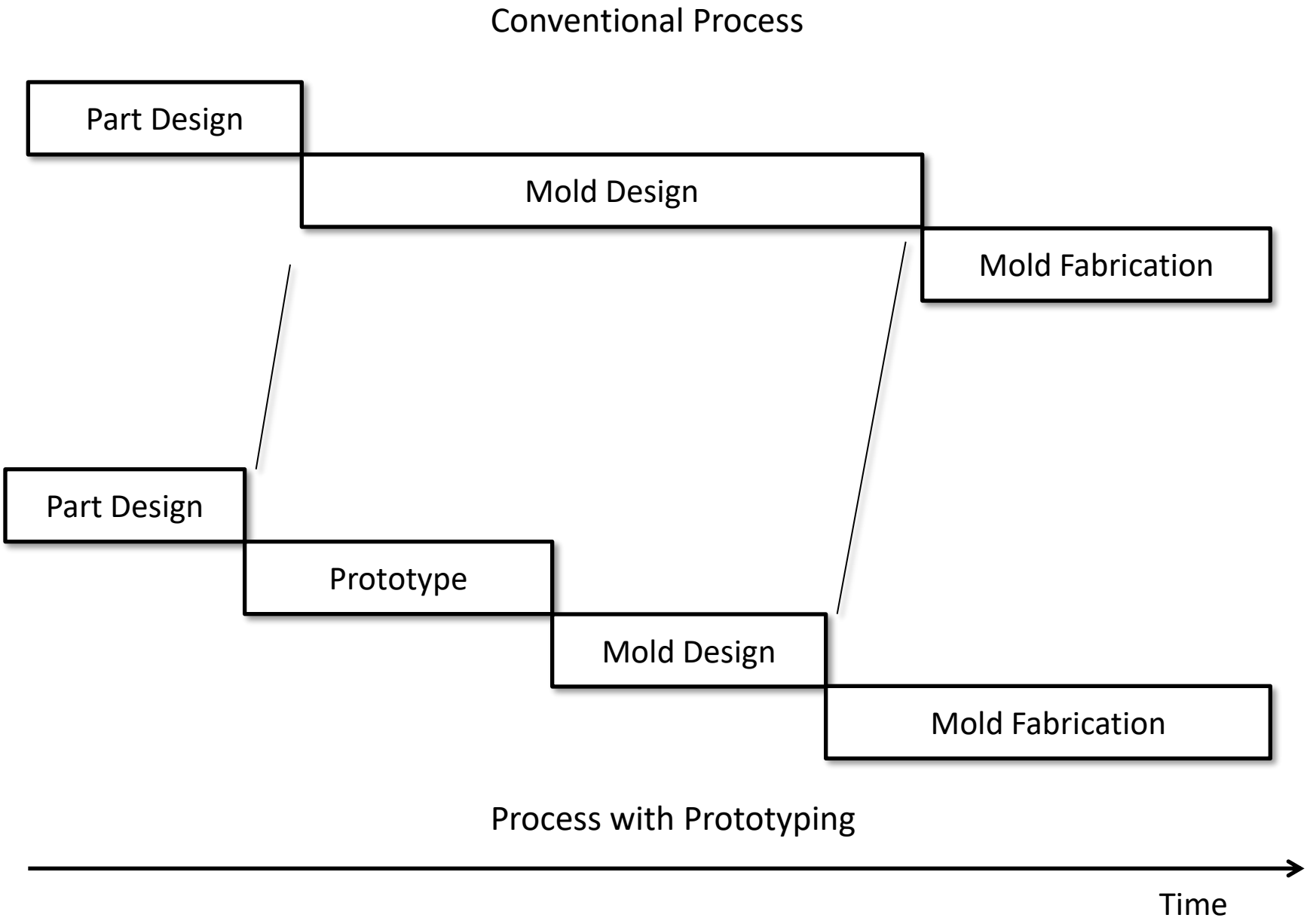


Conventional Process

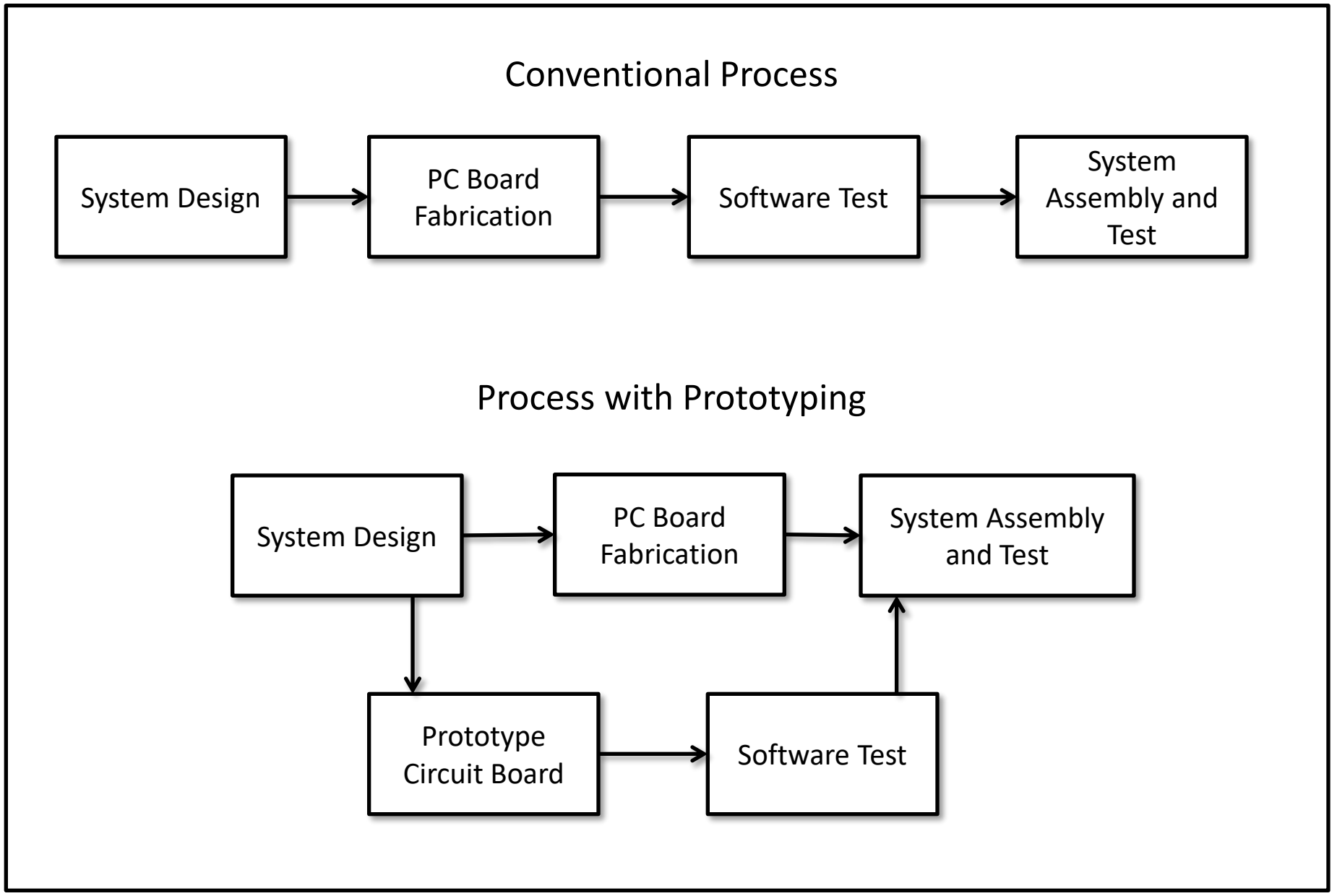


Process With Prototyping

A prototype may reduce the risk of costly iteration



Role of a prototype in expediting another step



Use of a prototype to remove a task from the critical Path

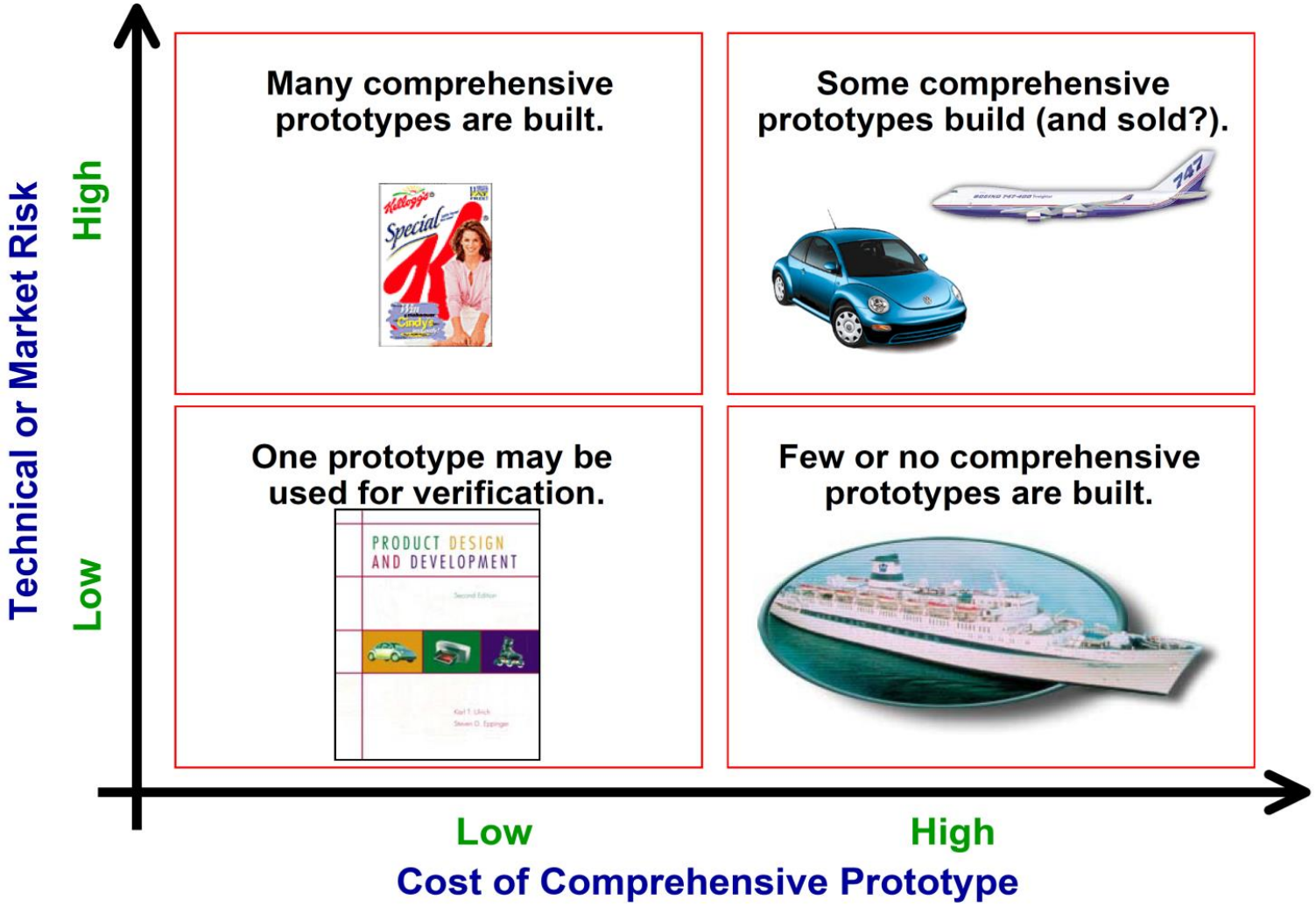
Planning for Prototypes

- A potential pitfall in product development is known as “hardware swamp”. The swamp is caused by misguided efforts, i.e., building and debugging prototypes that do not contribute to the goals of overall product development
  - Define the purpose of prototype
  - Establish the level of approximation of the prototype
  - Outline an experimental plan
  - Create a schedule for procurement, construction and test.

Boeing 777 Testing

- Brakes Test
  - Minimum rotor thickness
  - Maximum takeoff weight
  - Maximum runway speed
  - Will the brakes ignite?
- Wing Test
  - Maximum loading
  - When will it break?
  - Where will it break?

Comprehensive Prototypes



Prototyping Strategy

- Use prototypes to reduce uncertainty.
- Make models with a defined purpose.
- Consider multiple forms of prototypes.
- Choose the timing of prototype cycles.
  - Many early models are used to validate concepts.
  - Relatively few comprehensive models are necessary to test integration.
- Plan time to learn from prototype cycles.
  - Avoid the “hardware swamp”

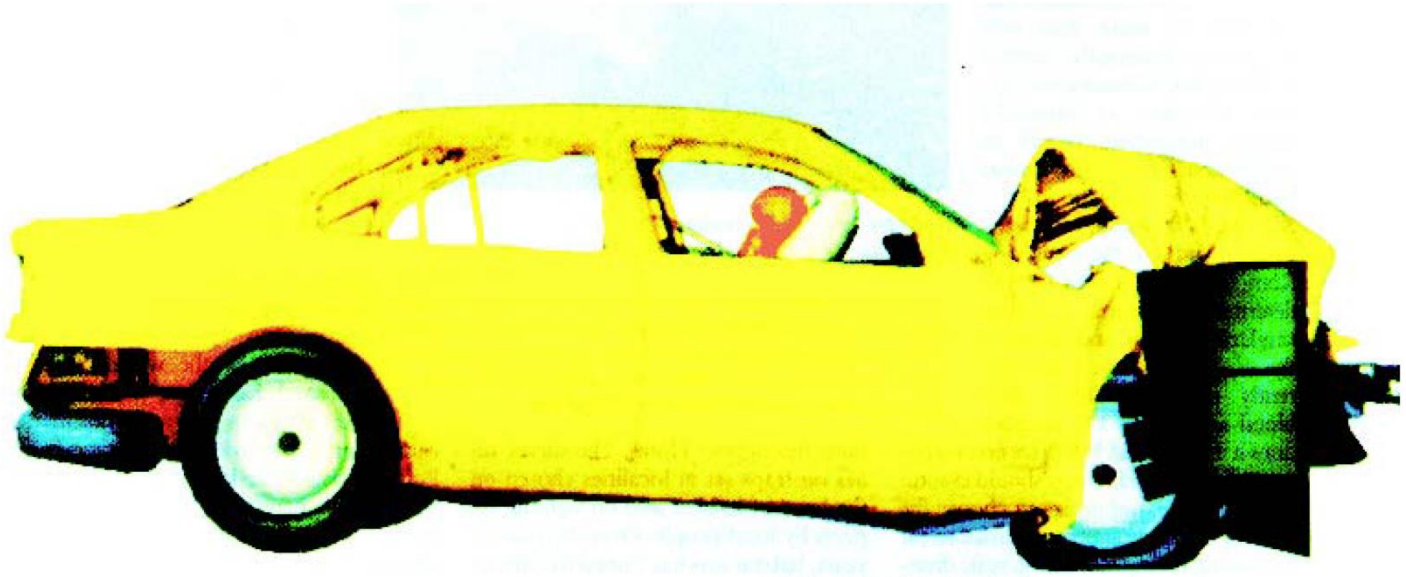
Rapid Prototyping Methods

- Most of these methods are additive, rather than subtractive, processes.
- Build parts in layers based on CAD model.
- SLA=Stereo Lithography Apparatus
- SLS=Selective Laser Sintering
- 3D Printing
- LOM=Laminated Object Manufacturing
- Others every year...

Virtual Prototyping

- 3D CAD model enable many kinds of analysis:
  - Fit and assembly
  - Manufacturability
  - Form and style
  - Kinematics
  - Finite element analysis (stress, thermal)
  - Crash testing
  - More every year…

BMW Virtual Crash Test



From : Scientific American, March 1999

Traditional Prototyping Methods

- CNC machining
- Rubber molding + urethane casting
- Materials: wood, foam, plastics, etc.
- Model making requires special skills.