Design Methodology in the Development of Mechatronic Products

- Part 1

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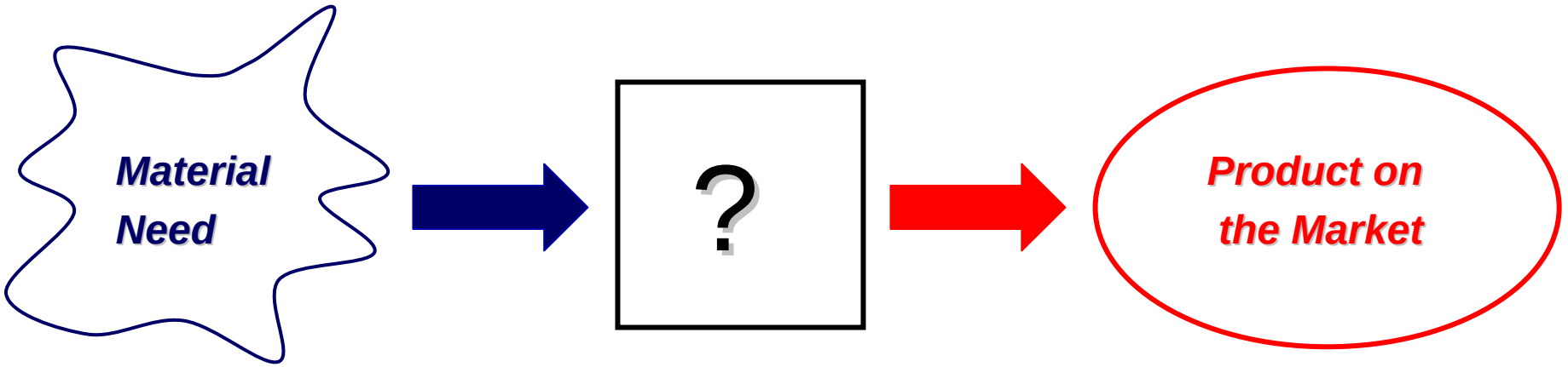
Agenda

- *On the Industrial Development of Products*
- *Some Basic Concepts Regarding Design and Development*
- *The Generic Development process by Ulrich and Eppinger*
- *Adapting the Generic Product Development Process*

The Industrial Development process - Prolog

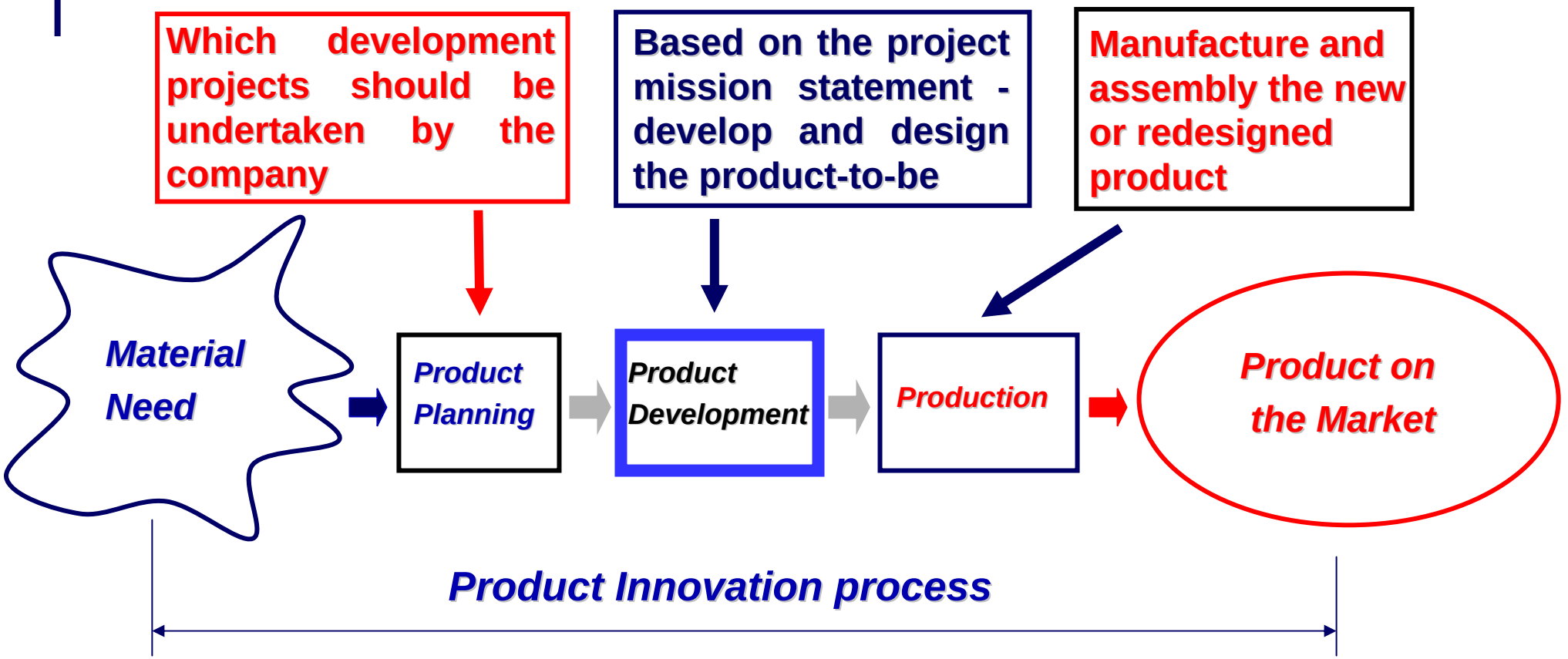
The Industrial Development Process



The industrial development process – one process or a number of subprocesses?

Explain each subprocess - in terms of what to accomplish during each of the processes?

The Overall Industrial Development Process



What is a Product – in the Given Context?

Product – is something *sold by an enterprise to a customer* – here an *artifact!*

Product development **–** is a *set of activities* beginning with the perception of a market opportunity and ending in the production, sale and delivery of the product.

Products – are here constrained to those *engineered, discrete and physical!*

The Development Process and the Product Technology

Is the origin of the technology applied in a product influencing the structuring and contents of the development process – especially with focus on engineering design?

Consider the following main product areas:

- *Electronics*
- *Software*
- *Mechanical products*
- *Civil Engineering products*
- *Pharmaceuticals*
- *Food and Diary products*

What about MECHATRONICS?

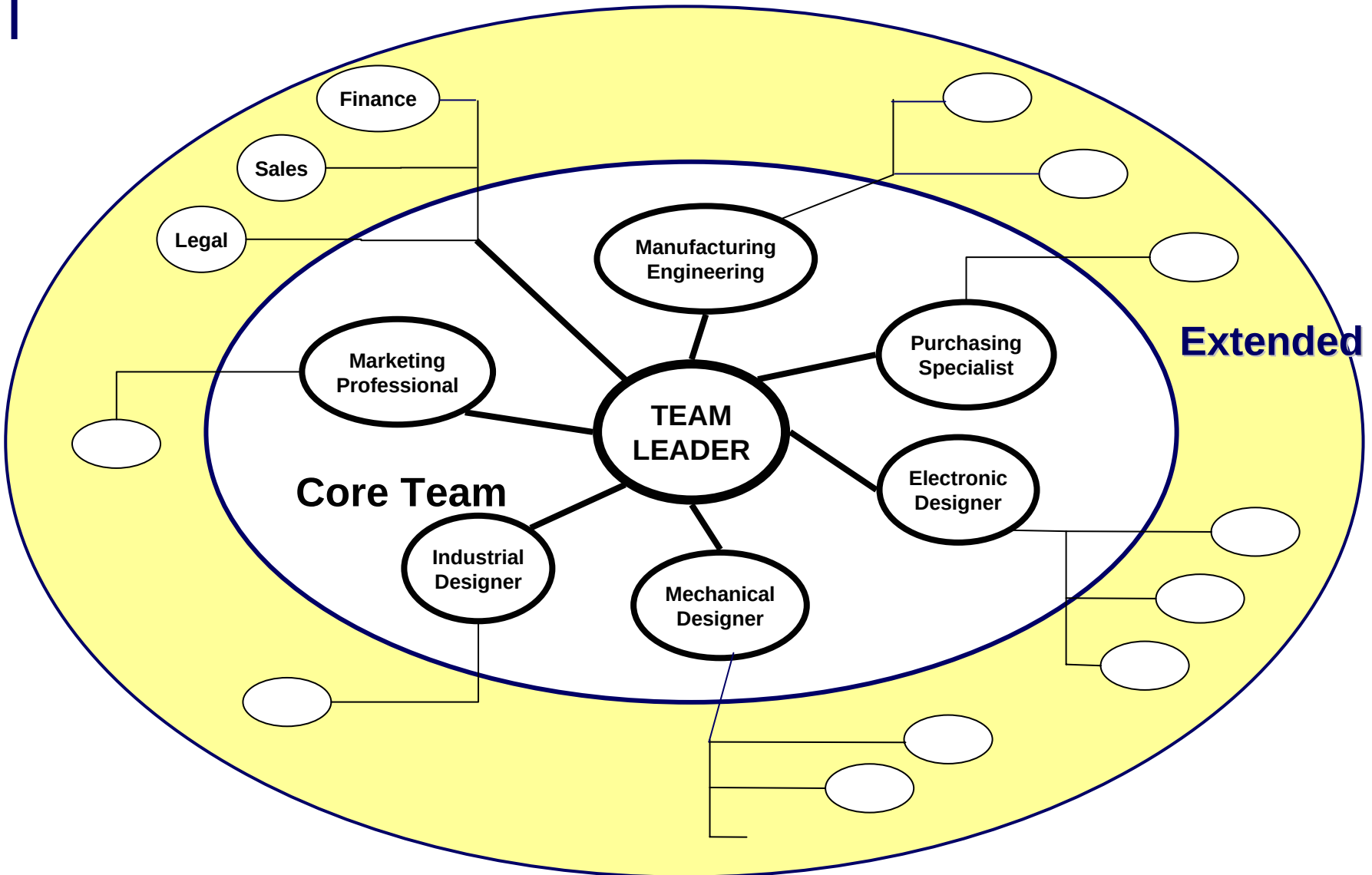
Who Designs and develop products?

The main ***functions*** in a company involved in the development and design of products are:

- ***Marketing*** – mediates the interactions between the firm and its customers.
- ***Design*** – plays the lead role in defining the *working principle and the form of the product* to best meet customer needs. Includes both Engineering design as well as Industrial design.
- ***Production*** – is primarily responsible for designing and operating the production system in order to produce the product. Includes both Manufacturing and Assembly.

From the book *Product Design and Development* by Ulrich & Eppinger

Who Design and Develops Products?



Characteristics of Successful Product Development

The following ***5 dimensions*** – all ultimately related to profit - are commonly ***used to evaluate the performance of a product development project:***

- ***Product quality*** - How good is the product resulting from the development effort?
- ***Product costs*** – What is the manufacturing cost of the product?
- ***Development time*** – How quickly did the team complete the product development effort?
- ***Development costs*** – How much did the firm have to spend to develop the product?
- ***Development capability*** - Are the team and the firm better able to develop future products as a result of their experience with the product development project?

Duration and Cost of Product Development

	Stanley Tools Jobmaster Screwdriver	Rollerblade In-Line Skate	Hewlett-Packard DeskJet Printer	Volkswagen New Beetle Automobile	Boeing 777 Airplane
Annual production volume	100,000 units/year	100,000 units/year	4 million units/year	100,000 units/year	50 units/year
Sales lifetime	40 years	3 years	2 years	6 years	30 years
Sales price	$3	$200	$300	$17,000	$130 million
Number of unique parts (part numbers)	3 parts	35 parts	200 parts	10,000 parts	130,000 parts
Development time	1 year	2 years	1.5 years	3.5 years	4.5 years
Internal development team (peak size)	3 people	5 people	100 people	800 people	6,800 people
External development team (peak size)	3 people	10 people	75 people	800 people	10,000 people
Development cost	$150,000	$750,000	$50 million	$400 million	$3 billion
Production investment	$150,000	$1 million	$25 million	$500 million	$3 billion

The Challenges of Development

- ***Trade-offs***
  An airplane can be made lighter, but this action will probably increase manufacturing cost.
- ***Dynamics***
  Technologies improve, customer preferences evolve, competitors introduce new products, and macroeconomic environment shifts.
- ***Details***
  The choice between using screws or snap-fits on the enclosure of a computer printer can have economic implications of millions of dollars.
- ***Time pressure***
  Any one of these difficulties would be easy manageable by itself given plenty of time, but product development decisions must usually be made quickly and without complete information.
- ***Economics***
  Developing, producing, and marketing a new product requires a large investment. To earn a reasonable return on this investment, the resulting product must be both appealing to customers and relatively inexpensive to produce.

From the book *Product Design and Development* by Ulrich & Eppinger

The Challenges of Development cont.

- ***Creation***

  The product development process begins with an idea and ends with the production of a physical artifact. When viewed both in its entirety and at the level of individual activities, the product development process is intensely creative.

- ***Satisfaction of societal and individual needs***

  All procedures are aimed at satisfying needs of some kind. Individuals interested in developing new products can almost always find institutional settings in which they can develop products satisfying what they consider to be important needs.

- ***Team diversity***

  Successful development requires many different skills and talents. As a result, development teams involve people with a wide range of different training, experience, perspectives and personalities.

- ***Team spirit***

  Product development teams are often highly motivated, cooperative groups. The team members may be colocated so they can focus their collective energy on creating the product. This situation can result in lasting camaraderie among team members.

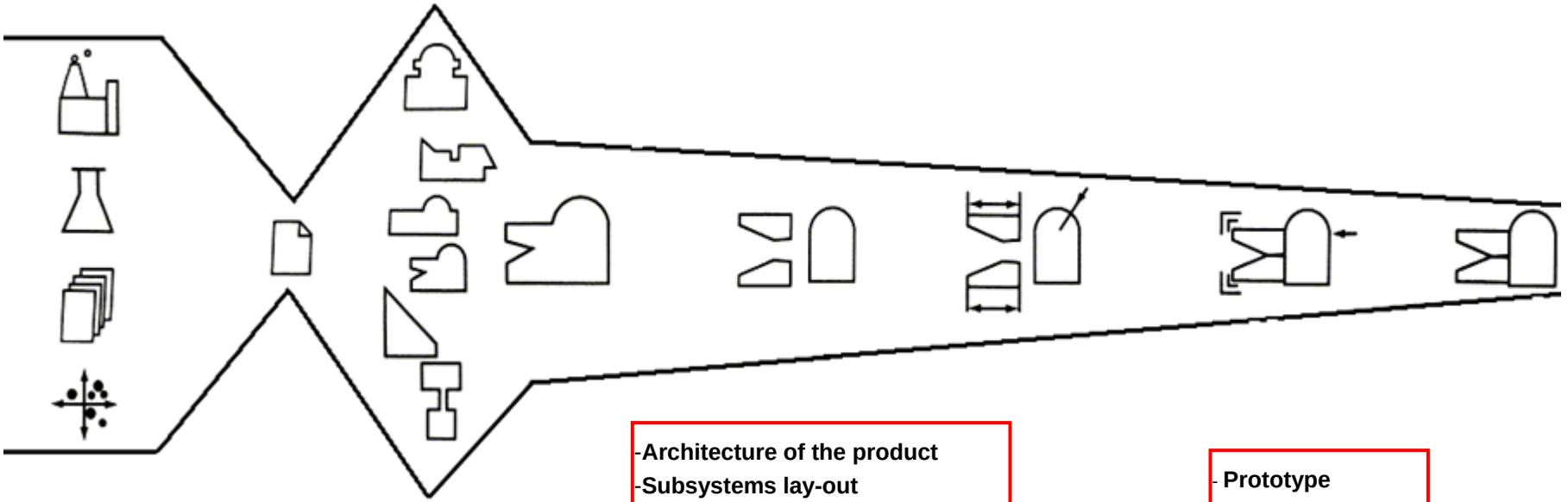
From the book *Product Design and Development* by Ulrich & Eppinger

The Benefits of a Well-Defined Development Process

- ***Quality assurance*** **-** A development process specifies the phases a development project will pass through and the checkpoints along the way. Assuming that these phases and checkpoints are chosen wisely, following the development process is one way of assuring the quality of the resulting product.
- ***Coordination*** **-** A clearly articulated development process acts as a master plan which defines the roles of each of the players on the development team. This plan informs the members of the team when their contribution will be needed and with whom they will need to exchange information and materials.
- ***Planning*** – A development process contains natural milestones corresponding to the completion of each phase. The timing of these milestones anchors the schedule of the development project.
- ***Management*** **–** A development process is a benchmark for assessing the performance of an ongoing development effort. By comprising the actual events to the established process, a manager can identify possible problem areas.
- ***Improvement*** **–** The careful documentation of an organization's development process often helps to identify opportunities for improvement.

From the book *Product Design and Development* by Ulrich & Eppinger

The Generic Development Process – According to Ulrich and Eppinger



-Project mission statement

-Architecture of the product
-Subsystems lay-out
-Preliminary process flow diagram for assembly process

- Prototype
- Production needs

Phase 0 Planning → Phase 1 Concept Development → Phase 2 System-level Design → Phase 3 Detail Design → Phase 4 Testing and Rrefinement → Phase 5 Production Ramp-up

-Corporate strategy
-Assessment of technology
-Market objectives

- Needs of target market
- Alternative product concepts chosen

-Complete specification of the product parts
-Process plan and tooling

-Production system

Adapting the Generic Product Development Process

Process Type	Examples
Generic = Market-Pull Products	Sporting goods, furniture, tools
Technology-Push Products	Gore-Tex rainwear
Platform Products	Automobiles, Computers
Process-Intensive Products	Chemicals, semiconductors
Customized Products	Motors, switches, batteries
High-Risk Products	Space systems
Quick-Build Products	Cellular phones
Complex Systems	Airplanes, jet engines, automobiles

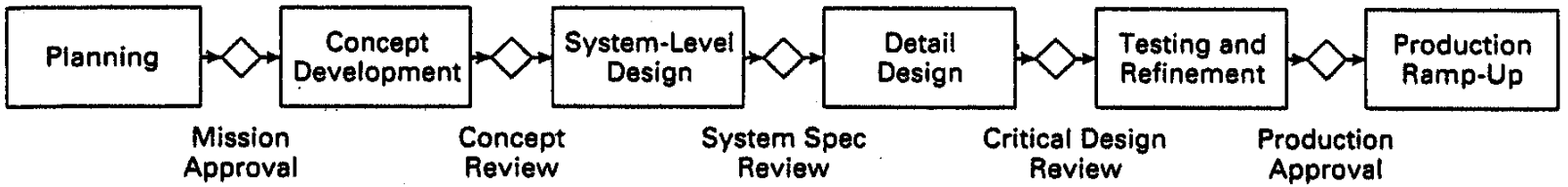
Adapting the Generic Product Development Process

What kind of development process is expected to be used when developing air-conditioners for private use – in homes – given that:

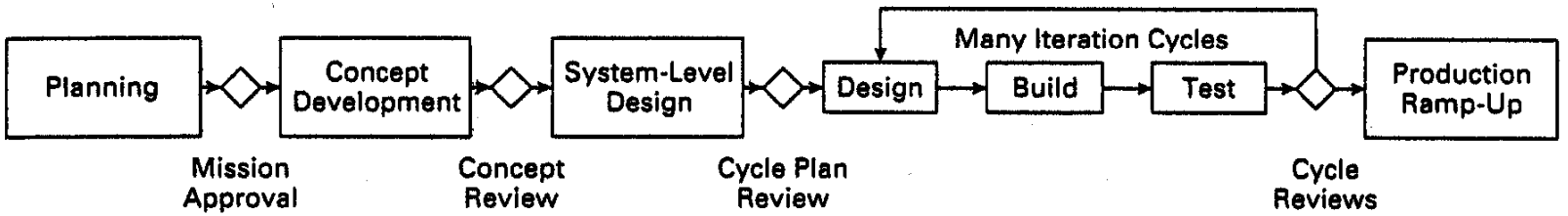
The company has never before developed air-conditioners?

The company has, since long, been developing air-conditioners for offices?

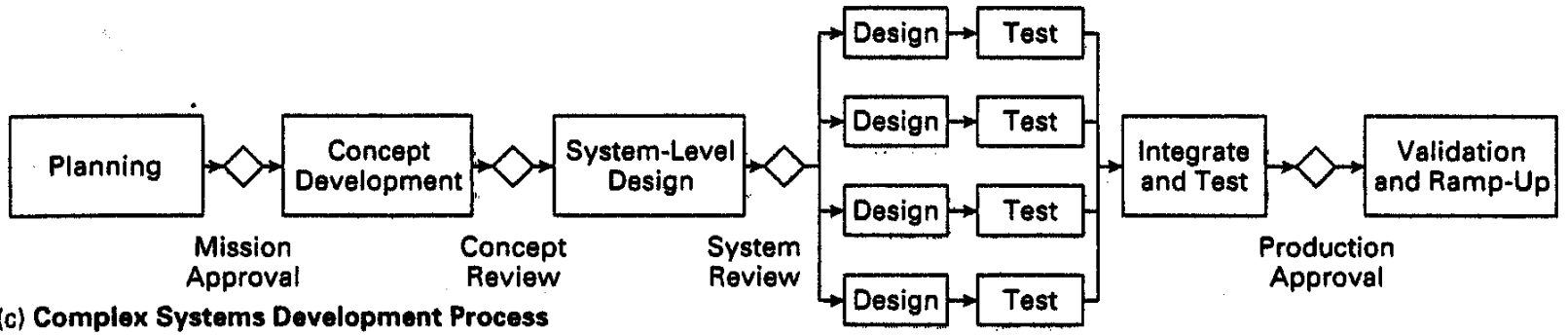
Adaptation of the Product Development Process Flows



(a) **Generic Product Development Process**

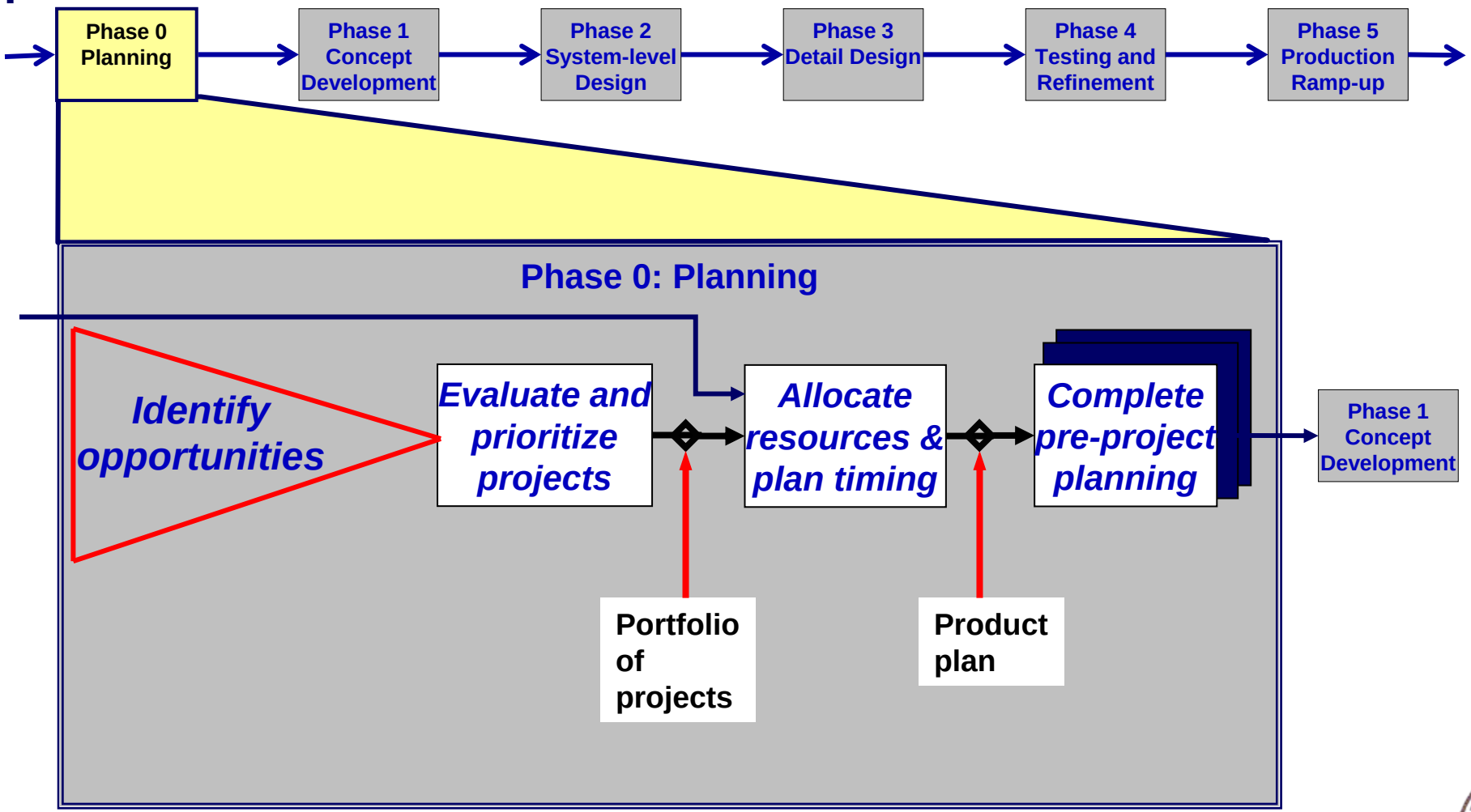


(b) **Spiral Product Development Process**



(c) **Complex Systems Development Process**

The Product Planning Process



Concept Development – the Front End Process