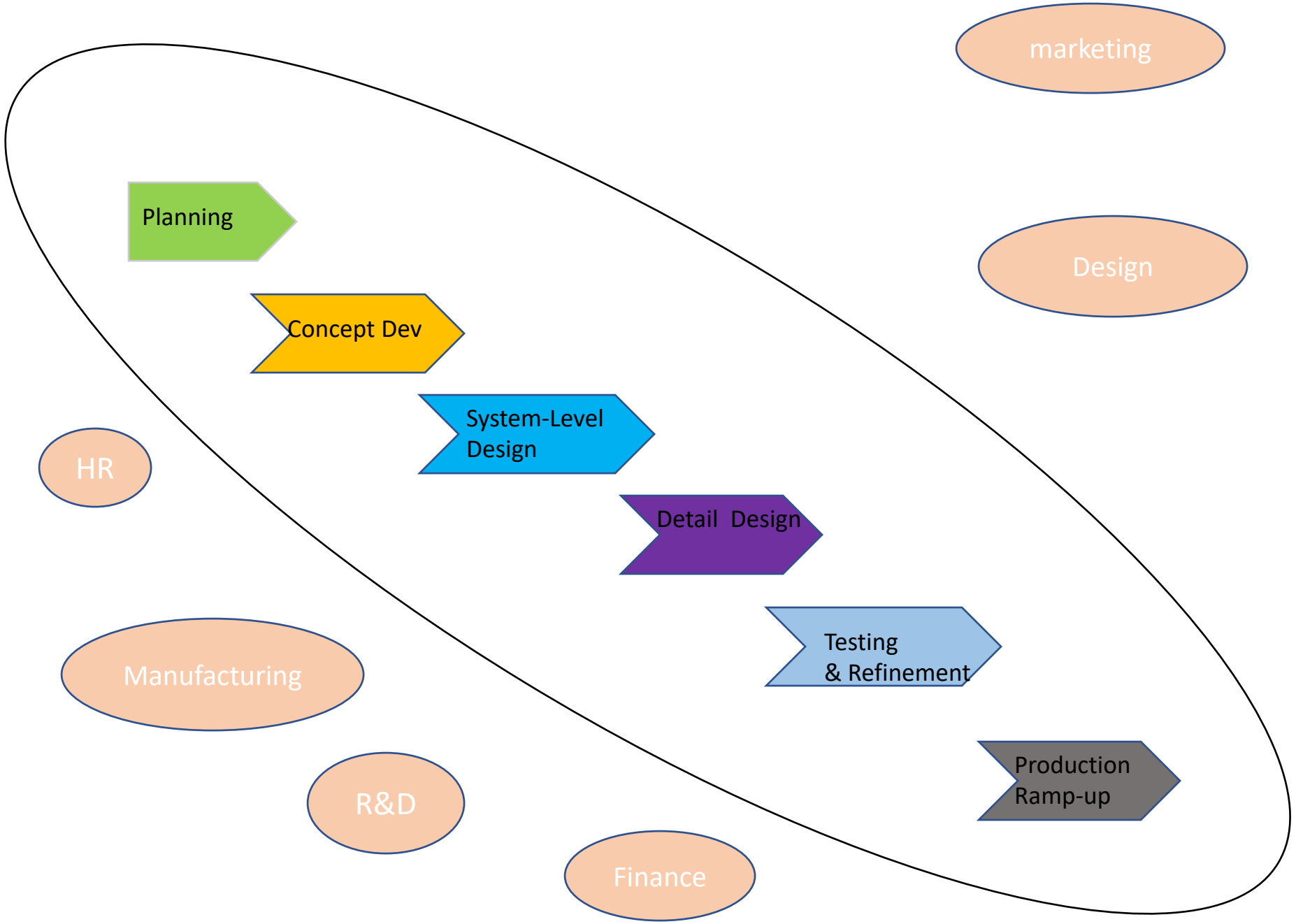
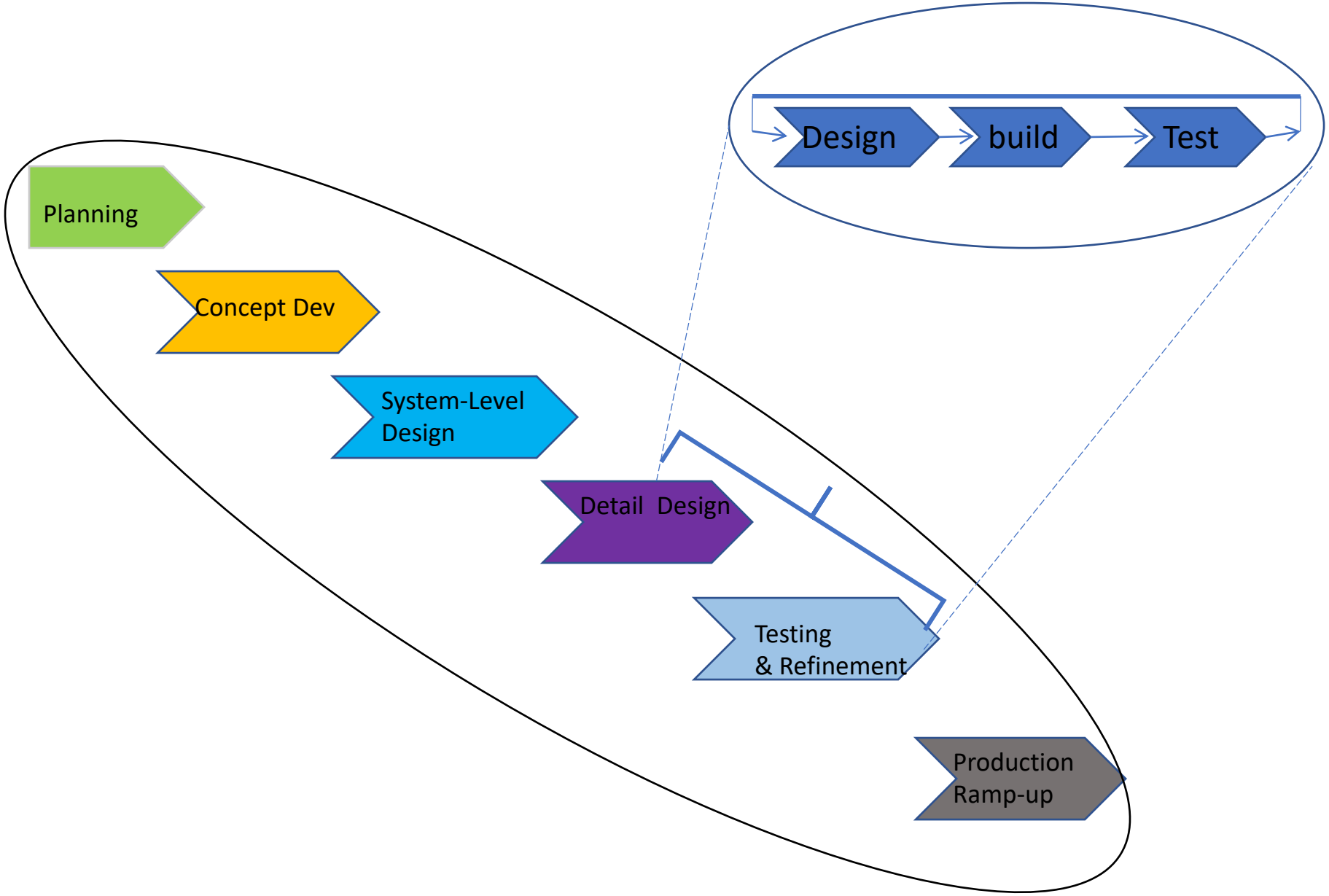
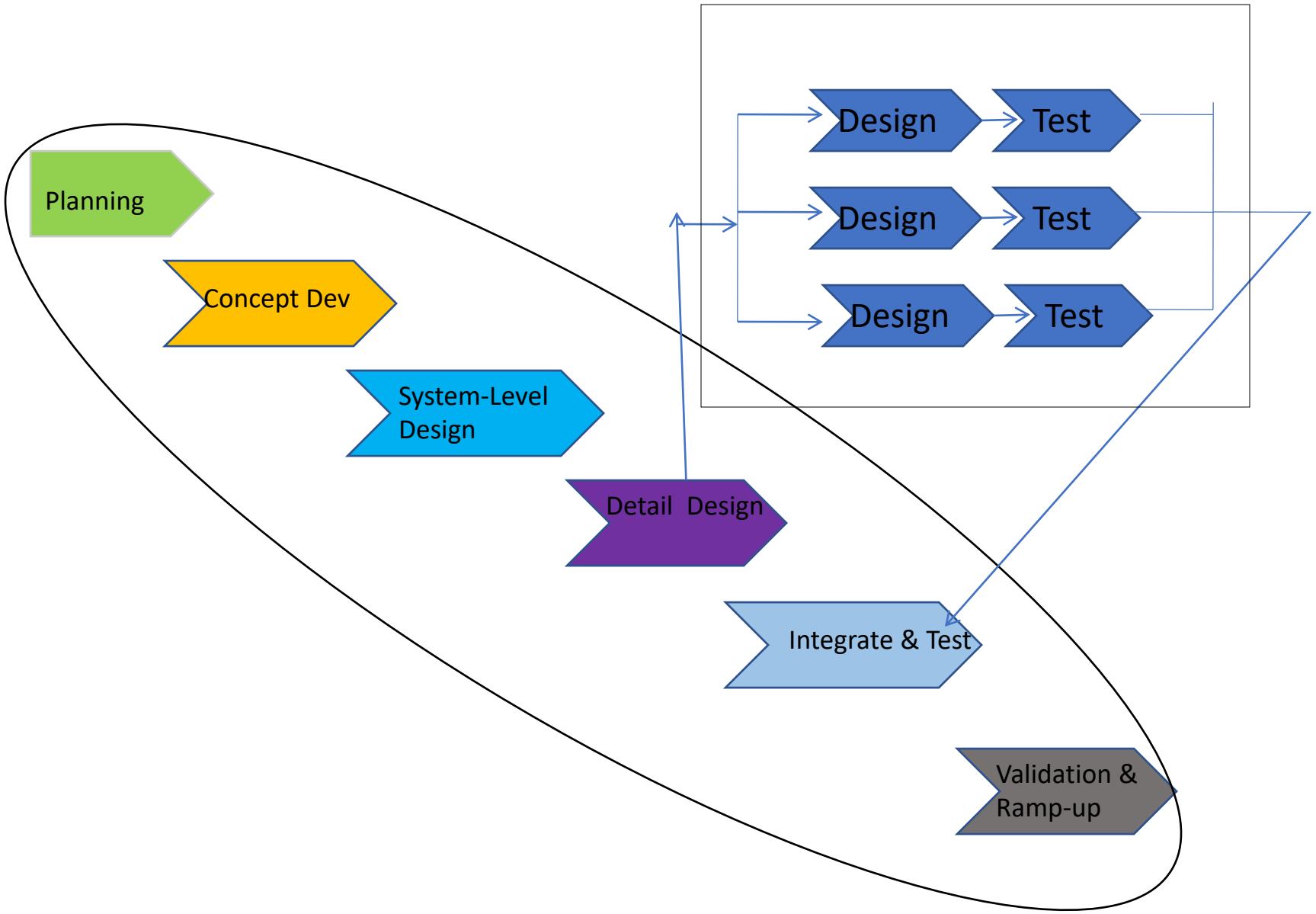
Product Design, Architecture and Development


marketing
Planning
Design
Concept Dev
System-Level
Design
HR
Detail Design
Testing
& Refinement
Manufacturing
Production
Ramp-up
R&D
Finance

Spiral Product Development Process



Complex Systems Devp Process



Generic PD process

Process Type	Desc	Examples
Generic (Market-Pull)Products	The Team begin with a market opportunity & selects appropriate tech	sporting goods, furniture,tools
Technology-push	The team begins with a new tech, then finds a market	High-end shoes
Platform	The team assumes that the new product will be built around an established tech subsytem	computers,printers,ipads
Process-intensive	Characteristics of the product are highly constrained by the production process	snack foods, chemicals
customized products	new products are slight variations of exisiting configurations	motors,switches,containers
high-risk	technical & market uncertainities create high risks of failure	pharma, space systems
quick build	rapid modelling & prototying enables many design-build-test cycles	software, cellular phones
complex systems	systems must be decomposed into sevral subsystems and many components	airplanes, automobiles

Product Architecture

Modular Architecture

- chunks implement one or a few elements
- interactions between chunks are well-defined and fundamental to the primary functions of the product
- allows a design change in one chunk without requiring changes to other chunks
- most modular: each functional element is implemented by exactly one chunk

Integral Architecture

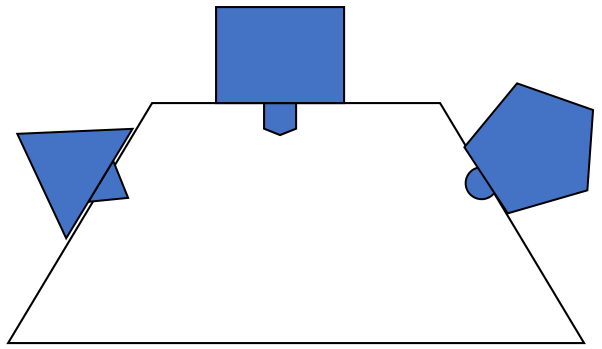
- functional elements of the product are implemented using more than one chunk
- a single chunk implements many elements
- interactions between chunks ill-defined, may be incidental to the primary functions of the products
- used with products with highest possible performance in mind

Types of Modularity

- Slot-modular architecture
- Bus-modular architecture
- Sectional-modular architecture

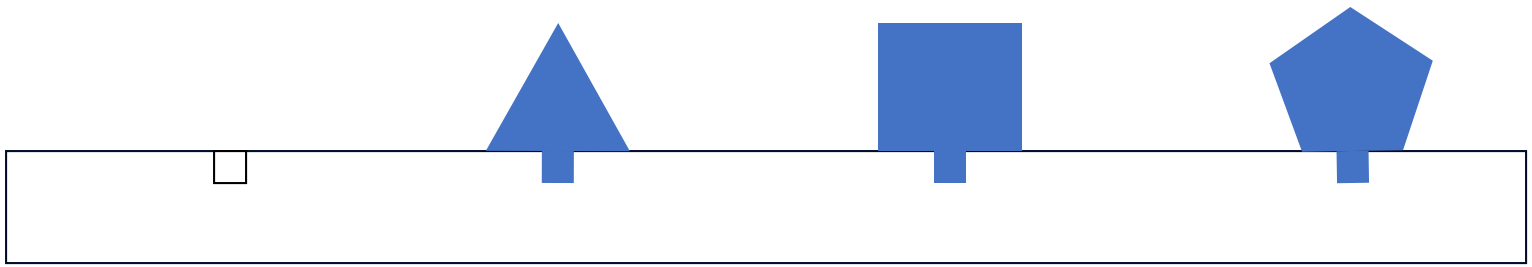
Slot-Modular Architecture

- **each interface between chunks different - various chunks cannot be interchanged**
- **example: automobile radio - implements exactly one function, but interface different from any other components in the vehicle**



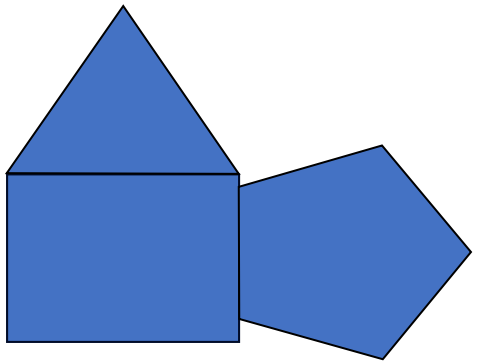
Bus-Modular Architecture

- a common bus to which chunks connect via the same type of interface
- examples: track-lighting, shelving system with rails, expansion card for PC



Sectional-Modular Architecture

- all interfaces of same type, but no single element to which all other chunks attach
- assembly built by connecting chunks to each other via identical interfaces
- examples: piping systems, office partitions



Fundamental Decisions

- Integral vs. modular architecture?
- What type of modularity?
- How to assign functions to chunks?
- How to assign chunks to teams?
- Which chunks to outsource?

Modular Product Architectures

- Chunks implement one or a few functions entirely.
- Interactions between chunks are well defined.
- Modular architecture has advantages in simplicity and reusability for a product family or platform.

Swiss Army Knife

Sony Walkman

Integral Product Architectures

- Functional elements are implemented by multiple chunks, or a chunk may implement many functions.
- Interactions between chunks are poorly defined.
- Integral architecture generally increases performance and reduces costs for any specific product model.

Compact Camera

Integral vs. Modular

Integral

- Higher system performance
- Tightly coupled design teams
- Hard to change

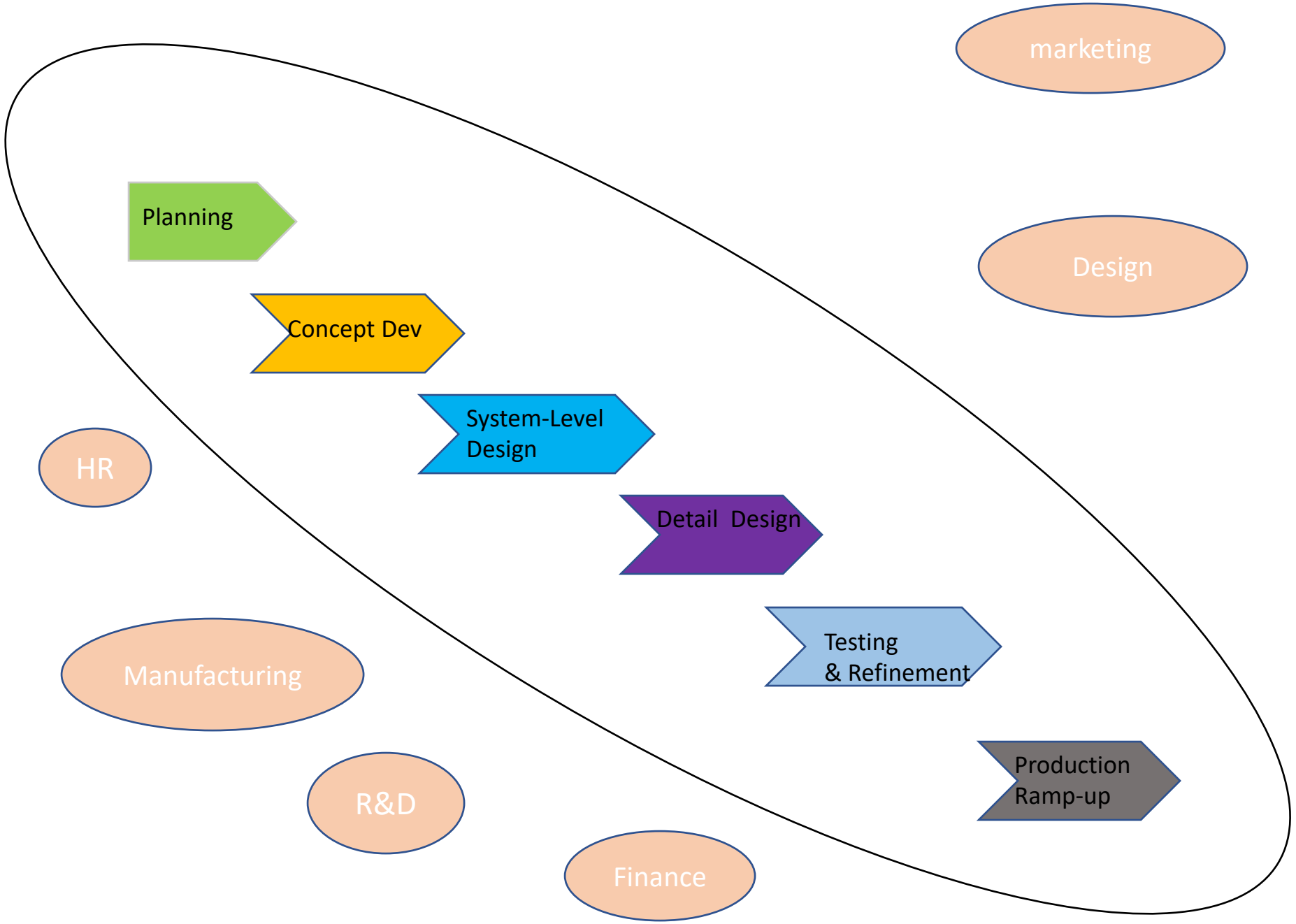
Modular

- Reduced performance
- Decoupled design teams
- Requires clear definition of interfaces
- Increased flexibility
- Accommodates made-to-order products

Case Study – NPD Segway

Segway

- http://www.youtube.com/watch?v=EBC0h7jxxM8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New Product Development(NPD)

- Many R&D projects never result in a commercial product, and between 33 and 60% of all new products that reach the market place fail to generate an economic return (Blagoevski-Trazof, 2007: 195).
- A company's new product must meet the following two basic objectives: 1) minimize time-to-market and 2) maximize the fit between customer requirements and product characteristics

About the company

- Segway Inc., a US-based international company, is named after its flagship product, the Segway Personal Transporter (PT), the first self-balancing transportation device in the world.
- The company was founded by Dean Kamen in 1999
- Segway went on sale for the first time to the public on Amazon.com in 2002
- As of 2008, over 1,000 police and security agencies are using Segway PT's in their patrolling operations worldwide.
- 2012: Segway boasts a worldwide network of more than 250 distributors, dealers and experience centers in 80 countries across the globe.
- In September 2014, Segway filed a complaint about the infringement of several of its patents by several Chinese companies, including Ninebot, Shenzhen INMOTION Technologies and Robstep Robot.
- Acquired by Ninebot (Chinese company) in 2015

Segway technology

- The Segway PT senses the lean of the rider with the assistance of five micro-machined angular rate sensors and two accelerometers that sense the angle of the PT, with respect to gravity, at 100 times per second.
- It balances the rider by applying forces to the ground in the direction of the lean. If you lean forward the PT applies motor torque to the wheel to push it forward, bring you upright and balance you. When you lean back, it applies reverse torque to slow you down and balance you accordingly

Phases

Phase 1: Opportunity identification and selection

Phase 2: Concept generation

Phase 3: Concept evaluation

Phase 4: Development

Phase 5: Launch

Phase 1: Opportunity identification and selection

- Dean Kamen's mission: a new DISCOVERY to replace the car, solve the problem of congestion, air pollution and dependency on fuel**.
- Design idea : focus on creating devices that took up a minimal amount of space, were extremely maneuverable and could operate on pedestrian sidewalks and pathways
- Market opportunity : universities, police force, security companies, and large retailers

*** In 1999, the United States consumed 95 quadrillion BTUs of energy, while producing 61 quadrillion BTUs. The result being a **34 quadrillion BTU energy deficit**.*

Phase 1: Opportunity identification and selection

- Inspired by :iBOT wheelchair

Concept generation

- Consumer feedback: The first problem was of Segway not being taken seriously by consumers who regard this invention as simply a high-end toy.
- Team decides to concentrate at first on major corporations, universities and government agencies--large, solid, established institutions--rather than dive straight into the consumer marketplace
- Design specifications: small footprint, flexibility, lightweight, run on electricity
- Design specs on Safety : Segway equipped with three computerized keys that set speed and performance limits to ensure safety on pedestrian pavements

Concept Evaluation

Category	Factor	Scale	Score	Weight (1-5)	Weighted score
Technical accomplishment	Technical task difficulty	1: difficult 5: easy	4	4	16
	Research skills required	1: none 5: perfect fit	5	3	15
	Development skills required	1: none 5: perfect fit	4	2	8
	Technical equipment/processes	1: none 5: have them	5	3	15
	Rate of technological change	1: high 5: stable	5	2	10
	Designing superiority assurance	1: none 5: high	5	2	10
	Security of design	1: none 5: have patent	5	2	10
	Technical services required	1: none 5: have it all	2	3	6
	Manufacturing equipment/processes	1: none 5: have them	3	5	15
	Vendor cooperation	1: none 5: have them	2	3	6
	Likelihood of competitive cost	1: above competition 5: 20% less	1	2	2
	Likelihood of quality product	1: below current levels 5: leadership	5	5	25
	Likelihood speed of to market	1: 2 years or more 5: under 6 months	1	5	5
	Team people available	1: none 5: have them	3	3	9
	Dollar investments required	1: over 20 million 5: under 1 million	1	2	2
	Legal issues	1: major 5: minor	2	3	6
	Total				160

Commercial accomplishment	Market volatility	1: high 5: stable	2	4	8
	Probable market share	1: low 5: high	5	4	20
	Probable product life	1: short 5: long	4	2	8
	Sales force requirements	1: no experience 5: very familiar	1	4	4
	Promotion requirements	1: no experience 5: very familiar	2	4	8
	Target customer	1: strangers 5: close	2	3	6
	Distributors	1: no relationship 5: current/strong	4	4	16
	Retailers	1: no relationship 5: current/strong	2	4	8
	Importance of task to user	1: trivial 5: critical	5	3	15
	Degree of unmet need	1: none 5: totally	5	4	20
	Likelihood of filling need	1: low 5: high	5	3	15
	Competition to be faced	1: tough 5: weak	4	3	12
	Environmental effects	1: negative 5: positive	5	3	15
	Global applications	1: none 5: fits global	5	3	15
	Probable profit	1: low 5: high	2	4	8
	Total				178

Sales prediction for NPV

"Dean Kamen, before selling a single Segway, he predicted that his company would sell 10,000 units per week, or 50,000 units a year "

- The proportion of Segway with Handle in 2015 is about 58.52%, and the proportion of Segway without Handle in 2015 is about 41.48%.

- China is the largest manufacturing region of Segway, with a sales market share nearly 12.19% in 2015.
- Europe is the second largest consumption area of Segway, enjoying production market share about17.23% in 2015.

The global Segway market is valued at 1320 million US$ in 2017 and will reach 1330 million US$ by the end of 2025, growing at a CAGR of 0.1% during 2018-2025.

Development

Segway's claim to fame – is that it develops systems not components or integrates parts….

so the main systems developed are:

a) **Dynamic stabilization -** enables balancing, incredible maneuverability (true zero turning radius)

b) **Electric propulsion -** fine adjustments to be made to each wheel (for turning and smoothing out the ride), and a precise, software-based approach to traction control and braking.

c) **Smart battery management** - includes regenerative braking capability (being able to recharge while decelerating).

d) **Intuitive user interfaces -** sensing technologies

e) **Digital dashboard -** Speed, battery life, and other connectivity information are all conveyed over a secure wireless connection to a handheld device that can be mounted on the dash

Launch

Sales through - Amazon.com – shipping costs

Analysis

- Pre launch ‘leaks’ were huge.
- Code named – Ginger or IT.
- Speculations - hydrogen-powered hovercraft; a magnetic anti-gravity device; a time-travel machine; a mind-reading robot

Thus: when Segway was revealed to the US, it was an anti-climax. Coupled with the high price, Segway never got a chance with consumers afterwards.

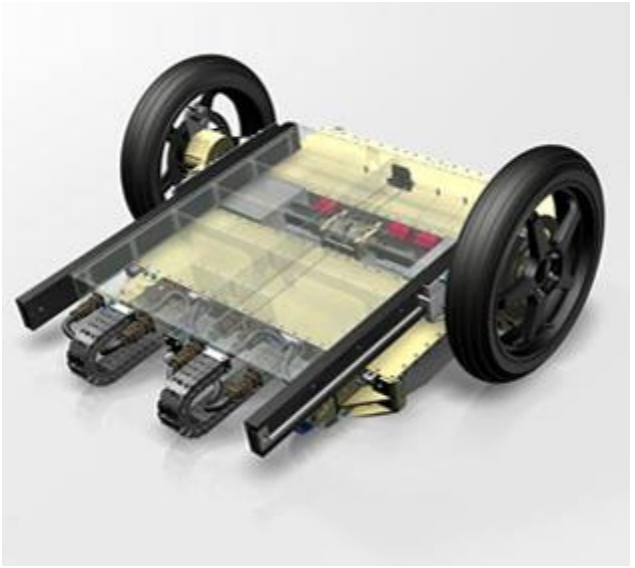
analysis:

- Phase 1: Opportunity identification and selection *– achieved his mission*
- Phase 2: Concept generation *– short on price point estimation , safety is an issue due to many software glitches.*
- Phase 3: Concept evaluation - *sales forecast was too high – hence poorly executed phase*.
- Phase 4: Development *-technologies serve the objectives of the vehicle well and in an advanced manner. Thus this phase has been a success*
- Phase 5: Launch : *did not manage its launch, media & public relations was poor, hype was not quelled*

Why Segway was seen as a curiosity and not a commodity?

- **Expectations were too high.**
- **It was a product not a solution.**
- **No clear need or target market**.
- **It was an invention rather than an innovation.**
- **Regulation.**

Next from Segway….



A collaboration between Segway and General Motors/SAIC, the EN-V project sets a vision for transportation in 2030

•Speed : 40 km/h [25 mph]
•Range : 40 km [25 miles]
•Drivetrain weight 210 kg [460 lb] - common across all three coach designs
•Average cabin dimensions: 1520 x 1415 x 1682 [60" x 55.5" 66.1"]