Value Chain Strategy: Clockspeed & 3-D Concurrent Engineering

Massachusetts Institute of Technology
Sloan School of Management

Value Chain Strategy: Clockspeed & 3-D Concurrent Engineering

1. Introduction
2. Fruit Flies & Value Chain Evolution
3. Value Chain Design & 3-DCE
4. Value Chain Roadmapping & Strategy Making

3-D Concurrent Engineering & *the imperative of concurrency*

Product

Detailed Design

Specs
Materials
Functions

Product Architecture

Modular/ Integral
Life Cycles

Process

Unit Processes

Technology
Equipment

Production System

Objectives
Systems
People
Capacity

Supply Chain

Supply Chain Architecture

Sourcing
Selection
Relationship

Technology Supply Chain

Logistics & Coord System

Information
Inventory
Integration

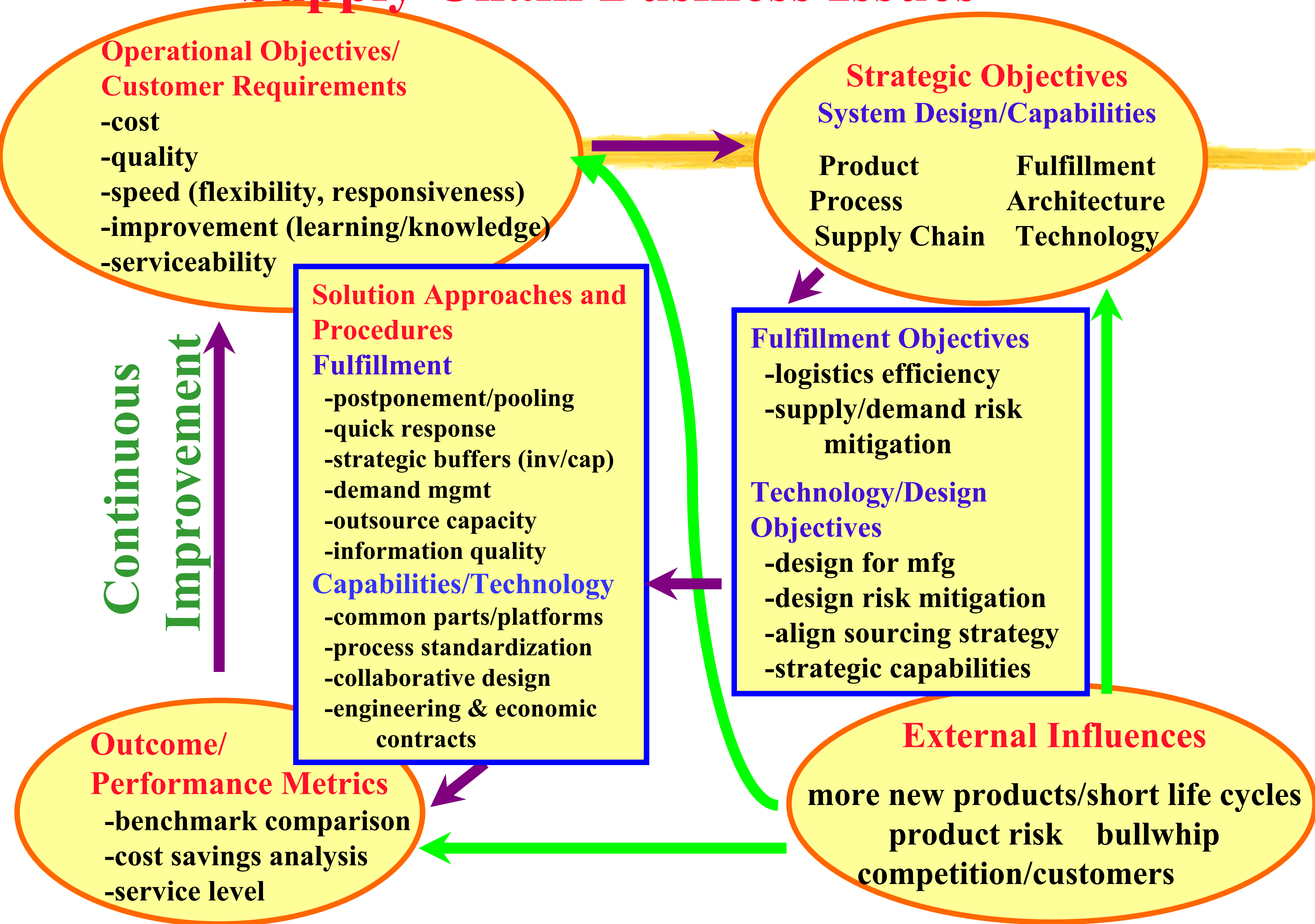
Fulfillment Supply Chain

Fulfillment **Architecture** **Technology**

SC Principles to Understand

Decision Scope \ Supply Chain Focus	Fulfillment Supply Chain	Technology Supply Chain
Tactical	Costs, Cycle Times, Inventories	Collaborative Prod Devel
Strategic	Bullwhip Revenue Management IT System Design Order Fulfill. Process Logistics System Design Supply-Demand balance Relationship Design Flexibility	Clockspeed Double Helix Supply Chain Architecture Value Migration 3-DCE

Supply Chain Business Issues



Value Chain Strategy: Clockspeed & 3-D Concurrent Engineering

1. Introduction
2. Fruit Flies & Value Chain Evolution
3. Value Chain Design & 3-DCE
4. Value Chain Roadmapping & Strategy Making

Supply Chain Design in a Fast-Clockspeed World: Study the Industry Fruitflies

Evolution in the natural world:

FRUITFLIES
evolve faster than
MAMMALS
evolve faster than
REPTILES

THE KEY TOOL:

Cross-SPECIES Benchmarking of Dynamic Forces

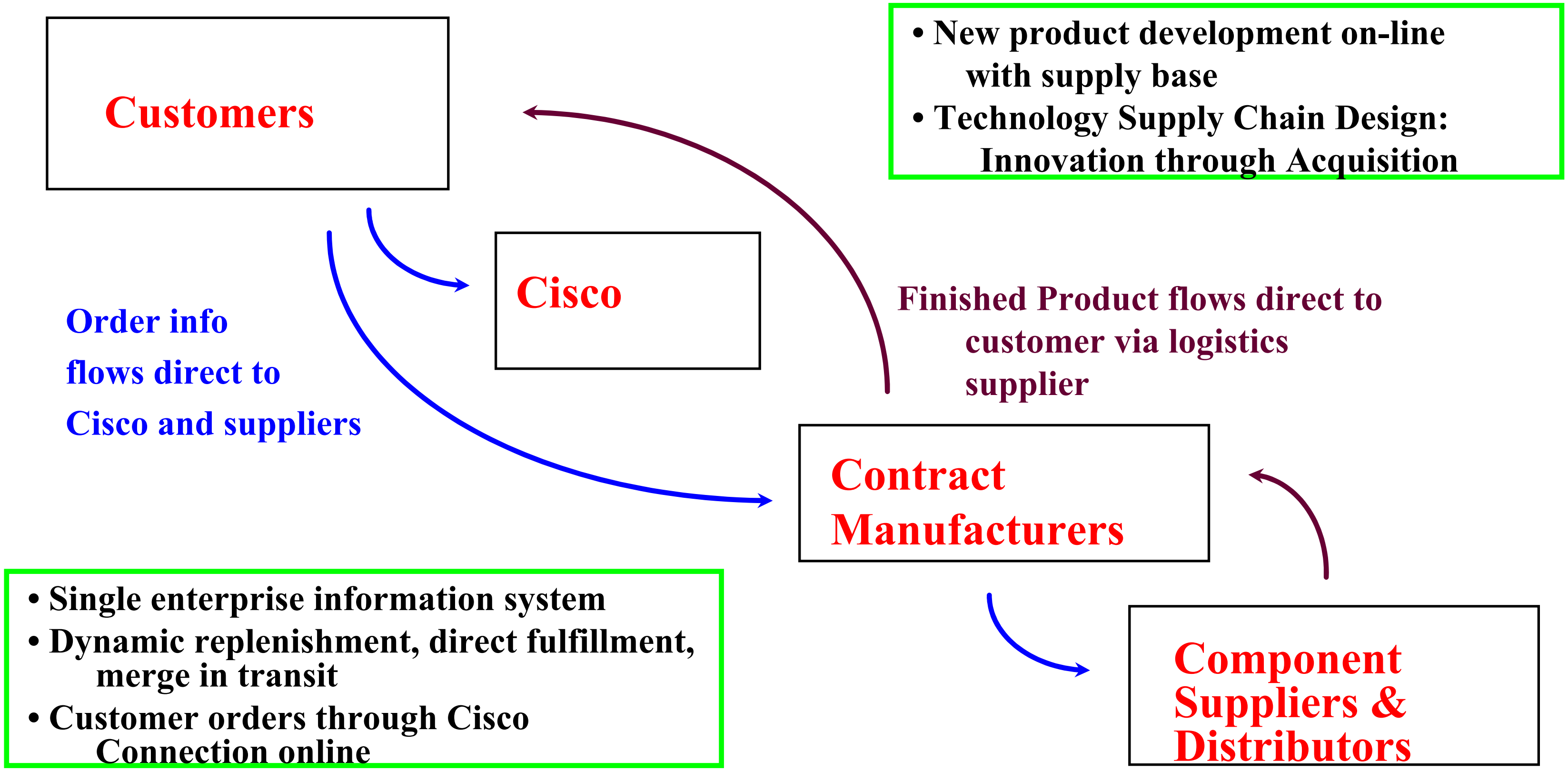
Evolution in the industrial world:

INFOTAINMENT is faster than
MICROCHIPS is faster than
AUTOS evolve faster than
AIRCRAFT evolve faster than
MINERAL EXTRACTION

THE KEY TOOL:

Cross-INDUSTRY Benchmarking of Dynamic Forces

Cisco’s End-to-End Integration for its Fulfillment Supply Chain



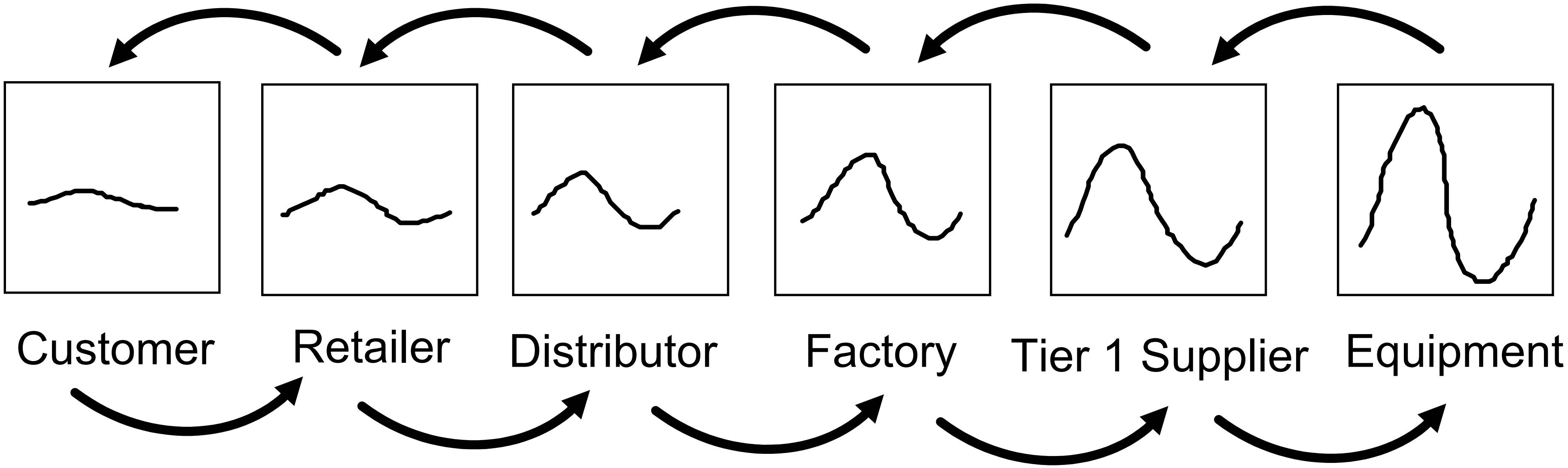
Basic Design Principle: Arm’s length Relationship with Fulfillment Chain Partners

Cisco's Strategy for Technology Supply Chain Design

1. Integrate technology around the router to be a communications network provider.
2. Leverage acquired technology with
   - sales muscle and reach
   - end-to-end IT
   - outsourced manufacturing
   - market growth
3. Leverage venture capital to supply R&D

Basic Design Principle: Acquisition Relationship with Technology Chain Partners

Volatility Amplification in the Supply Chain:
"The Bullwhip Effect"



Information lags
Delivery lags
Over- and underordering
Misperceptions of feedback
Lumpiness in ordering
Chain accumulations

SOLUTIONS:
Countercyclical Markets
Countercyclical Technologies
Collaborative channel mgmt.
(Cincinnati Milacron & Boeing)

Supply Chain Volatility Amplification: Machine Tools at the tip of the Bullwhip

- - -

"We are experiencing a 100-year flood." J. Chambers, 4/16/01

See "Upstream Volatility in the Supply Chain: The Machine Tool Industry as a Case Study,"
E. Anderson, C. Fine & G. Parker *Production and Operations Management,*
Vol. 9, No. 3, Fall 2000, pp. 239-261.

LESSONS FROM A FRUIT FLY: *CISCO SYSTEMS*

1. KNOW YOUR LOCATION IN THE VALUE CHAIN
2. UNDERSTAND THE DYNAMICS OF VALUE CHAIN FLUCTUATIONS
3. THINK CAREFULLY ABOUT THE ROLE OF VERTICAL COLLABORATIVE RELATIONSHIPS
4. INFORMATION AND LOGISTICS SPEED DO NOT REPEAL BUSINESS CYCLES OR THE BULLWHIP.

Bonus Question:

How does clockspeed impact volatility?

INDUSTRY CLOCKSPEED IS A COMPOSITE:

OF PRODUCT, PROCESS, AND ORGANIZATIONAL CLOCKSPEEDS

Mobile Phone **INDUSTRY CLOCKSPEED**

THE
Mobile Phone
product technology

THE
Mobile Phone
PRODUCTION PROCESS
process technology

THE
Mobile Phone
MANUFACTURING COMPANY
organization

Mobile Phone System CLOCKSPEED is a mix of Transmission Standards, Software and Handsets

Mobile Phone System

- **TRANSMISSION STANDARD**
  slow clockspeed
- **OPERATING SYSTEM**
  slow clockspeed
- **SOFTWARE APPLICATIONS**
  medium clockspeed
- **SERVICES**
  fast clockspeed
- **HAND SET**
  fast clockspeed

ISSUE: THE FIRMS THAT ARE FORCED TO RUN AT THE FASTEST CLOCKSPEED ARE THE MOST LIKELY TO STAY AHEAD OF THE GAME.

Automobile CLOCKSPEED IS A MIX OF ENGINE, BODY & ELECTRONICS

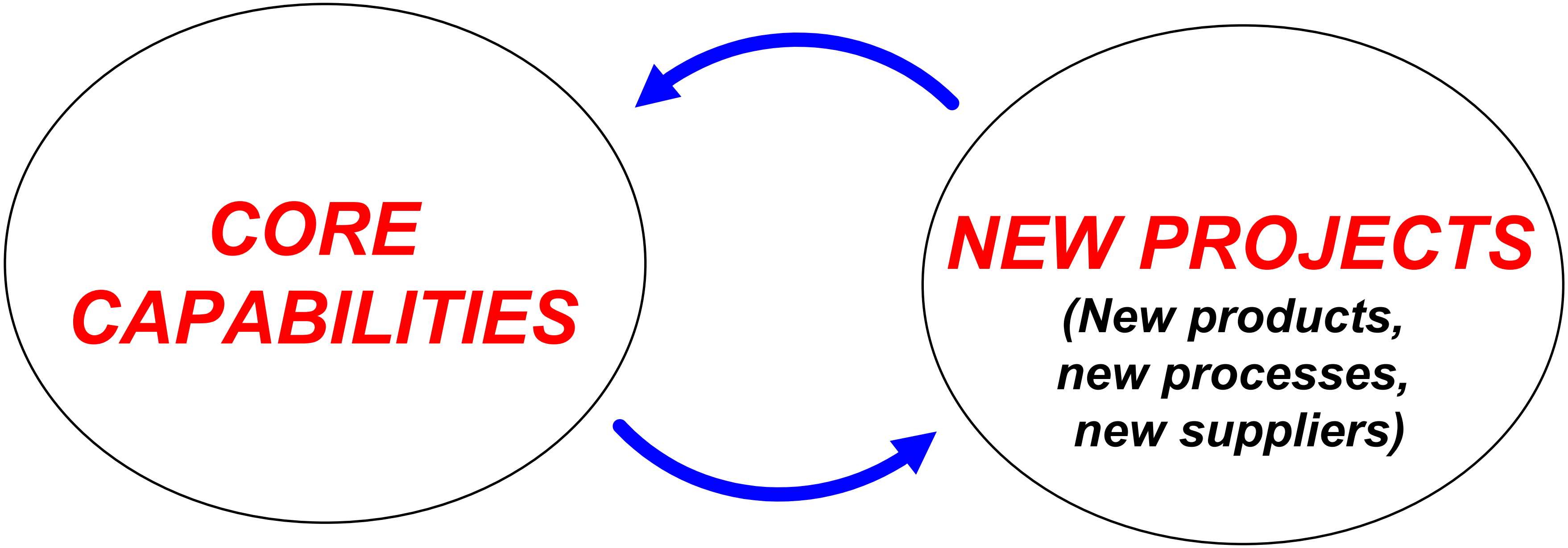
Automobile

ENGINE	BODY	ELECTRONICS
slow clockspeed	medium clockspeed	fast clockspeed

ISSUE: MOST AUTO FIRMS OPERATE AT ***ENGINE OR BODY CLOCKSPEEDS***; IN THE FUTURE THEY WILL NEED TO RUN AT ***ELECTRONICS CLOCKSPEED.***

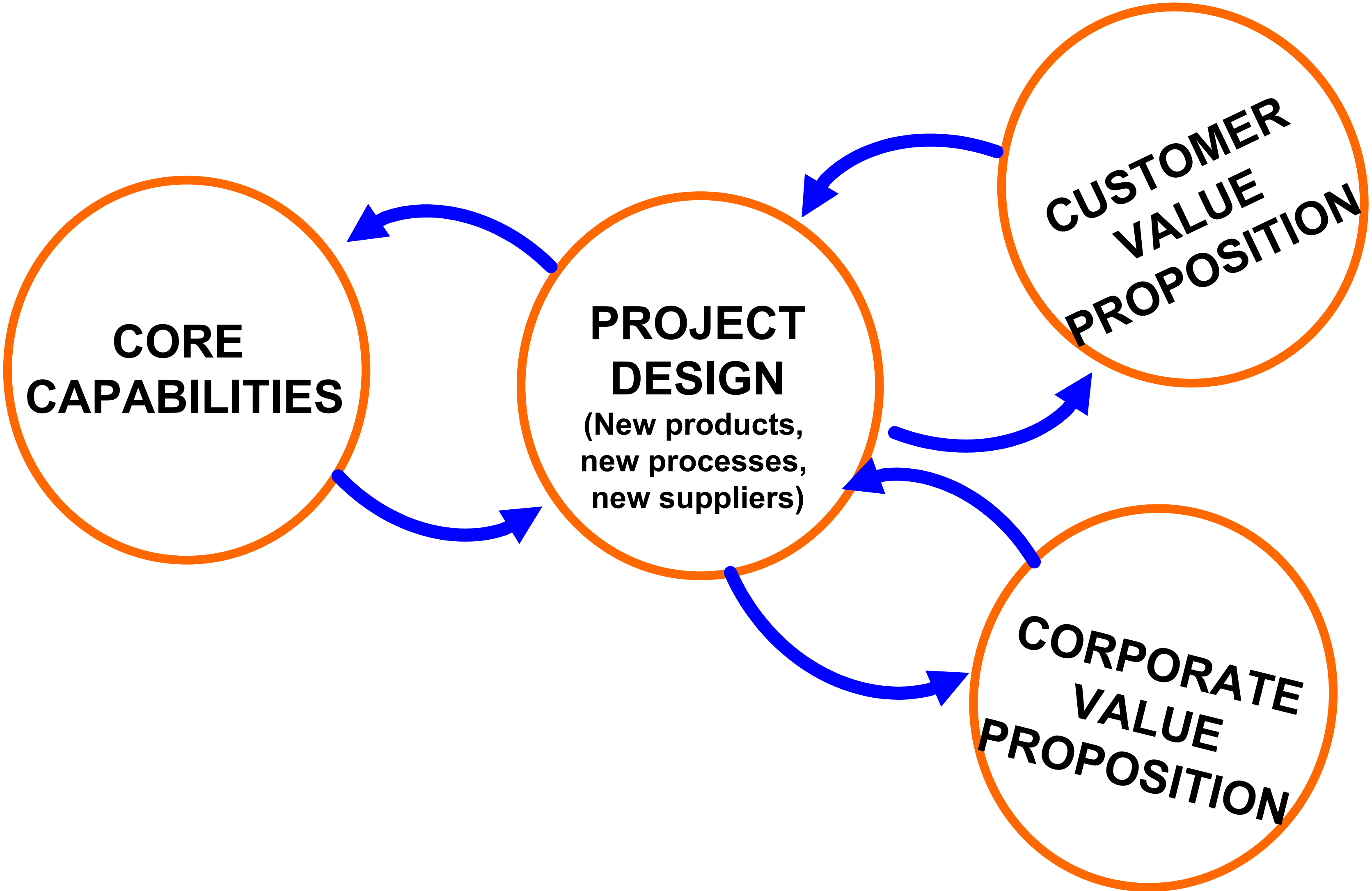
Clockspeed drives *Business Strategy Cadence*

Dynamics between New Projects and Core Capability Development: PROJECTS MUST MAKE MONEY AND BUILD CAPABILITIES



See Leonard-Barton, D. *Wellsprings of Knowledge*

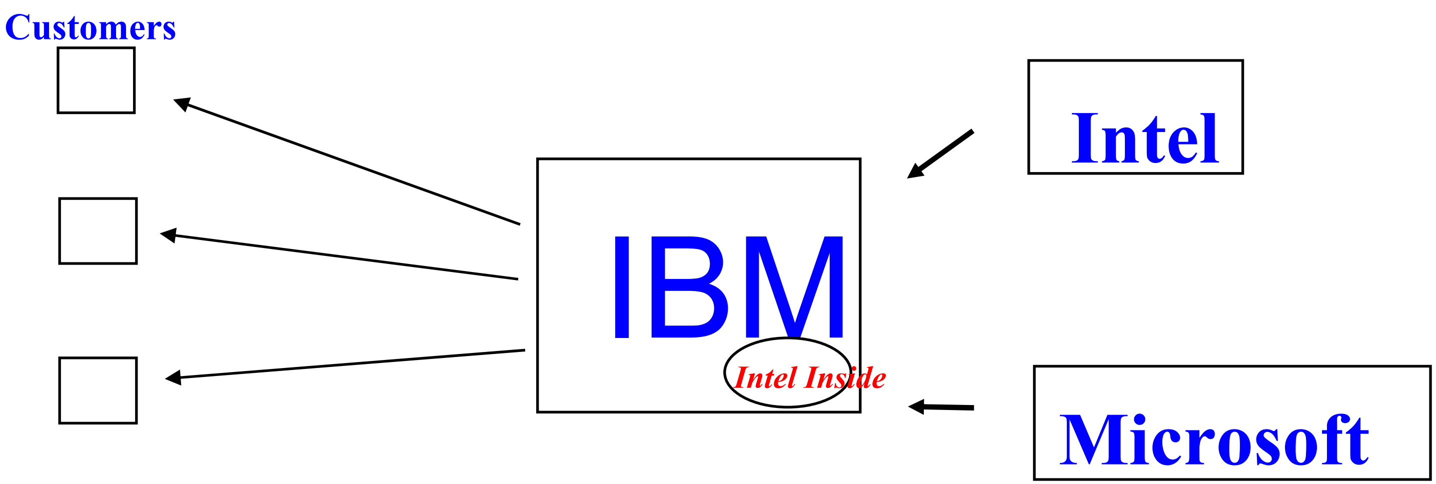
Projects Serve Three Masters: Capabilities, Customers, & Corporate Profit



The Strategic Leverage of Value Chain Design:

Who let Intel Inside?

1980: IBM designs a product, a process, & a value chain



The Outcome:

A phenomenonally successful product design
A disastrous value chain design (for IBM)

LESSONS FROM A FRUIT FLY:
THE PERSONAL COMPUTER

1. BEWARE OF *INTEL INSIDE* (Regardless of your industry)
2. MAKE/BUY IS **NOT** ABOUT WHETHER IT IS *TWO CENTS CHEAPER* OR *TWO DAYS FASTER* TO OUTSOURCE VERSUS INSOURCE.
3. DEVELOPMENT PARTNERSHIP DESIGN CAN DETERMINE THE FATE OF COMPANIES AND INDUSTRIES, AND OF PROFIT AND POWER
4. THE LOCUS OF VALUE CHAIN CONTROL CAN SHIFT IN UNPREDICTABLE WAYS

Vertical Industry Structure with *Integral* Product Architecture

Computer Industry Structure, 1975-85

	IBM	DEC	BUNCH
Microprocessors Operating Systems Peripherals Applications Software Network Services Assembled Hardware	All Products	All Products	All Products

(See A. Grove, Intel; and Farrell, Hunter & Saloner, Stanford)

Horizontal Industry Structure with *Modular* Product Architecture

Computer Industry Structure, 1985-95

Microprocessors	Intel	**Moto**	**AMD**	**etc**	
Operating Systems	Microsoft	Mac	Unix		
Peripherals	HP	Epson	Seagate	**etc**	**etc**
Applications Software	Microsoft	Lotus	Novell	etc	
Network Services	AOL/Netscape	Microsoft	EDS	etc	
Assembled Hardware	HP	Compaq	IBM	Dell	etc

(See A. Grove, Intel; and Farrell, Hunter & Saloner, Stanford)

THE DYNAMICS OF PRODUCT ARCHITECTURE AND VALUE CHAIN STRUCTURE:

THE DOUBLE HELIX

See Fine & Whitney, "Is the Make/Buy Decision Process a Core Competence?"

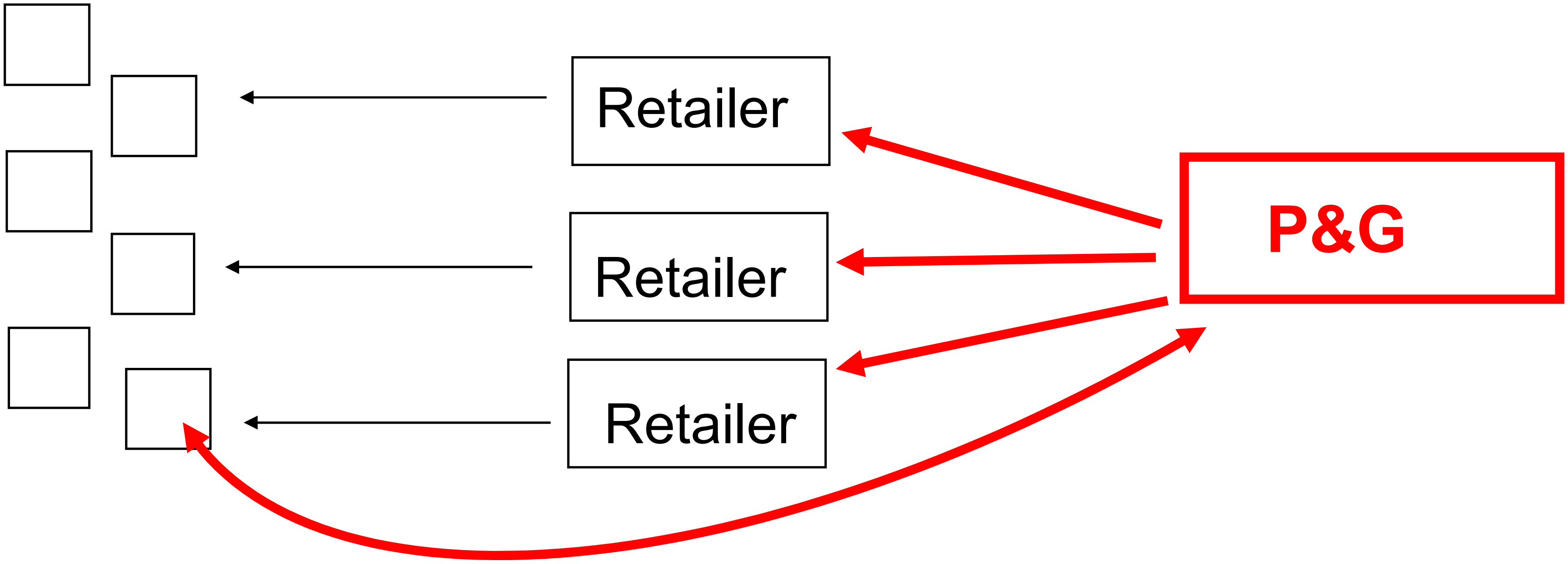
THE *DOUBLE HELIX* IN OTHER INDUSTRIES

- ***TELECOMMUNICATIONS--***
  - **"MA BELL" was Vertical /Integral**
  - **BABY BELLS & LONG LINES & CELLULAR are Horizontal/Modular**
  - **Today's Verizon is going back to Vertical /Integral**
- ***AUTOMOTI VE--***
  - **Detroit in the 1890's was Horizontal/Modular**
  - **Ford & GM in the mid 1900's were Vertical /Integral**
  - **Today's Auto Industry is going back to Horizontal/Modular**
- ***TELEVISION--***
  - **RCA was Vertical /Integral**
  - **1970'S THROUGH 1990'S were Horizontal/Modular**
  - **Today's media giants are going back to Vertical /Integral**
- ***BICYCLES--***
  - **Safety Bikes to 1890's boom to Schwinn to *Shimano Inside***

Controlling the Chain Through Distribution: The End of *P&G Inside* ?

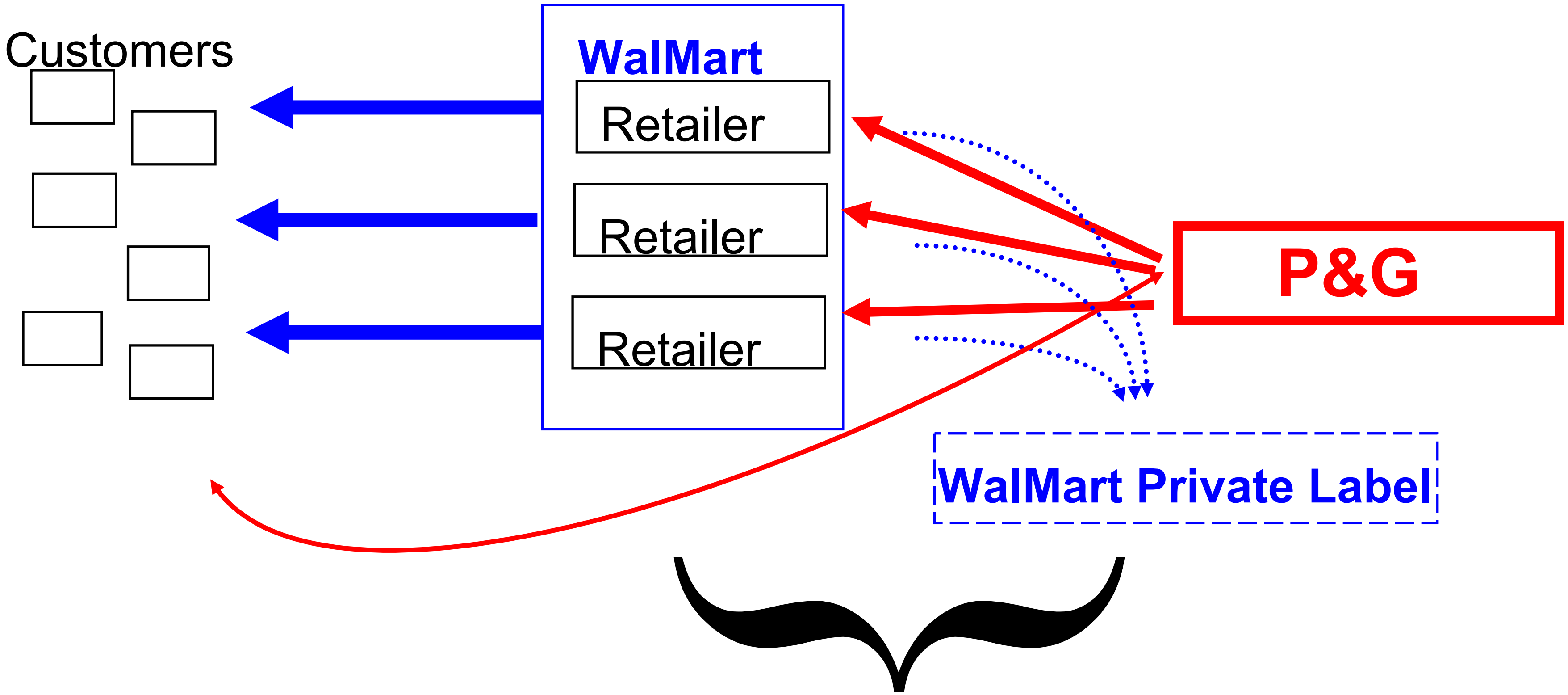
- *Controlling the Channel Through Closeness to Customers:*
- *consumer research, pricing, promotion, product development*

Customers



Controlling the Chain Through Distribution: Beware of *Walmart Outside*

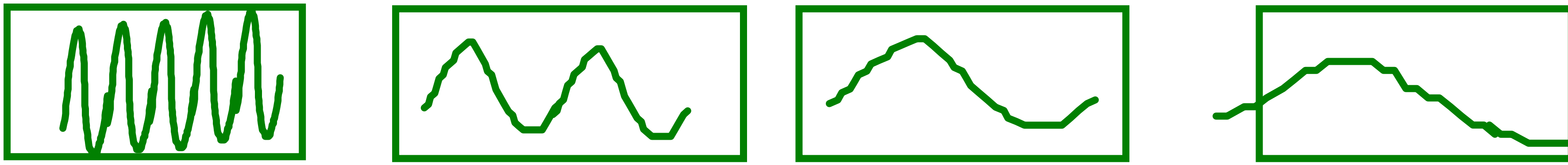
Controlling the Channel Through Closeness to Customers: Chain Proximity



Vertical Growth on the Double Helix

Clockspeeds accelerate as you head downstream, closer to the final customer ;

Clockspeed = f(technology push, customer pull, system complexity)



New Phone Applications	Handset Platforms	Telecom Equipment	Optical Components
Web Site Developer	PC Maker	Chip maker	Semiconductor Equipment Maker
In-Vehicle Services	Automobile	Telematics System	Vehicle Electronics Architecture

Media Supply Chains: An Industry at *Lightspeed*

Customers

The box

- Wired Phone
- Wireless phone
- PC/laptop
- PDA
- Television
- VCR
- Pager

The Pipe
(Access, Metro, Backbone)

- Land-basedTelco:
  - -copper POTS
  - -fiber
  - -DSL
- Cable Networks
- Wireless:
  - -broadcast TV
  - -CDMA, TDMA, GSM
  - -satellite/microwave
- Retail Outlets
  - -Borders:
  - -Blockbuster
  - -Seven-Eleven
- Delivery (e.g., Fedex)

The Content

- Video/Audio:
  Movies & Art
  & News & Sports
- News/articles/books (newspapers & magazines)
- Communication: voice & video & email
- Banking
- Education
- Shopping
- Internet, *et al*

ALL COMPETITIVE ADVANTAGE IS TEMPORARY

Autos:

Ford **in 1920,** ***GM*** **in 1955,** ***Toyota*** **in 1990**

Computing:

IBM **in 1970,** ***DEC*** **in 1980,** ***Wintel*** **in 1990**

World Dominion:

Greece **in 500 BC,** ***Rome*** **in 100AD,** ***G.B.*** **in 1800**

Sports:

Bruins **in 1971,** ***Celtics*** **in 1986,** ***Yankees*** **no end**

The faster the clockspeed, the shorter the reign

Value Chain Strategy: Clockspeed & 3-D Concurrent Engineering

1. Introduction
2. Fruit Flies & Value Chain Evolution
3. Value Chain Design & 3-DCE
4. Value Chain Roadmapping & Strategy Making

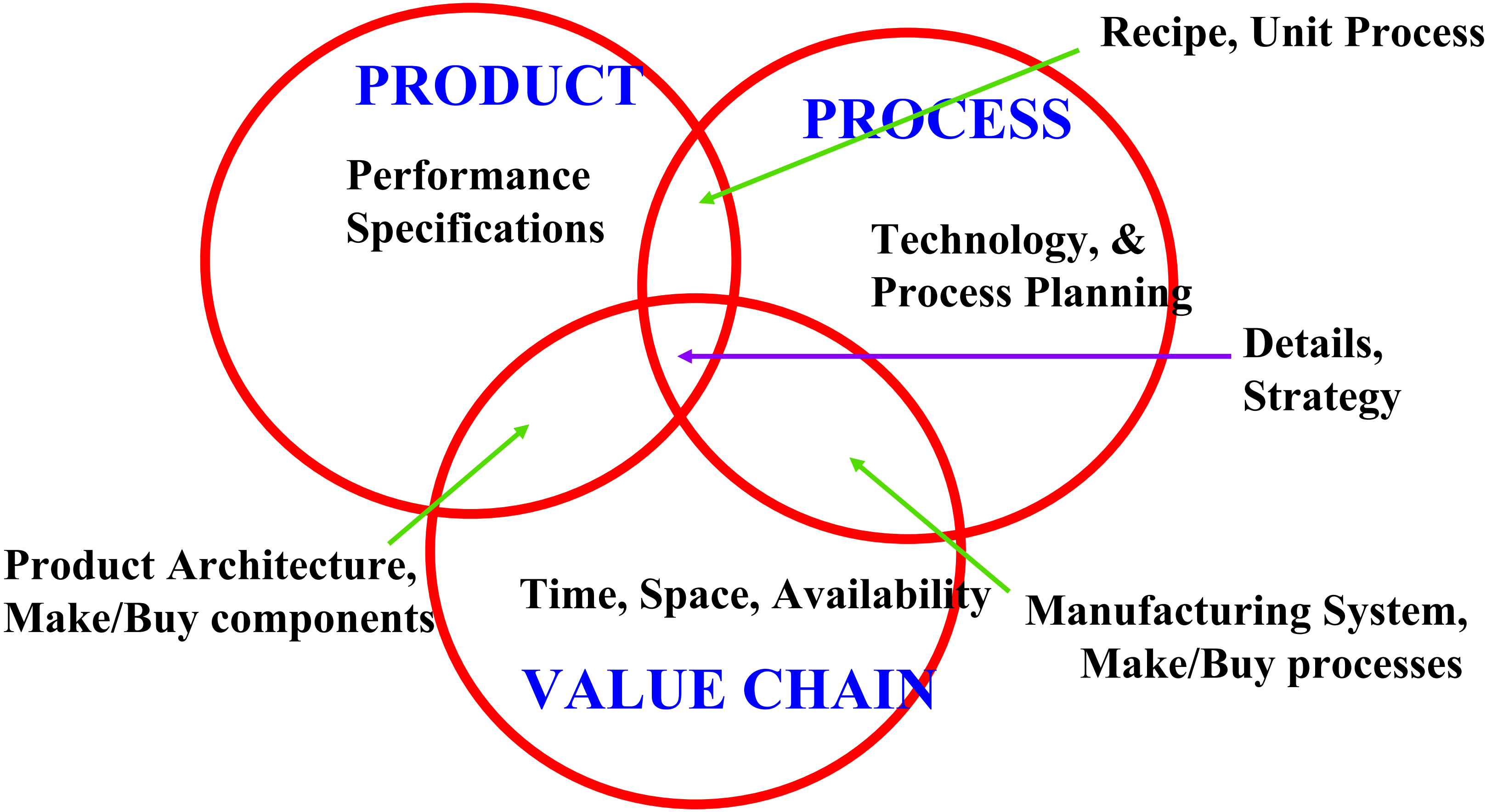
VALUE CHAIN DESIGN:
Three Components

1. Insourcing/OutSourcing
(The Make/Buy or Vertical Integration Decision)

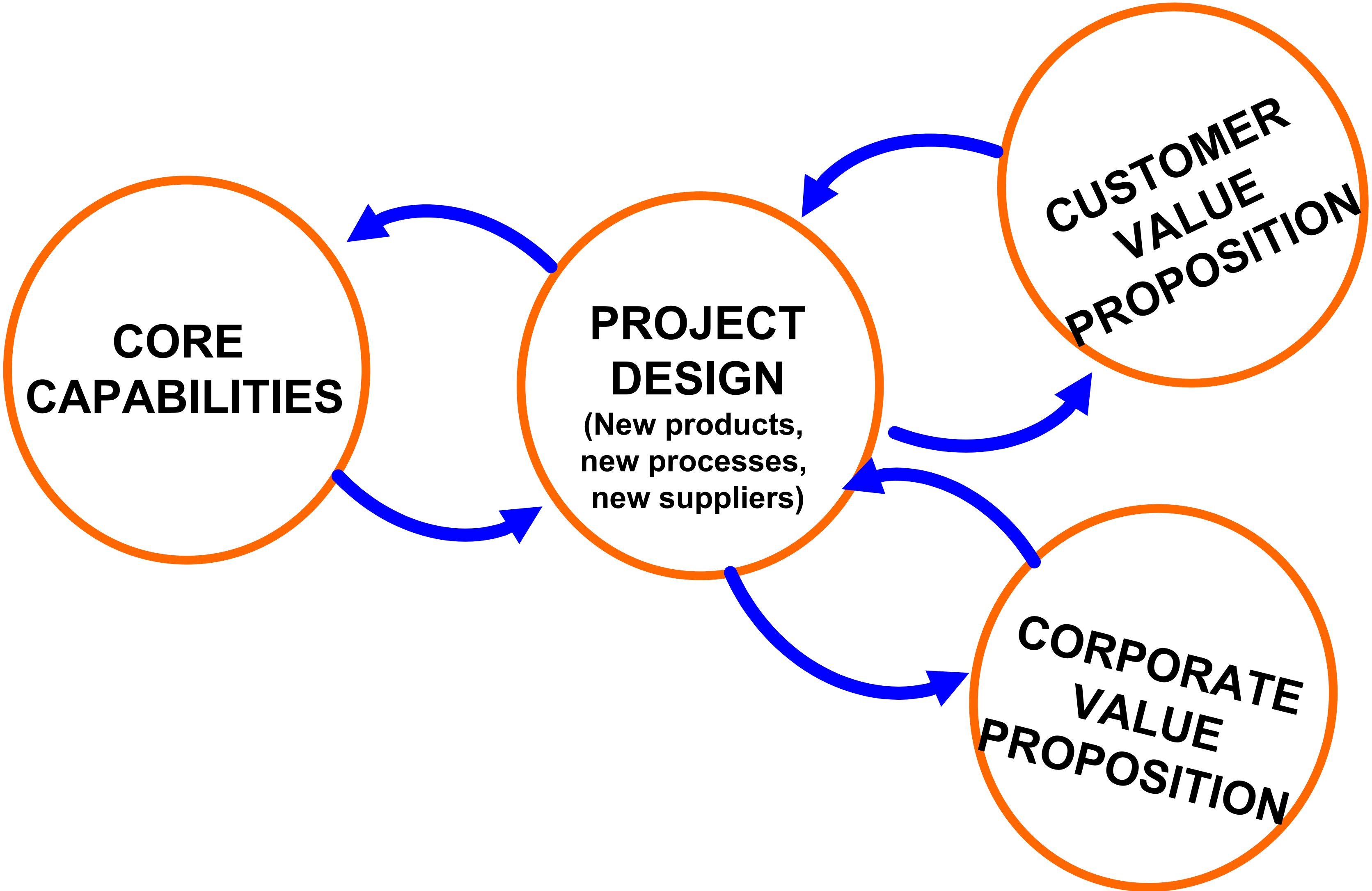
2. Partner Selection
(Choice of suppliers and partners for the chain)

3. The Contractual Relationship
(Arm's length, joint venture, long-term contract, strategic alliance, equity participation, etc.)

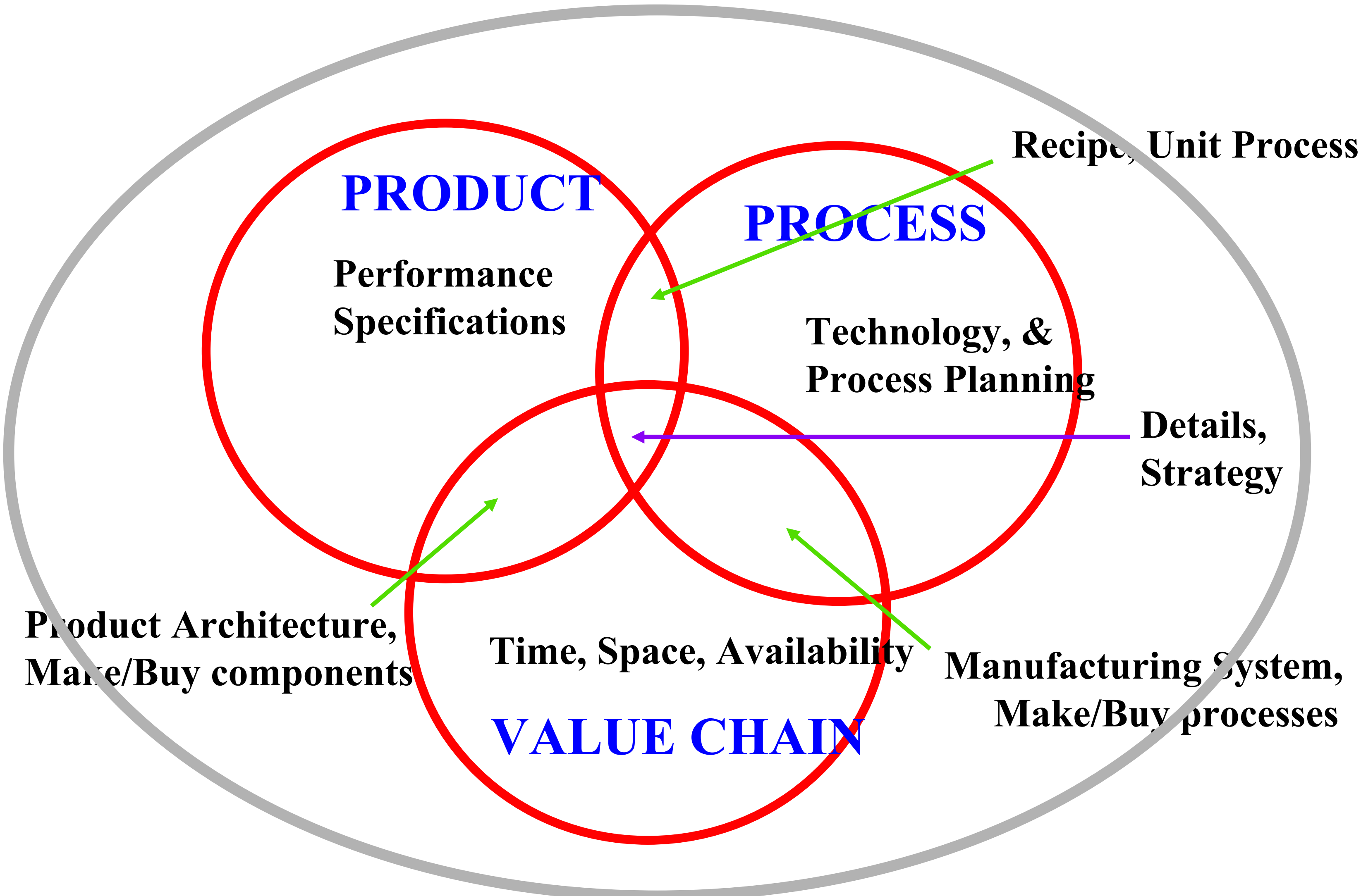
IMPLEMENTATION OF VALUE CHAIN DESIGN: EMBED IT IN 3-D CONCURRENT ENGINEERING



Projects Serve Three Masters: Capabilities, Customers, & Corporate Profit



IMPLEMENTATION OF *PROJECT DESIGN:* FRAME IT AS 3-D CONCURRENT ENGINEERING



ARCHITECTURES IN 3-D
INTEGRALITY VS. *MODULARITY*

Integral product architectures **feature close coupling among the elements**

- Elements perform many functions
- Elements are in close spacial proximity
- Elements are tightly synchronized

- Ex: jet engine, airplane wing, microprocessor

Modular product architectures **feature separation among the elements**

- Elements are interchangeable
- Elements are individually upgradeable
- Element interfaces are standardized
- System failures can be localized

- Ex: stereo system, desktop PC, bicycle

VALUE CHAIN ARCHITECTURE

Integral value-chain architecture
features close proximity among its elements
- Proximity metrics: Geographic, Organizational
Cultural, Electronic
- Example: Toyota city
- Example: Ma Bell (AT&T in New Jersey)
- Example: IBM mainframes & Hudson River Valley

Modular value-chain architecture features multiple,
interchangeable supplier and standard interfaces
- Example: Garment industry
- Example: PC industry
- Example: General Motors' global sourcing
- Example: Telephones and telephone service

ALIGNING ARCHITECTURES: BUSINESS SYSTEMS & TECHNOLOGICAL SYSTEMS

BUSINESS SYSTEM/SUPPLY CHAIN ARCHITECTURE
(Geog., Organ., Cultural, Elec.)

INTEGRAL ⟷ MODULAR

TECHNOLOGY/PRODUCT ARCHITECTURE: INTEGRAL ⟷ MODULAR

TECHNOLOGY/PRODUCT ARCHITECTURE \ BUSINESS SYSTEM	INTEGRAL		MODULAR
INTEGRAL	Microprocessors Mercedes & BMW vehicles	Lucent Nortel	Polaroid
	MSFT Windows	Chrysler vehicles	Cisco
MODULAR	Digital Rights/ Music Distribution		Dell PC'S Bicycles

ALIGNING ARCHITECTURES: BUSINESS SYSTEMS & TECHNOLOGICAL SYSTEMS

BUSINESS SYSTEM ARCHITECTURE
(Geog., Organ., Cultural, Elec.)

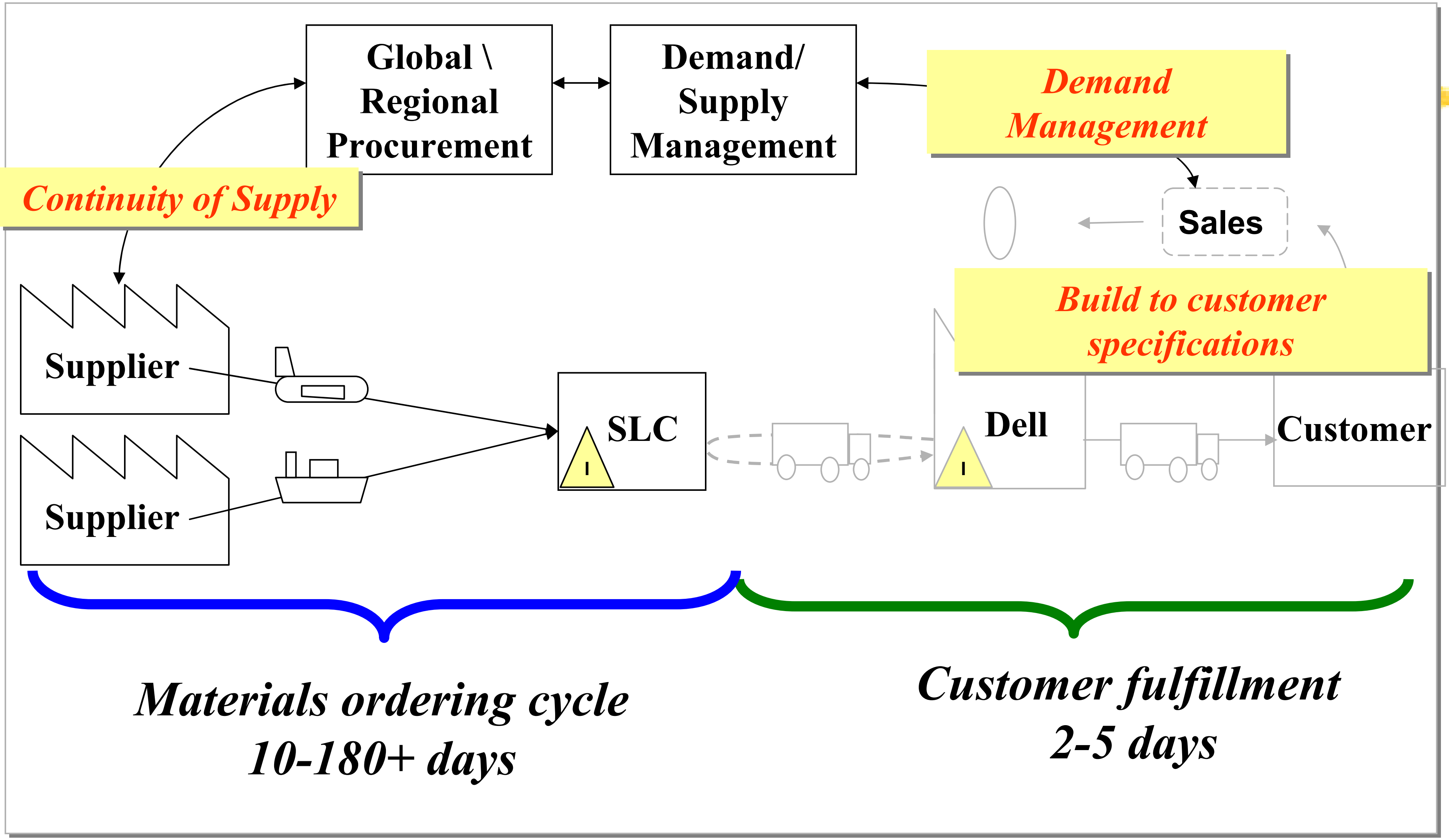
TECHNOLOGICAL SYSTEM ARCHITECTURE	INTEGRAL	MODULAR
INTEGRAL	Jet engines Microprocessors Mercedes vehicles	Polaroid Lucent, Nortel
MODULAR	Automotive Supplier Parks	Personal Computers Bicycles Chrysler Vehicles Cisco

Demand-Supply Chain Management @ Dell

- **Demand Management:**
- **Forecast = Buy = Sell**
- **Buy to Plan, but Build to Order**

- **Inventory Velocity is a wonderful thing …**
  - Customers have immediate access to the latest technology.
  - Suppliers get their products to market quickly
  - Quality is improved with fewer touches.
  - Cash is generated through negative cash cycle.
  - Model efficiencies drive Market Share gain.

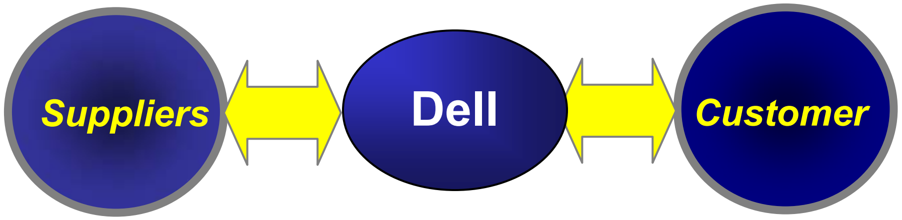
Dell Supply Chain



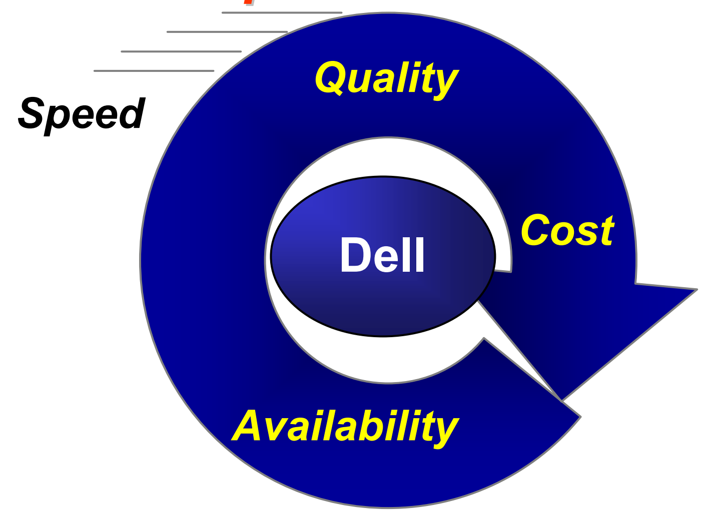
Modular Product Architecture enables Modular Supply Chain

The Dell Model:
Simple, Focused, Efficient

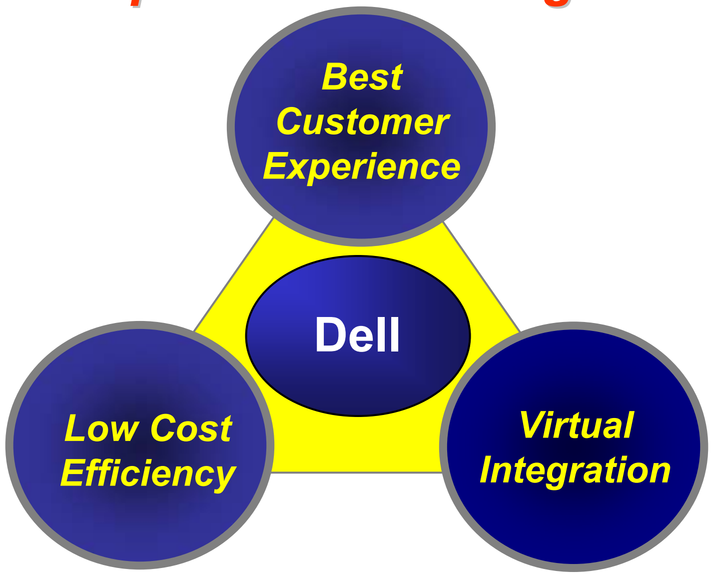
Keep It Simple…Direct



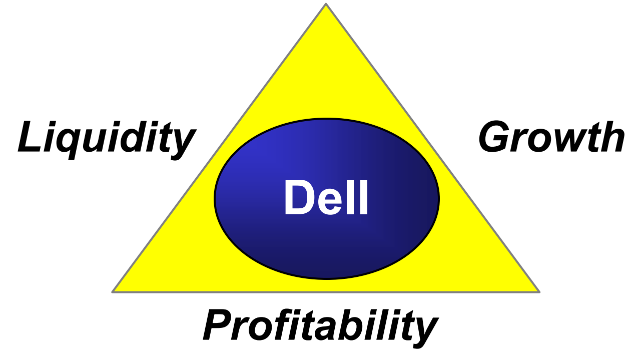
Execute Operational Efficiency



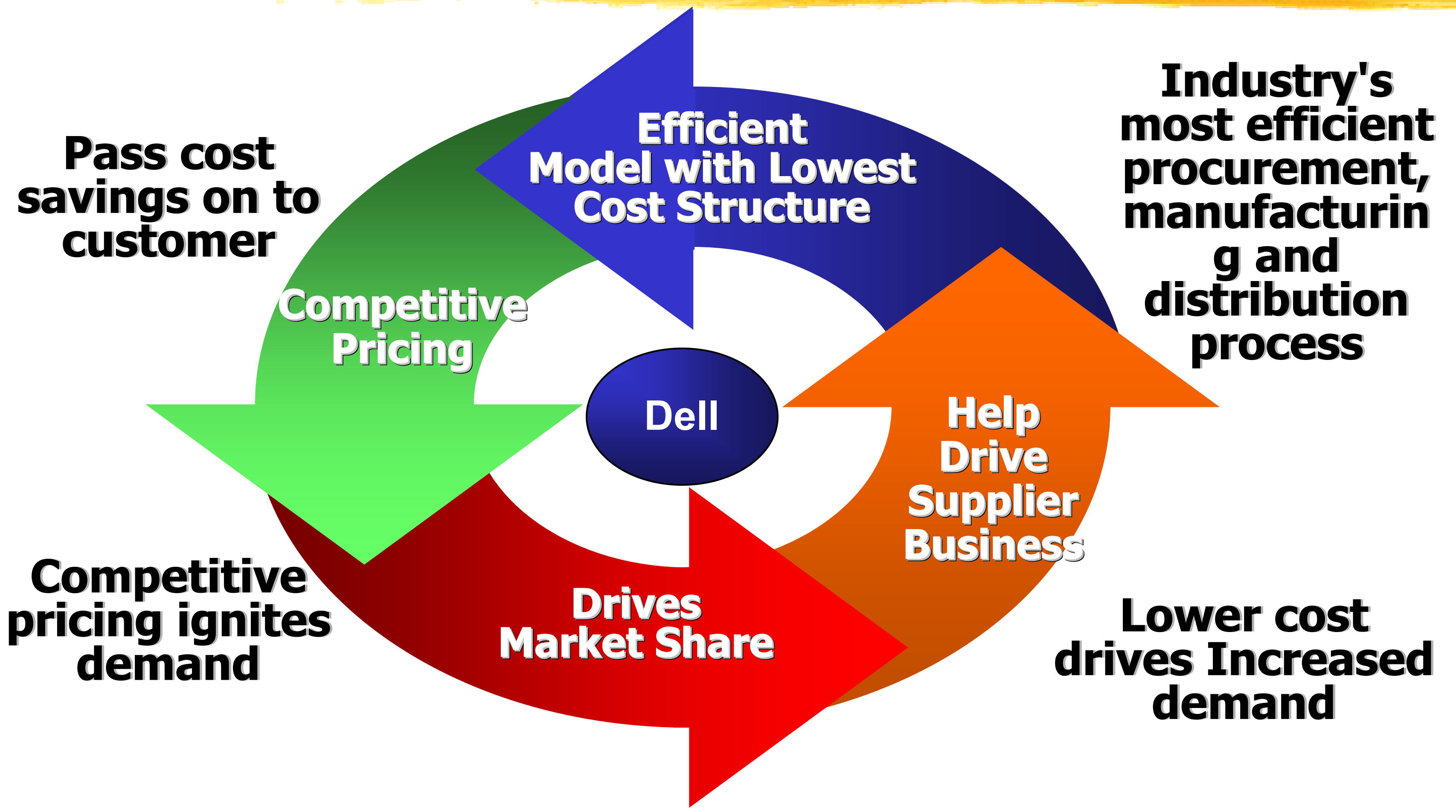
Competitive Advantages



Measure What Matters



Dynamics of Dell Success



LESSON: SYSTEM SPEED FROM MODULAR PRODUCT

Can "Dell Direct" Work for Autos?

- **Appealing to OEM's on Many Dimensions**
  - **Satisfy customer need for Speed**
  - **Reduce Supply Line Inventories**
  - **Reduce mismatches and discounting**
  - **Direct OEM-Customer Relationships (& Data!)**
  - **Information Transparency**

Adapted from Prof. J.P. MacDuffie, IMVP & The Wharton School

BUT, A Car is not a Computer!!

- ***Personal Computer***

- ~50 components
- 8-10 key parts
- 40 key suppliers
- 24 hour burn-in
- 100 design
- variations
- Modular
- Architecture

- ***Car***

- ~ 4000 components
- 100 key subsystems
- 300 key suppliers
- 12 month validation
- 1,000,000
- variations
- Integral
- Architecture

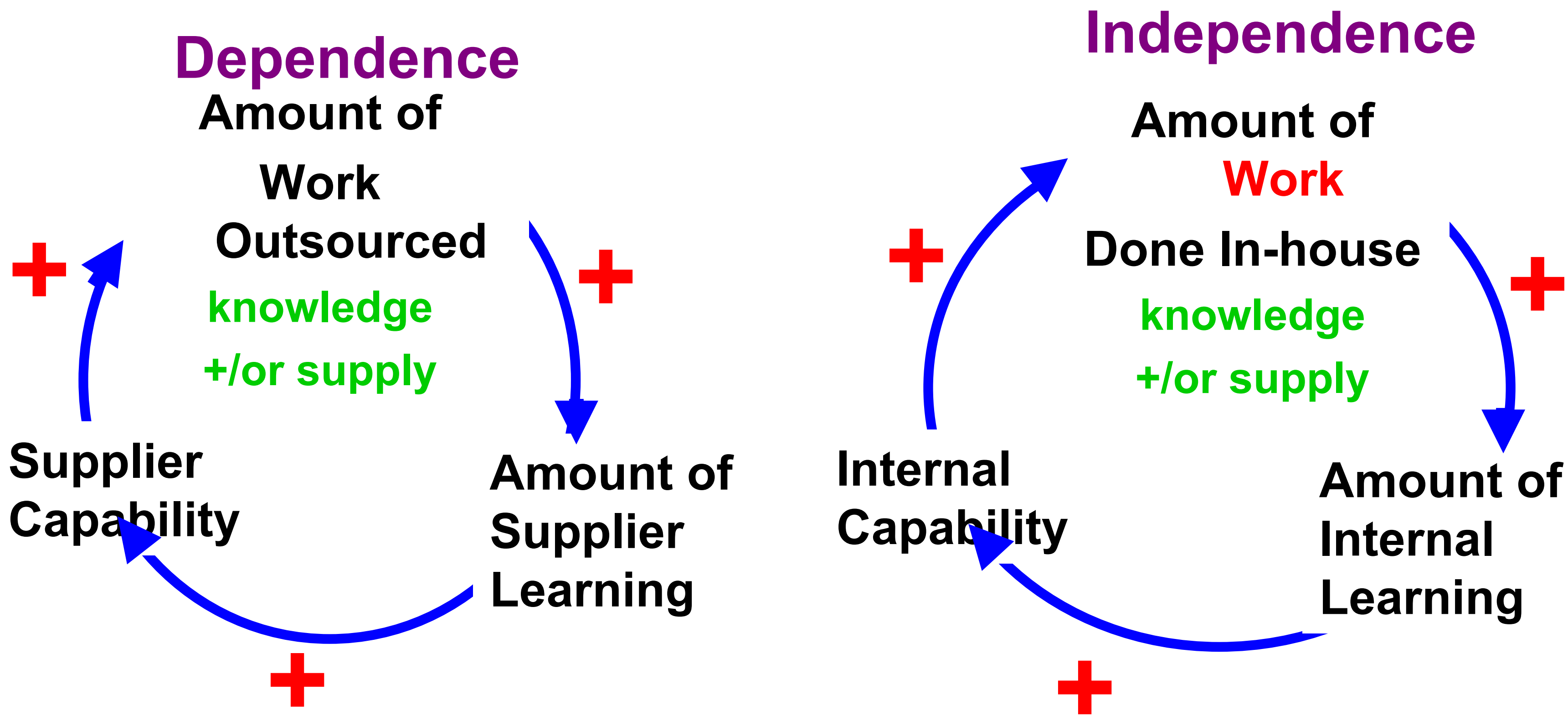
Adapted from Prof. J.P. MacDuffie, IMVP & The Wharton School

DESIGNING ARCHITECTURES FOR PRODUCTS & VALUE CHAINS: MODULARITY VS. OPENNESS

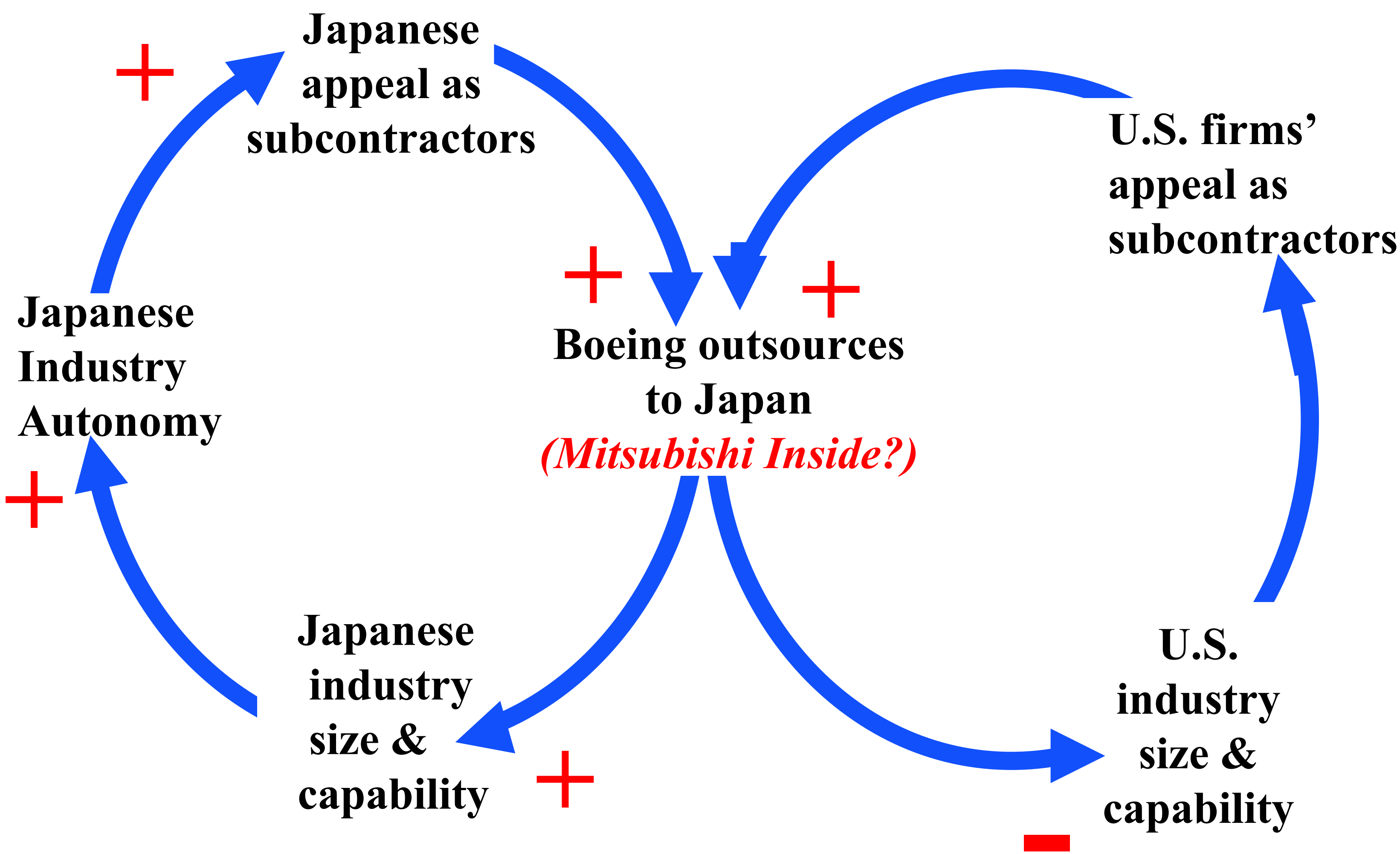
ARCHITECTURAL STRUCTURE \ ARCHITECTURAL PROPRIETARINESS	CLOSED	OPEN
INTEGRAL	Pentium Chip Mercedes Vehicles SAP ERP	Linux
MODULAR	IBM Mainframes Microsoft *Windows* Chrysler Vehicles	Palm Pilot software & accessories Phones & service Web-based ERP

INFORMATION ARCHITECTURE MUST REFLECT BUSINESS MODEL

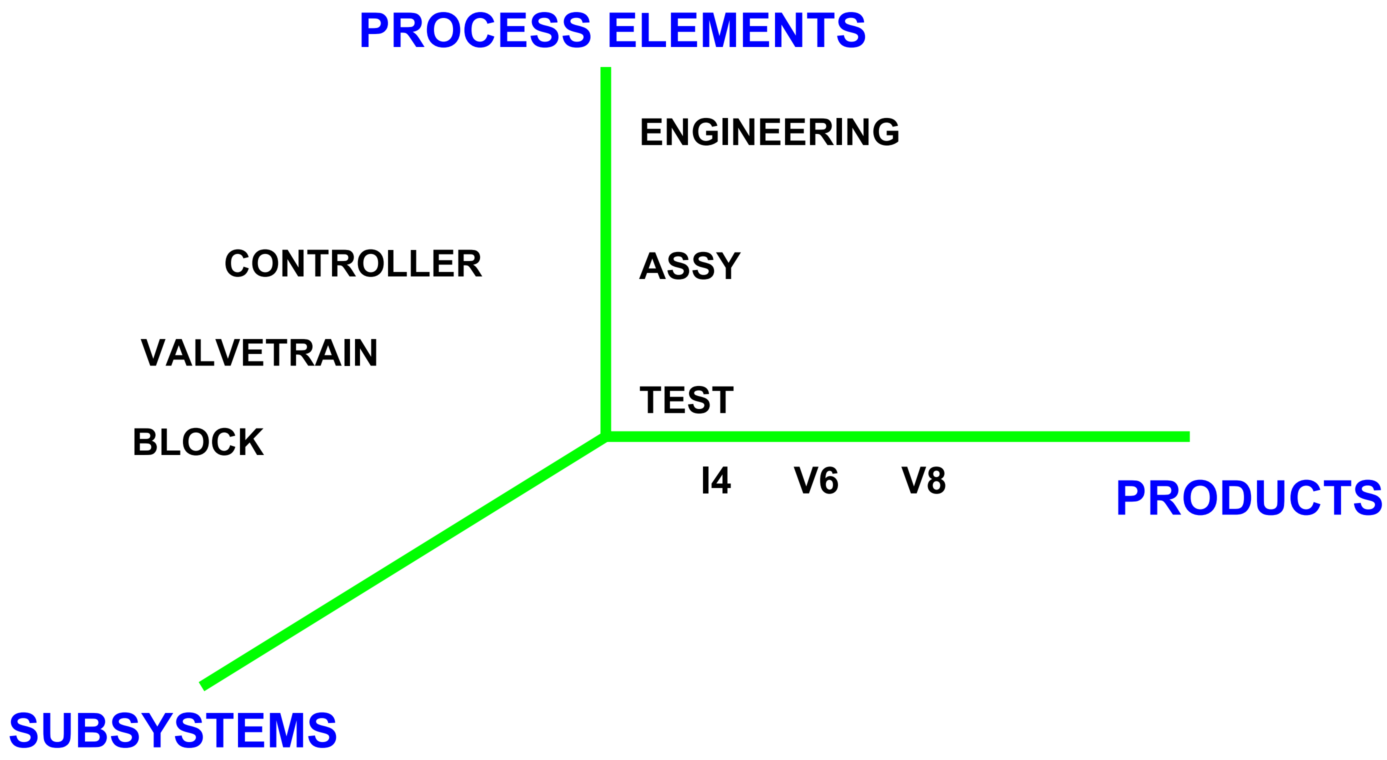
In/Outsourcing: Sowing the Seeds of Competence Development to develop dependence for knowledge or dependence for capacity



Technology Dynamics in the Aircraft Industry: LEARNING FROM THE DINOSAURS



SOURCEABLE ELEMENTS

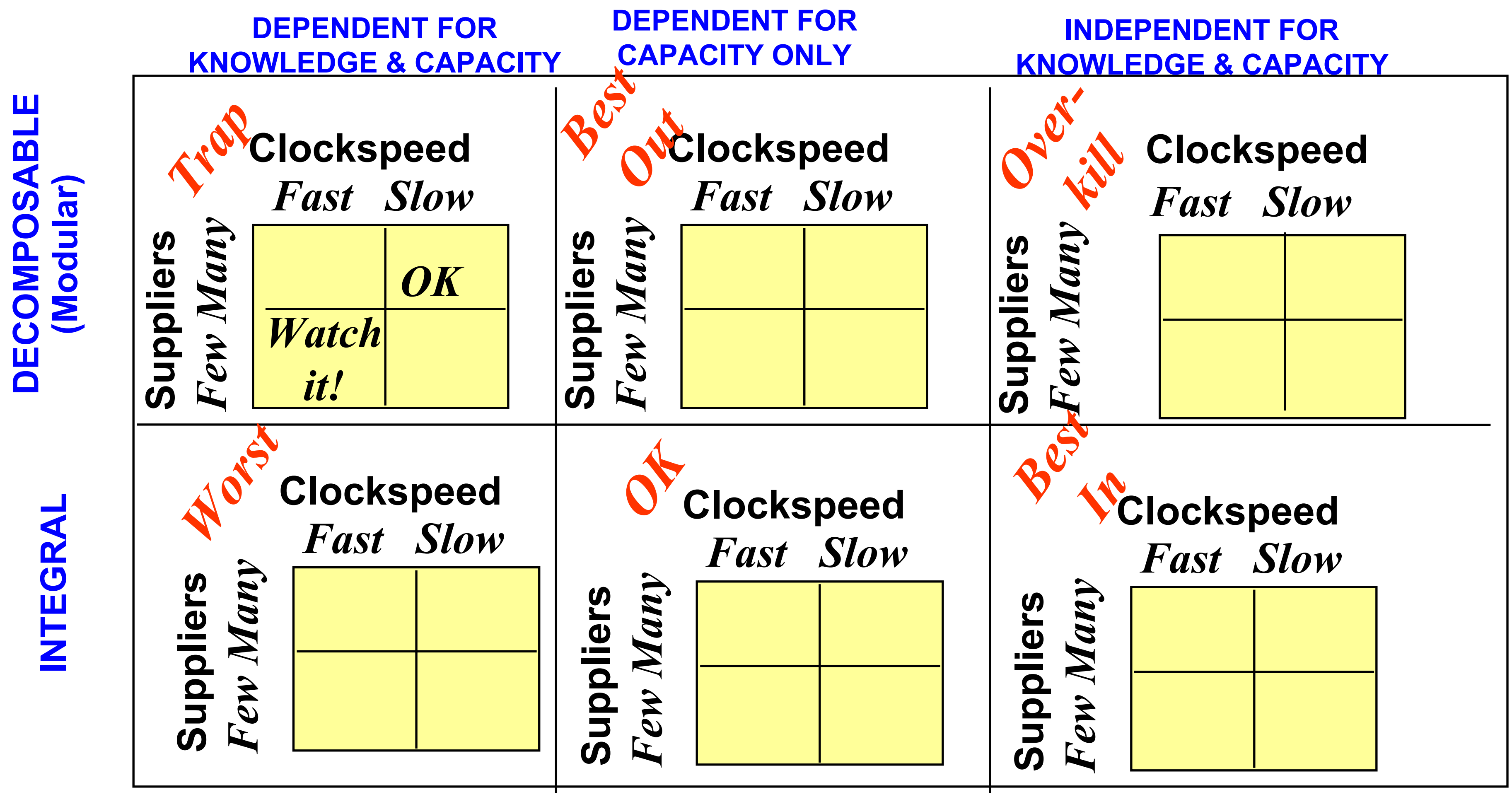


Strategic Make/Buy Decisions: Assess Critical Knowledge & Product Architecture

	DEPENDENT FOR KNOWLEDGE & CAPACITY	INDEPENDENT FOR KNOWLEDGE & DEPENDENT FOR CAPACITY	INDEPENDENT FOR KNOWLEDGE & CAPACITY
ITEM IS MODULAR	A POTENTIAL OUTSOURCING TRAP	BEST OUTSOURCING OPPORTUNITY	OVERKILL IN VERTICAL INTEGRATION
ITEM IS INTEGRAL	WORST OUTSOURCING SITUATION	CAN LIVE WITH OUTSOURCING	BEST INSOURCING SITUATION

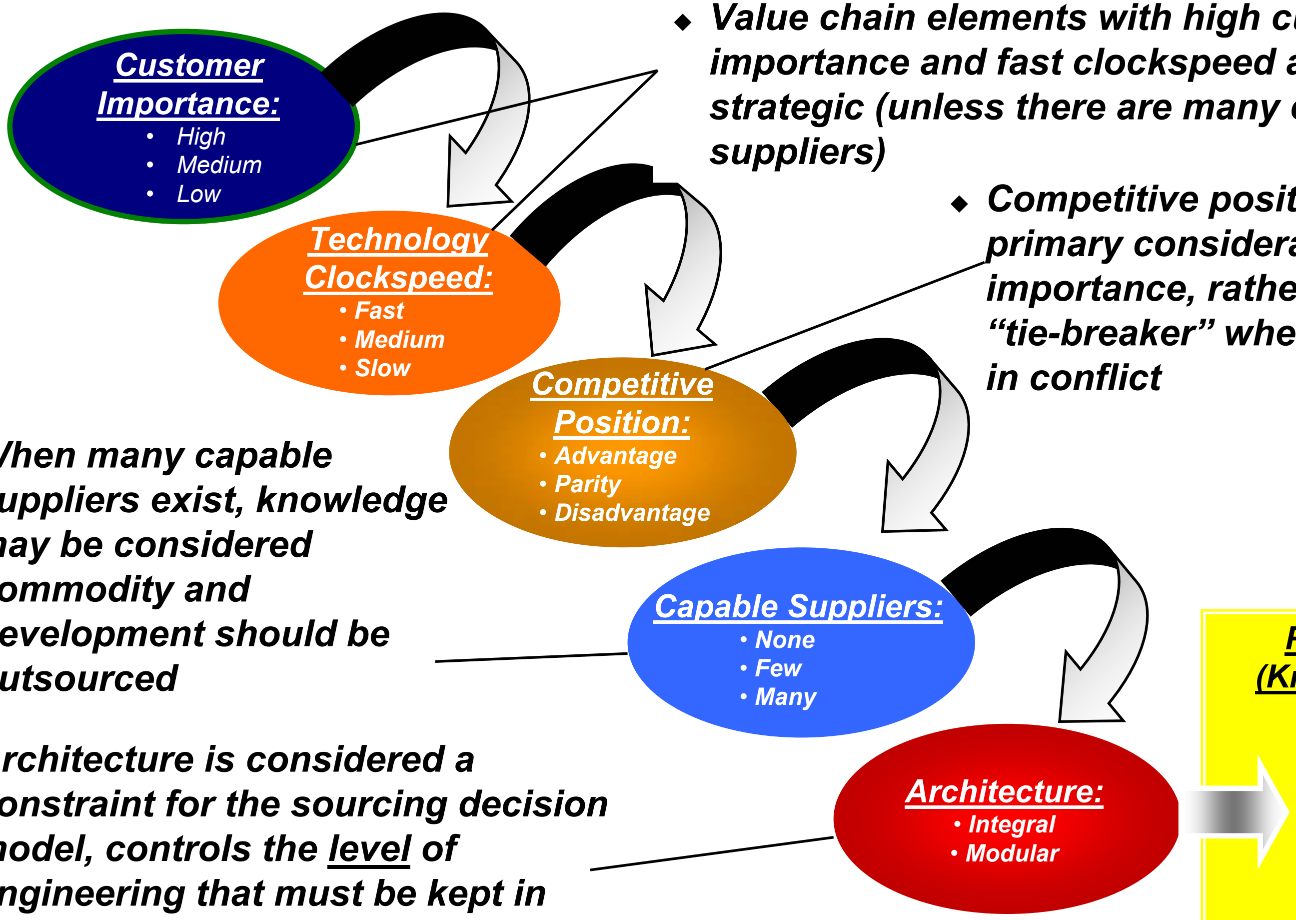
Adapted from Fine & Whitney, "Is the Make/Buy Decision Process a Core Competence?"

Strategic Make/Buy Decisions: Also consider Clockspeed & Supply Base Capability



Adapted from C. Fine, *Clockspeed*, Chap. 9

Qualitative analysis of strategic importance uses five key criteria



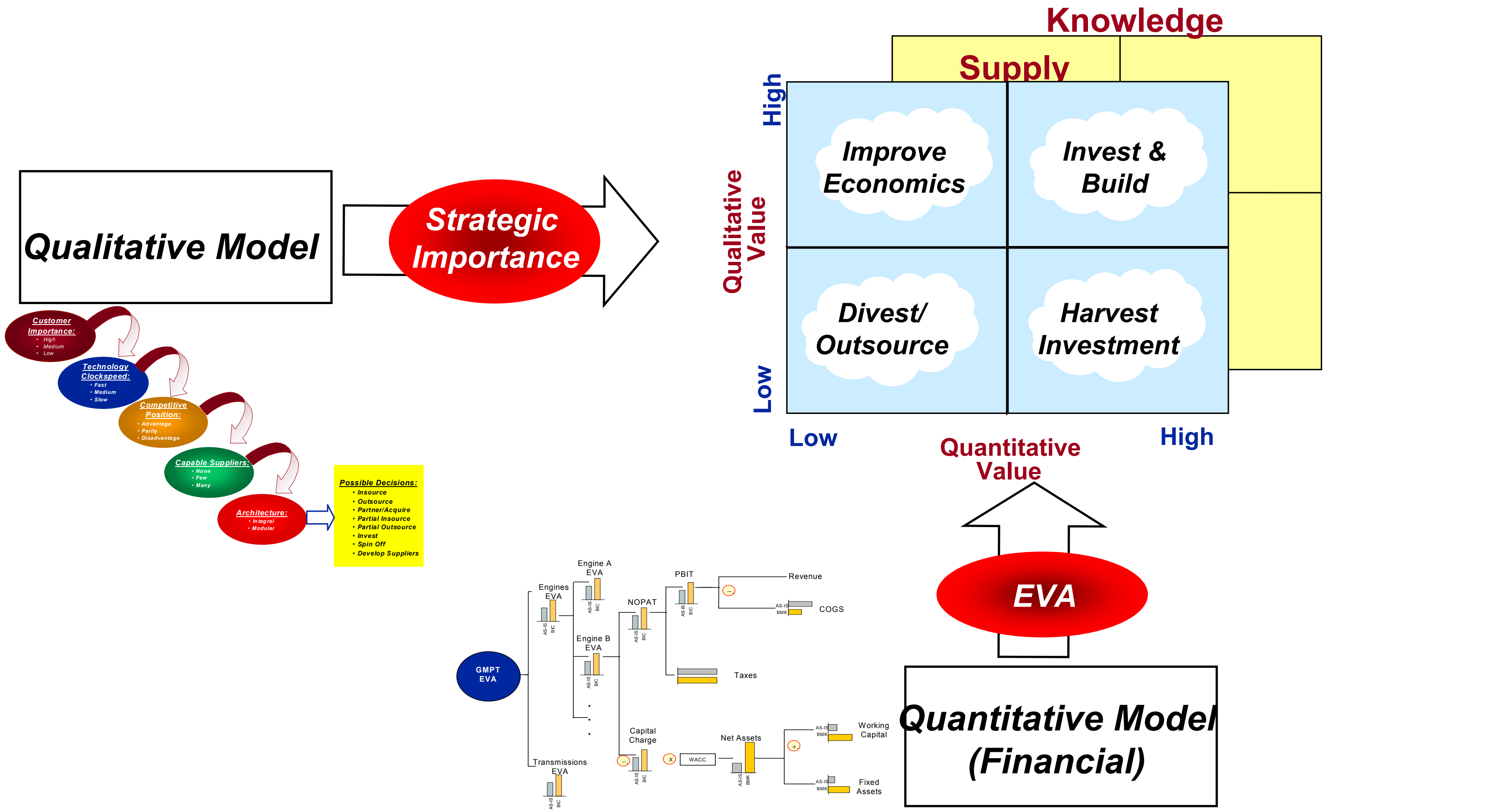
- ***Value chain elements with high customer importance and fast clockspeed are generally strategic (unless there are many capable suppliers)***
- ***Competitive position is seldom the primary consideration for strategic importance, rather it serves as a "tie-breaker" when other criteria are in conflict***
- ***When many capable suppliers exist, knowledge may be considered commodity and development should be outsourced***
- ***Architecture is considered a constraint for the sourcing decision model, controls the level of engineering that must be kept in house for integration purposes***

Possible Decisions (Knowledge & Supply):

- ***Insource***
- ***Outsource***
- ***Partner/Acquire***
- ***Partial Insource***
- ***Partial Outsource***
- ***Invest***
- ***Spin Off***
- ***Develop Suppliers***

Model developed by GM Powertrain, PRTM, & Clockspeed, Inc.

Every decision requires qualitative and quantitative analysis to reach a conclusion



Model developed by GM Powertrain, PRTM, & Clockspeed, Inc.

Value Chain Mapping

Organizational Supply Chain

Chrysler	Eaton	casting supplier	clay supplier

Technology Supply Chain

engines	valve lifters	casting manufacturing process	clay chemistry

Capability Chain

Supply Chain Management	Quality assurance	NVH engineering	R&D

Underlying Assumption: You have to draw the maps before you can assess their dynamics.

VALUE CHAIN DESIGN IS *THE ULTIMATE* CORE COMPETENCY

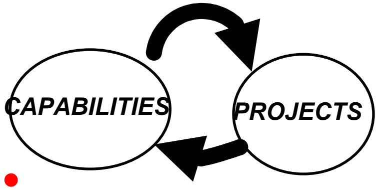
Since all advantages are temporary, the only lasting competency is to continuously build and assemble capabilities chains.

KEY SUB-COMPETENCIES:

1. **Forecasting the dynamic evolution of market power and market opportunities**

2. **Anticipating Windows of Opportunity**

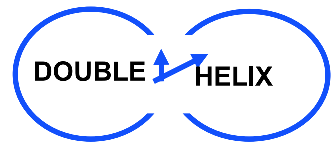
3. **3-D Concurrent Engineering: Product, Process, Value Chain**



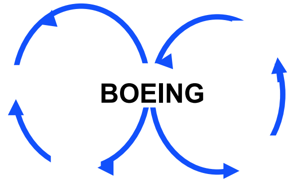
Fortune Favors the Prepared Firm

PROCESS FOR VALUE CHAIN DESIGN

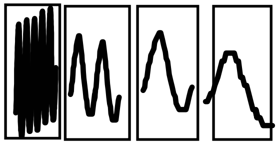
1. Benchmark the Fruit Flies



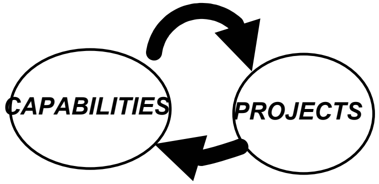
2. Map your Supply Chain
   - Organizational Value Chain
   - Technology Value Chain
   - Competence Chain



3. Dynamic Chain Analysis at each node of each chain map

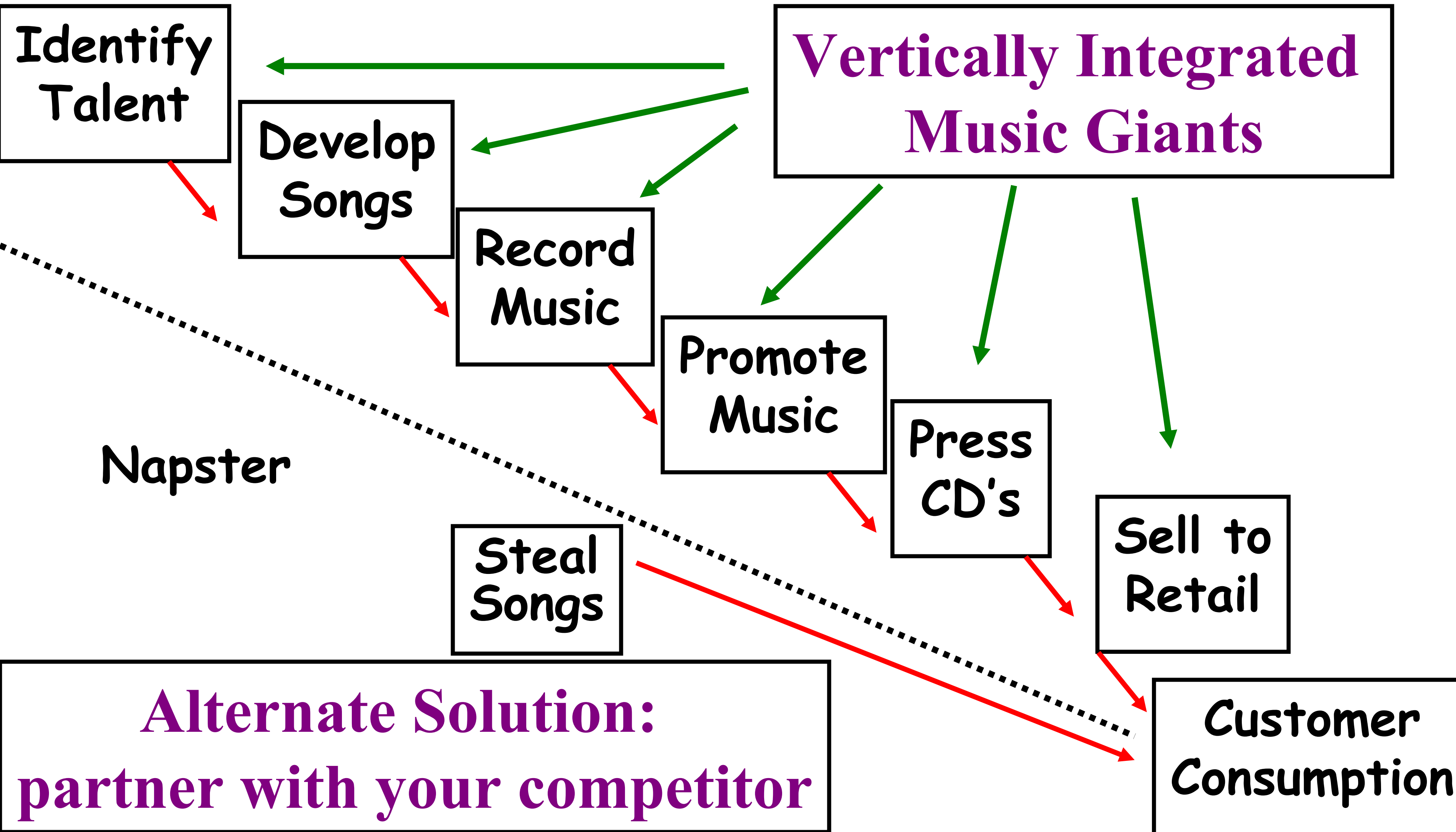


4. Identify Windows of Opportunity
5. Exploit Competency Development Dynamics with 3-D Concurrent Engineering



DOT.COM COMPETITION: FOCUS ON THE SUPPLY CHAIN

Napster's New Supply Chain Strategy
(go to the end and steal everything!)



STRATEGY IN 3-D: CASE EXAMPLES

Boeing: Static 3-D in airplane Projects
Dynamic, Strategic Value Chain,
unintegrated w/ Product & Process

Intel: Modular Product vs. Process
Integral Process and Value Chain

Chrysler: Modular Product & Value Chain
(weak on process?)

Toyota: Integral 3-D in Nagoya
(weak on global 3-D?)

Team Exercise: Value Chain Analysis

What are the key elements in the value chain?

What are the key dynamic processes
influencing power in the chain?

What are the key dependency relationships in the value chain?

What is driving the clockspeed in the chain?

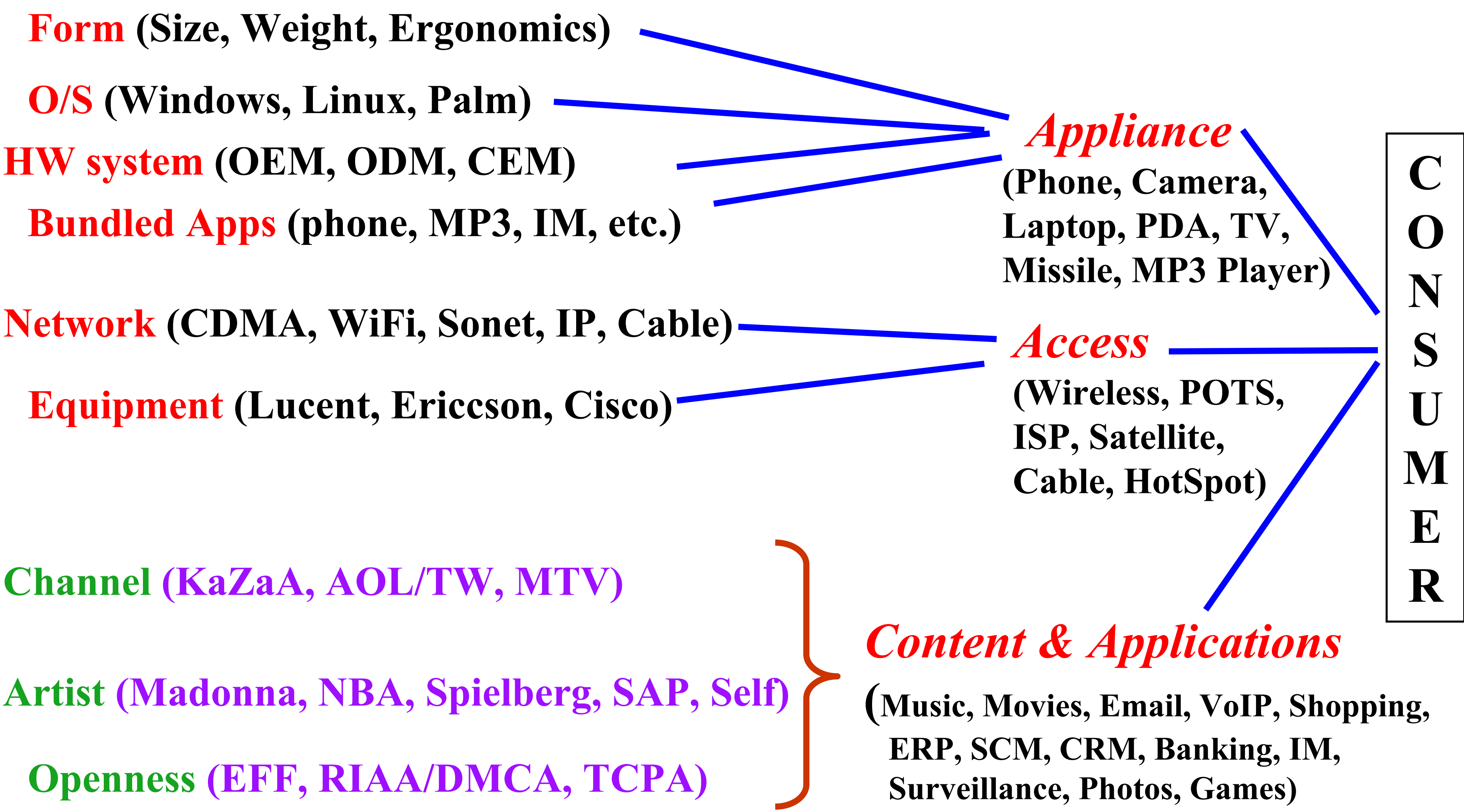
What are the opportunities for outsourcing
to contract manufacturers?

What are the windows of opportunity in the chain?

Value Chain Strategy: Clockspeed & 3-D Concurrent Engineering

1. Introduction
2. Fruit Flies & Value Chain Evolution
3. Value Chain Design & 3-DCE
4. Value Chain Roadmapping & Strategy Making

One View (the consumer's) of the Communications Value Chain



Another View of the Communications Value Chain

MATERIALS & PROCESS EQUIP	COMP-ONENTS	EQUIPMENT MAKERS	NETWORK OWNERS	SERVICE PROVIDERS	CONTENT & APPLICS	APPLI-ANCES	END USERS
•Silicon •Gaas •InP •Polymers •Steppers •Etchers •MEMS •Insertion •Etc..	•Lasers •Amplifiers •Transceiver •Filters •Processors •Memories •Fiber •ASICS •MEMS •DSP's •Etc..	•Routers •Switches •Hubs •Base Stations •Satellites •Servers •Software •O/S •Etc..	•Wireless •Backbone •Metro •Access •Substations •Satellites •Broadcast Spectrum •Communic Spectrum •Etc..	•Long dist. •Local •Cellular •ISP •Broadcast •Hot Spots •Cable TV •Satellite TV •VPN's •MVNO's •Etc..	•Music •Movies •Email •VoIP •POTS •Shopping •ERP •SCM, CRM •Surveillance •eBusiness •Etc..	•Computers •Phones •Media Players • Cameras •PDA's •Weapons •Etc..	•Business •Consumer •Gov't •Military •Education •Medical •Etc..

Roadmapping Communications: What are the Premises?

Communications Value Chain is in ill health
(ROADKILL MAPPING?)

Vertical *dis*integration is the dominant structure. Silo execs tend to focus on their own narrow slices. Most industry consortia are *within*-silo.

Silos in the value chain are interdependent (integrality).

Absence of leadership and coordination across an interdependent value chain creates uncertainty, risk, and reluctance to invest.

SOME VALUE CHAIN COORDINATION COULD SPEED GROWTH.

HOW TO ACHIEVE COORDINATION IN THE ABSENCE OF VERTICAL INTEGRATION?

Roadmapping Communications: What are the Premises?

Technology dynamics, Industry dynamics, and Regulatory dynamics are interdependent.

Technology and industry roadmapping are typically done by different people

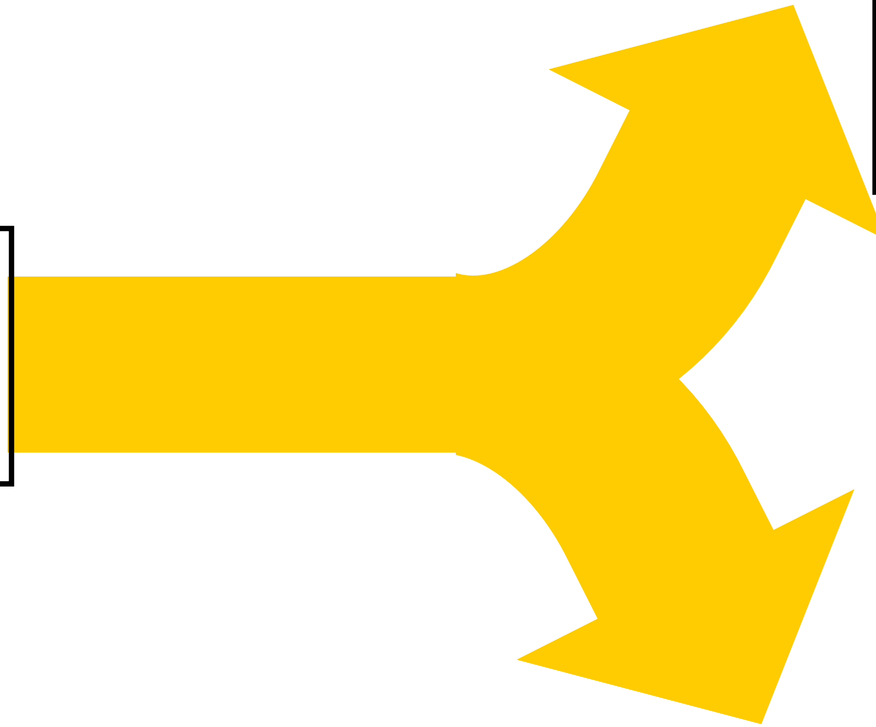
SIA roadmaps provided productive coordination in semiconductors, but focused only on technology & a narrow slice of the value chain. Industry growth was assumed.

--> Not a good model for Communications.

Productive roadmapping must encompass multiple links of the value chain, a multidisciplinary team, and the co-evolution of technology, industry, and regulatory policy.

“If you come to a fork in the Road[map], Take it.”
--Yogi Berra

Internet explosion
Wireless Explosion
Connectivity Explosion
File Sharing Explosion



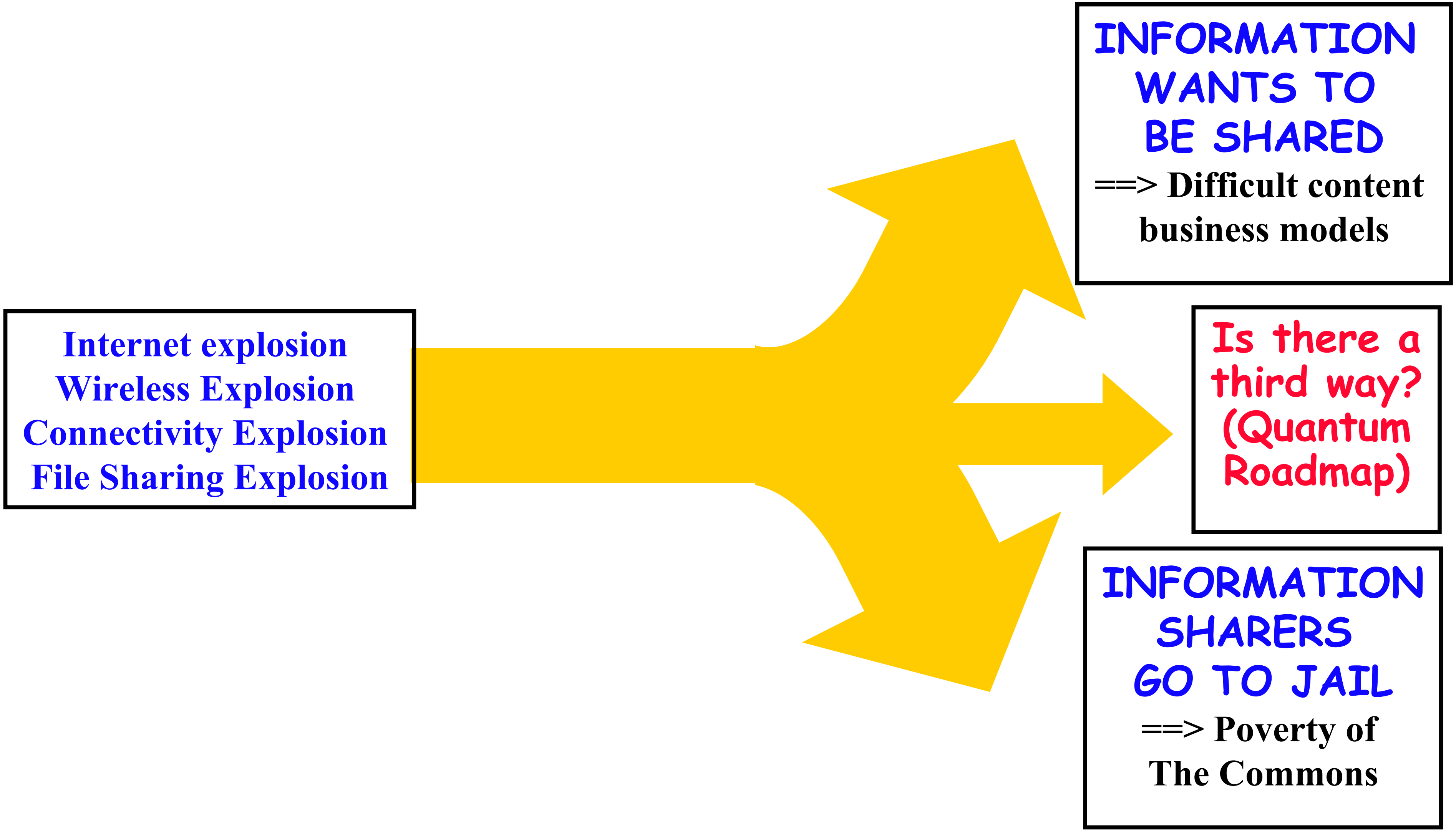
INFORMATION WANTS TO BE SHARED

==> Difficult content business models

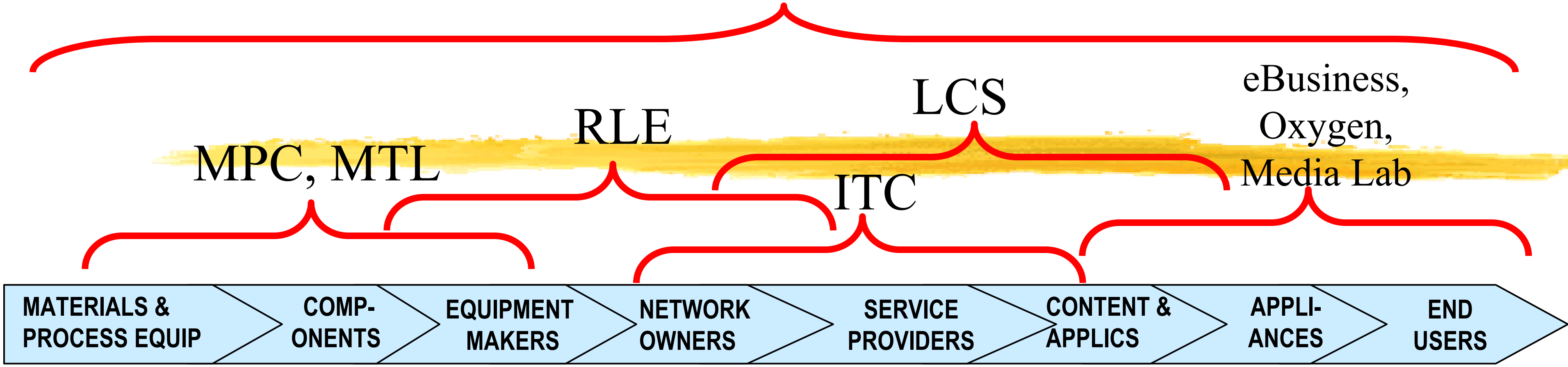
INFORMATION SHARERS GO TO JAIL

==> Poverty of The Commons

"If you come to a fork in the Road[map], Take it."
--Yogi Berra



Proposed MIT Communications Roadmap Consortium



•Silicon •Gaas •InP •Polymers •Steppers •Etchers •MEMS •Insertion •Etc..	•Lasers •Amplifiers •Transceiver •Filters •Processors •Memories •Fiber •ASICS •MEMS •DSP's •Etc..	•Routers •Switches •Hubs •Base Stations •Satellites •Servers •Software •O/S •Etc..	•Wireless •Backbone •Metro •Access •Substations •Satellites •Broadcast Spectrum •Communic Spectrum •Etc..	•Long distance •Local Phone •Cellular •ISP •Broadcast •Hot Spots •Cable TV •Satellite TV •VPN's •MVNO's •Etc..	•Music •Movies •Email •VoIP •POTS •Shopping •ERP •SCM, CRM •Surveillance •eBusiness •Etc..	•Computers •Phones •Media Players • Cameras •PDA's •Weapons •Etc..	•Business •Consumer •Gov't •Military •Education •Medical •Etc..

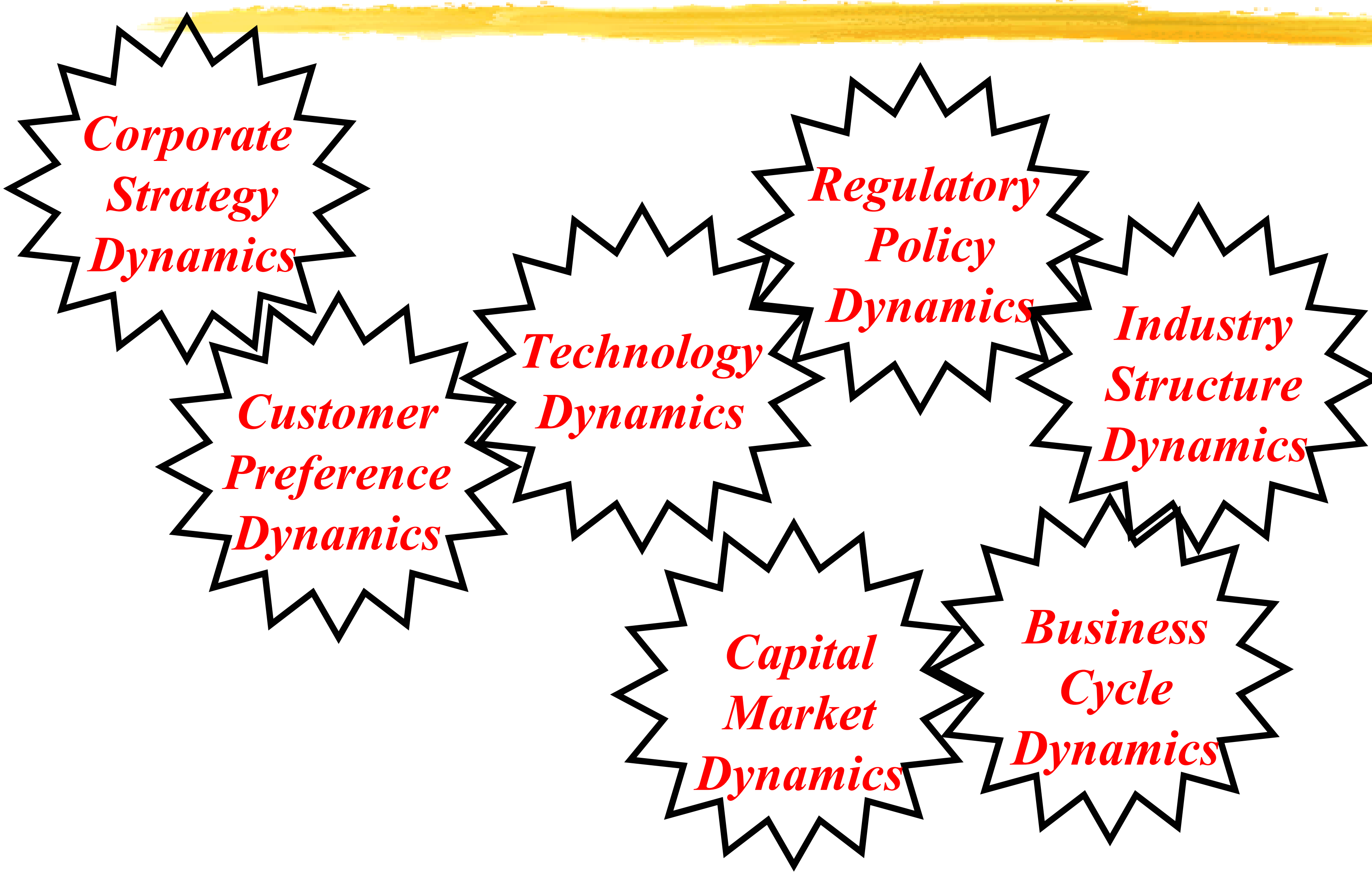
CROSS-INDUSTRY CHALLENGES

Digital Rights ("To promote the Progress of Science and useful Arts, by securing for limited Times to Authors and Inventors the exclusive Right to their respective Writings and Discoveries;" U.S. Constitution, Article 1, Section 8, Clause 8)

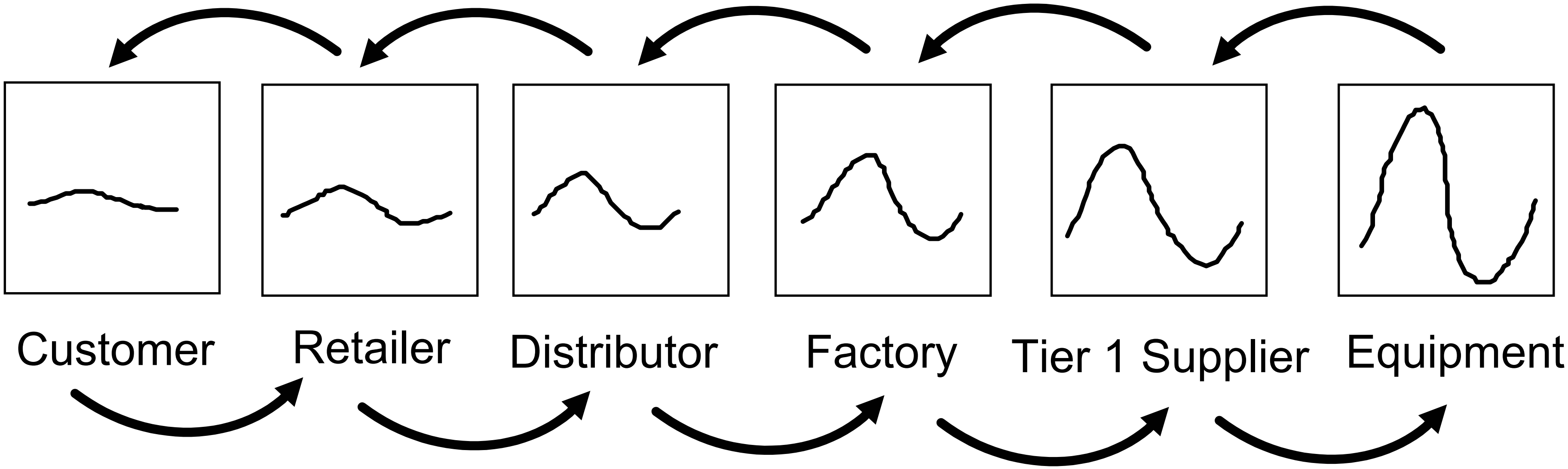
Access Architecture

Prof. C. Fine, MIT

Dynamic Analysis to Support Industry & Technology Roadmapping



Business Cycle Dynamics
"The Bullwhip Effect"



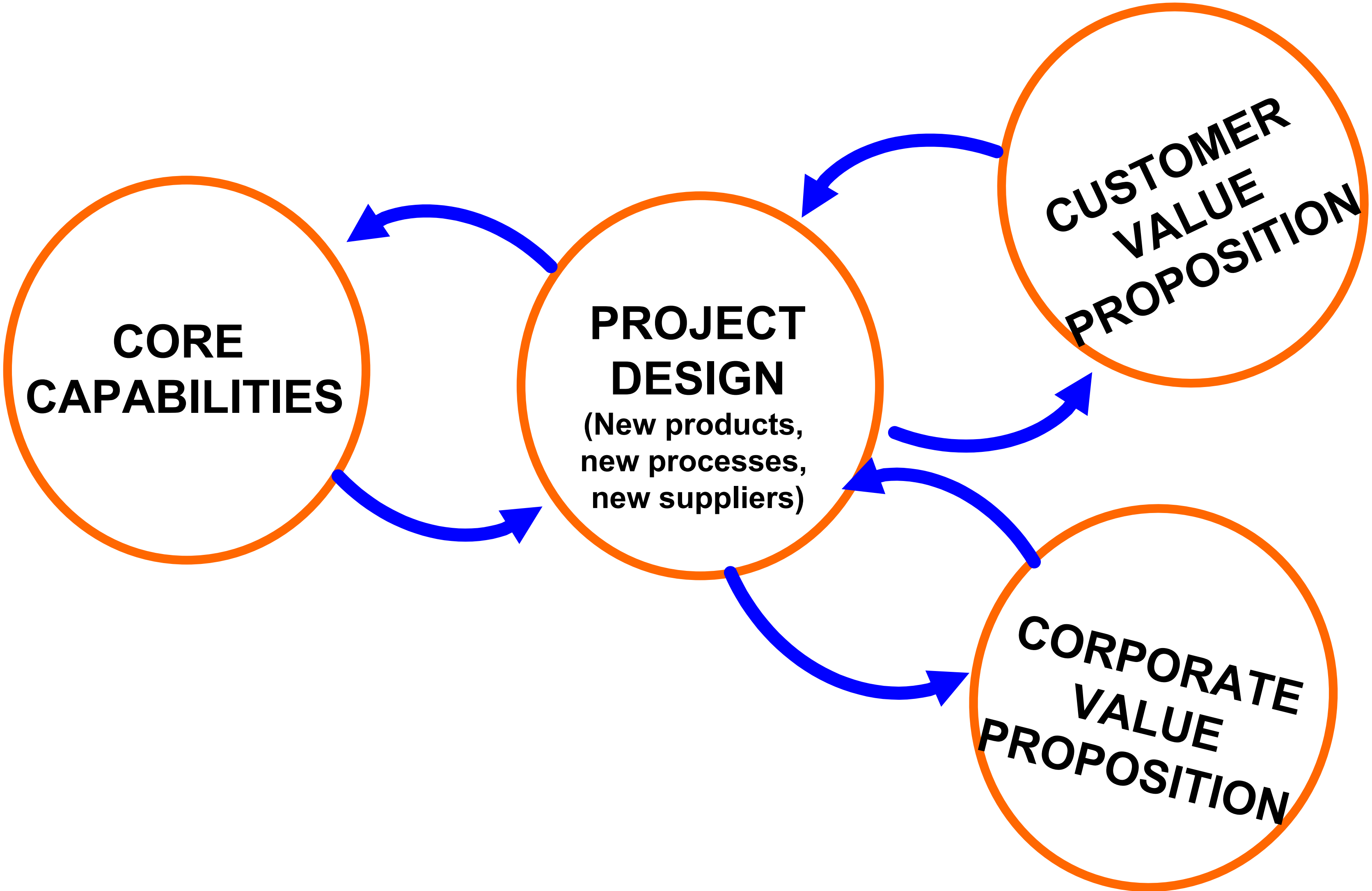
Information lags
Delivery lags
Over- and underordering
Misperceptions of feedback
Lumpiness in ordering
Chain accumulations

SOLUTIONS:
Countercyclical Markets
Countercyclical Technologies
Collaborative channel mgmt.
(Cincinnati Milacron & Boeing)

Industry Structure Dynamics

See Fine & Whitney, “Is the Make/Buy Decision Process a Core Competence?”

Corporate Strategy Dynamics



Corporate Strategy Dynamics

BUSINESS SYSTEM/SUPPLY CHAIN ARCHITECTURE
(Geog., Organ., Cultural, Elec.)

INTEGRAL ↔ MODULAR

TECHNOLOGY/PRODUCT ARCHITECTURE: INTEGRAL ↕ MODULAR

INTEGRAL	Microprocessors Mercedes & BMW vehicles	Lucent Nortel	Polaroid
	MSFT Windows	Chrysler vehicles	Cisco
MODULAR	Digital Rights/ Music Distribution		Dell PC'S Bicycles

Customer Preference Dynamics

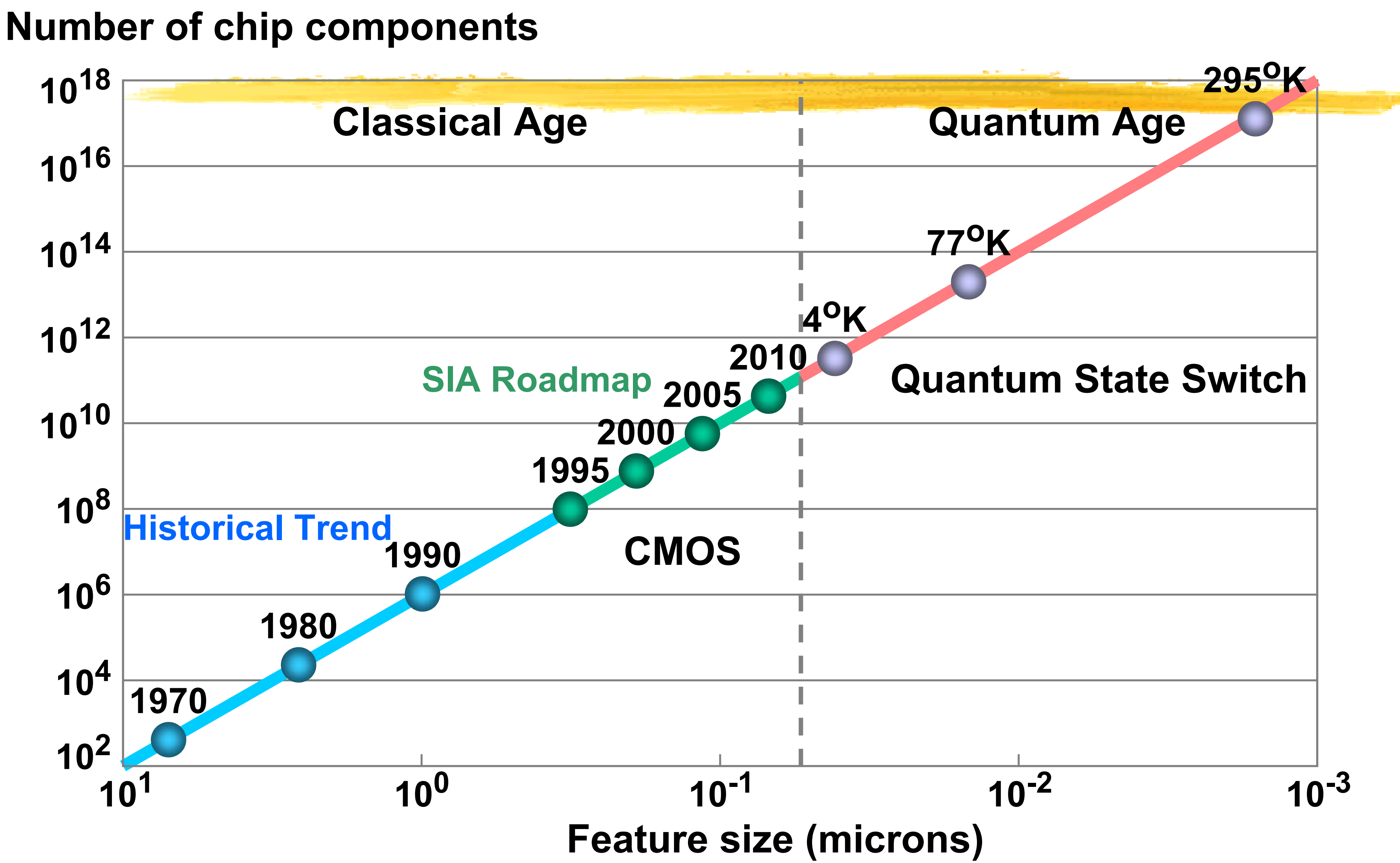
(adapted from Sadek Esener, UCSD and Tom O'Brien, Dupont "Macro-Trends" process)

1. **Population**
   - Aging, Growth
2. **Awareness**
   - of Environment/Energy costs, Personal Health
   - of consumption possibilities & disparities
3. **Globalization**
   - of commerce, culture, knowledge, disease, terrorism
4. **Clusters**
   - urbanization
   - wealth
   - affinity/ethnic groups
5. **Technology**
   - cheap computation, pervasive connectivity
   - technology at the molecular (nano) level (life sciences, electronics, polymers)

Regulatory Policy Dynamics: Some Components

1. **Players:**
   United States: FCC, Congress, Consumers, Corporations, Interest Groups
2. **Environments:**
   Wireless in Europe, NTT DoCoMo,
   Broadband in Sweden & Korea
   India vs. China Development
   US: Access, Digital Rights
3. **Standards:**
   e.g., wCDMA vs CDMA2000

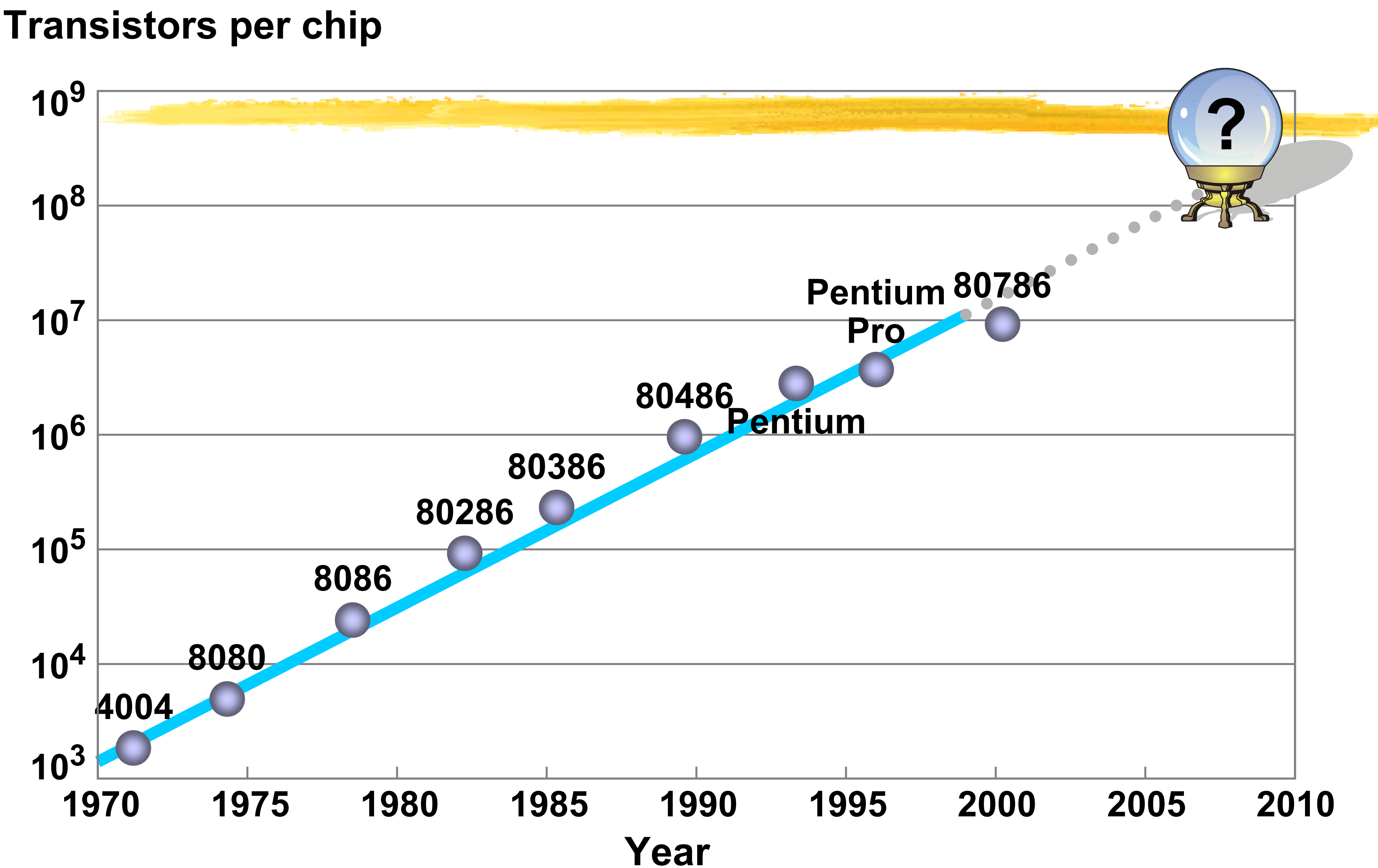
Roadmap for Electronic Devices



International Technology Roadmap for Semiconductors '99

Year	2005	2008	2011	2014
Technology (nm)	100	70	50	35
DRAM chip area (mm^2)	526	603	691	792
DRAM capacity (Gb)	8		64	
MPU chip area (mm^2)	622	713	817	937
MPU transistors ($x10^9$)	0.9	2.5	7.0	20.0
MPU Clock Rate (GHz)	3.5	6.0	10.0	13.5

Moore's Law



Source: Joel Birnbaum, HP, Lecture at APS Centennial, Atlanta, 1999

Disk Drive Development 1978-1991

Disk Drive Generation	Dominant Producer	Dominant Usage	Approx cost per Megabyte
14”	IBM	mainframe	$750
8”	Quantum	Mini-computer	$100
5.25”	Seagate	Desktop PC	$30
3.5”	Conner	Portable PC	$7
2.5”	Conner	Notebook PC	$2

From 1991-98, Disk Drive storage density increased by 60%/year while semiconductor density grew ~50%/year. Disk Drive cost per megabyte in 1997 was ~ $ .10

"Killer Technologies" of the Information Age: Semiconductors, Magnetic Memory, Optoelectronics

"We define a *<u>'killer technology'</u>* as one that delivers enhanced systems performance of a factor of at least a hundred-fold per decade."

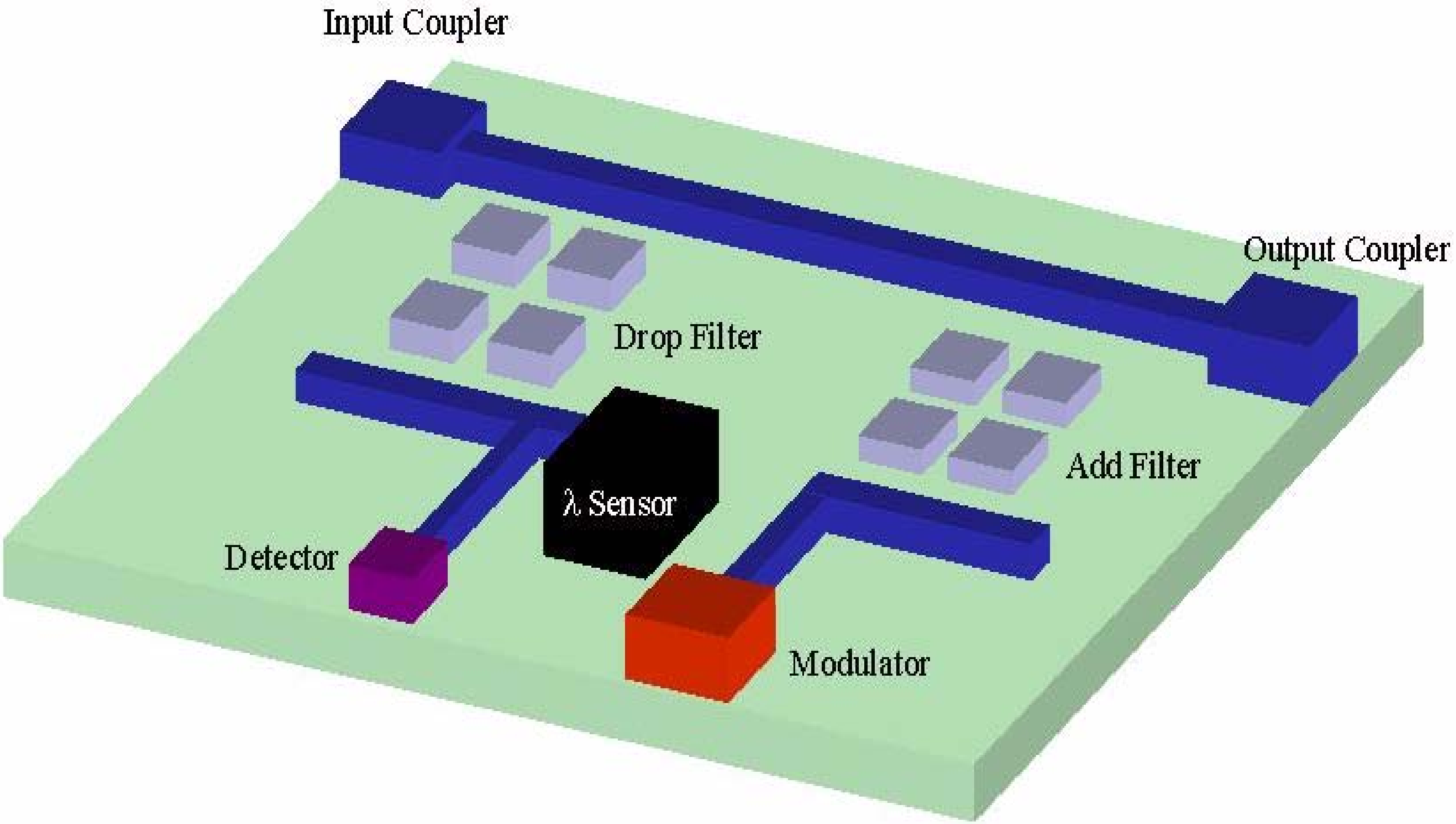
C.H.Fine & L.K. Kimerling, "Biography of a Killer Technology: Optoelectronics Drives Industrial Growth with the Speed of Light," published in 1997 by the Optoelectronics Industry Develoment Association, 2010 Mass Ave, NW, Suite 200, Wash. DC 20036-1023.

Killer Question:

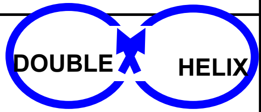
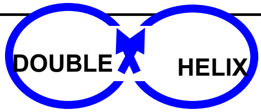
Will *<u>Integrated Optics</u>* evolve linearly like Semiconductors with Moore's Law or like Disk Drives with repeated industry disruptions?

Example Concept for Integrated Photonics Chip

Dr. Gale Petrich, MIT Microphotonics Center



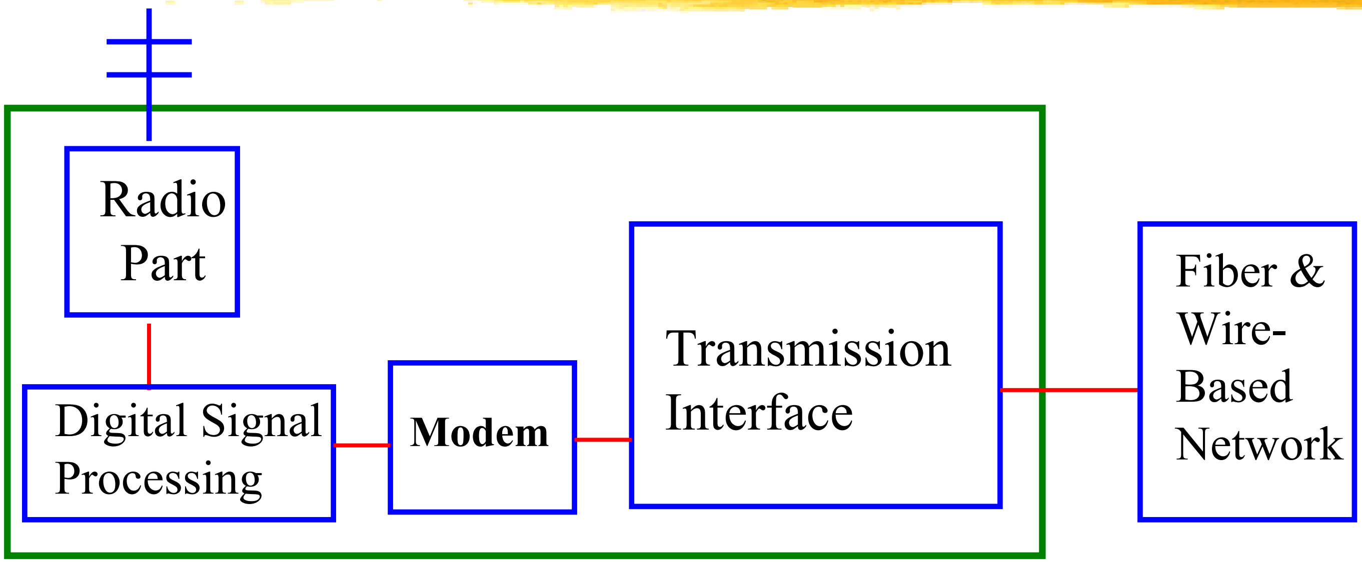
Optical Technology Evolution: Navigating the Generations with an Immature Technology

	1	2	3	4	5
Timeline	**Now**	**Starting**	**Starting**	**3-5 years**	**5-15 years**
Stage	**Discrete Components**	**Hybrid Integration**	**Low-level monolithic integration**	**Medium Monolithic integration**	**High-level monolithic integration**
Examples	**MUX/ DEMUX**	**TX/RX module OADM**	**TX/RX module OADM**	**OADM, Transponder Switch Matrix**	**Transponder**
Core Techno-logies	**FBGs, Thin-film, fused fiber, mirrors**	**Silicon Bench, Ceramic substrates**	**Silica Silicon InP**	**InP, ??**	**InP, ??**
How many Functions?	**1**	**2-5**	**2-5**	**5-10**	**10-XXX**
Industry Structure	**Integrated**	**Integrated/ Horizontal**	**Integrated /Horizontal**		

Dr. Yanming Liu, MIT & Corning

WIRELESS VALUE CHAIN: MINI CASE EXAMPLE

Wireless Base Stations (WSB'S) comprise 4 key subsystems:



WSB architectures are
-integral & proprietary
Suppliers include: Nortel, Moto, Ericsson, Siemens, Nokia
Disruptive Modem advances (e.g., MUD) can double Base Station Capacity

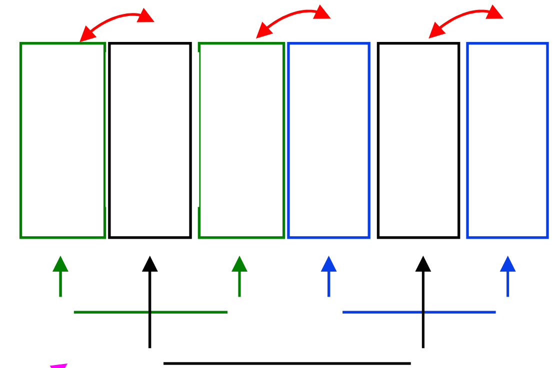
Modular WSB's might
(1) Stimulate new WSB entrants (ala Dell)
(2) Stimulate standard subsystem suppliers
(3) lower prices to the network operators
(4) Speed base station performance imp.
(5) Increase demand for basestations due to improved price-performance ratios.

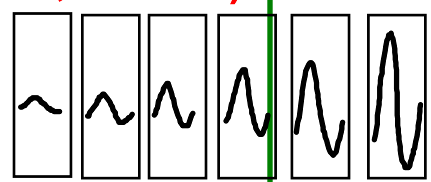
Supply Chain Design is the Ultimate Core Competency:

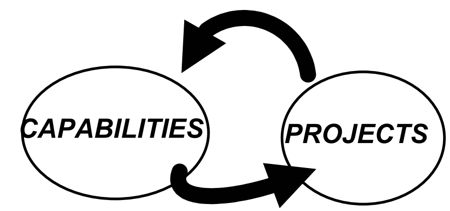
Competency of passing judgement on all other competencies

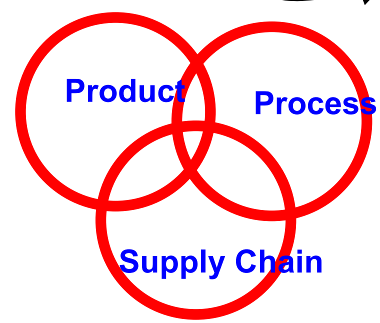
Benchmark the Fruit Flies

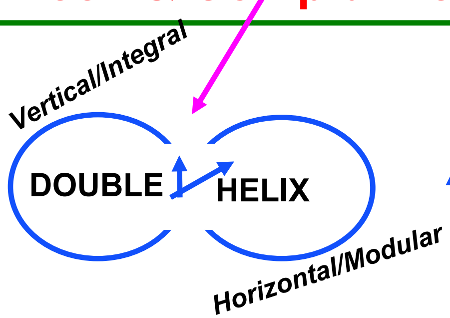
- Beware of *Intel Inside*
- SC control point unstable (comp, assem, distrib)
- SC structures oscillate
  -- int/int or mod/mod
- The Bullwhip lives
- Dependence/Independence has positive feedback
- Projects feed capabilities & vice-versa
- eBusiness accelerates Clockspeeds
- All Advantage is Temporary
- Align Architectures in Pdt, Proc, & SC
- Tech & Comp drive clockspeeds

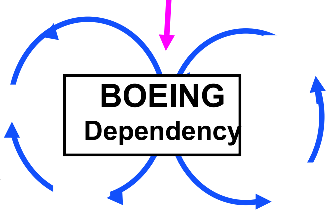


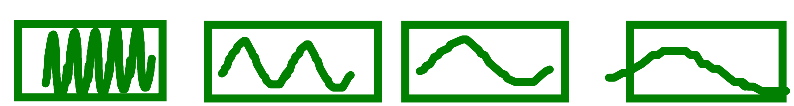










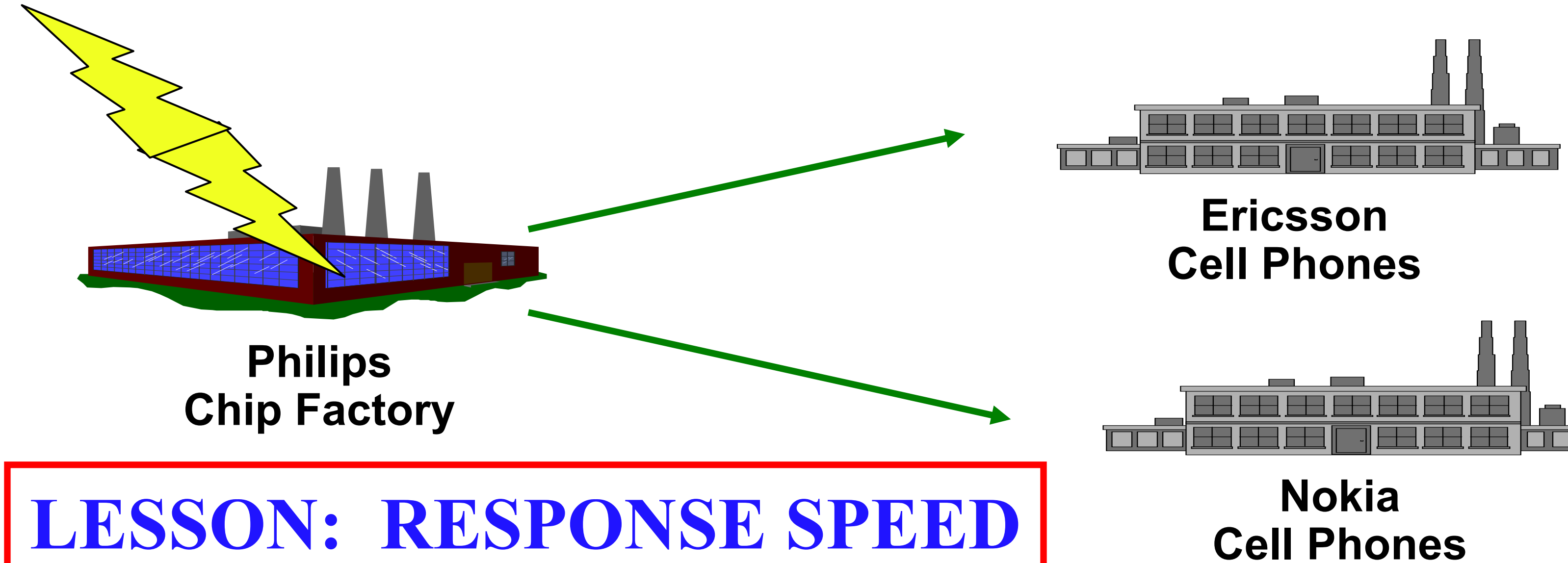


All Conclusions are *Temporary*

- Clockspeeds are increasing almost everywhere
- Many technologies and industries exhibits fast clockspeed & high volatility
- Value chain design and service system key competencies
- Study of Fruit Flies can help with crafting strategy

Mother Nature strikes
The Cell Phone Supply Chain

8:00 pm, Friday 17 March 2000: Lightning Strikes an ASIC semiconductor plant of Philips in Albuquerque, New Mexico, USA
8:10 pm: Fire is extinguished. Plant will be down for months.



LESSON: RESPONSE SPEED

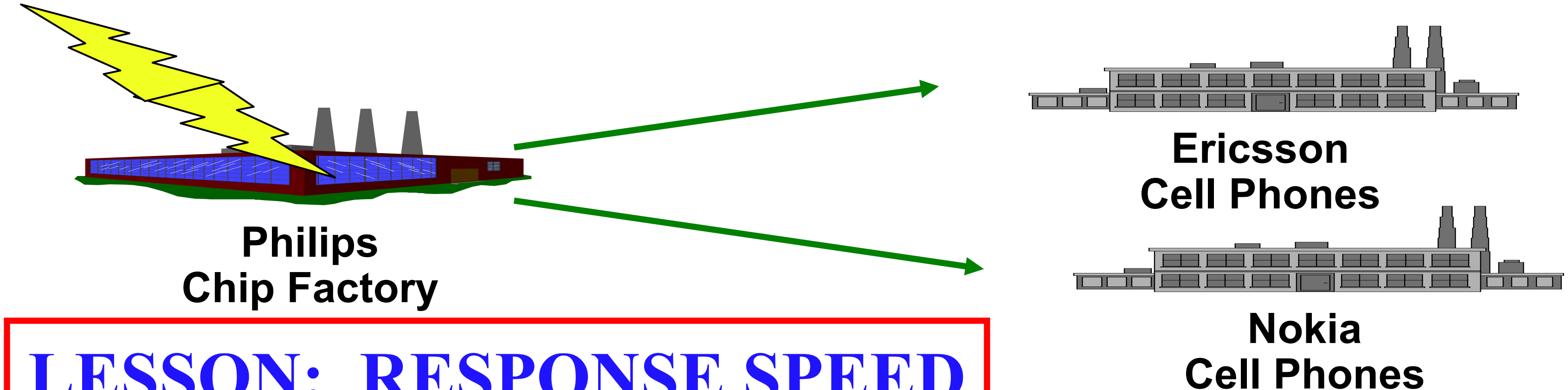
Mother Nature strikes
The Cell Phone Supply Chain

NOKIA

Shipment discrepancies noticed within 3 days.
Philips is pushed hard.
New supply sources.
New chip design.
Global capacity grab.

ERICSSON

Problem undiscovered for weeks.
Slow chain of command.
Slow response.
Capacity already taken.
$400M revenue loss.
Exits phone manufacture.



LESSON: RESPONSE SPEED