Value Chain Roadmapping for Communications and Media

Excerpts from

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

Form (Size, Weight, Ergonomics)

O/S (Windows, Linux, Palm)

HW system (OEM, ODM, CEM)

Bundled Apps (phone, MP3, IM, etc.)

Network (CDMA, WiFi, Sonet, IP, Cable)

Equipment (Lucent, Ericsson, Cisco)

Channel (KaZaA, AOL/TW, MTV)

Artist (Madonna, NBA, Spielberg, SAP, Self)

Openness (EFF, RIAA/DMCA, TCPA)

Appliance (Phone, Camera, Laptop, PDA, TV, Missile, MP3 Player)

Access (Wireless, POTS, ISP, Satellite, Cable, HotSpot)

Content & Applications (Music, Movies, Email, VoIP, Shopping, ERP, SCM, CRM, Banking, IM, Surveillance, Photos, Games)
Another View of the Communications Value Chain
Roadmapping Communications: What are the Premises?

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

Vertical disintegration 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.

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.

Technology and industry roadmapping are typically done by different people.

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

Internet explosion
Wireless Explosion
Connectivity Explosion
File Sharing Explosion

INFORMATION WANTS TO BE SHARED

=> Difficult content business models

Is there a third way?
(Quantum Roadmap)

INFORMATION SHARERS GO TO JAIL

=> Poverty of The Commons
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
Dynamic Analysis to Support Industry & Technology Roadmapping

Interdependent sectors represented as intermeshed gears.
Roadmap Components: Dynamic Analyses

• Business cycle dynamics (e.g., the bullwhip effect)
• Industry structure dynamics (e.g., double helix in *Clockspeed*)

3. Corporate strategy dynamics (e.g., dynamic matching of customer needs with corporate opportunities)

4. Customer Preference Dynamics

5. Technology dynamics (e.g., the Semiconductor Industry Assoc. roadmap built around Moore's law)

6. Regulatory Policy Dynamics (Cross-National, Cross Sector)

7. Capital Markets Dynamics
Cisco’s End-to-End Integration for its Fulfillment Supply Chain

- New product development on-line with supply base
- Technology Supply Chain Design: Innovation through Acquisition

Basic Design Principle: Arm’s length Relationship with Fulfillment Chain Partners
Cisco's Strategy for Technology Supply Chain Design

- Integrate technology around the router to be a communications network provider.
- Leverage acquired technology with:
  - sales muscle and reach
  - end-to-end IT
  - outsourced manufacturing
  - market growth
- 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

Volatility in the Electronics & Semiconductors Supply Chain

% Change, Year-to-Year

Year

Worldwide Semiconductor Manufacturing Equipment Sales
Worldwide Semiconductor Shipments
Electronics, Computing and Communications Equipment Output
GDP World
GDP USA
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?
Roadmap Components: Dynamic Analyses

- Business cycle dynamics
  (e.g., systems dynamics-like models of the bullwhip effect)
- Industry structure dynamics
  (e.g., double helix in Clockspeed)

3. Corporate strategy dynamics (e.g., dynamic matching of customer needs with corporate opportunities)

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6. Regulatory Policy Dynamics
   (Cross-National, Cross Sector)
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.

   • 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

(A. Grove, Intel; and Farrell, Hunter & Saloner, Stanford)
## Horizontal Industry Structure with Modular Product Architecture

### Computer Industry Structure, 1985-95

<table>
<thead>
<tr>
<th>Microprocessors</th>
<th>Intel</th>
<th>Moto</th>
<th>AMD</th>
<th>etc</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating Systems</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peripherals</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Applications Software</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Network Services</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Assembled Hardware</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(A. Grove, Intel; and Farrell, Hunter & Saloner, Stanford)
THE DYNAMICS OF PRODUCT ARCHITECTURE STANDARDS, AND VALUE CHAIN STRUCTURE: THE DOUBLE HELIX

INTEGRAL PRODUCT VERTICAL INDUSTRY PROPRIETARY STANDARDS

MODULAR PRODUCT HORIZONTAL INDUSTRY OPEN STANDARDS

NICHES COMPETITORS

HIGH-DIMENSIONAL COMPLEXITY

ORGANIZATIONAL RIGIDITIES

PRESSURE TO DIS-INTEGRATE

INCENTIVE TO INTEGRATE

TECHNICAL ADVANCES

SUPPLIER MARKET POWER

PROPRIETARY SYSTEM PROFITABILITY

Fine & Whitney, “Is the Make/Buy Decision Process a Core Competence?”
Roadmap Components: Dynamic Analyses

• Business cycle dynamics  
  (e.g., systems dynamics-like models of the bullwhip effect)

• Industry structure dynamics  
  (e.g., double helix in *Clockspeed*)

3. Corporate strategy dynamics (e.g., dynamic matching of customer needs w/corp. oppor)

4. Customer Preference Dynamics

5. Technology dynamics (e.g., the Semiconductor Industry Assoc. roadmap built around Moore's law)

6. Regulatory Policy Dynamics  
  (Cross-National, Cross Sector)
ALL COMPETITIVE ADVANTAGE IS TEMPORARY

Autos:

Computing:

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 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.)*
Clockspeed drives Business Strategy Cadence

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

CORE CAPABILITIES

NEW PROJECTS
(New products, new processes, new suppliers)

Leonard-Barton, Wellsprings of Knowledge
Projects Serve Three Masters: Capabilities, Customers, & Corporate Profit

- **Core Capabilities**
- **Project Design** (New products, new processes, new suppliers)
- **Customer Value Proposition**
- **Corporate Value Proposition**
IMPLEMENTATION OF PROJECT DESIGN: FRAME IT AS 3-D CONCURRENT ENGINEERING

PRODUCT
- Performance Specifications

PROCESS
- Technology, & Process Planning
- Details, Strategy

VALUE CHAIN
- Time, Space, Availability
- Manufacturing System, Make/Buy processes

Recipe, Unit Process

Product Architecture, Make/Buy components

Prof C. Fine
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**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
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

INTEGRAL MODULAR

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

Microprocessors
Mercedes & BMW vehicles

Lucent
Nortel

Polaroid

MSFT Windows

Chrysler vehicles

Cisco

Digital Rights/
Music Distribution

Dell PC'S
Bicycles

TECHNOLOGY/PRODUCT ARCHITECTURE

INTTEGRAL

MODULAR

INTTEGRAL

MODULAR

© MIT 2003

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

**Dependence**
- Amount of Work Outsourced
- Knowledge +/or supply

Supplier Capability

**Independence**
- Amount of Work Done In-house
- Knowledge +/or supply

Internal Capability

Amount of Supplier Learning

Amount of Internal Learning
Technology Dynamics in the Aircraft Industry: LEARNING FROM THE DINOSAURS

Japanese Industry Autonomy

Japanese appeal as subcontractors

Boeing outsources to Japan (Mitsubishi Inside?)

U.S. firms’ appeal as subcontractors

Japanese industry size & capability

U.S. industry size & capability
SOURCEABLE ELEMENTS

PROCESS ELEMENTS

ENGINEERING

ASSY

TEST

I4 V6 V8

PRODUCTS

SUBSYSTEMS

CONTROLLER

VALVETRAIN

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

<table>
<thead>
<tr>
<th></th>
<th>DEPENDENT FOR KNOWLEDGE &amp; CAPACITY</th>
<th>INDEPENDENT FOR KNOWLEDGE &amp; DEPENDENT FOR CAPACITY</th>
<th>INDEPENDENT FOR KNOWLEDGE &amp; CAPACITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>ITEM IS MODULAR</td>
<td>A POTENTIAL OUTSOURCING TRAP</td>
<td>BEST OUTSOURCING OPPORTUNITY</td>
<td>OVERKILL IN VERTICAL INTEGRATION</td>
</tr>
<tr>
<td></td>
<td>WORST OUTSOURCING SITUATION</td>
<td>CAN LIVE WITH OUTSOURCING</td>
<td>BEST INSOURCING SITUATION</td>
</tr>
</tbody>
</table>

### Strategic Make/Buy Decisions

**Assess Critical Knowledge & Product Architecture**

Adapted from Fine & Whitney, “Is the Make/Buy Decision Process a Core Competence?”
Strategic Make/Buy Decisions: Also consider Clockspeed & Supply Base Capability

<table>
<thead>
<tr>
<th>Suppliers</th>
<th>Clockspeed</th>
<th>Best</th>
<th>Out</th>
<th>Over-kill</th>
</tr>
</thead>
<tbody>
<tr>
<td>Few</td>
<td>Fast</td>
<td>OK</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Many</td>
<td>Slow</td>
<td>Watch it!</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

INTEGRAL

<table>
<thead>
<tr>
<th>Suppliers</th>
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<th>Clockspeed</th>
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<tbody>
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<td></td>
<td>Slow</td>
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DECOMPOSABLE (Modular)

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<td>Slow</td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

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

Model developed by GM Powertrain, PRTM, & Clockspeed, Inc.
Every decision requires qualitative and quantitative analysis to reach a conclusion
VALUES 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
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**
Nortel Networks plays at at least three levels of the Optical Network Telecom value chain:

- Network design & installation
- Modules (OC-192 network elements)
- Components (lasers, amplifiers)

**QUIZ:** Should Nortel sell their components business?

**Hint:** How likely are the scenarios of:

- An *Intel Inside* effect in components?
- Networks become sufficiently modular as to be assembled by the customer?
Wireless Base Stations (WSB’S) comprise 4 key subsystems:

- **Radio Part**
- **Digital Signal Processing**
- **Modem**
- **Transmission Interface**
- **Fiber & Wire-Based Network**

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.
Roadmap Components: Dynamic Analyses

• Business cycle dynamics
  (e.g., systems dynamics-like models of the bullwhip effect)

• Industry structure dynamics
  (e.g., double helix in Clockspeed)

3. Corporate strategy dynamics (e.g., dynamic matching of customer needs with corporate opportunities)

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5. Technology dynamics (e.g., Semiconductor Industry Assoc. roadmap & Moore's law)

6. Regulatory Policy Dynamics
  (Cross-National, Cross Sector)
Customer Preference Drivers
(adapted from Sadek Esener, UCSD and Tom O’Brien, Dupont “Macro-Trends” process)

- **Population**
  - Aging, Growth

- **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)
Roadmap Components: Dynamic Analyses

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  (Cross-National, Cross Sector)
Roadmap for Electronic Devices

Number of chip components

Classical Age

Quantum Age

SIA Roadmap

Quantum State Switch

Historical Trend

CMOS


10^2 10^3 10^4 10^5 10^6 10^7 10^8 10^9 10^10 10^11 10^12 10^13 10^14 10^15 10^16 10^17 10^18

Feature size (microns)

10^-1 10^-2 10^-3

Horst D. Simon

Lawrence Berkeley National Laboratory
### International Technology Roadmap for Semiconductors ‘99

<table>
<thead>
<tr>
<th>Year</th>
<th>2005</th>
<th>2008</th>
<th>2011</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technology (nm)</td>
<td>100</td>
<td>70</td>
<td>50</td>
<td>35</td>
</tr>
<tr>
<td>DRAM chip area (mm²)</td>
<td>526</td>
<td>603</td>
<td>691</td>
<td>792</td>
</tr>
<tr>
<td>DRAM capacity (Gb)</td>
<td>8</td>
<td>64</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MPU chip area (mm²)</td>
<td>622</td>
<td>713</td>
<td>817</td>
<td>937</td>
</tr>
<tr>
<td>MPU transistors (x10⁹)</td>
<td>0.9</td>
<td>2.5</td>
<td>7.0</td>
<td>20.0</td>
</tr>
<tr>
<td>MPU Clock Rate (GHz)</td>
<td>3.5</td>
<td>6.0</td>
<td>10.0</td>
<td>13.5</td>
</tr>
</tbody>
</table>
# Disk Drive Development

## 1978-1991

<table>
<thead>
<tr>
<th>Disk Drive Generation</th>
<th>Dominant Producer</th>
<th>Dominant Usage</th>
<th>Approx cost per Megabyte</th>
</tr>
</thead>
<tbody>
<tr>
<td>14”</td>
<td>IBM</td>
<td>mainframe</td>
<td>$750</td>
</tr>
<tr>
<td>8”</td>
<td>Quantum</td>
<td>Mini-computer</td>
<td>$100</td>
</tr>
<tr>
<td>5.25”</td>
<td>Seagate</td>
<td>Desktop PC</td>
<td>$30</td>
</tr>
<tr>
<td>3.5”</td>
<td>Conner</td>
<td>Portable PC</td>
<td>$7</td>
</tr>
<tr>
<td>2.5”</td>
<td>Conner</td>
<td>Notebook PC</td>
<td>$2</td>
</tr>
</tbody>
</table>

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 ~ $0.10
Optical Networking is Keeping Up!

- Voice growth
- TDM line rate growth
- Data growth
- Optical network capacity growth

Capacity vs. Time graph with markers for OC12, OC48, OC192, and OC768.
“Killer Technologies” of the Information Age: Semiconductors, Magnetic Memory, Optoelectronics

“We define a ‘killer technology’ as one that delivers enhanced systems performance of a factor of at least a hundred-fold per decade.”


Killer Question: Will Integrated Optics evolve linearly like Semiconductors with Moore’s Law or like Disk Drives with repeated industry disruptions?
## Optical Technology Evolution: Navigating the Generations with an Immature Technology

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Timeline</strong></td>
<td>Now</td>
<td>Starting</td>
<td>Starting</td>
<td>3-5 years</td>
<td>5-15 years</td>
</tr>
<tr>
<td><strong>Stage</strong></td>
<td>Discrete Components</td>
<td>Hybrid Integration</td>
<td>Low-level monolithic integration</td>
<td>Medium Monolithic integration</td>
<td>High-level monolithic integration</td>
</tr>
<tr>
<td><strong>Examples</strong></td>
<td>MUX/DEMUX</td>
<td>TX/RX module OADM</td>
<td>TX/RX module OADM</td>
<td>OADM, Transponder Switch Matrix</td>
<td>Transponder</td>
</tr>
<tr>
<td><strong>Core Technologies</strong></td>
<td>FBGs, Thin-film, fused fiber, mirrors</td>
<td>Silicon Bench, Ceramic substrates</td>
<td>Silica Silicon InP</td>
<td>InP, ??</td>
<td>InP, ??</td>
</tr>
<tr>
<td><strong>How many Functions?</strong></td>
<td>1</td>
<td>2-5</td>
<td>2-5</td>
<td>5-10</td>
<td>10-XXX</td>
</tr>
<tr>
<td><strong>Industry Structure</strong></td>
<td>Integrated</td>
<td>Integrated/Horizontal</td>
<td>Integrated/Horizontal</td>
<td><strong>DOUBLE-Helix</strong></td>
<td><strong>DOUBLE-Helix</strong></td>
</tr>
</tbody>
</table>

*Dr. Yanming Liu, MIT & Corning*
Roadmap Components: Dynamic Analyses

• Business cycle dynamics
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5. Technology dynamics (e.g., the Semiconductor Industry Assoc. roadmap built around Moore's law)
6. Regulatory Policy Dynamics (Cross-National, Cross Sector)
All Conclusions are *Temporary*

Clockspeeds are increasing almost everywhere
Value Chains are changing rapidly

Assessment of value chain dynamics

Roadmap Construction