DFMA 2016

31st International Forum on Design for Manufacture and Assembly

DFMA & Breakthrough Innovation Techniques

Bradford L. Goldense

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DFMA & BREAKTHROUGH INNOVATION TECHNIQUES

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DFMA & BREAKTHROUGH INNOVATION TECHNIQUES

Disruption & Big Financial Returns

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Where Are All the Breakthrough New Products?

Using Portfolio Management to Boost Innovation

Ensuring that high-risk projects receive their fair share of the resources requires a different approach to portfolio management and different analytical tools.

Robert G. Cooper

OVERVIEW: There is a real shortage of breakthrough initiatives in businesses' development portfolios. A major challenge in developing these high-risk projects is portfolio management—how executives make R&D investment decisions. Financial approaches, such as net present value and the productivity index, are traditionally recommended to lend rigor to go/kill decisions. An overreliance on financial tools favors incremental projects whose financial forecasts are reliable, however, producing an abundance of small, low-hanging–fruit projects and a failure to allocate resources to strategic projects. Different toolsets must be used to assess high-risk breakthrough initiatives, including strategic buckets, expected commercial value, and spiral development processes. All of these must be supported by a climate and culture that provide the appetite to take on risky projects.

KEYWORDS: Breakthrough innovation, Portfolio management, Options, Strategic buckets, Expected commercial value

Source: Robert G. Cooper, "Where Are All the Breakthrough New Products?," *Research & Technology Management*, Industrial Research Institute, 1550 M Street NW, Washington, DC, September-October 2013, Pages 25-33.

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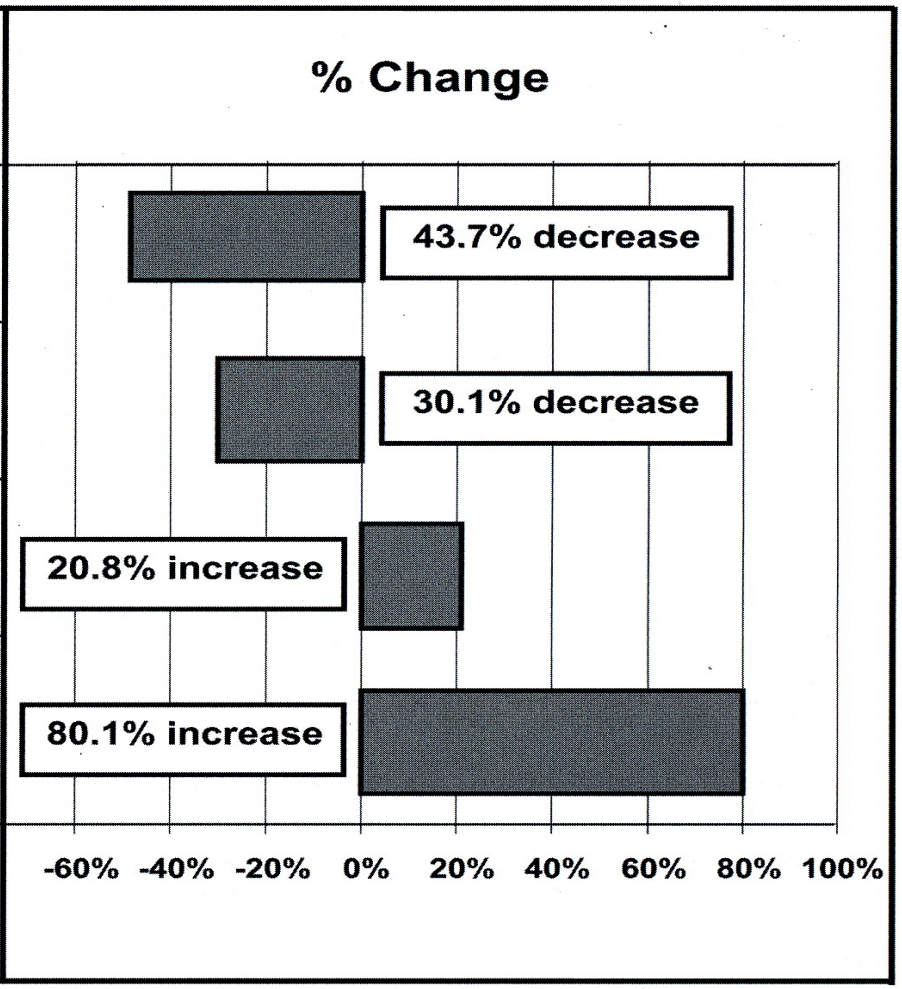
Disruption: Breakthrough Spending Has Decreased - Composition 1990s vs. 2000s

Project Type	1990s	2000s
New to world, new to market – innovations	20.4%	11.5%
New product lines to the company	38.8%	27.1%
Additions to existing product line in company	20.4%	24.7%
Improvements & modifications to existing company products	20.4%	36.7%
Total	100.0%	100.0%



Source: Robert G. Cooper, "Where Are All the Breakthrough New Products?," *Research & Technology Management*, Industrial Research Institute, 1550 M Street NW, Washington, DC, September-October 2013, Pages 25-33; Figure 1 – Page 26. Percent of projects by type in the typical development portfolio, then and now.

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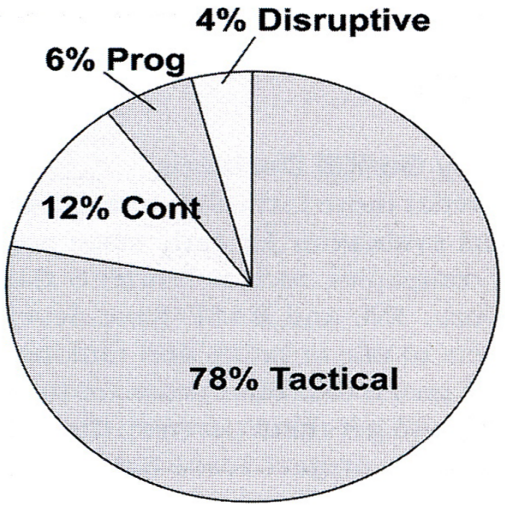
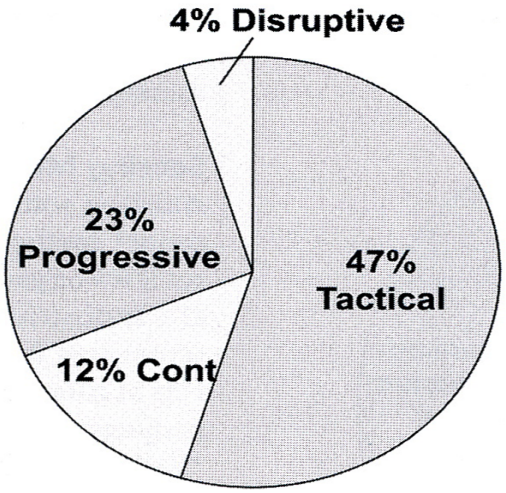
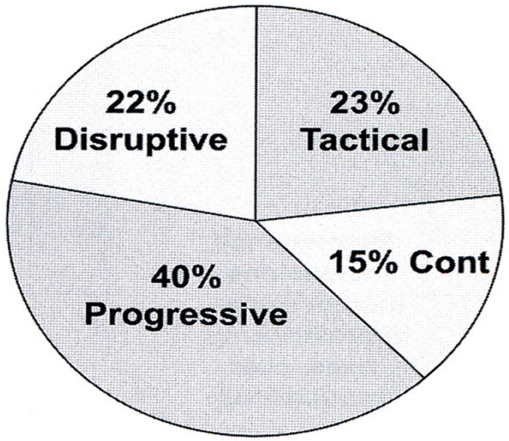
Disruption: Portfolios Are Overweight In Tactical & Operational Projects



Number of Projects



Resource Allocation



Incremental Sales
(NSV - First Full Year)

DISRUPTIVE	PROGRESSIVE	CONTINUOUS	TACTICAL
Unmet consumer need. New technology.	Addresses consumer need better than competition. Significant technology development.	Range extension or upgrade. Technology available, some development required.	Graphics change, bonus bags, deletions, seasonal.

Source: Robert G. Cooper, "Where Are All the Breakthrough New Products?," *Research & Technology Management*, Industrial Research Institute, 1550 M Street NW, Washington, DC, September-October 2013, Pages 25-33; Figure 2 – Page 27. A sample current-state assessment showing an overabundance of tactical projects.

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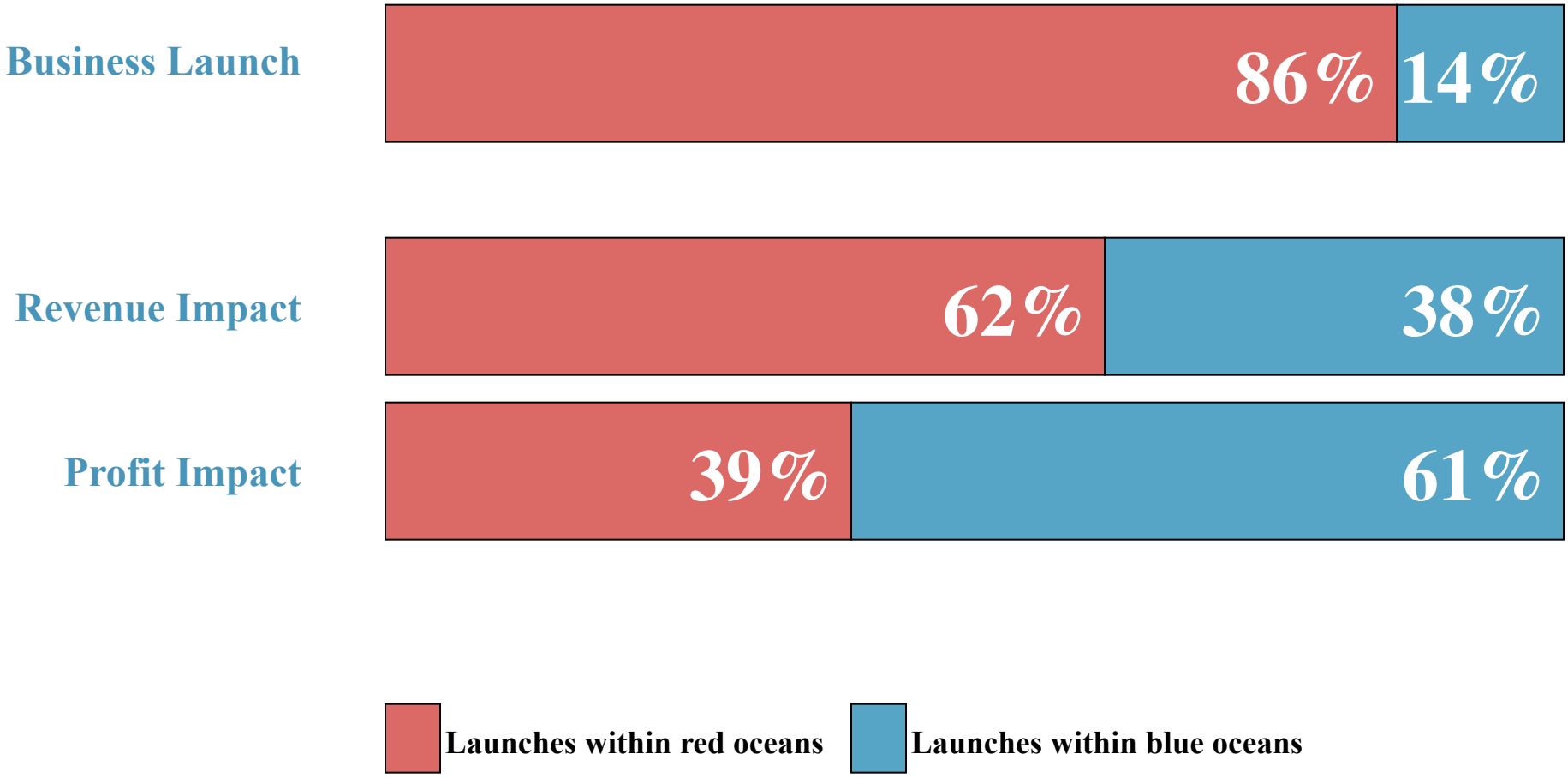
Disruption: Blue Ocean Strategy - Growth & Profit Opportunities Are Tremendous



Source: W. Chan Kim and Renee Mauborgne, "Blue Ocean Strategy," Harvard Business School Press, 2005, Copyright 2005 Harvard Business School Publishing Corporation. Page 7. Figure 1-1.

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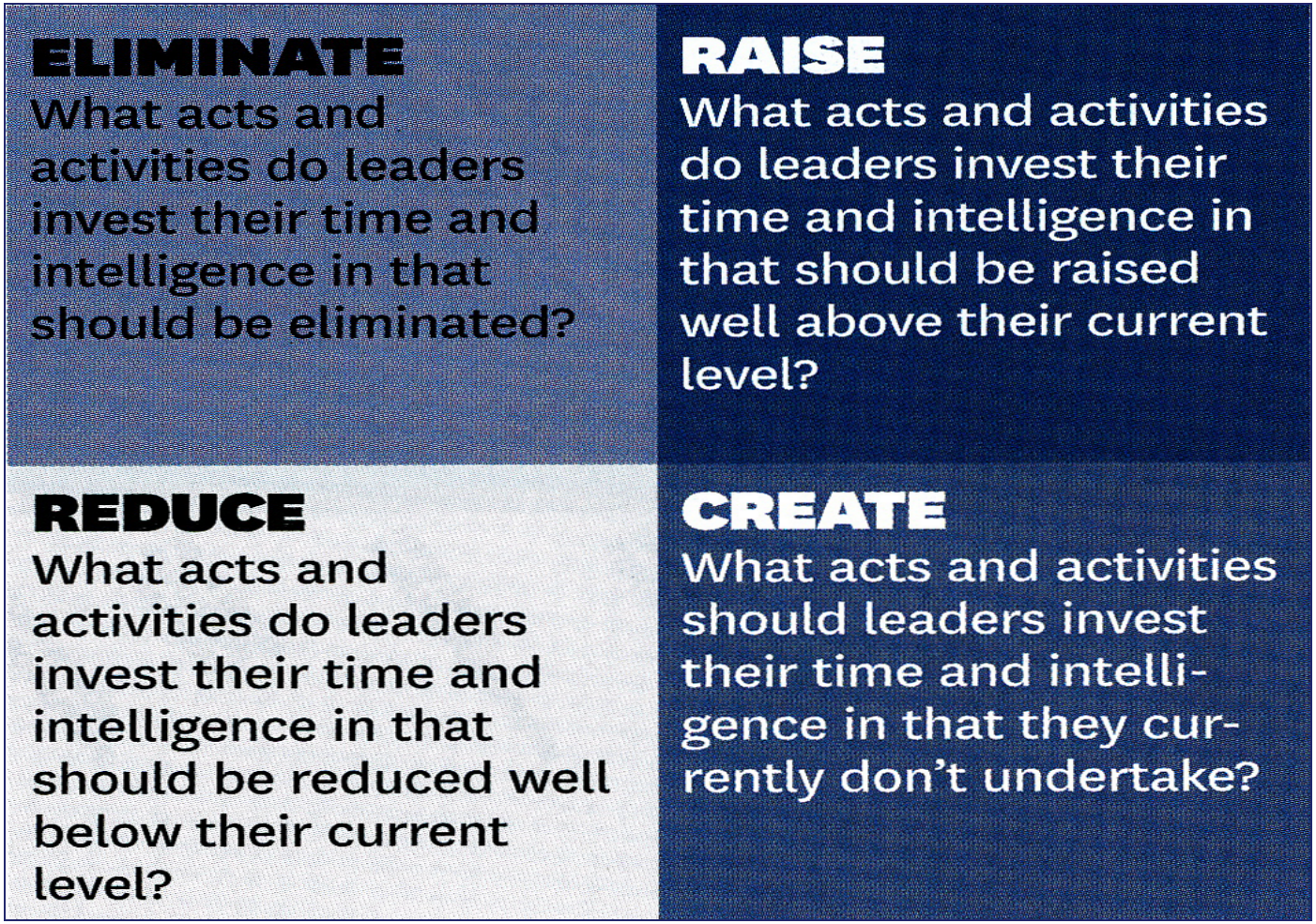
Disruption: Blue Ocean Leadership - Top Executives Must Examine What They Do

"The Blue Ocean Leadership Grid is an analytic tool that challenges people to think about which acts and activities leaders should do less of because they hold people back, and which leaders should do more of because they inspire people to give their all. Current activities from the leaders "as-is" profiles (which may add value or not), along with new activities that employees believe would add a lot of value if leaders started doing them, are assigned to the four categories in the grid. Organizations then use the grids to develop new profiles of effective leadership."



Source: W. Chan Kim and Renee Mauborgne, "Blue Ocean Leadership: Are your employees fully engaged in moving your company forward? Here's how to release their untapped talent and energy.," *Harvard Business Review*, Harvard Business School Publishing, 60 Harvard Way, Boston, MA, 02163, USA, May 2014, Page 65, Inset: The Blue Ocean Leadership Grid.

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Disruption: Personalities Are Important for Radical, Disruptive, & Breakthrough

When you're building an innovation team, it's a given that you need creative people. But they're not enough. Our research shows that groups with a variety of cognitive types produce higher levels of innovation. And getting the right balance of types is key.

We studied 41 radical-innovation teams in R&D and manufacturing units of a large defense contractor. The groups had varying proportions of three types of people—extremely creative, detail oriented, and highly conformist—along with more-general thinkers, typically the largest component. Our most surprising finding: Conformists, though they may be useless at generating breakthrough ideas, dramatically increase a team's radical innovations.

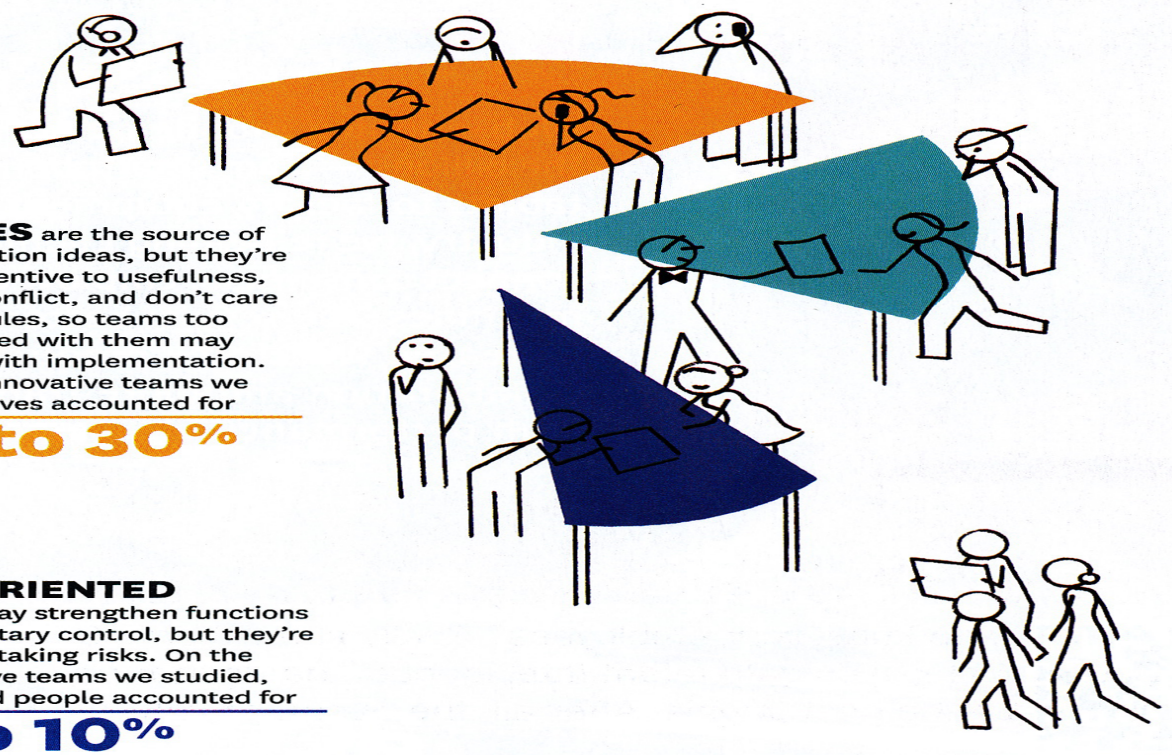
Few managers spend much time thinking about cognitive styles or their influence on groups. Moreover, in an effort to meet strict timetables, companies such as Intel and Toyota have started placing quality and reliability engineers—detail-oriented types, to be sure—on innovation teams. They should beware of overdoing it: Large numbers of detail-oriented people can suppress creativity in their eagerness for precision. It's important to ensure that the other cognitive styles are properly represented, too.

WHAT'S THE OPTIMAL BALANCE?

About 50% of people have a mix of thought patterns, but the rest fall into one of three distinct cognitive types. The best radical-innovation teams have a sprinkling of the three.

CONFORMISTS support the creatives, boosting cooperation and improving a team's confidence. On the most innovative teams we studied, conformists accounted for

10% to 20%



CREATIVES are the source of radical-innovation ideas, but they're not always attentive to usefulness, may initiate conflict, and don't care much about rules, so teams too heavily weighted with them may have trouble with implementation. On the most innovative teams we studied, creatives accounted for

20% to 30%

DETAIL-ORIENTED PEOPLE may strengthen functions such as budgetary control, but they're skittish about taking risks. On the most innovative teams we studied, detail-oriented people accounted for

up to 10%

Source: Ella Miron-Spektor, Miriam Erez, and Eitan Navesh, "Teamwork: To Drive Creativity, Add Some Conformity," *Harvard Business Review*, Harvard Business School Publishing, 60 Harvard Way, Boston, MA, 02163, USA, March 2012, Page 30.

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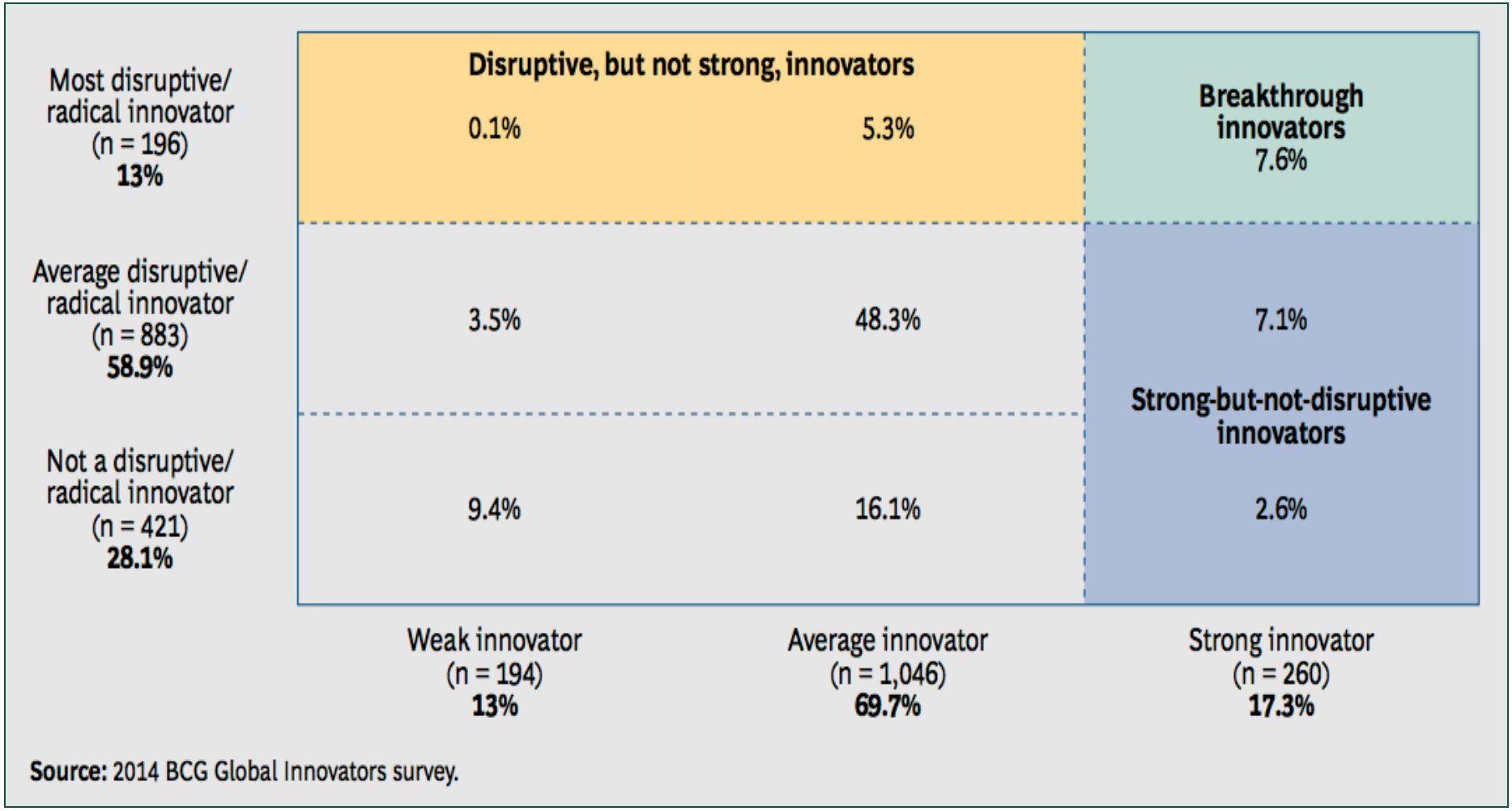
Disruption: Only 7.6% Are Breakthrough Innovators



Source: Kim Wagner, Andrew Taylor, et. al., "The Most Innovative Companies 2014: Breaking Through Is Hard To Do", The Boston Consulting Group, Inc. [BCG], One Beacon Street, Boston, Massachusetts, USA, October 2014, Page 10, Exhibit 4: A Small Universe of Breakthrough Innovators.

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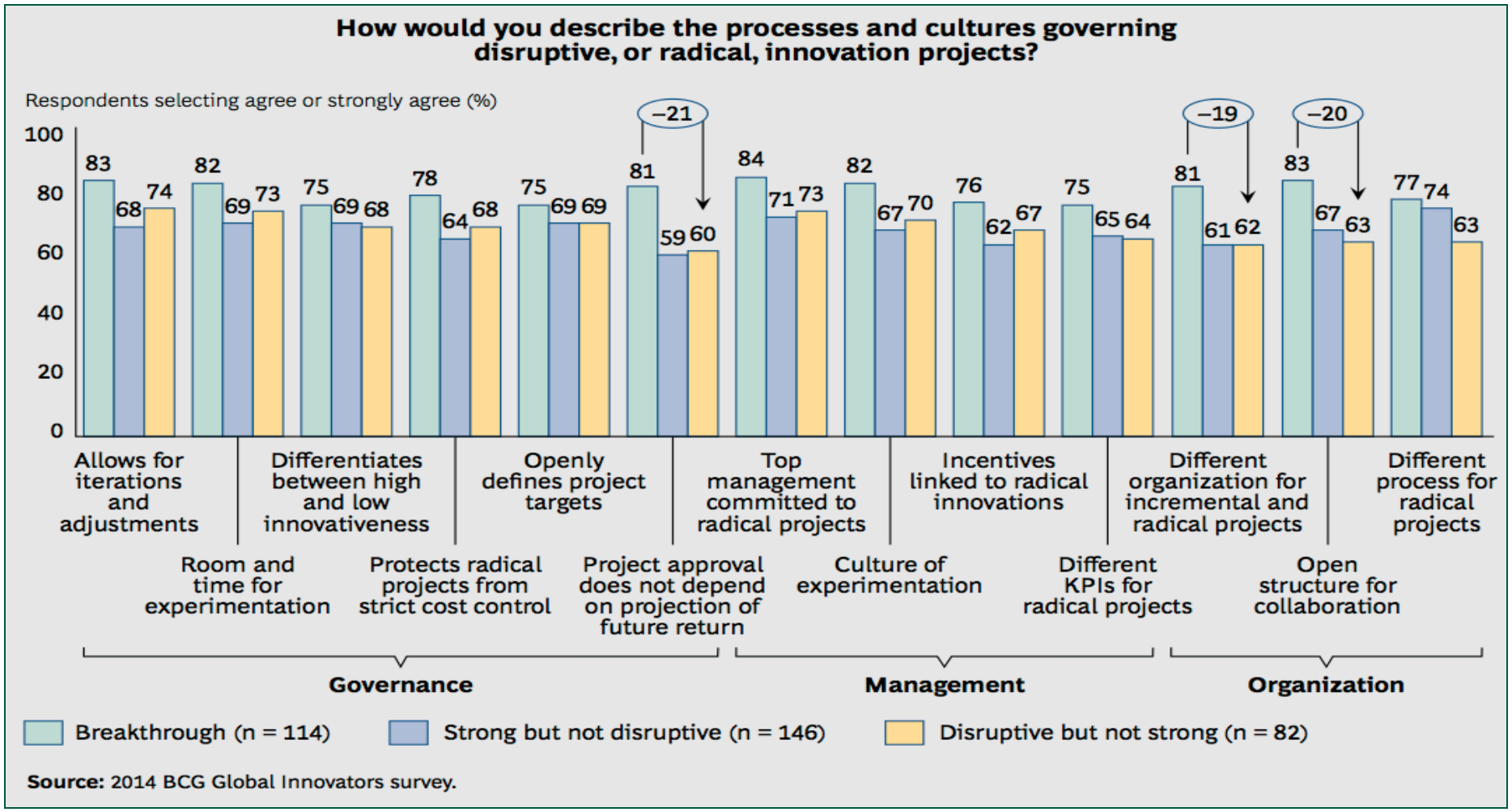
Disruption: Attributes of Breakthrough vs. Strong or Disruptive



Source: Kim Wagner, Andrew Taylor, et. al., "The Most Innovative Companies 2014: Breaking Through Is Hard To Do", The Boston Consulting Group, Inc. [BCG], One Beacon Street, Boston, Massachusetts, USA, October 2014, Page 20, Breakthrough Innovators Bring Together All the Pieces Required for Radical Innovation.

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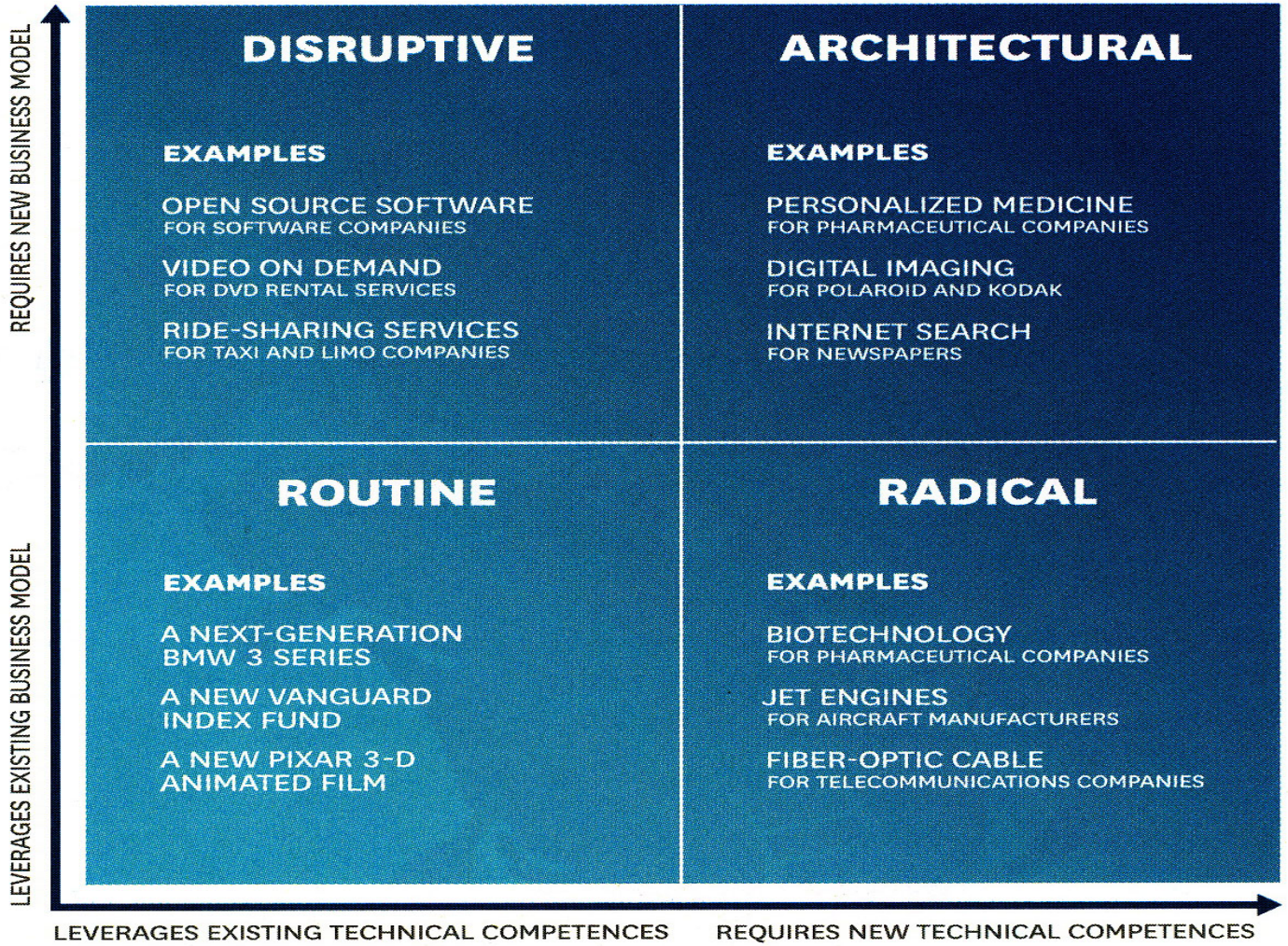
Disruption: The Innovation Landscape Map - Business Model vs. Tech Disruption

When creating an innovation strategy, companies have a choice about how much to focus on technological innovation and how much to invest in business model innovation. This matrix, which considers how a potential innovation fits with a company's existing business model and technical capabilities, can assist with that decision.



Source: Pisano, Gary P., "You Need An Innovation Strategy," Harvard Business Review, Harvard Business School Publishing, 60 Harvard Way, Boston, MA, 02163, USA, June 2015, Pages 44-54; Figure: The Innovation Landscape Map, Pages 51.

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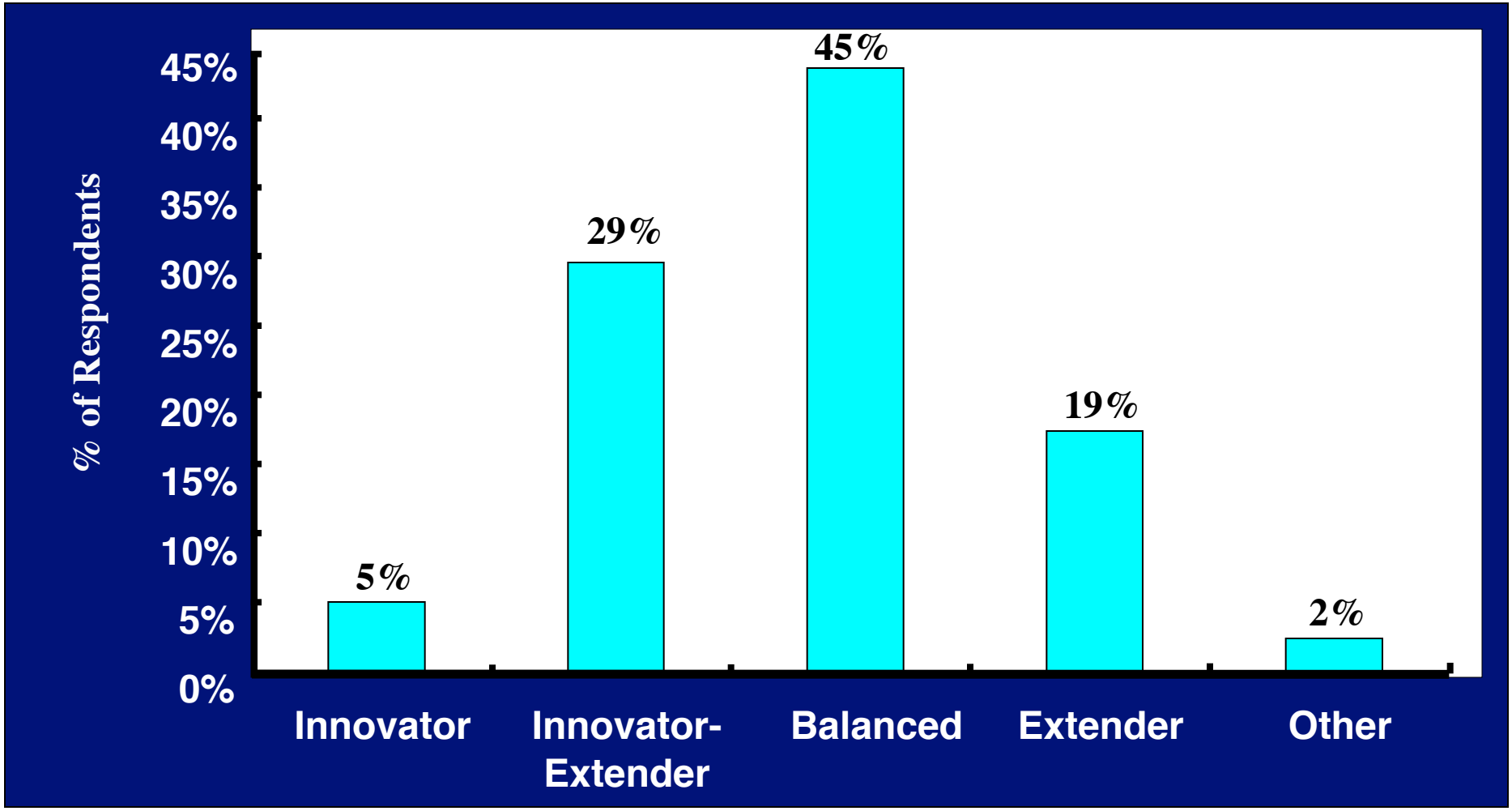
Disruption: Breakthrough Can Be Part of Every Strategy - Percentages Differ



QUESTION: B1. What is your company's fundamental approach to new product creation today? Please reply for what you currently do. Please do not reply as to what your company might do in the future or has done in the past, today's environment is the focus of this research. [Check One Box Only]

Number of Respondents = 198, Margin of Error = +/- 4%

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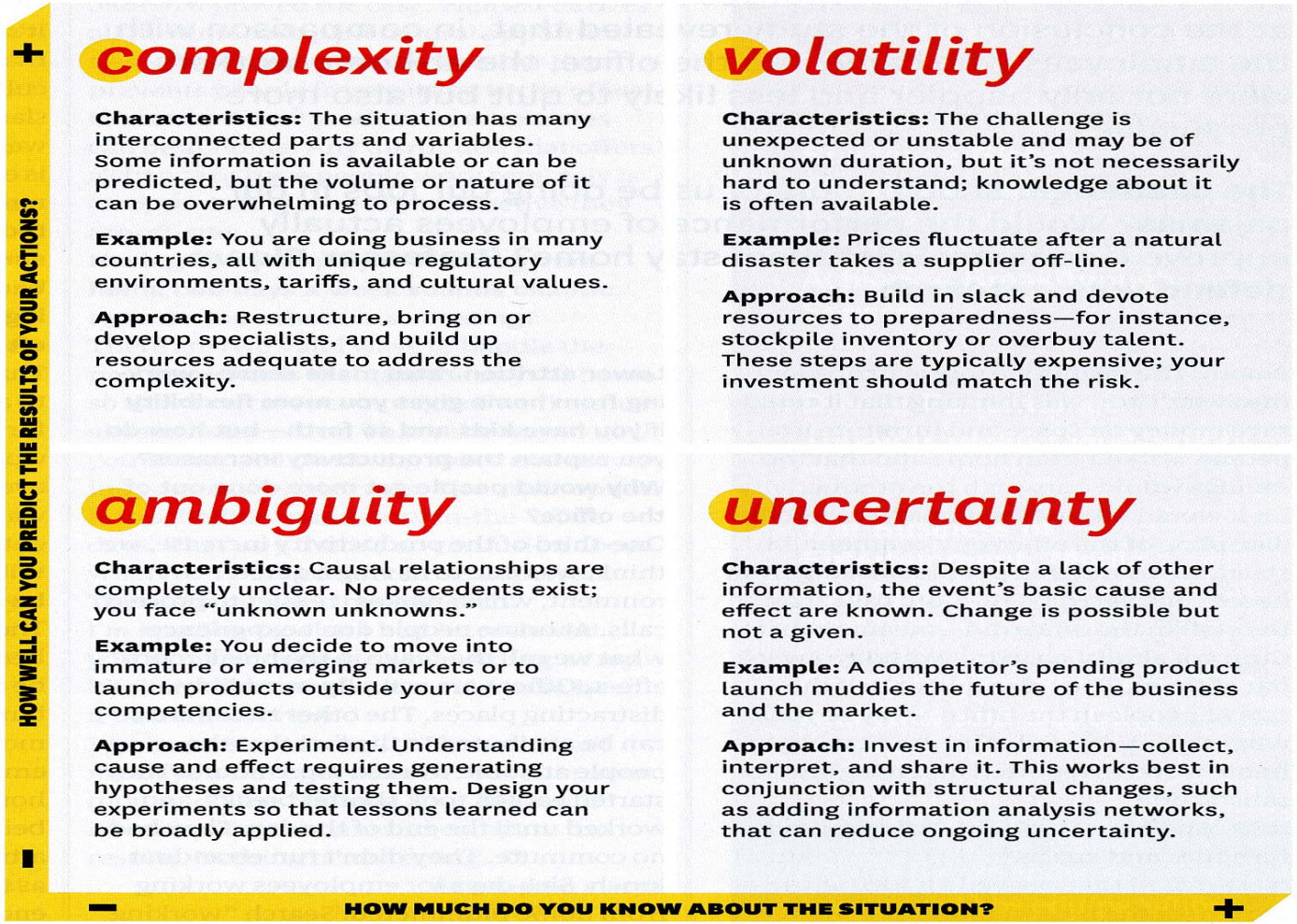
Disruption: Dealing With VUCA

It's become a trendy managerial acronym: VUCA, short for *volatility, uncertainty, complexity,* and *ambiguity,* and a catchall for "Hey, it's crazy out there!" It's also misleading: VUCA conflates four distinct types of challenges that demand four distinct types of responses. That makes it difficult to know how to approach a challenging situation and easy to use VUCA as a crutch, a way to throw off the hard work of strategy and planning—after all, you can't prepare for a VUCA world, right?

Actually, you can. Here is a guide to identifying, getting ready for, and responding to events in each of the four VUCA categories.

HBR Reprint F1401C

Nathan Bennett is a professor at Georgia State University's Robinson College of Business. **G. James Lemoine** is a doctoral candidate at Georgia Institute of Technology's Scheller College of Business.



Source: Bennett, Nathan and Lemoine, G. James, "What VUCA Means for You," *Harvard Business Review*, Harvard Business School Publishing, 60 Harvard Way, Boston, MA, 02163, USA, , January-February 2014, Page 27.

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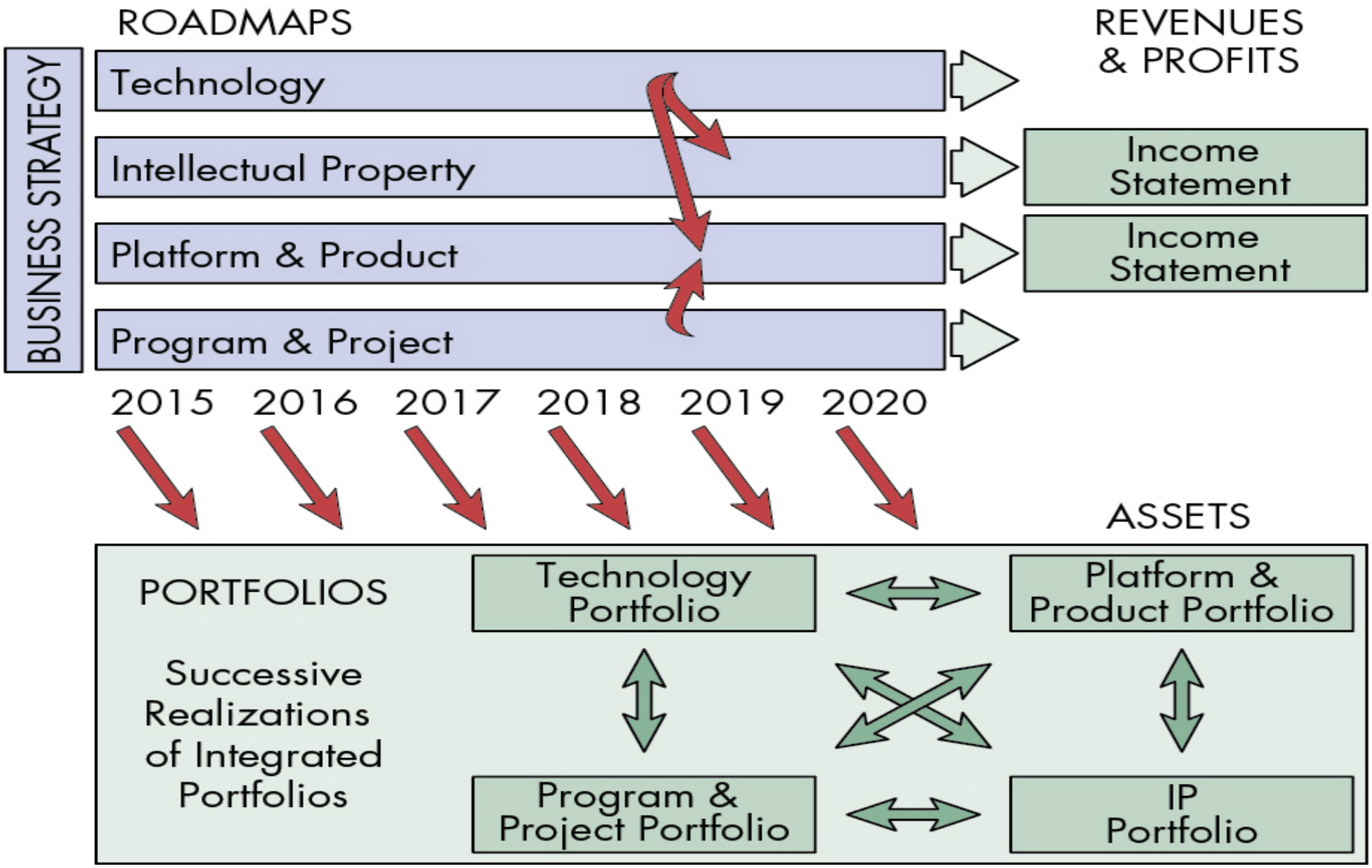
Disruption: Dealing With VUCA - Better Have A Sound But Flexible Plan



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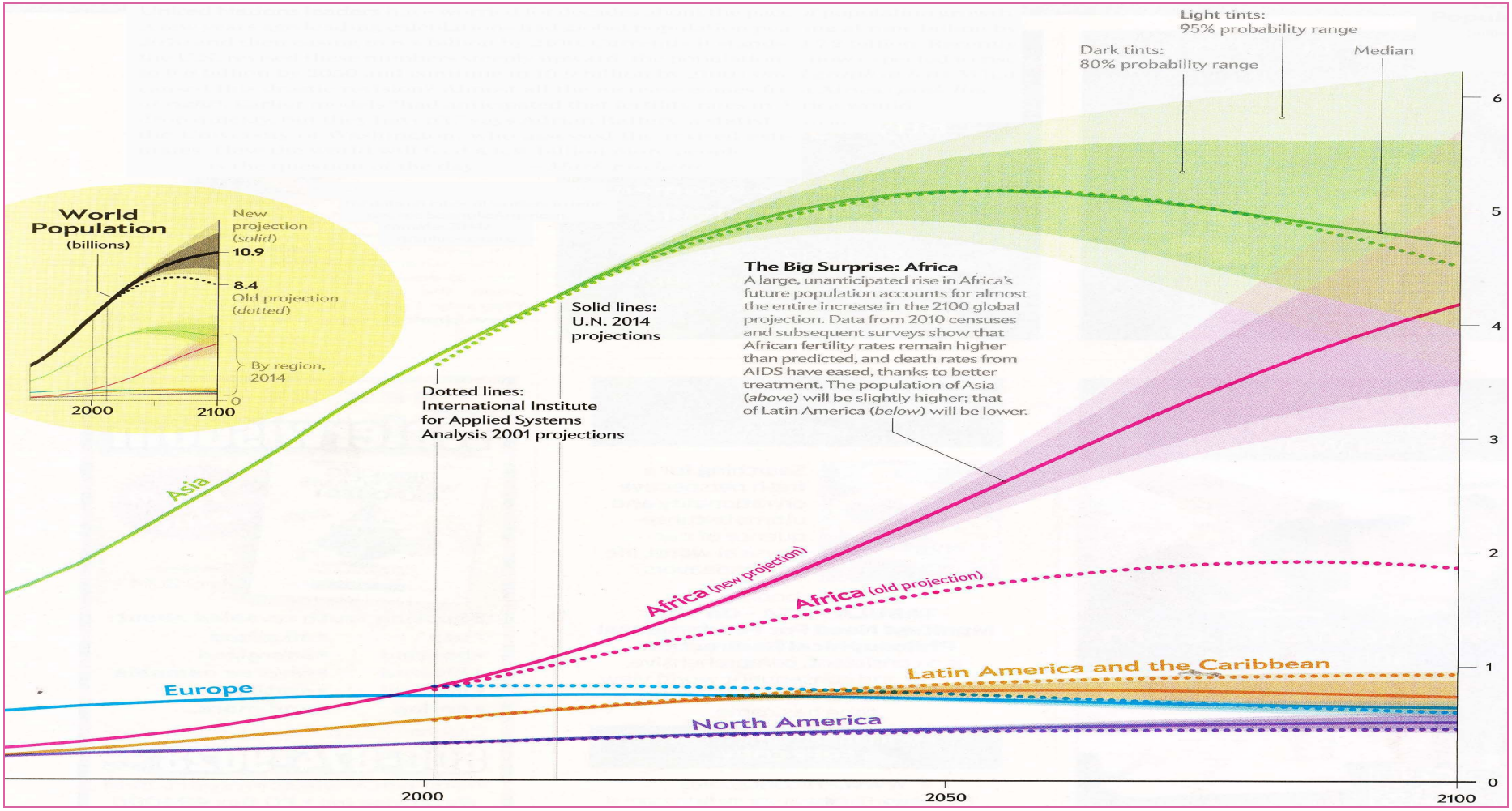
Disruption: The Future Of Global Growth Will Affect All Strategies



Source: Fischetti, Mark, "Up, Up and Away: World Population Will Hit Nearly 11 Billion By 2100," *Scientific American*, Nature America, Inc., Nature Publishing Group, London, UK, December 2014, Page 100.

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Breakthrough Innovation Strategies

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Breakthrough Strategies: Ten Methods To Achieve Radical Innovation and Disrupt

1 Disruptive Innovation

2 Big Bang Innovation

3 Emerging Technology Innovation

4 Digical Innovation

5 Lead User Analysis

6 Reverse Trickle-Up Innovation

7 Bottom-of-Pyramid Innovation

8 Design Thinking

9 Ambidextrous Innovation

10 Sustainable Innovation

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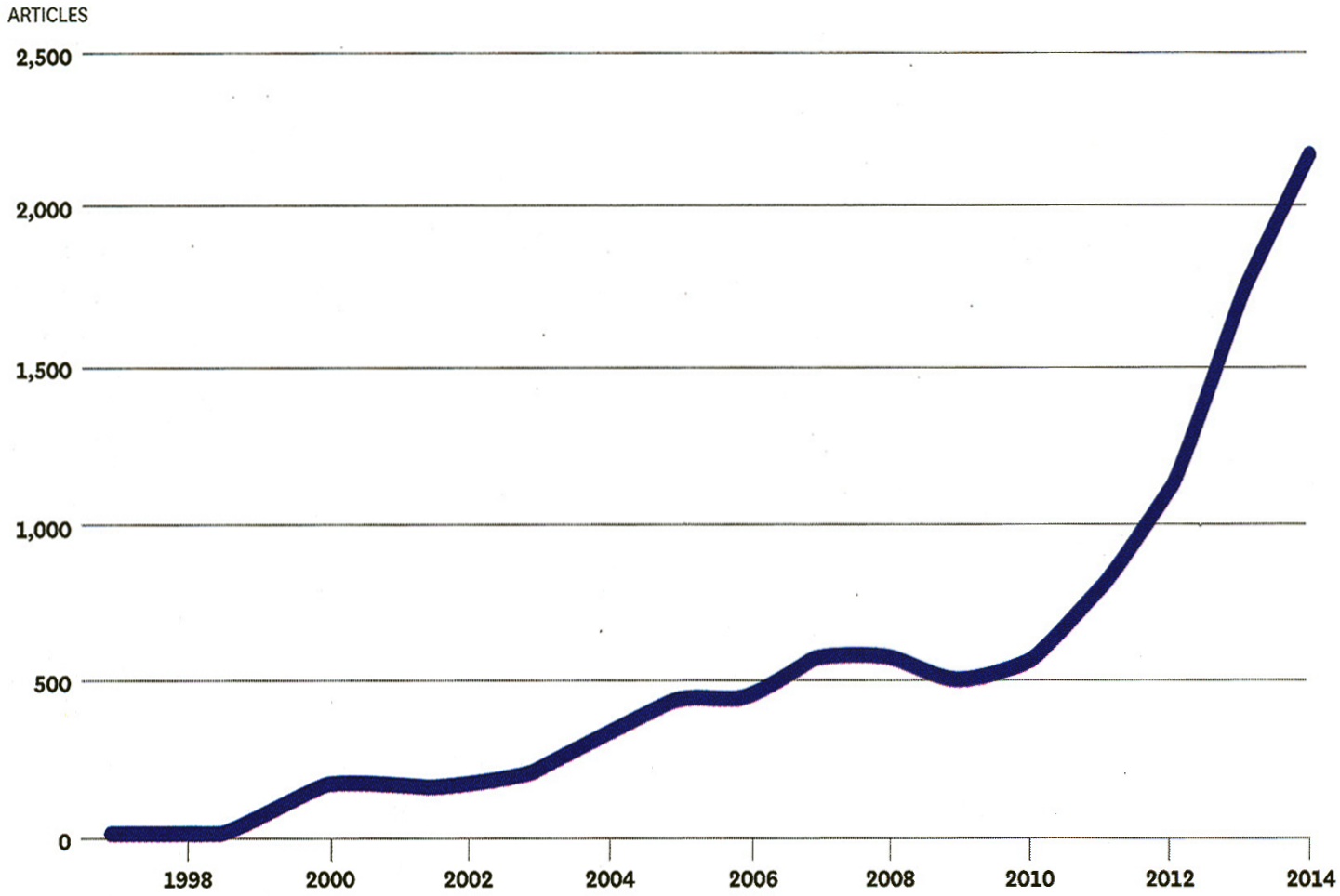
Breakthrough Strategies: Disruptive Innovation - 20th Anniversary - Literature

THE UBIQUITOUS "DISRUPTIVE INNOVATION"

"Disruptive innovation" and "disruptive technology" are now part of the popular business lexicon, as suggested by the dramatic growth in the number of articles using those phrases in recent years.



Source: Clayton M. Christiansen, Michael Raynor, and Rory McDonald, "Disruptive Innovations: Twenty years after the introduction of the theory, we revisit what it does – and doesn't – explain., *Harvard Business Review*, Harvard Business School Publishing, 60 Harvard Way, Boston, MA, 02163, USA, December 2015, Page 50, Inset - The Ubiquitous "Disruptive Innovation."

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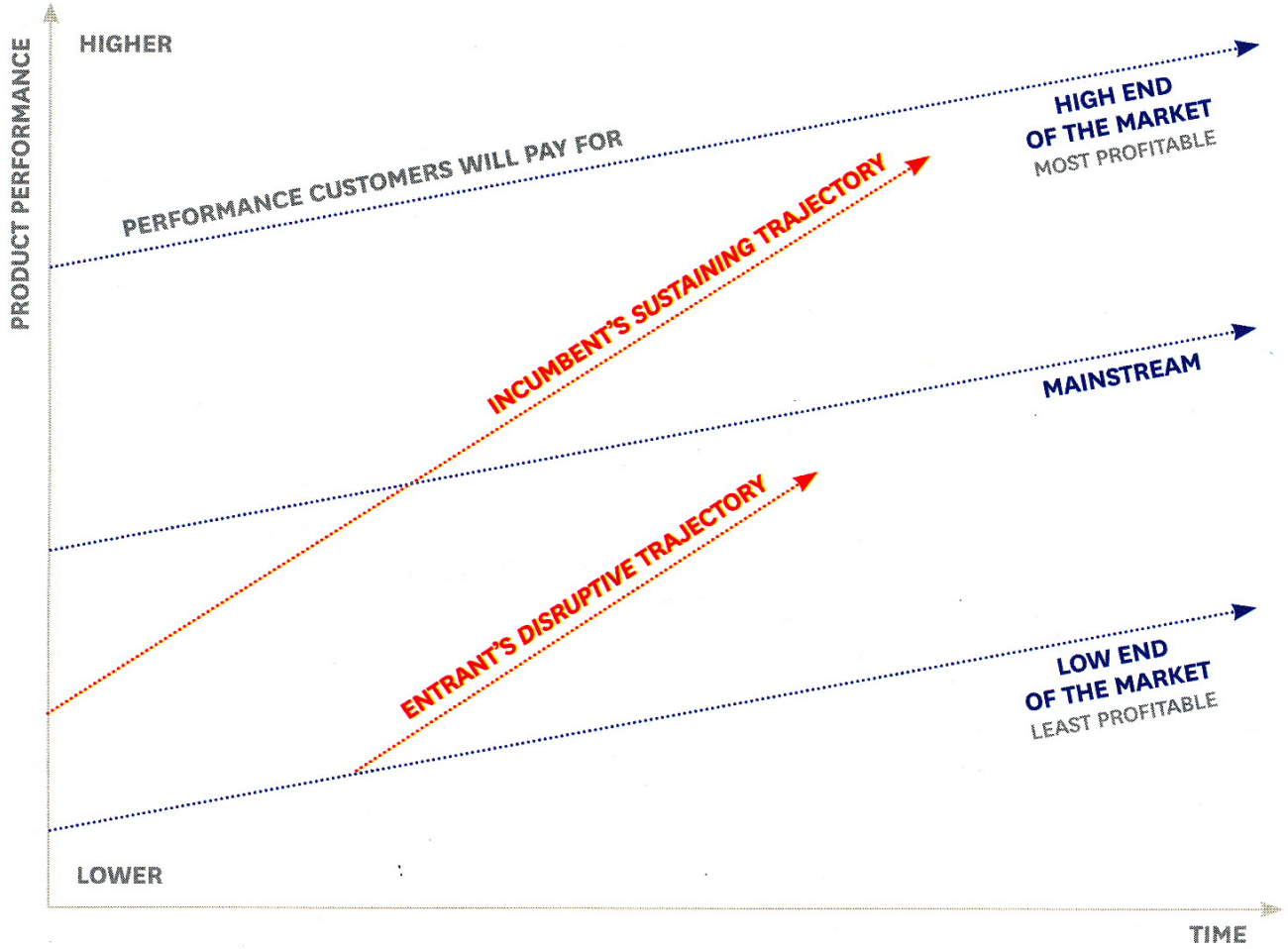
Breakthrough Strategies: Disruptive Innovation - 20th Anniversary - Revisit Model



THE DISRUPTIVE INNOVATION MODEL

This diagram contrasts *product performance trajectories* (the red lines showing how products or services improve over time) with *customer demand trajectories* (the blue lines showing customers' willingness to pay for performance). As incumbent companies introduce higher-quality products or services (upper red line) to satisfy the high end of the market (where profitability is highest), they overshoot the needs of low-end customers and many mainstream customers. This leaves an opening for entrants to find footholds in the less-profitable segments that incumbents are neglecting. Entrants on a disruptive trajectory (lower red line) improve the performance of their offerings and move upmarket (where profitability is highest for them, too) and challenge the dominance of the incumbents.

Source: Clayton M. Christiansen, Michael Raynor, and Rory McDonald, "Disruptive Innovations: Twenty years after the introduction of the theory, we revisit what it does – and doesn't – explain., *Harvard Business Review*, Harvard Business School Publishing, 60 Harvard Way, Boston, MA, 02163, USA, December 2015, Page 49, Inset - The Disruptive Innovation Model.

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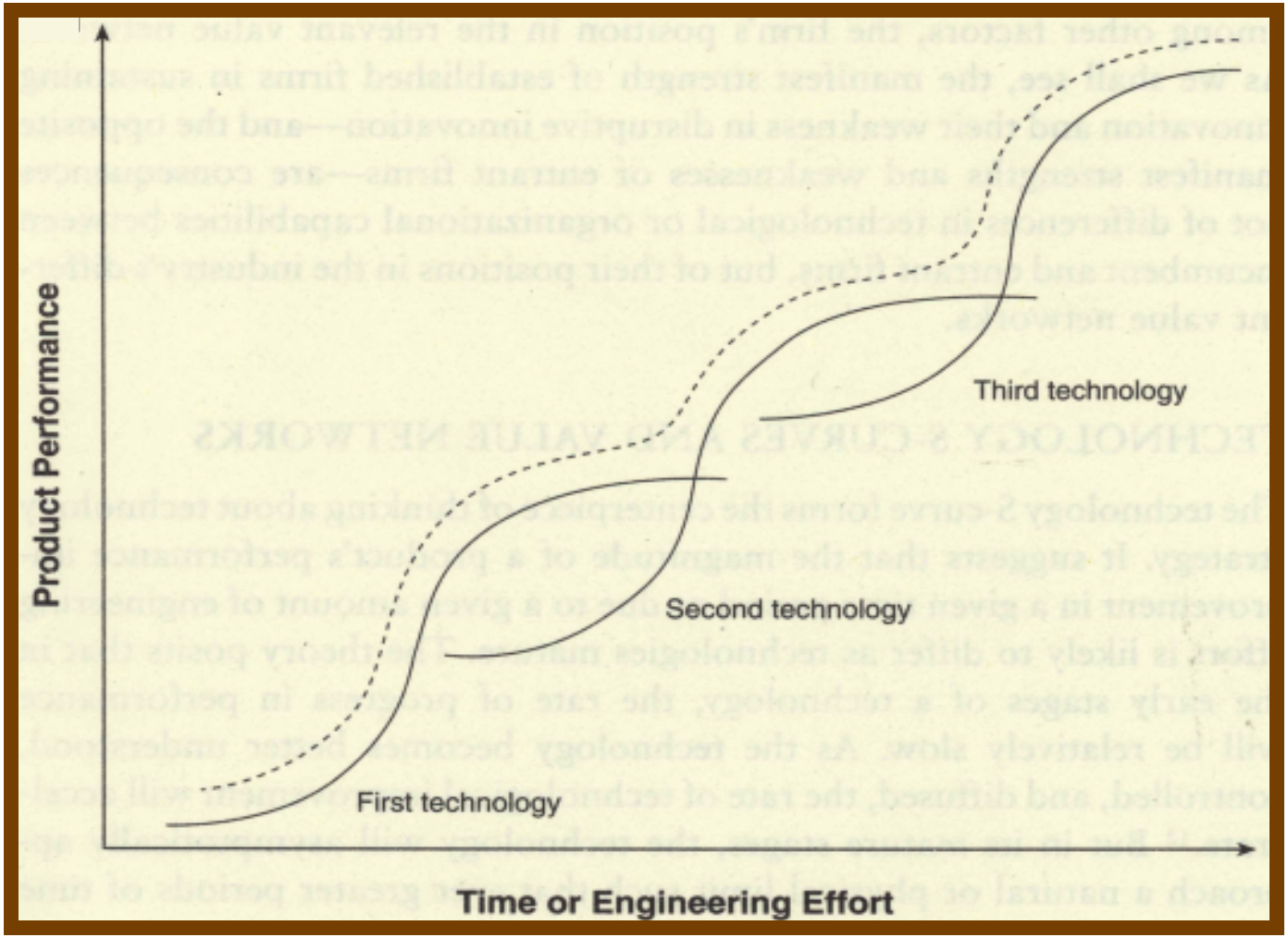
Breakthrough Strategies: Disruptive Innovation - Conventional Technology S-Curve



Source: Clayton M. Christensen, "The Innovator's Dilemma: When New Technologies Cause Great Firms To Fail.," Harvard Business School Press, Copyright 1997 by the President and Fellows of Harvard College, Page 40.

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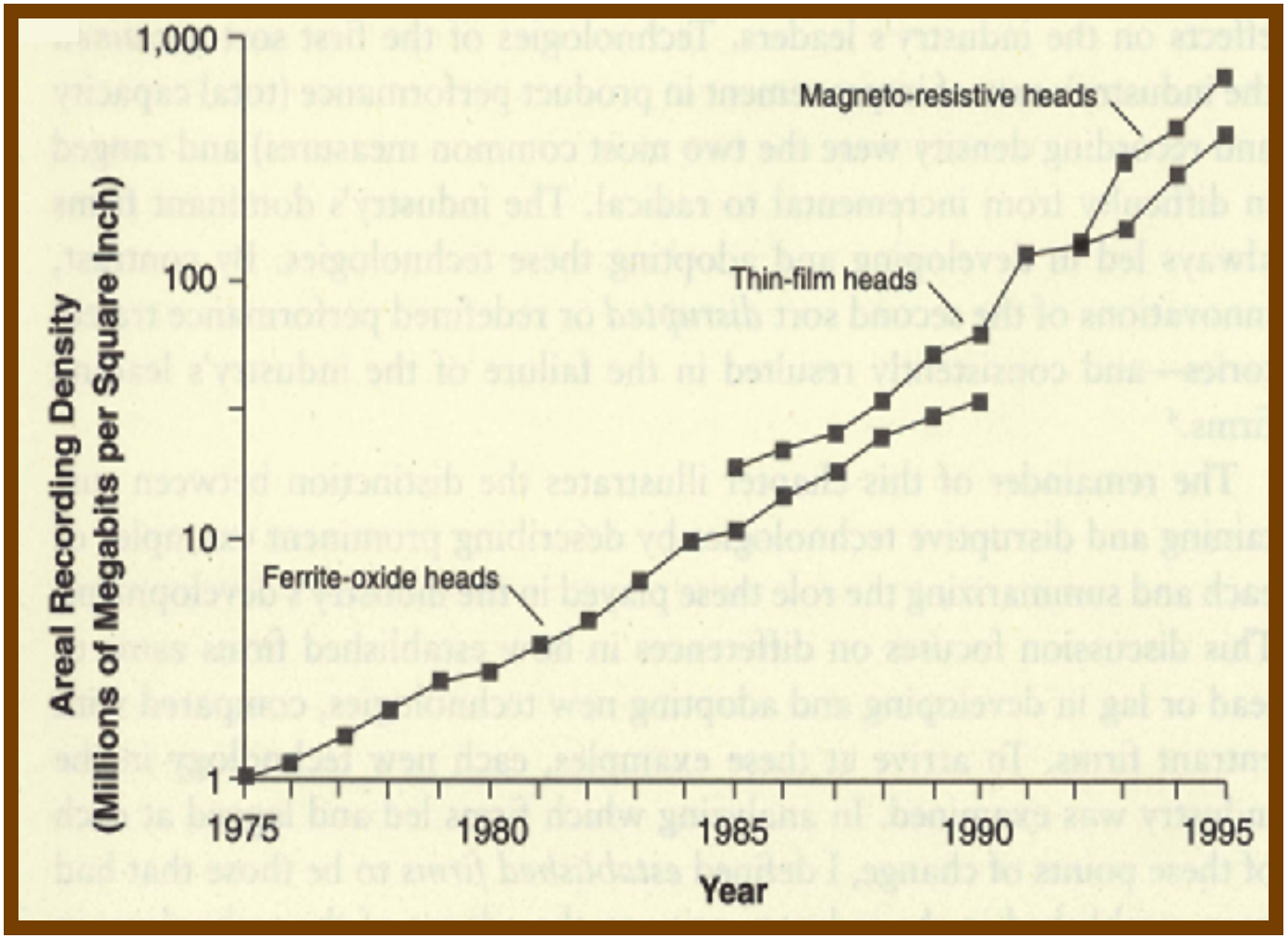
Breakthrough Strategies: Disruptive Innovation - Read-Write Head Tech Example



Source: Clayton M. Christensen, "The Innovator's Dilemma: When New Technologies Cause Great Firms To Fail.," Harvard Business School Press, Copyright 1997 by the President and Fellows of Harvard College, Page 10.

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Breakthrough Strategies: Big-Bang Disruption - Characteristics & Countermeasures

Idea in Brief

Disruptive technological innovations have traditionally started out cheap and simple, gradually improving in quality until they challenged incumbents.

New digital platforms such as the smartphone, however, are enabling innovations that offer customers both a better experience and a much lower price, right out of the gate. (Think of free mobile apps' superiority to dedicated GPS devices.)

These "big-bang" disruptions are often unplanned and unintentional. They do not follow conventional strategic paths or normal patterns of market adoption.

To survive them, incumbents need to develop new tools to detect radical change in the offing, new strategies to slow down disrupters, new ways to leverage existing assets in other markets, and a more diversified approach to investment.

Source: Downes, Larry and Nunes, Paul F., "Big Bang Disruption," Harvard Business Review, Harvard Business School Publishing, 60 Harvard Way, Boston, MA, 02163, USA, March 2013, Pages 44-56; Inset: Idea In Brief, Page 47.

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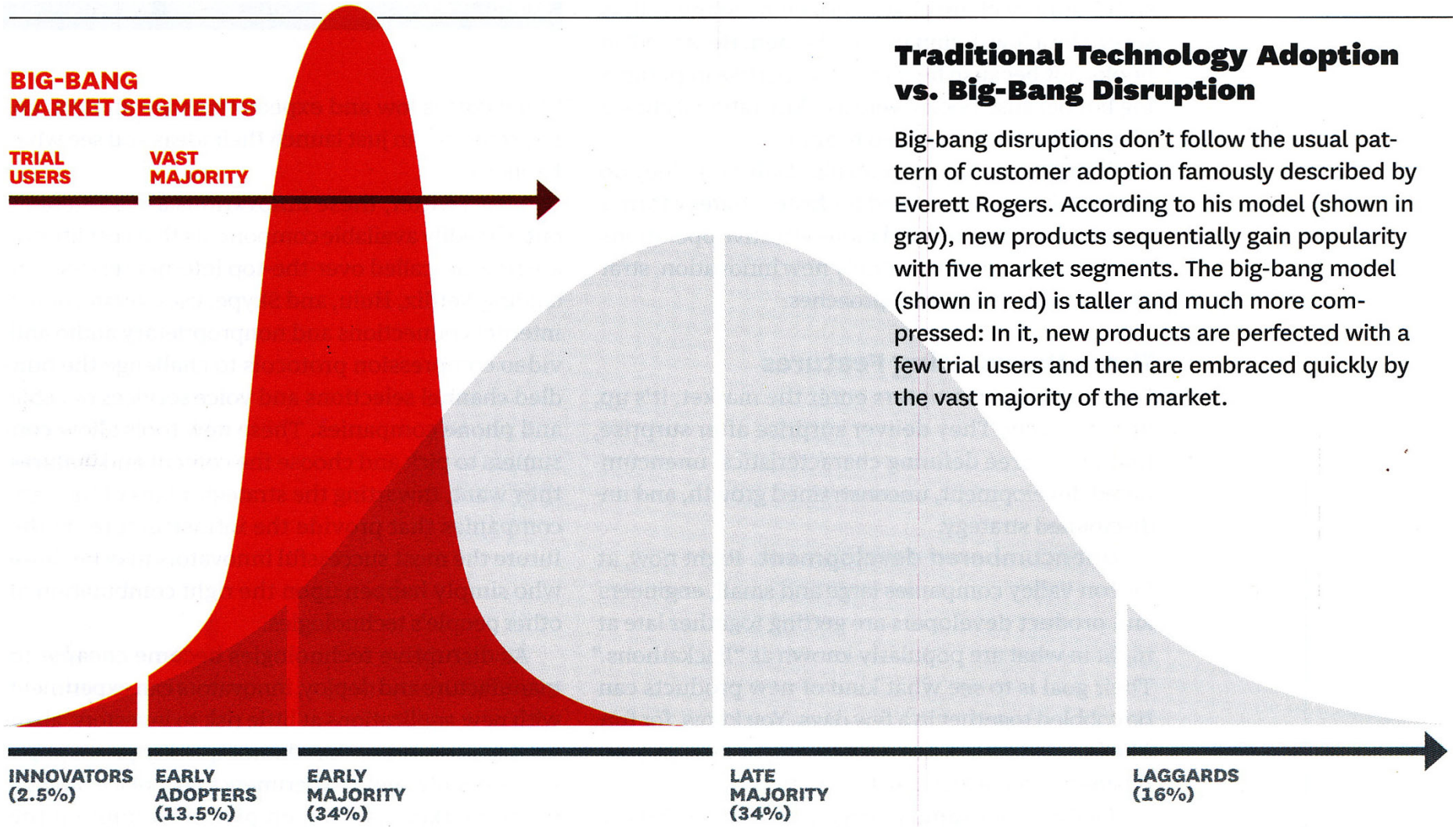
Breakthrough Strategies: Big-Bang Disruption - Perfecting With Trial Users



Traditional Technology Adoption vs. Big-Bang Disruption

Big-bang disruptions don't follow the usual pattern of customer adoption famously described by Everett Rogers. According to his model (shown in gray), new products sequentially gain popularity with five market segments. The big-bang model (shown in red) is taller and much more compressed: In it, new products are perfected with a few trial users and then are embraced quickly by the vast majority of the market.

Source: Downes, Larry and Nunes, Paul F., "Big Bang Disruption," Harvard Business Review, Harvard Business School Publishing, 60 Harvard Way, Boston, MA, 02163, USA, March 2013, Pages 44-56; Inset: Idea In Brief, Page 47.

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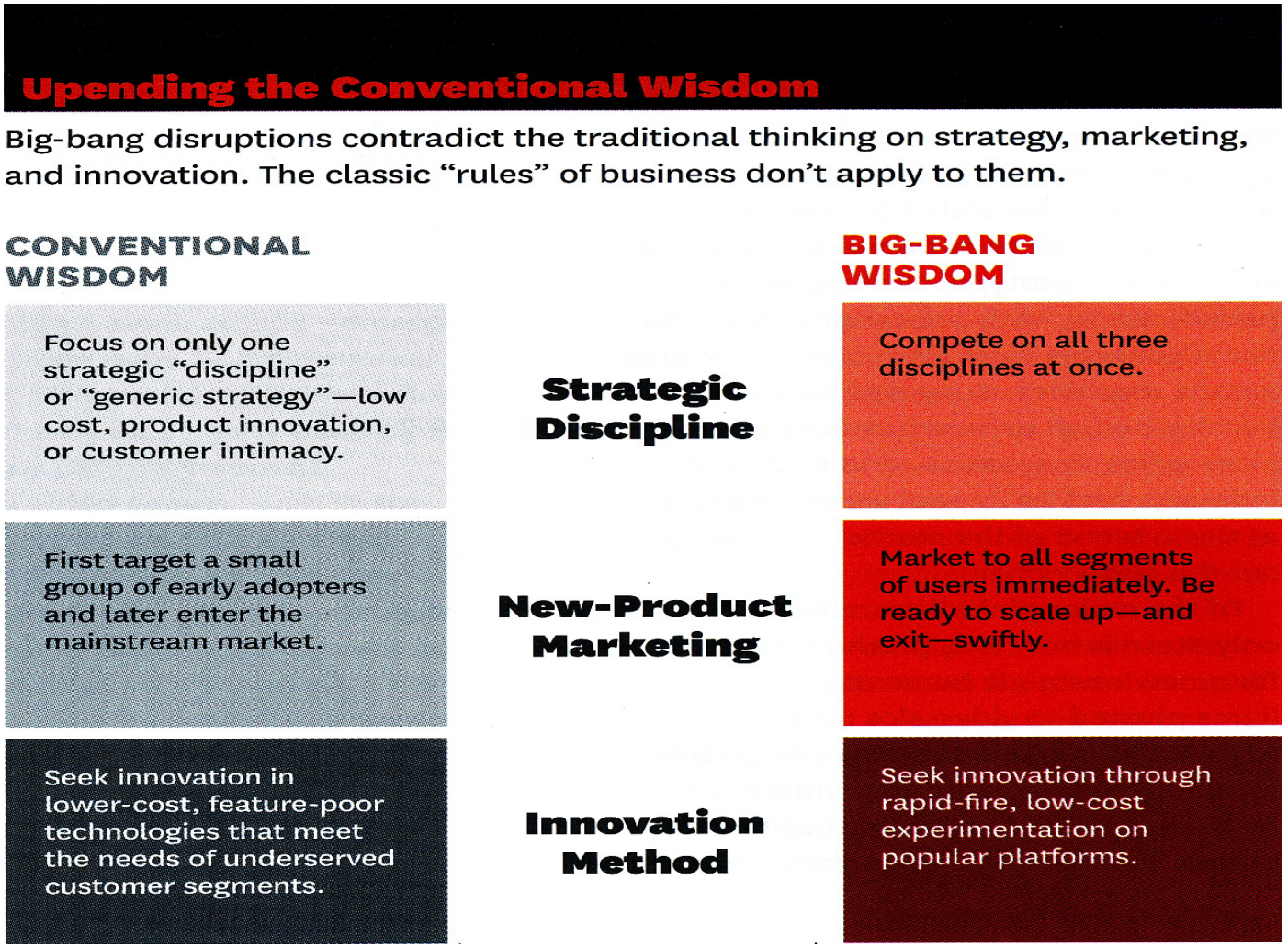
Breakthrough Strategies: Big-Bang Disruption - Strategic Approach



Source: Downes, Larry and Nunes, Paul F., "Big Bang Disruption," Harvard Business Review, Harvard Business School Publishing, 60 Harvard Way, Boston, MA, 02163, USA, March 2013, Pages 44-56; Inset: Upending The Conventional Wisdom, Page 52.

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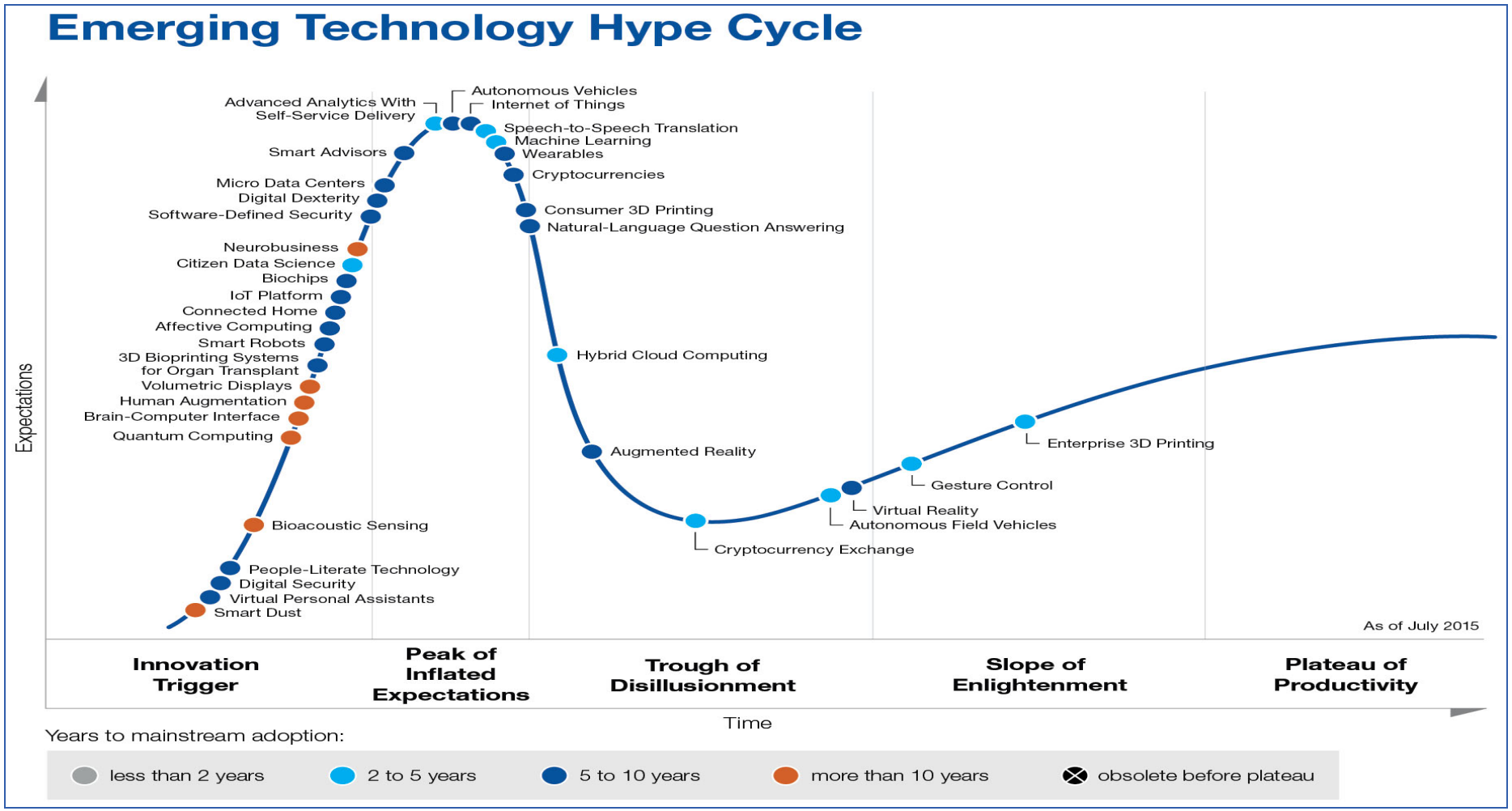
Breakthrough Strategies: Emerging Technology Innovation - Gartner Hype Cycle



Source: Press Release, "Gartner's 2015 Hype Cycle for Emerging Technologies Identifies the Computing Innovations That Organizations Should Monitor," Gartner, Inc., 56 Top Gallant Road, Stamford, CT, 06902, USA, August 18, 2015, Figure 1: Hype Cycle for Emerging Technologies, 2015.

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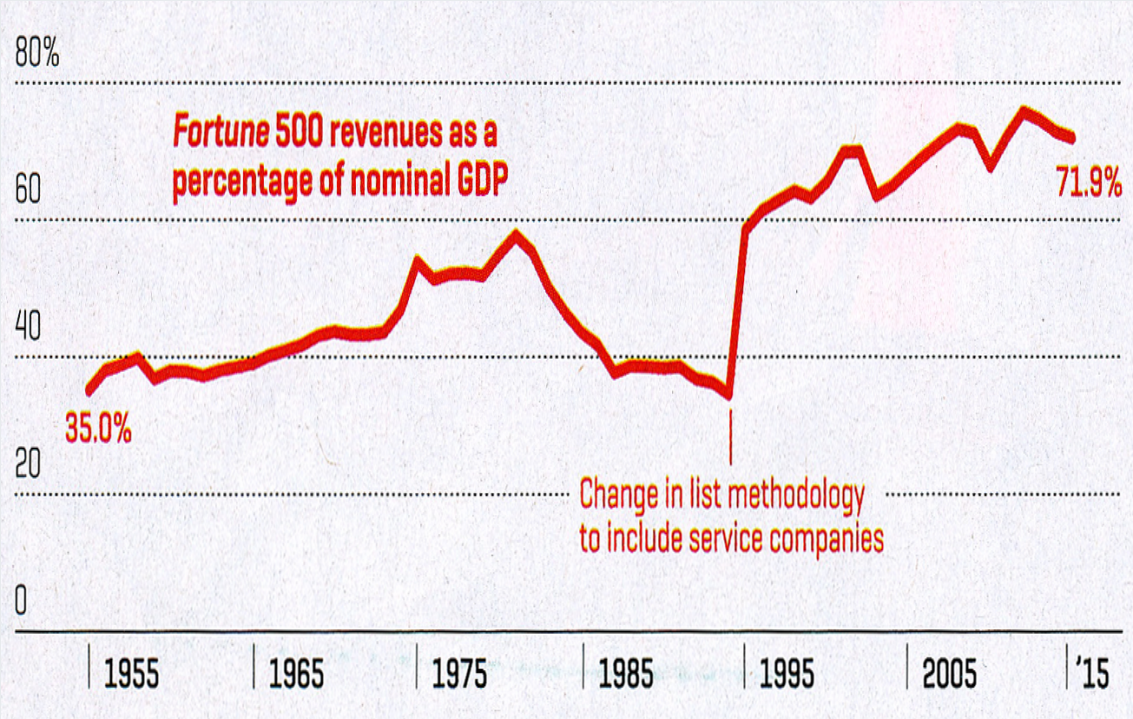
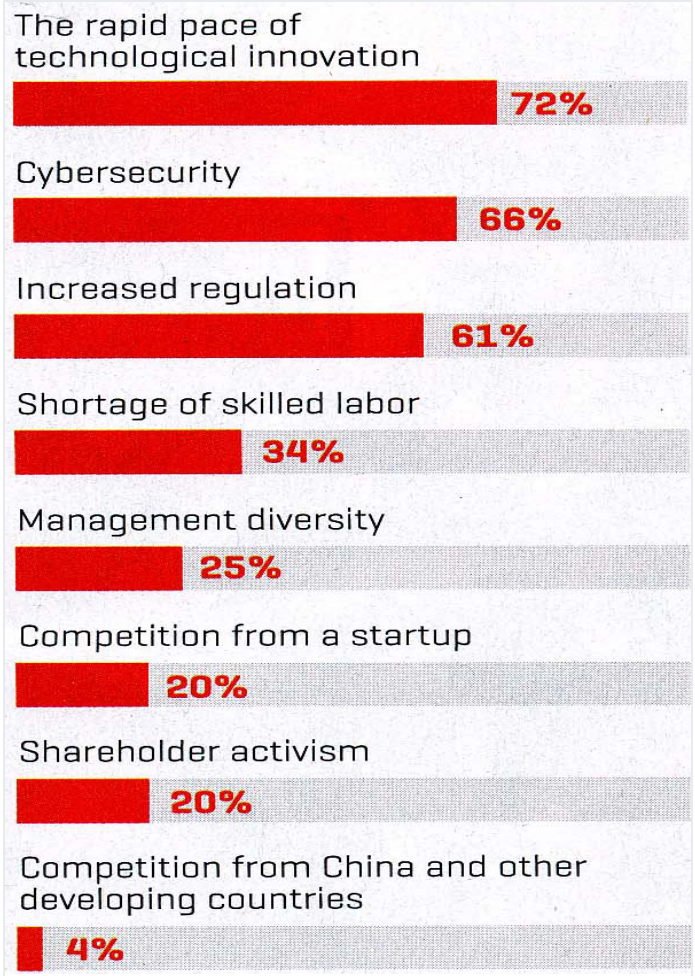
Breakthrough Strategies: Emerging Technology Innovation - Greatest Challenges





Source: Alan Murray, "Editor's Desk: Myth Busting the Fortune 500.," *Fortune Magazine*, Time Inc., Time & Life Building, Rockefeller Center, NY, NY 10020, USA, Volume 171, Number 8, June 15, 2015; Inset Page 14 - Size Matters and Inset Page 16 - Greatest Challenge.

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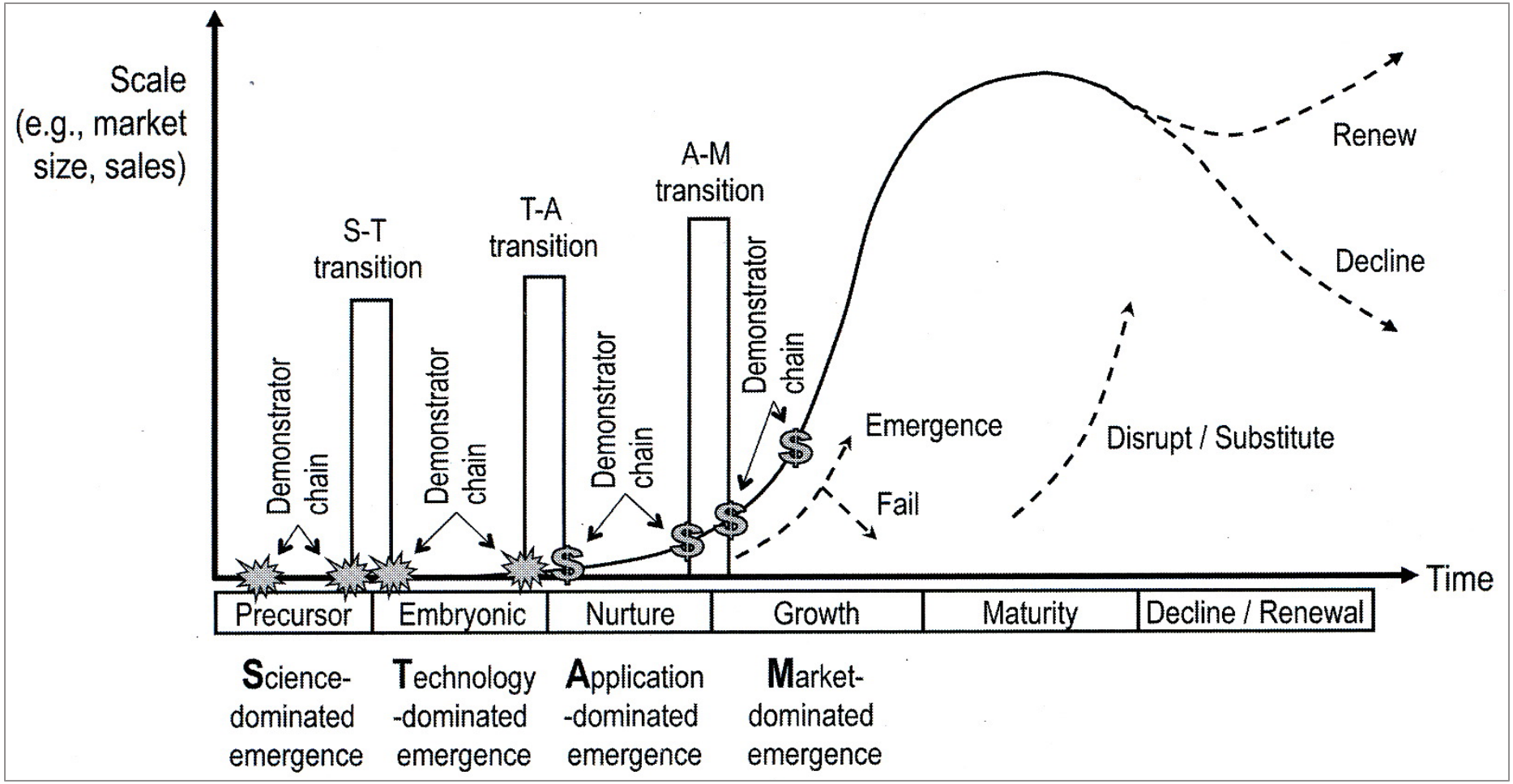
Breakthrough Strategies: Emerging Technology Innovation - Phases



Source: Robert Phaal, Michele Routley, Nikoletta Athanassopoulou, and David Probert, "Charting Exploitation Strategies for Emerging Technology," *Research & Technology Management*, Industrial Research Institute, 1550 M Street NW, Washington, DC, March-April 2012, Pages 34-42; Figure 1 - Phases and transitions of industrial emergence (adapted from Phaal et al. 2011, 221).

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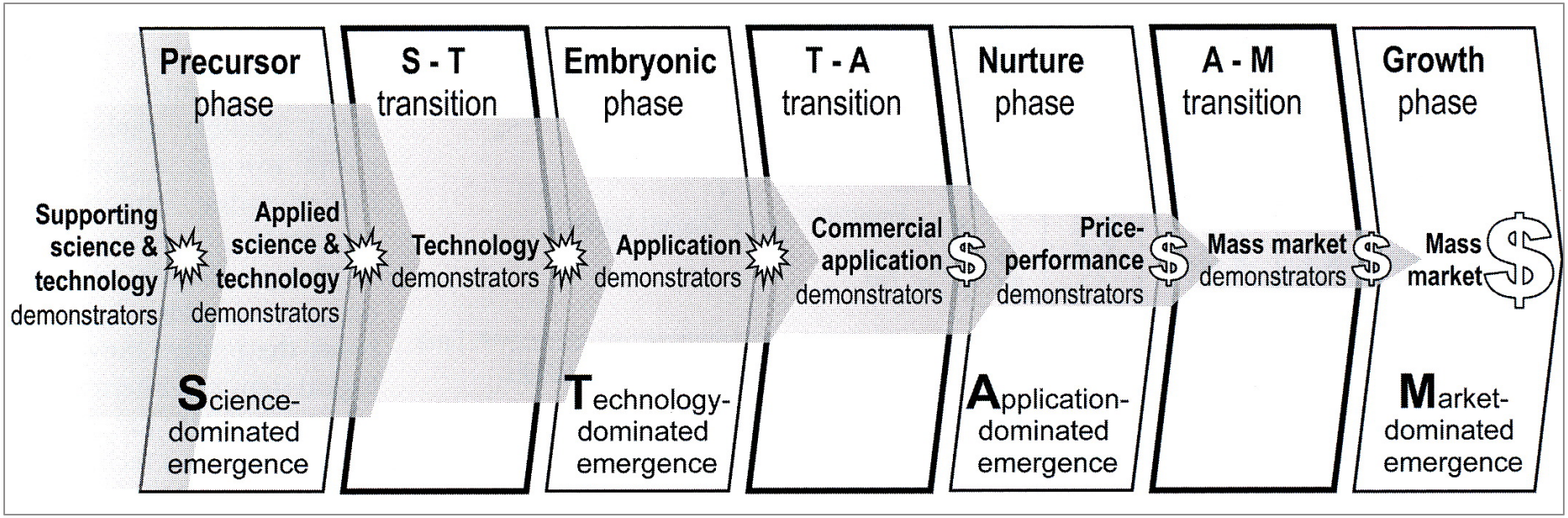
Breakthrough Strategies: Emerging Technology Innovation - Demonstration



Source: Robert Phaal, Michele Routley, Nikoletta Athanassopoulou, and David Probert, "Charting Exploitation Strategies for Emerging Technology," *Research & Technology Management*, Industrial Research Institute, 1550 M Street NW, Washington, DC, March-April 2012, Pages 34-42; Figure 2 - Demonstration milestones, phases, and transitions.

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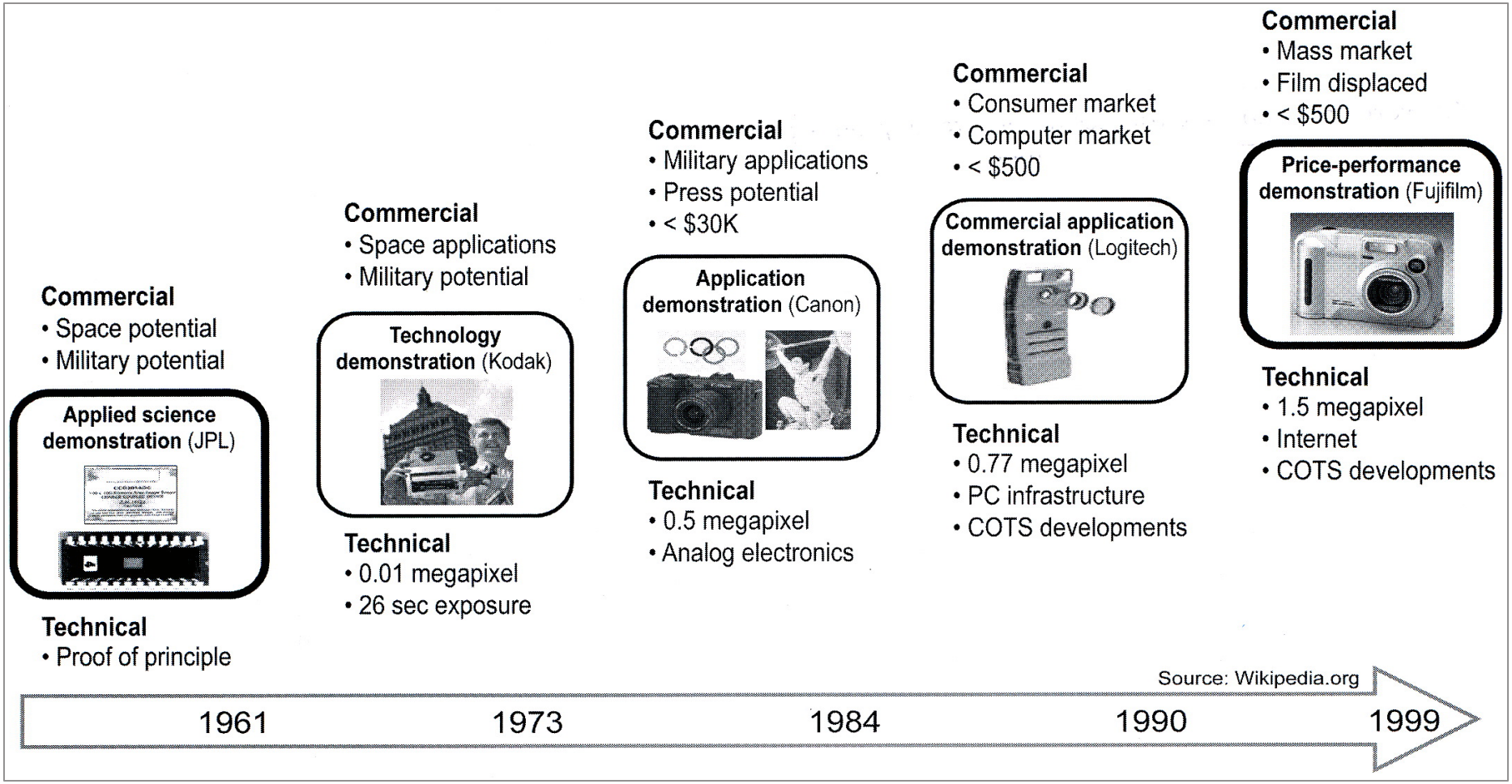
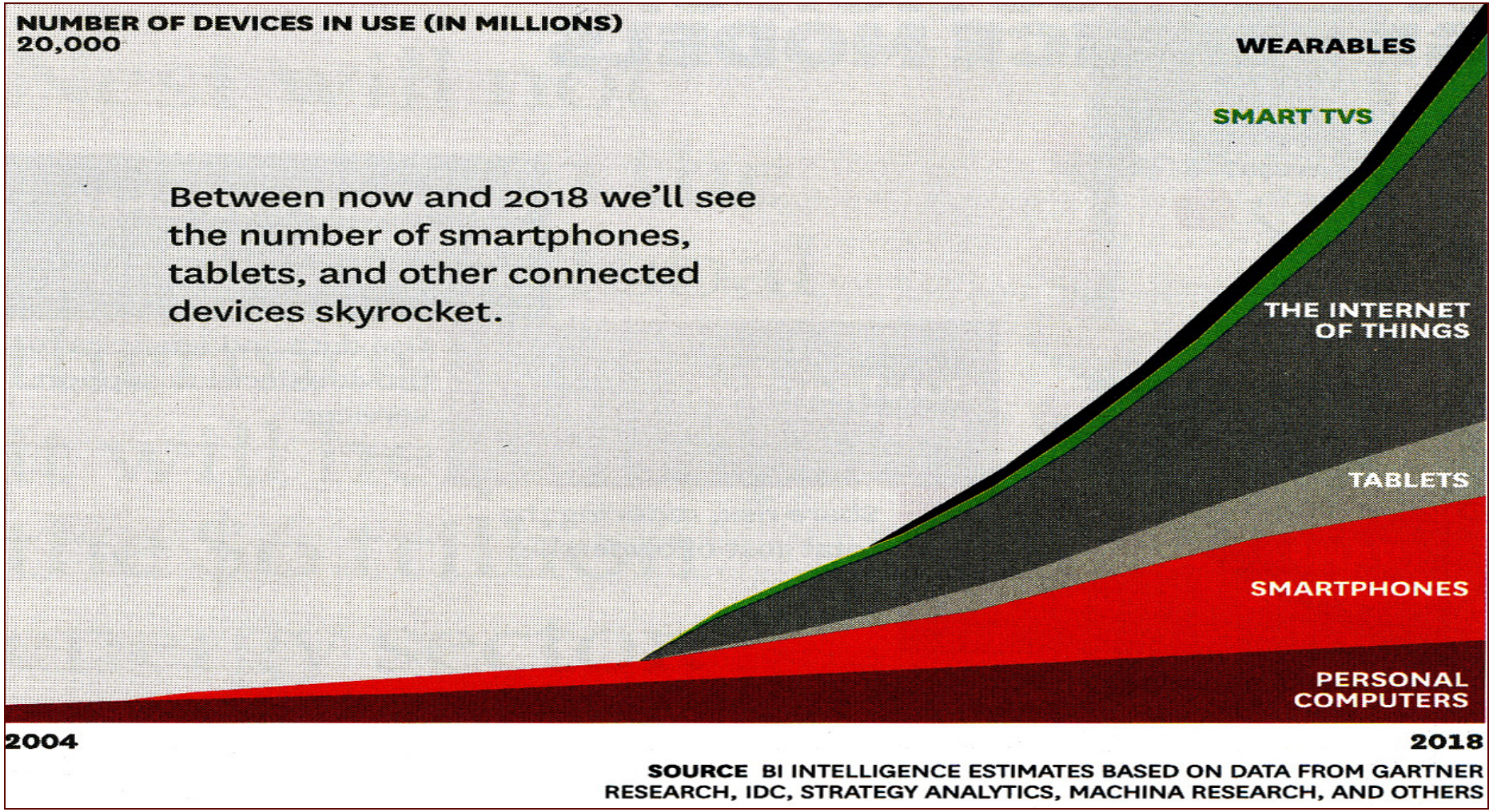
Breakthrough Strategies: Emerging Technology Innovation - Case Study - Cameras



Source: Robert Phaal, Michele Routley, Nikoletta Athanassopoulou, and David Probert, "Charting Exploitation Strategies for Emerging Technology," *Research & Technology Management*, Industrial Research Institute, 1550 M Street NW, Washington, DC, March-April 2012, Pages 34-42; Figure 3 - Key demonstration milestones in the emergence of consumer digital cameras.

DFMA & BREAKTHROUGH INNOVATION TECHNIQUES

Breakthrough Strategies: Digical Innovation & The Smart Connected Company



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Source: Marco Iansiti and Karim R. Lakhani, "Digital Ubiquity: How Connections, Sensors, and Data Are Revolutionizing Business," *Harvard Business Review*, Harvard Business School Publishing, 60 Harvard Way, Boston, MA, 02163, USA, November 2014, Page 93, Inset: An Explosion In Connected Devices.

DFMA & BREAKTHROUGH INNOVATION TECHNIQUES

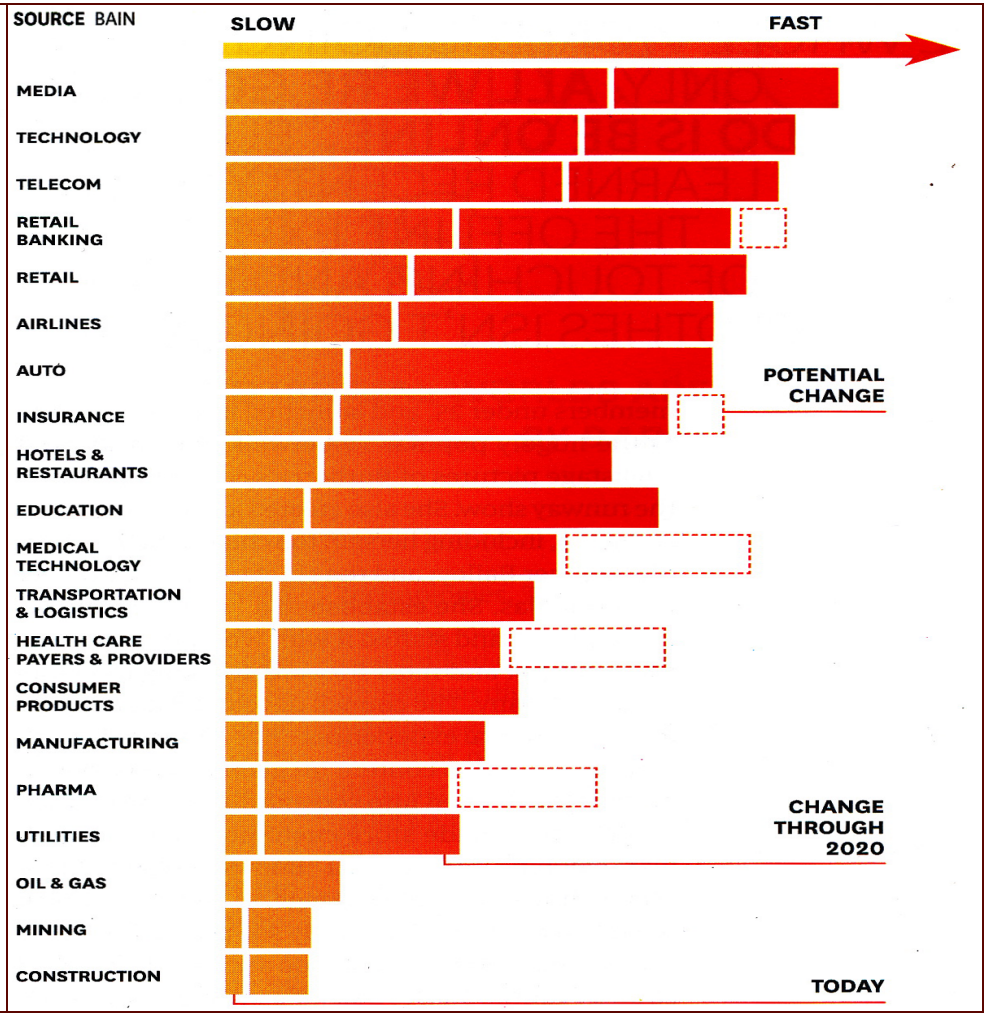
Breakthrough Strategies: Digical Innovation

"Digical" (combined digital and physical) innovations will hit some businesses much harder and faster than others, so a key first step is to assess your company's environment. How much has the ongoing transformation already changed your industry's offerings and competitive dynamics? How much is it likely to do so in the next several years? The figure below captures Bain's assessment of digical transformation for 20 industries. You can see at a glance some of the key findings:

The range of impact is wide. Change has been several times as extensive in media, technology, and telecom as in oil and gas, mining, and construction.

The biggest change is yet to come. The next several years will bring far more innovation to most industries than they have seen in the past. Airlines, automobiles, and insurance, for instance, are on the verge of far-reaching digical transformations.

Wild cards can affect the pace of change. Some industries will be held back by external factors. Medical technology and health care, in particular, won't evolve as quickly as they otherwise might, owing to regulations, reimbursement practices, and liability issues.



Source: Darrell K. Rigby, "Digital-Physical Mashups: To consumers, the real and virtual worlds are one. The same should go for your company.," *Harvard Business Review*, Harvard Business School Publishing, 60 Harvard Way, Boston, MA, 02163, USA, September 2014, Page 91, Inset: Digical's Growing Momentum.

Idea in Brief

A RADICAL SHIFT
Smart, connected products are forcing companies to redefine their industries and rethink nearly everything they do, beginning with their strategies. This article, the second in a two-part series, focuses on the impact of these products on companies' operations and organizational structure.

NEW RELATIONSHIPS
The unprecedented data and capabilities that smart, connected products provide are changing the way firms interact with their customers. Those relationships are becoming continuous and open-ended.

NEW PROCESSES
The new product capabilities and infrastructure and the data they generate are reshaping the work of virtually every function in the value chain, including product development, IT, manufacturing, logistics, marketing, sales, and after-sale service. In addition, far more intense coordination among functions is now required.

NEW STRUCTURES
New forms of cross-functional collaboration and entirely new functions are emerging. These include unified data organizations, units to continuously improve products postsale, and groups charged with optimizing customer relationships.

THE NEW TECHNOLOGY STACK

Smart, connected products require companies to build and support an entirely new technology infrastructure. This "technology stack" is made up of multiple layers, including new product hardware, embedded software, connectivity, a product cloud consisting of software running on remote servers, a suite of security tools, a gateway for external information sources, and integration with enterprise business systems.

Source: Michael E. Porter and James E. Heppelmann, "How Smart, Connected Products Are Transforming Companies, *Harvard Business Review*, Harvard Business School Publishing, 60 Harvard Way, Boston, MA, 02163, USA, October 2015; Page 99, Inset - Idea In Brief and Page 101, Inset - The New Technology Stack. [Part 2 of 2 – A Two Part Series]

DFMA & BREAKTHROUGH INNOVATION TECHNIQUES

Breakthrough Strategies: Digical Innovation - Smart - 10 Strategic Decisions

IMPLICATIONS FOR STRATEGY

In a smart, connected world, companies face 10 new strategic decisions. A firm's choices will have a major impact on every activity in its value chain.

SOURCE "HOW SMART, CONNECTED PRODUCTS ARE TRANSFORMING COMPETITION," HBR, NOVEMBER 2014

1. **Which set of smart, connected product capabilities and features should the company pursue?**
2. **How much functionality should be embedded in the product and how much in the cloud?**
3. **Should the company pursue an open or closed system?**
4. **Should the company develop the full set of smart, connected product capabilities and infrastructure internally or outsource to vendors and partners?**
5. **What data must the company capture, secure, and analyze to maximize the value of its offering?**
6. **How does the company manage ownership and access rights to its product data?**
7. **Should the company fully or partially disintermediate distribution channels or service networks?**
8. **Should the company change its business model?**
9. **Should the company enter new businesses by monetizing its product data through selling it to outside parties?**
10. **Should the company expand its scope?**

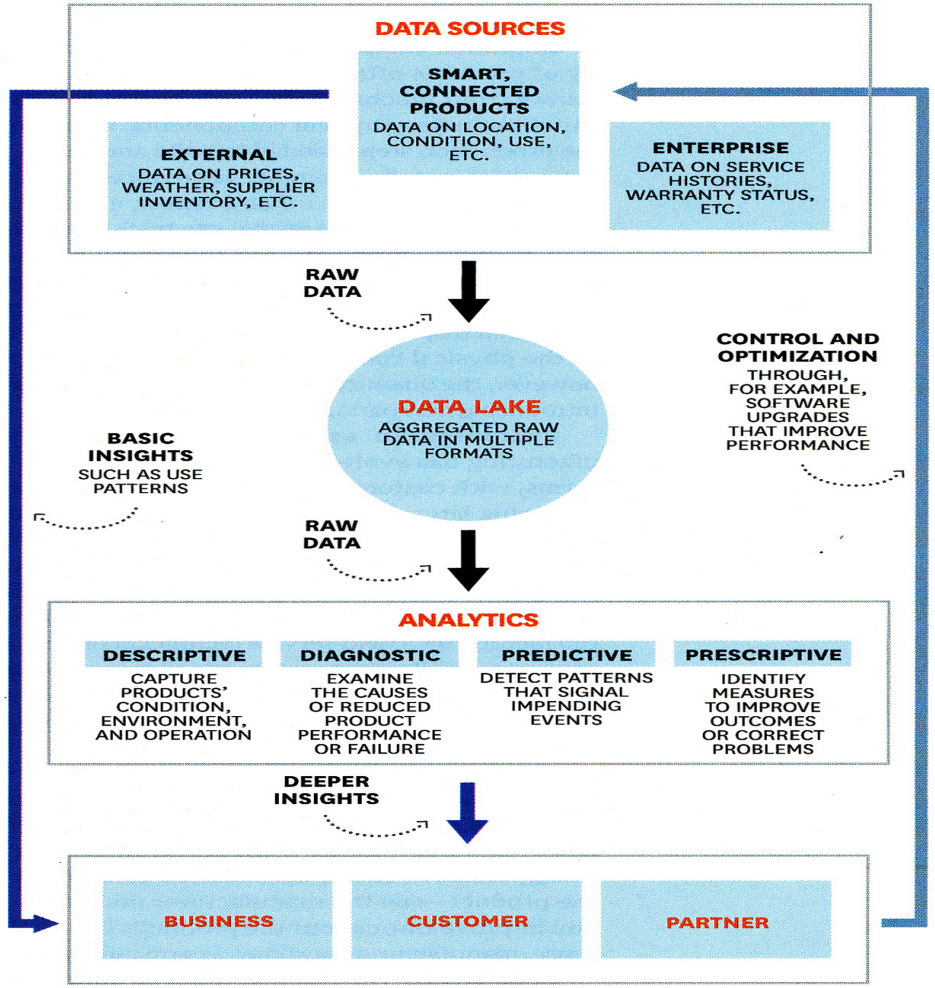
Source: Michael E. Porter and James E. Heppelmann, "How Smart, Connected Products Are Transforming Companies, *Harvard Business Review*, Harvard Business School Publishing, 60 Harvard Way, Boston, MA, 02163, USA, October 2015; Page 99, Inset - Implications For Strategy. [Part 2 of 2 - A Two Part Series]

DFMA & BREAKTHROUGH INNOVATION TECHNIQUES

Breakthrough Strategies: Digical Innovation - Smart - Value Equation Changes

CREATING NEW VALUE WITH DATA

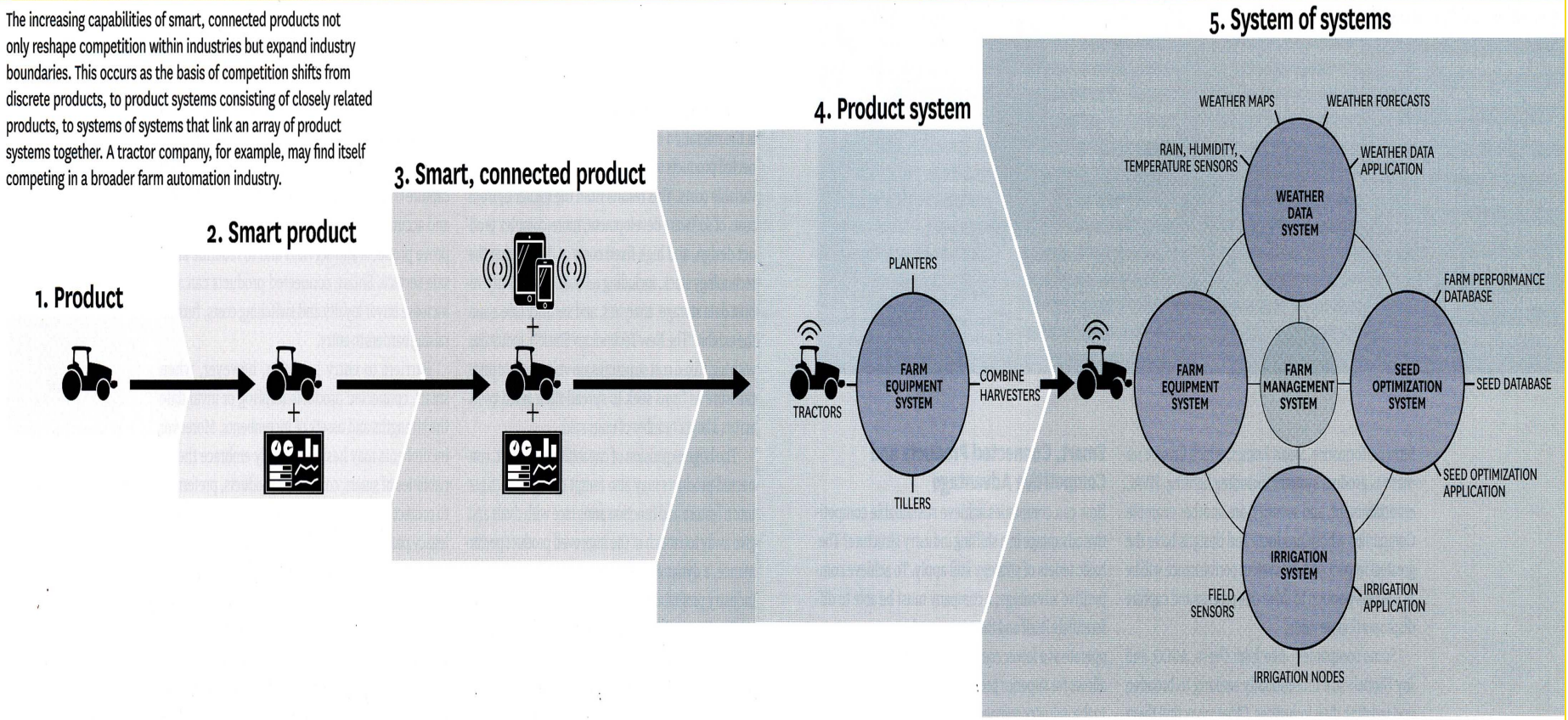
Data from smart, connected products is generating insights that help businesses, customers, and partners optimize product performance. Simple analytics, applied by individual products to their own data, reveal basic insights; more-sophisticated analytics, applied to product data that has been pooled into a "lake" with data from external and enterprise sources, unearth deeper insights.



Source: Michael E. Porter and James E. Heppelmann, "How Smart, Connected Products Are Transforming Companies, *Harvard Business Review*, Harvard Business School Publishing, 60 Harvard Way, Boston, MA, 02163, USA, October 2015; Page 103, Inset - Creating New Value With Data. [Part 2 of 2 - A Two Part Series]

REDEFINING INDUSTRY BOUNDARIES

The increasing capabilities of smart, connected products not only reshape competition within industries but expand industry boundaries. This occurs as the basis of competition shifts from discrete products, to product systems consisting of closely related products, to systems of systems that link an array of product systems together. A tractor company, for example, may find itself competing in a broader farm automation industry.

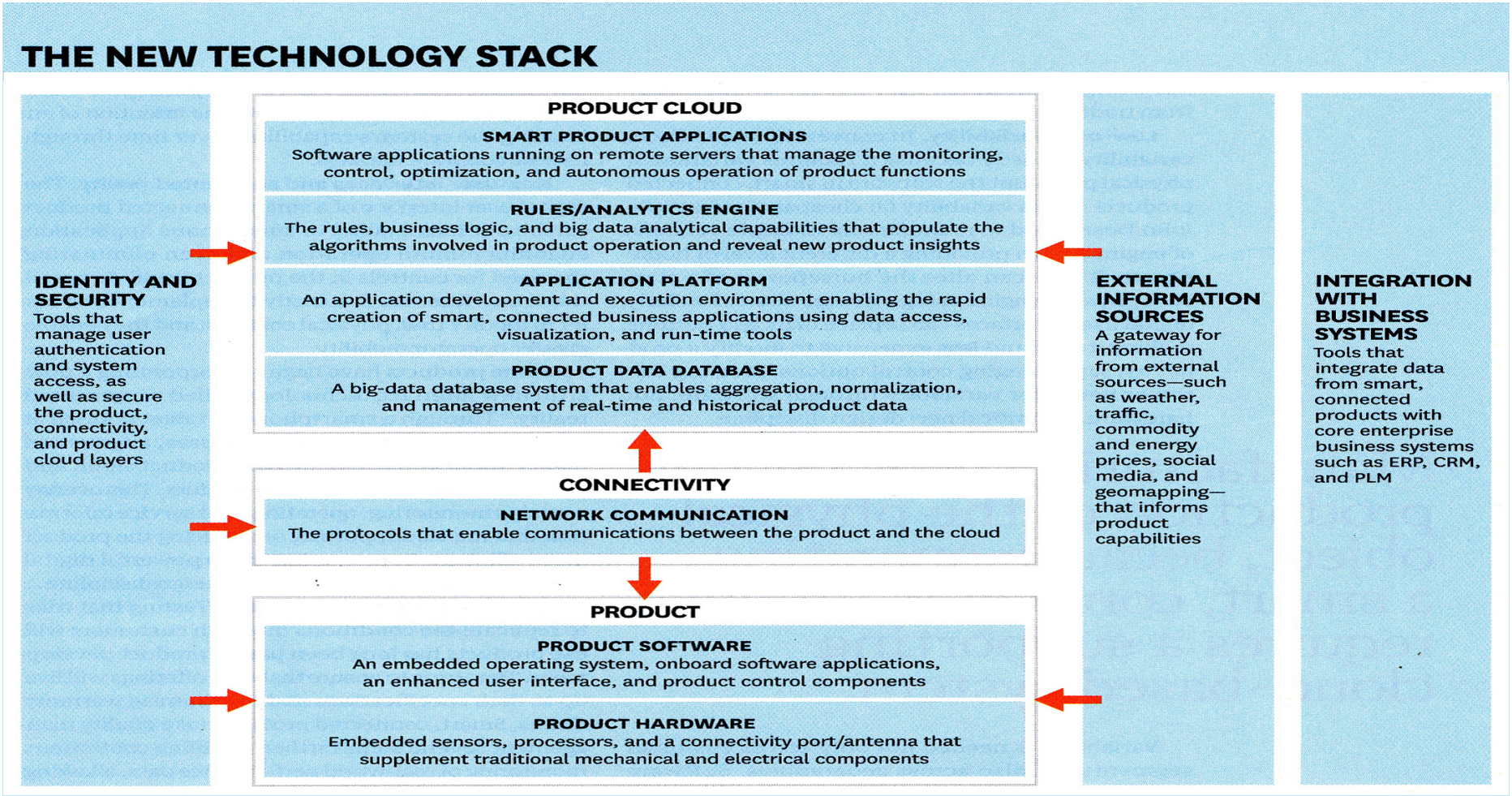


Source: Michael E. Porter and James E. Heppelmann, "How Smart, Connected Products Are Transforming Competition, *Harvard Business Review*, Harvard Business School Publishing, 60 Harvard Way, Boston, MA, 02163, USA, November 2014; Page 74-75, Inset - Redefining Industry Boundaries. [Part 1 of 2 – A Two Part Series]

DFMA & BREAKTHROUGH INNOVATION TECHNIQUES

Breakthrough Strategies: Digical Innovation - Smart - Technology Architecture

SOURCE "HOW SMART, CONNECTED PRODUCTS ARE TRANSFORMING COMPETITION," HBR, NOVEMBER 2014



Source: Michael E. Porter and James E. Heppelmann, "How Smart, Connected Products Are Transforming Companies, *Harvard Business Review*, Harvard Business School Publishing, 60 Harvard Way, Boston, MA, 02163, USA, October 2015; Page 101, Inset - The New Technology Stack. [Part 2 of 2 - A Two Part Series]

DFMA & BREAKTHROUGH INNOVATION TECHNIQUES

Breakthrough Strategies: Digical Innovation - Smart - Possible Mistakes

MISTAKES TO AVOID

Smart, connected products offer a rich new set of value creation and growth opportunities. However, efforts to seize those opportunities will not be without challenges. Some of the greatest strategic risks include the following:

Adding functionality that customers don't want to pay for. Just because a feature is now possible does not mean there is a clear value proposition for the customer. Adding enhanced capabilities and options can reach the point of diminishing returns, due to the cost and complexity of use.

Underestimating security and privacy risks. Smart, connected products open major new gateways to corporate systems and data, requiring stepped-up network security, device and sensor security, and information encryption.

Failing to anticipate new competitive threats. New competitors offering products with smart, connected capabilities (such as connectivity and embedded software) or performance- or service-based business models can emerge quickly and reshape competition and industry boundaries.

Waiting too long to get started. Moving slowly enables competitors and new entrants to gain a foothold, begin capturing and analyzing data, and start moving up the learning curve.

Overestimating internal capabilities. The shift to smart, connected products will demand new technologies, skills, and processes throughout the value chain (for example, big data analytics, systems engineering, and software application development). A realistic assessment about which capabilities should be developed in-house and which should be developed by new partners is crucial.

Source: Michael E. Porter and James E. Heppelmann, "How Smart, Connected Products Are Transforming Competition, *Harvard Business Review*, Harvard Business School Publishing, 60 Harvard Way, Boston, MA, 02163, USA, November 2014; Page 84, Inset - Mistakes To Avoid. [Part 1 of 2 – A Two Part Series]

DFMA & BREAKTHROUGH INNOVATION TECHNIQUES

Breakthrough Strategies: Digical Innovation - Smart - Lean Jumps To Another Level

A NEW ERA OF LEAN

Smart, connected products will help make people, materials, energy, and plant and equipment far more productive, and the repercussions for business processes will be felt throughout the economy.

We will see a whole new era of "lean." Data flowing to and from products will allow product use and activities across the value chain to be streamlined in countless new ways.

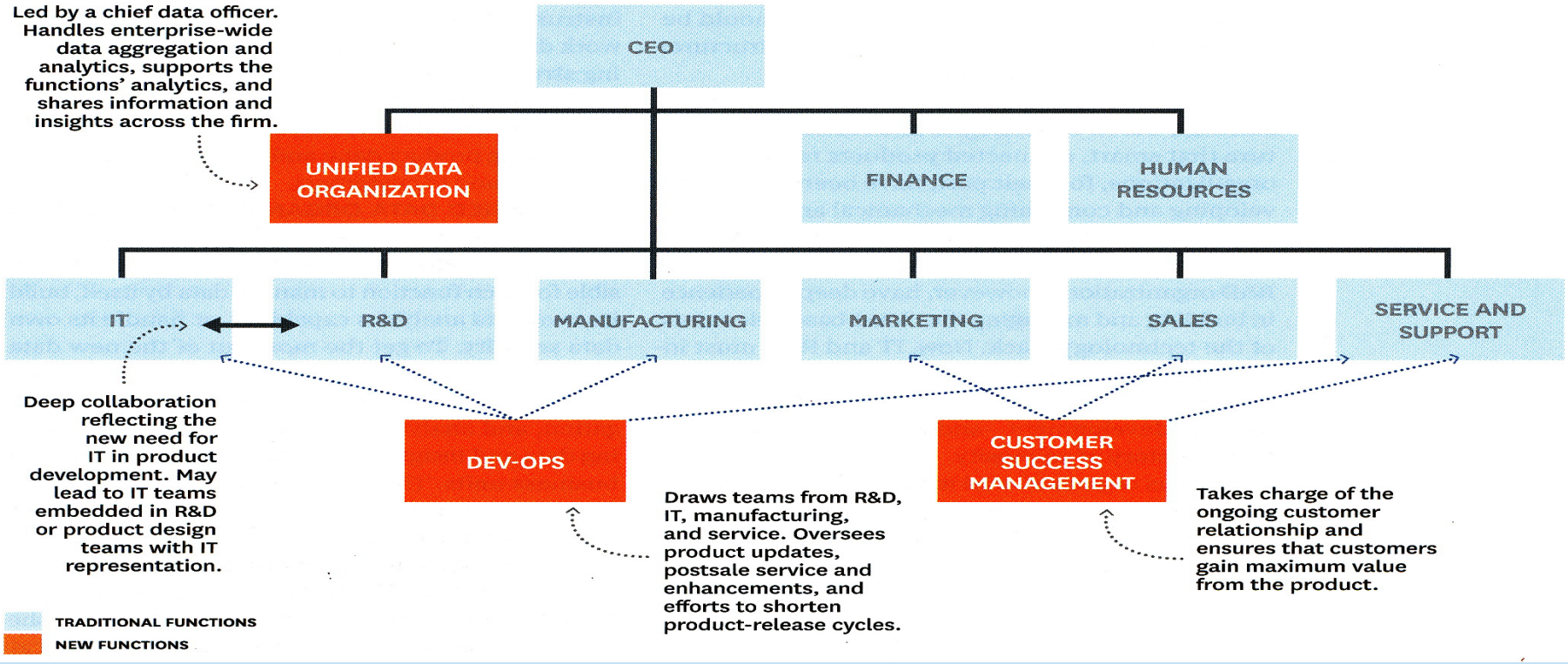
Waste will be cut or eliminated. Sensors in products can identify the need for service before a component fails, reducing downtime. Or they can reveal that maintenance isn't yet necessary. An oil change, for instance, will take place only after oil contamination has hit a certain threshold, rather than according to a schedule. New data analytics will lead to previously unattainable efficiency improvements.

Wasted capacity will be driven out. Because products will report on their location and use, we will be able to make the most of them. Smart, connected elevators, for example, can predict and act on user demand patterns, reducing wait times and electricity use. A building that once might have needed six elevators can provide better service with four. Product-as-a-service models will allow customers to pay only for what they actually need. With data and connectivity, the sharing of assets (think cars or bikes) will become possible or easier than ever before.

Source: Michael E. Porter and James E. Heppelmann, "How Smart, Connected Products Are Transforming Companies, *Harvard Business Review*, Harvard Business School Publishing, 60 Harvard Way, Boston, MA, 02163, USA, October 2015; Page 105, Inset - A New Era of Lean. [Part 2 of 2 - A Two Part Series]

A NEW ORGANIZATIONAL STRUCTURE

Smart, connected products require functions within manufacturing firms to collaborate in new ways. As a result, firms' structures are rapidly evolving. A new functional unit focused on data management is starting to appear. Though rare, units focused on ongoing product development and customer success are also beginning to be recognized.



Source: Michael E. Porter and James E. Heppelmann, "How Smart, Connected Products Are Transforming Companies, *Harvard Business Review*, Harvard Business School Publishing, 60 Harvard Way, Boston, MA, 02163, USA, October 2015; Page 109, Inset – A New Organizational Structure. [Part 2 of 2 - A Two Part Series]

DFMA & BREAKTHROUGH INNOVATION TECHNIQUES

Breakthrough Strategies: Lead Users - Context

Empirical Research

"...users have a great deal more to contribute to the inquiring market researcher than data regarding their unfilled needs.

Lead User Value

Often, they can contribute insights regarding solutions responsive to their needs as well. This "solution" data can range from rich insight to working and tested prototypes of the desired novel product, process, or service.

Lead User Results

In some fields, users have been shown to be the actual developers of most of the successful new products eventually commercialized by manufacturers. For example, users were found to be the actual developers of 82% of all commercialized scientific instruments studied and 63% of all semiconductor and electronic subassembly manufacturing equipment innovations studied (von Hippel, 1976, 1977)."

Source: Glen L. Urban and Eric von Hippel, "Lead User Analyses For The Development of New Industrial Products," White Paper, June 1986, Page 1.

DFMA & BREAKTHROUGH INNOVATION TECHNIQUES

Breakthrough Strategies: Lead Users - Definitions

Marketplace Attributes

"In a previous paper, von Hippel (1986) has proposed that analysis of need and solution data from "lead users" can improve the productivity of new product development in fields characterized by rapid change. In this paper we enhance the lead user methodology by adding modern market research techniques and then test it in one industrial setting.

Individual Characteristics

"Lead users" of a novel or enhanced product, process or service are defined as those who display two characteristics with respect to it:

- Lead users face needs that will be general in a market place - but face them months or years before the bulk of that marketplace encounters them, and

- Lead users are positioned to benefit significantly by obtaining a solution to those needs.

Industry Example

Thus, a manufacturing firm with current strong need for a process innovation which many manufacturers will need in two years' time would fit the definition of a lead user with respect to that process."

Source: Glen L. Urban and Eric von Hippel, "Lead User Analyses For The Development of New Industrial Products," White Paper, June 1986, Page 1.

DFMA & BREAKTHROUGH INNOVATION TECHNIQUES

Breakthrough Strategies: Lead Users - Rationale

Lead users face needs that will be general in a market place - but face them months or years before the bulk of that marketplace encounters them,

"…users who have real world experience with a need are in the best position to provide market researchers with accurate (need or solution) data regarding it. When new product needs are evolving rapidly, as in many high technology product categories, only users at the "front of the trend" will presently have the real-world experience which manufacturers must analyze if they are accurately to understand the needs which the bulk of the market will have tomorrow."

<u>and</u>

Lead users are positioned to benefit significantly by obtaining a solution to those needs.

"..users who expect high benefit from a solution to a need can provide the richest need and solution data to inquiring market researchers…"

"…the greater the benefit a given user expects to obtain from a needed novel product or process, the greater will be his investment in obtaining a solution."

5

Source: Glen L. Urban and Eric von Hippel, "Lead User Analyses For The Development of New Industrial Products," White Paper, June 1986, Pages 1-2.

DFMA & BREAKTHROUGH INNOVATION TECHNIQUES

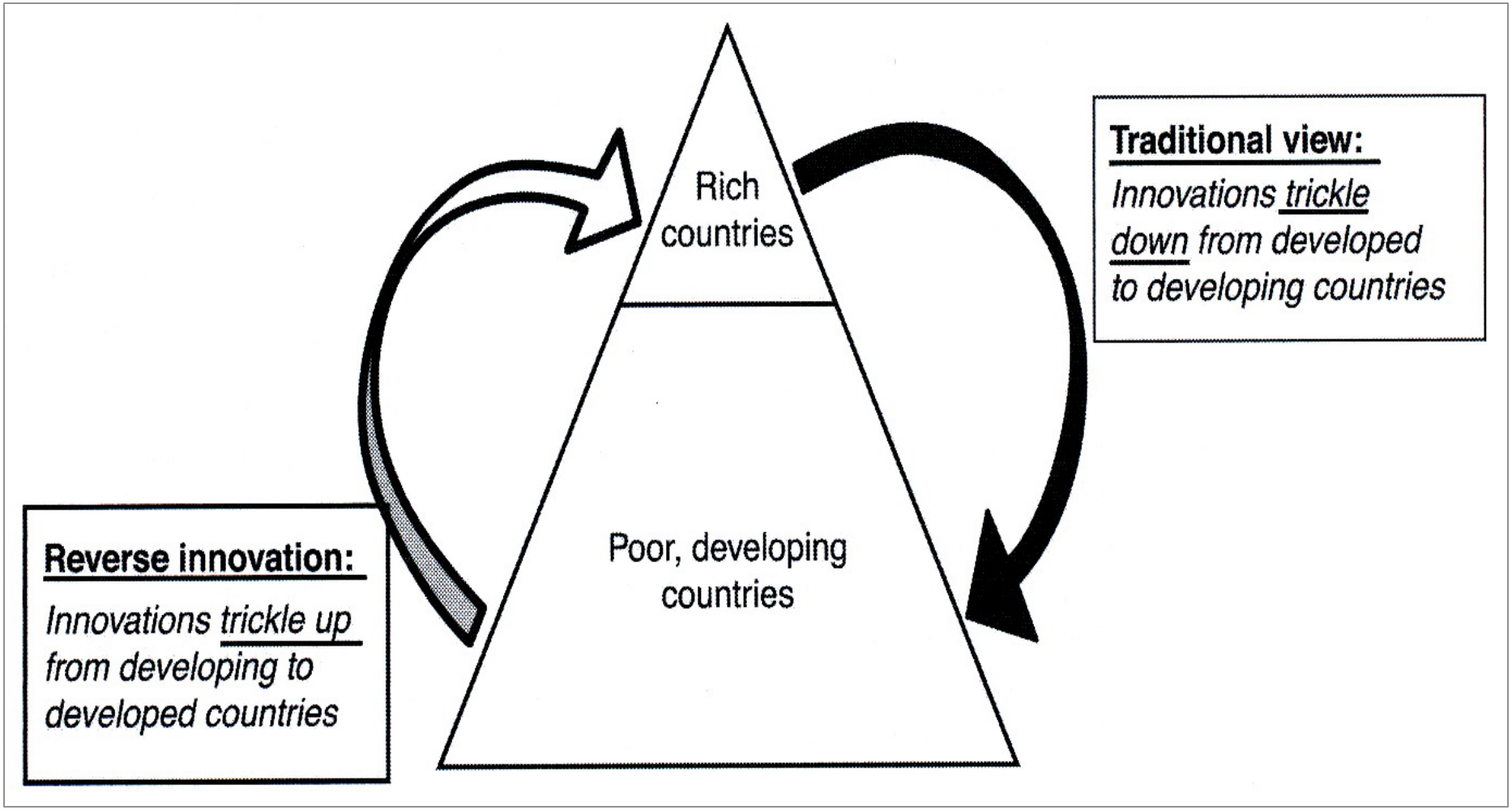
Breakthrough Strategies: Lead Users - 3M … Case Study - The Four Phases

Phase I	Lead User teams locate and specify the future markets they intend to target.
Phase II	The teams take aim on this far distant future, identifying the trends that are going to be driving and shaping demand in these target markets.
Phase III	The teams find and enlist Lead Users and Lead Use Experts in a Process of "deep collaboration."
Phase IV	The team develops breakthrough products, typically during a collaborative workshop with invited Lead Users and Lead Use Experts.

Source: K. John Pournoor, Ph.D., Senior Scientist, 3M Company, "Managed Innovation," PDMA Visions, April 2000, Vol XXIV NO. 2, Page 26

DFMA & BREAKTHROUGH INNOVATION TECHNIQUES

Breakthrough Strategies: Reverse Trickle-Up Innovation - Logic



Source: Vijay Govindarajan and Ravi Ramamurti, "Reverse Innovation, Emerging Markets, and Global Strategy," IEEE Engineering Management Review, Vol. 42, No. 2, Second Quarter, June 2014, Page 80, Figure 1 - Reverse Innovation.

DFMA & BREAKTHROUGH INNOVATION TECHNIQUES

Breakthrough Strategies: Reverse Trickle-Up Innovation - Mainstream vs. Reverse

Table 1. Mainstream Theories and Reverse Innovation

Topic	Mainstream view	Observed aspects of reverse innovation that do not fit with mainstream view	Specific questions explored in article
Innovation	1. Innovations trickle down from rich to poor countries 2. Innovations begin with lead users and spread to others	1. Innovations may also occur in poor countries and 'trickle up' to rich ones 2. Reverse innovations may beginwith laggards rather than leadusers	• What kinds of innovations do EMs spawn? • Why is this occurring now and not earlier? • Why would innovations 'trickle up?'
Internationalization Process	1. MNEs originate in rich countries and spread globally, including to poor countries, based on proprietary technologies/ brands	1. MNEs also originate in EMs and spread globally, including to developed countries, leveraging home-based innovations	• What are the competitive advantages of EM firms and how do these facilitate internationalization? • How do EMNEs and DMNEs compete in the different stages of reverse innovation?
DMNE strategy and management	1. DMNEs develop global product platforms in Triad markets and adapt them for EMs 2. DMNEs give global product mandates to subsidiaries in other Triad markets	1. DMNEs develop new product platforms in EMs for EMs 2. DMNEs give global mandates for some products to subsidiaries in EMs	• How does reverse innovation affect the 'glocalization' strategy of DMNEs? • Can DMNEs pursue glocalization and reverse innovation at the same time?
FDI spillovers	1. Local firms in EMs capture spillovers from DMNEs that invest in EMs	1. DMNEs capture spillovers from local firms when they invest in EMs(i.e., learning is bidirectional)	• Who learns from whom and why, when EMNEs and DMNEs come into contact in differentmarkets?

Note: EM = Emerging markets; EMNEs = Emerging-market MNEs; DMNEs = Developed-country MNEs.

Source: Vijay Govindarajan and Ravi Ramamurti, "Reverse Innovation, Emerging Markets, and Global Strategy," IEEE Engineering Management Review, Vol. 42, No. 2, Second Quarter, June 2014, page 79, Table 1- Mainstream Theories and Reverse Innovation.

DFMA & BREAKTHROUGH INNOVATION TECHNIQUES

Breakthrough Strategies: Reverse Trickle-Up Innovation - Sources

Table 2. Why Innovations May Trickle up From Poor to Rich Countries

No.	Trickle-up mechanisms	Examples
1	Innovations developed in EMs may have a ready market among poor people in rich countries.	■ Microfinance, invented in Bangladesh, works also for the inner city poor in rich countries like the U.S.
2	Dramatic cost and price reductions of 70 to 90 percent achieved to succeed in EMs can help expand demand in rich countries.	■ Dropping prices to 15 percent of original levels expanded demand for GE's ultrasound machines in the U.S.
3	New features incorporated for EMs, such as sturdiness, portability, or ease of use, may reate bew market segments in rich countries.	■ Making ECG machines portable and more compact created new market segments for GE in the U.S.
4	Technology of 'good enough' products developed for EMsmay improve over time to satisfy high-end applications in rich countries.	■ Portable ultrasounds developed by GE for China were lateruseable for high-end radiology and obstetrics applications.
5	EMs may leapfrog to latest technologies, especially if they have large internal demand, are unencumbered by legacy technologies, and face fewer regulatory obstacles.	■ EMs have advanced capabilities in industries such as wireless banking, nonconventional energy, and electric cars, which have relevance and value in developed-country markets.

Note: EM = Emerging market.

Source: Vijay Govindarajan and Ravi Ramamurti, "Reverse Innovation, Emerging Markets, and Global Strategy," IEEE Engineering Management Review, Vol. 42, No. 2, Second Quarter, June 2014, Page 84, Table 2 - Why Innovations May Trickle up From Poor to Rich Countries.

DFMA & BREAKTHROUGH INNOVATION TECHNIQUES

Breakthrough Strategies: Reverse Trickle-Up Innovation - EMNEs vs. DMNEs

Table 3. EMNEs vs. DMNEs in the Three Stages of Reverse Innovation

Stage	Main challenges for DMNEs	Relative advantages of DMNES	Relative advantages of emerging-market MNEs (EMNEs)
1 Winning in key emerging markets	• Zero-based innovation for a foreign market • Giving the emerging-market subsidiary access to firm's global technology	• Technology reservoirs within the firm • Familiarity with several emerging markets • Deep pockets	• Customer intimacy • Flair for low-cost solutions • Clean slate approach because of fewer prior investments • Strong commitment to local market • Access to local resources and capabilities • Patient capital
2 Winning in other emerging markets	• Managing transfer to other EMs	• Preexisting distribution and brand recognition in EMs	• Product pricing and featuresbetter suited to emerging markets
3 Winning in developed-country markets	• Positioning the reverse innovation vs. existing offerings • Managing the risk of cannibalization	• Strong presence, customer intimacy, brand recognition, and distribution in rich country markets	• Unconstrained by prior investments or risk of cannibalization • Prospect of rising margins in moving upscale • No internal resistance to expansion

Note: EMNEs = Emerging-market MNEs; DMNEs = Developed-country MNEs.

Source: Vijay Govindarajan and Ravi Ramamurti, "Reverse Innovation, Emerging Markets, and Global Strategy," IEEE Engineering Management Review, Vol. 42, No. 2, Second Quarter, June 2014, Page 86, Table 3 - EMNEs vs. DMNEs in the Three Stages of Reverse Innovation.

Nine Kinds of Opportunities

The nine opportunity types fall into three main investment classes: mature markets, growth markets, and frontier markets, shown in different shades below. As you move away from the bottom left corner, the opportunities become increasingly complex and resource-intensive, because they require more consumer learning and value-chain modification. New market creation is the most challenging opportunity of all.

	VALUE-CHAIN MODIFICATION	
MATURE MARKETS INVESTMENT <$50K BREAKEVEN 1–3 YEARS These market segments provide opportunities to hit near-term sales targets and chip away at competitors' market shares. In many cases, mature-market opportunities can be pursued by country-level general managers from their discretionary budgets.	**GROWTH MARKETS** INVESTMENT >$200K BREAKEVEN 4–7 YEARS These market segments offer long-term opportunities to increase category sales and capture market share. Growth-market opportunities require regional leadership from the equivalent of a vice president.	**FRONTIER MARKETS** INVESTMENT >$500K BREAKEVEN 10+ YEARS These market segments provide long-term positioning opportunities to drive significant category growth or discover new categories. These projects need leadership from the senior vice president of a business platform.

Source: Erik Simanis and Duncan Duke, "The Profits At The Bottom Of The Pyramid: A Tool For Assessing Your Opportunities. The same should go for your company.," *Harvard Business Review*, Harvard Business School Publishing, 60 Harvard Way, Boston, MA, 02163, USA, October 2014, Page 92, Inset: Nine Kinds of Opportunities.

DFMA & BREAKTHROUGH INNOVATION TECHNIQUES

Breakthrough Strategies: Bottom-Of-Pyramid Innovation - Types

Source: Erik Simanis and Duncan Duke, "The Profits At The Bottom Of The Pyramid: A Tool For Assessing Your Opportunities. The same should go for your company.," *Harvard Business Review*, Harvard Business School Publishing, 60 Harvard Way, Boston, MA, 02163, USA, October 2014, Page 92, Inset: Nine Kinds of Opportunities.

DFMA & BREAKTHROUGH INNOVATION TECHNIQUES

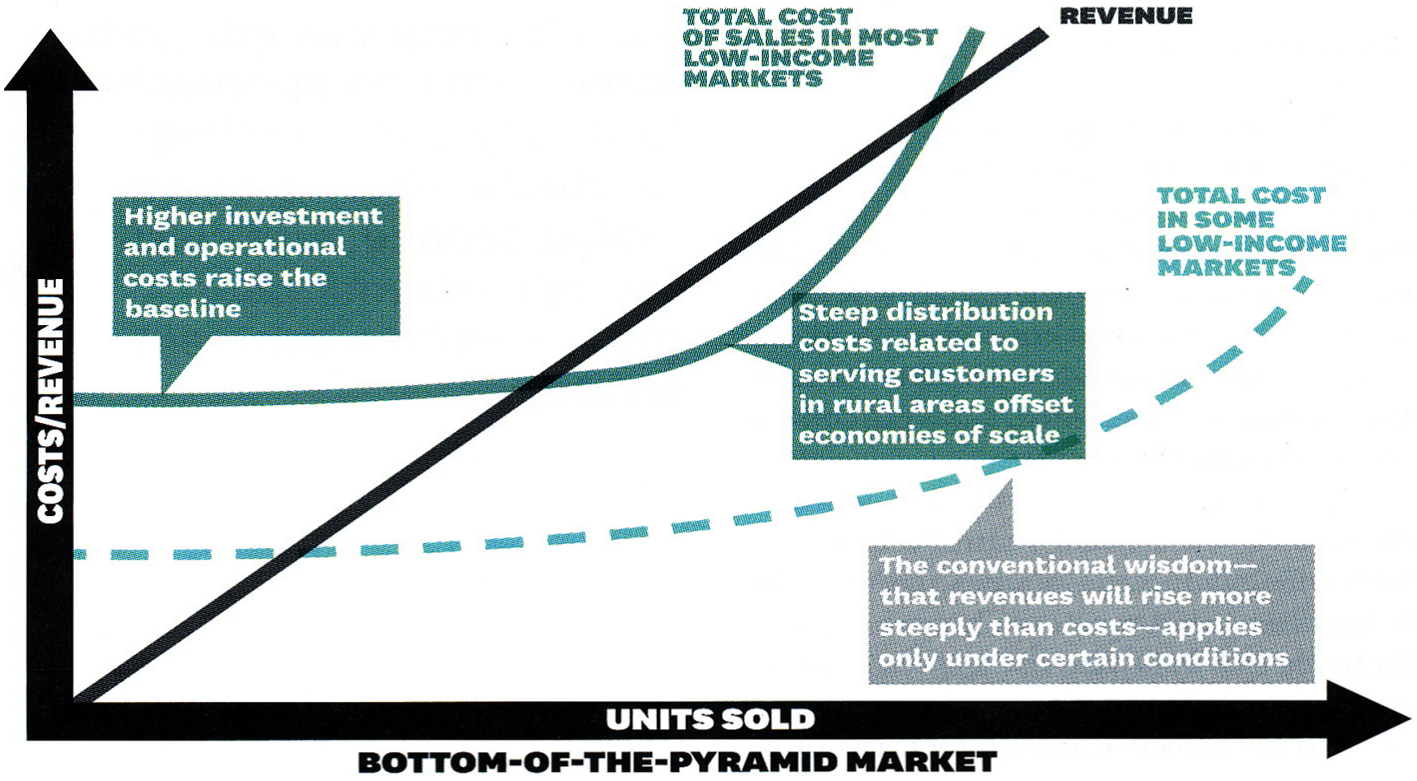
Breakthrough Strategies: Bottom-Of-Pyramid Innovation - ROI Considerations

Margin-Boosting Platforms

Achieving sustainable margins in low-income markets requires integrating three common approaches—localizing and bundling products, offering an enabling service, and cultivating customer peer groups—into a coherent strategy.

The Volume Game: A Losing Proposition

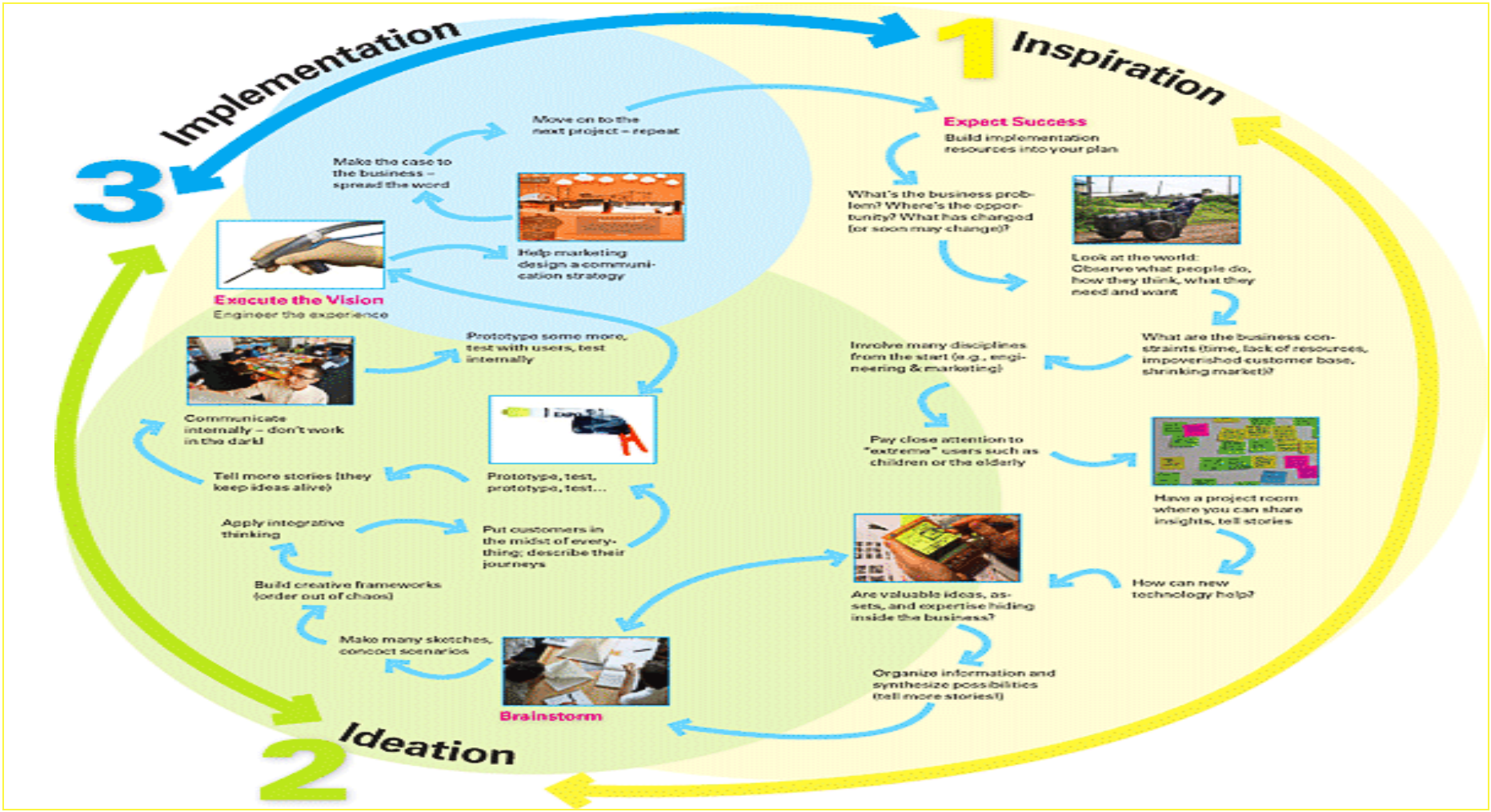
Experience in most bottom-of-the-pyramid markets contradicts the conventional wisdom that very-low-priced consumer products can be profitable at high volumes.



Source: Erik Simanis, "Reality Check at the Bottom of the Pyramid," Harvard Business School Publishing, 60 Harvard Way, Boston, MA, 02163, USA, June 2012, Page 120-125; Inset – Page 123, The Volume Game: A Losing Proposition and Inset – Page 124, Margin Boosting Platforms.

DFMA & BREAKTHROUGH INNOVATION TECHNIQUES

Breakthrough Strategies: Design Thinking - Conceptual Approach



Source: Tim Brown, "Design Thinking," Harvard Business School Publishing, 60 Harvard Way, Boston, MA, 02163, USA, June 2008, Page 84-95; Figure Page 85.

DFMA & BREAKTHROUGH INNOVATION TECHNIQUES

Breakthrough Strategies: Design Thinking - Process

How to Make Design Thinking Part of the Innovation Drill

Begin at the beginning. Involve design thinkers at the very start of the innovation process, before any direction has been set. Design thinking will help you explore more ideas more quickly than you could otherwise.

Take a human-centered approach. Along with business and technology considerations, innovation should factor in human behavior, needs, and preferences. Human-centered design thinking—especially when it includes research based on direct observation—will capture unexpected insights and produce innovation that more precisely reflects what consumers want.

Try early and often. Create an expectation of rapid experimentation and prototyping. Encourage teams to create a prototype in the first week of a project. Measure progress with a metric such as average time to first prototype or number of consumers exposed to prototypes during the life of a program.

Seek outside help. Expand the innovation ecosystem by looking for opportunities to co-create with customers and consumers. Exploit Web 2.0 networks to enlarge the effective scale of your innovation team.

Blend big and small projects. Manage a portfolio of innovation that stretches from shorter-term incremental ideas to longer-term revolutionary ones. Expect business units to drive and fund incremental innovation, but be willing to initiate revolutionary innovation from the top.

Budget to the pace of innovation. Design thinking happens quickly, yet the route to market can be unpredictable. Don't constrain the pace at which you can innovate by relying on cumbersome budgeting cycles. Be prepared to rethink your funding approach as projects proceed and teams learn more about opportunities.

Find talent any way you can. Look to hire from interdisciplinary programs like the new Institute of Design at Stanford and progressive business schools like Rotman, in Toronto. People with more-conventional design backgrounds can push solutions far beyond your expectations. You may even be able to train nondesigners with the right attributes to excel in design-thinking roles.

Design for the cycle. In many businesses people move every 12 to 18 months. But design projects may take longer than that to get from day one through implementation. Plan assignments so that design thinkers go from inspiration to ideation to implementation. Experiencing the full cycle builds better judgment and creates great long-term benefits for the organization.

Source: Tim Brown, "Design Thinking," Harvard Business School Publishing, 60 Harvard Way, Boston, MA, 02163, USA, June 2008, Page 84-95; Inset - Page 86.

DFMA & BREAKTHROUGH INNOVATION TECHNIQUES

Breakthrough Strategies: Ambidextrous Innovation - Conceptual Approach

Idea in Brief

Balancing the needs of core businesses and innovation efforts is a central leadership task.

Unfortunately, most CEOs cede that responsibility to core-business heads, because innovation efforts are typically embedded in their units. The result is that competition for resources and attention usually gets resolved in favor of the established business.

On the basis of an in-depth study of 12 top-management teams at major companies, the authors suggest that CEOs take a very different approach. Specifically, they should:

- engage the senior team around a forward-looking strategic aspiration,
- hold the tension between the demands of innovation units and the core business at the top of the organization, and
- maintain multiple and often conflicting strategic agendas.

When leaders take this approach, they empower their senior teams to move from a negotiation of feudal interests to an explicit, ongoing debate about the conflicting interests on which the future of the business depends.

Firms thrive when senior teams embrace the tension between old and new and foster a state of constant creative conflict at the top.

When conflicts about funding old and new businesses are resolved at lower levels, innovation usually loses out.

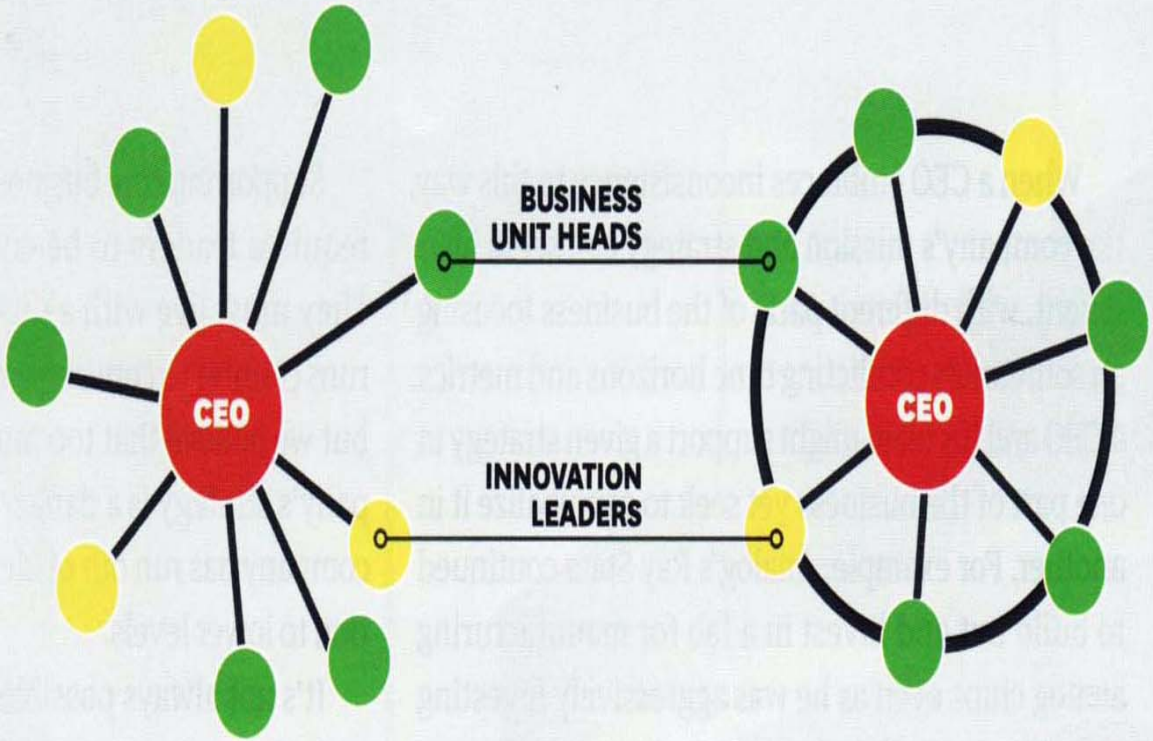
Source: Michael L. Tushman, et al., "The Ambidextrous CEO," Harvard Business School Publishing, 60 Harvard Way, Boston, MA, 02163, USA, June 2011, Page 74-80; Insets - Page 76 Firms Thrive, Page 77 Idea In Brief, Page 78 When Conflicts.

DFMA & BREAKTHROUGH INNOVATION TECHNIQUES

Breakthrough Strategies: Ambidextrous Innovation - Two Approaches

How to Hold Tension at the Top:
Two Approaches

HUB-AND-SPOKE TEAM members each have a mission to optimize their units in the service of a shared strategic intent. The CEO, with an inner circle of advisers, negotiates tension among units, insulating innovation from short-term pressures and making trade-offs across the business.



RING TEAMS own innovation as a strategic responsibility and make dynamic trade-offs as a collective unit. Team meetings focus on contentious, high-stakes issues and find resolutions that serve the overall needs of the business over the short and long term.

Source: Michael L. Tushman, et al., "The Ambidextrous CEO," Harvard Business School Publishing, 60 Harvard Way, Boston, MA, 02163, USA, June 2011, Page 74-80; Inset - Page 79, How To Hold Tension At The Top: Two Approaches.

DFMA & BREAKTHROUGH INNOVATION TECHNIQUES

Breakthrough Strategies: Ambidextrous Innovation - Three Principles

PRINCIPLE 1

Are you developing an overarching identity?
Here's what to ask:

IDENTITY
Does your firm have an emotionally compelling identity that encompasses your existing products and services?

Is your identity broad enough to be aspirational?

Does your identity limit you to customer groups or solutions that may be disrupted in the future?

PRINCIPLE 2

Are you holding tension at the top?
Here's what to ask:

REPORTING LINES
Do innovation business units report directly to the CEO? If not, you may be allowing your current business to starve innovation at lower levels in the organization.

OWNERSHIP
Does someone at the top own innovation? If the answer is "everyone owns it," the reality is probably that no one does. In such cases, the needs of established businesses will almost always trump those of speculative units.

LOCUS OF DEBATE
Are the fiercest strategy battles being fought among top executives? Pushing the conflict down to lower levels often means that important decisions about the company's future will devolve into turf battles.

COORDINATION
Do you know what the innovation units need from the core business to be successful?

PRINCIPLE 3

Are you embracing inconsistency?
Here's what to ask:

MANAGEMENT SYSTEM
Are your innovation businesses measured and rewarded against the same metrics as established ones? If so, you are probably setting those units up for failure.

DECISION MAKING
Are you continually shifting resources (financial investments, talent) between core businesses and innovation units? If not, you may be limiting the value your resources offer your firm.

Source: Michael L. Tushman, et al., "The Ambidextrous CEO," Harvard Business School Publishing, 60 Harvard Way, Boston, MA, 02163, USA, June 2011, Page 74-80; ; Insets - Page 77 Principle 1, Page 78 Principle 2, Page 79 Principle 3.

Sustainable Products Fatten Corporate Coffers

For many large companies, revenues from sustainable products are growing much faster than overall sales.

Many large companies are deriving a growing portion of their revenues from portfolios of products and services designed to enhance sustainability, according to research by The Conference Board.

Among a sample of 12 S&P Global 100 companies, aggregate revenues from such products and services grew 91% from 2010 to 2013, while overall sales climbed by just 15%.

Manifestations of the trend were startlingly extreme at some of the companies. For example, at Kimberly-Clark, while overall company revenue increased a modest 7.6% from 2010 to 2013, the topline tally from sustainable products ballooned by 296%. Over that period the company's share of revenue driven by such products shot from 10% all the way to 37%.

The trend was also evident at seven other companies, including household names like Dow Chemical, General Electric, Philips, Siemens, and Toshiba. Data for 2014 were available for just a few of the companies, but the trend clearly continued.

"More than a matter of responsibility or reputation, sustainability has become a potentially lucrative business strategy for a broad range of companies," says the report's author, Thomas Singer, The Conference Board's principal researcher for corporate leadership.

Indeed, a big part of the appeal of developing sustainable products and services is the opportunity to price them at a premium. The report cited a 2014 study by Nielsen in which 55% of online consumers indicated they were willing to pay more for products and services provided by companies that were committed to positive social and environmental impact. CFO

Source: David McCann, "Sustainable Products Fatten Corporate Coffers," CFO Magazine, The Economist Group, 25 St. Jame's Street, London, SW1A 1HG, United Kingdom, Volume 31, Number 7, September 2015, Page 16.

DFMA & BREAKTHROUGH INNOVATION TECHNIQUES

Synergies Between DFMA & Breakthrough Strategies

Goldense Group, Inc. 1346 South Street Needham, MA 02492 Phone 781-444-5400
Goldense Group, Inc. P. O. Box 350 Dedham, MA 02027 Fax 781-444-5475
www.goldensegroupinc.com

DFMA & BREAKTHROUGH INNOVATION TECHNIQUES

Synergies: Breakthrough Strategies - Degree Of Effect On DFMA Practices

If a company were to pursue a number of products using the strategy, what would be the likely effect on DFMA practices?

		ERODE			INCREASE	
		-2	-1	0	+1	+2
1	Disruptive Innovation				■	
2	Big Bang Innovation		■			
3	Emerging Technology Innovation					■
4	Digical Innovation	■				
5	Lead User Analysis				■	
6	Reverse Trickle-Up Innovation			■		
7	Bottom-Of-Pyramid Innovation					■
8	Design Thinking					■
9	Ambidextrous Innovation			■		
10	Sustainable Innovation					■

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Implementation Considerations

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DFMA & BREAKTHROUGH INNOVATION TECHNIQUES

Implementation: Crossing The Chasm

"The fault line upon which technology-enabled businesses are built is the technology adoption life cycle. It causes dramatic shifts in alignment among the various strata that make up the competittive-advantage hierarchy. Azs a aresult, competitive-advantage positions that once seemed secure are abruptly overthrown, and management teams on the verge of congratulating themselves now must scramble to recover. Here's how it plays out.

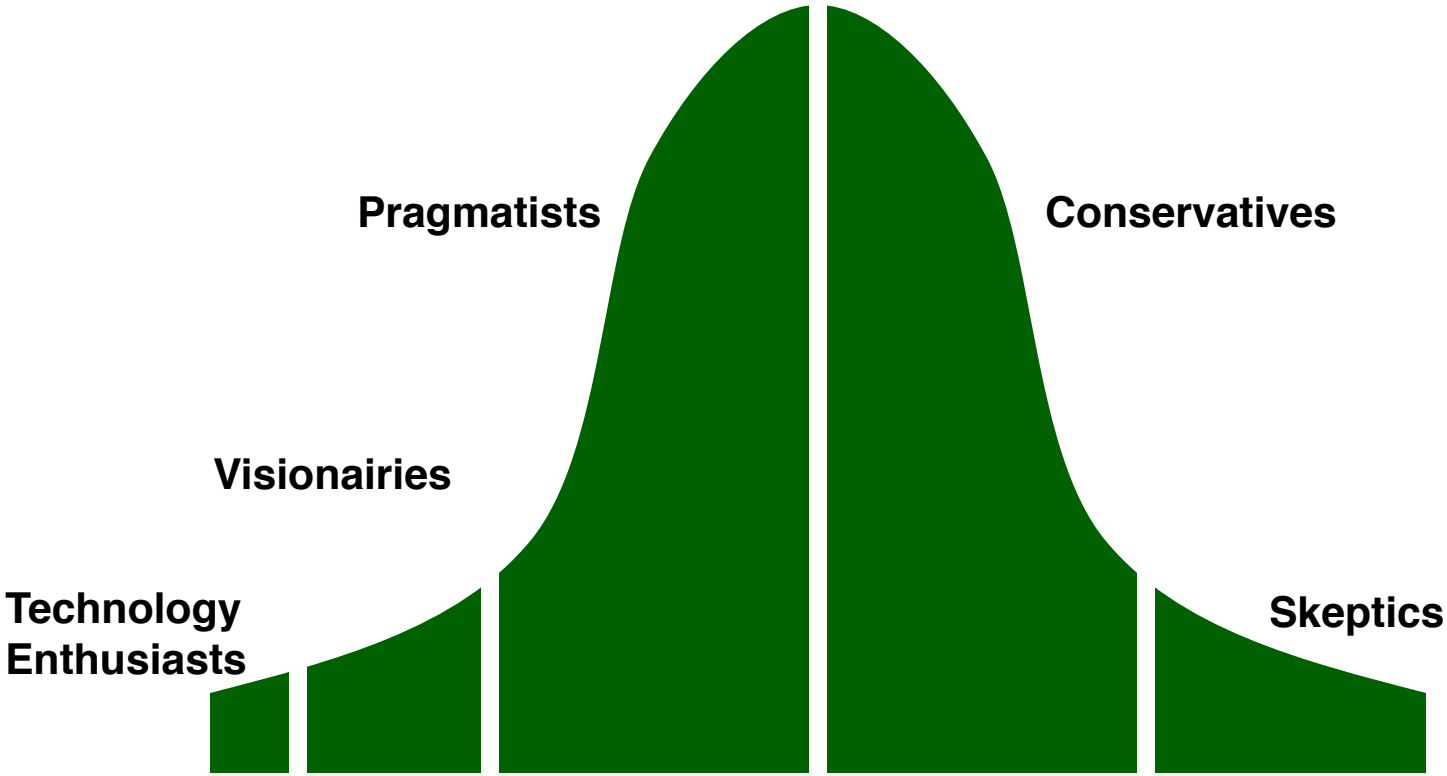
Before a disruptive technology can be assimilated into a mainstream marketplace, it must pass through multiple phases of adoption during which the market behaves in different ways specific to each phase. The end goal of all these mutations is to create and populate a sustainable value chain that can transform the new technology into reliable, deployable offerings. We call this goal Main Street, a state of business maturity in which technology-enabled businesses resemble most other sectors of the economy

To reach Main Street, however, technology-enabled markets must pass through three prior phases. There are thus four phases of adoption in all, and each one rewards a very different market strategy. Indeed, the competitive-advantage strategy that brings success in any one phase causes failure at the next stage. This creates extraordinary management challenges for organizations that develop momentum and inertia around any one stage."

Source: Geoffrey A. Moore, Chasm Group, "Living On The Fault Line: Managing For Shareholder Value In The Age Of The Internet.," Harper Business, HarperCollins Publishers Inc., New York, New York, Copyright 2000 by Geoffrey A. Moore, Page 139

DFMA & BREAKTHROUGH INNOVATION TECHNIQUES

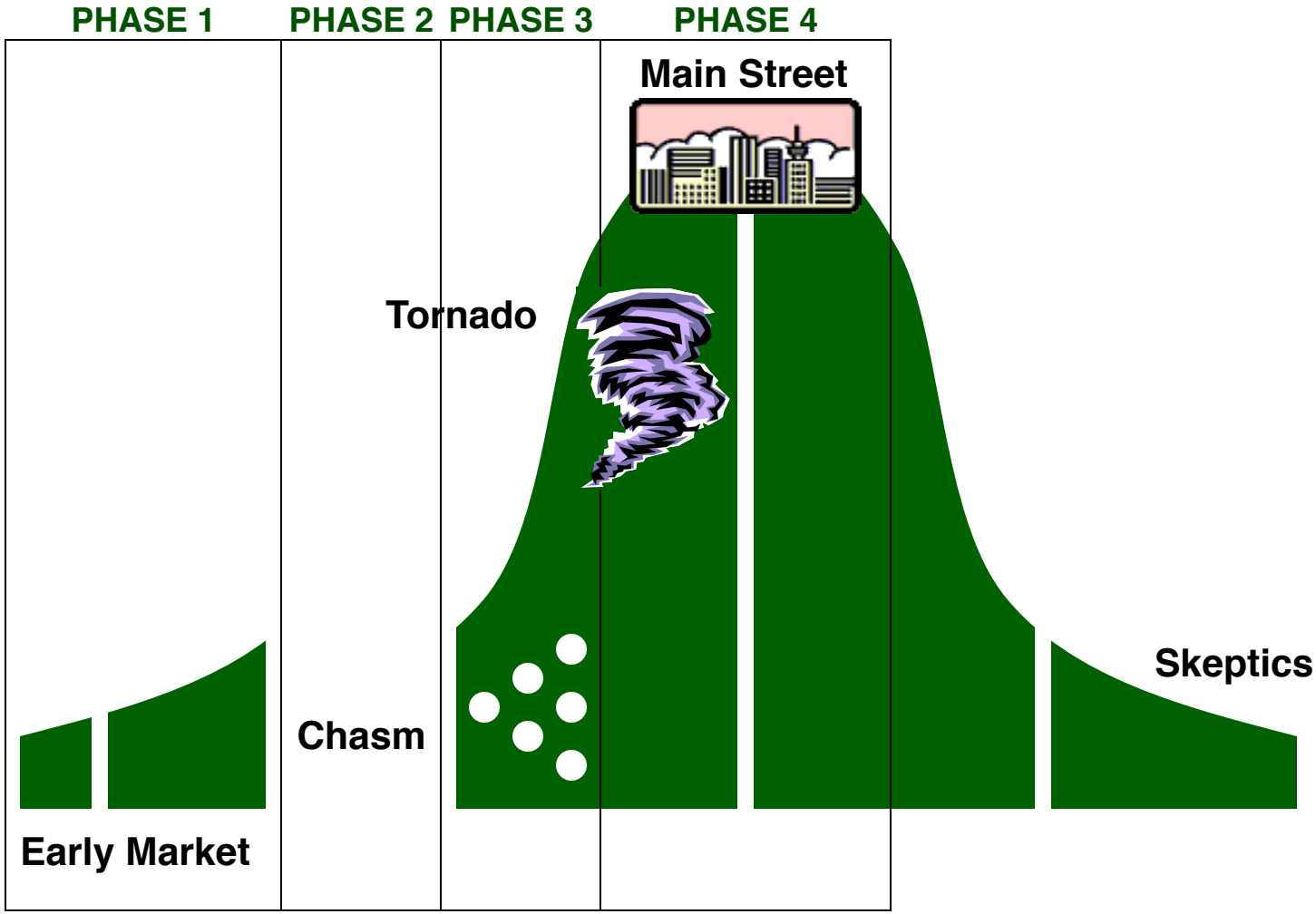
Implementation: Crossing The Chasm - Technology Adoption Life Cycle



Source: Geoffrey A. Moore, Chasm Group, "Living On The Fault Line: Managing For Shareholder Value In The Age Of The Internet.," Harper Business, HarperCollins Publishers Inc., New York, New York, Copyright 2000 by Geoffrey A. Moore, Page 141.

DFMA & BREAKTHROUGH INNOVATION TECHNIQUES

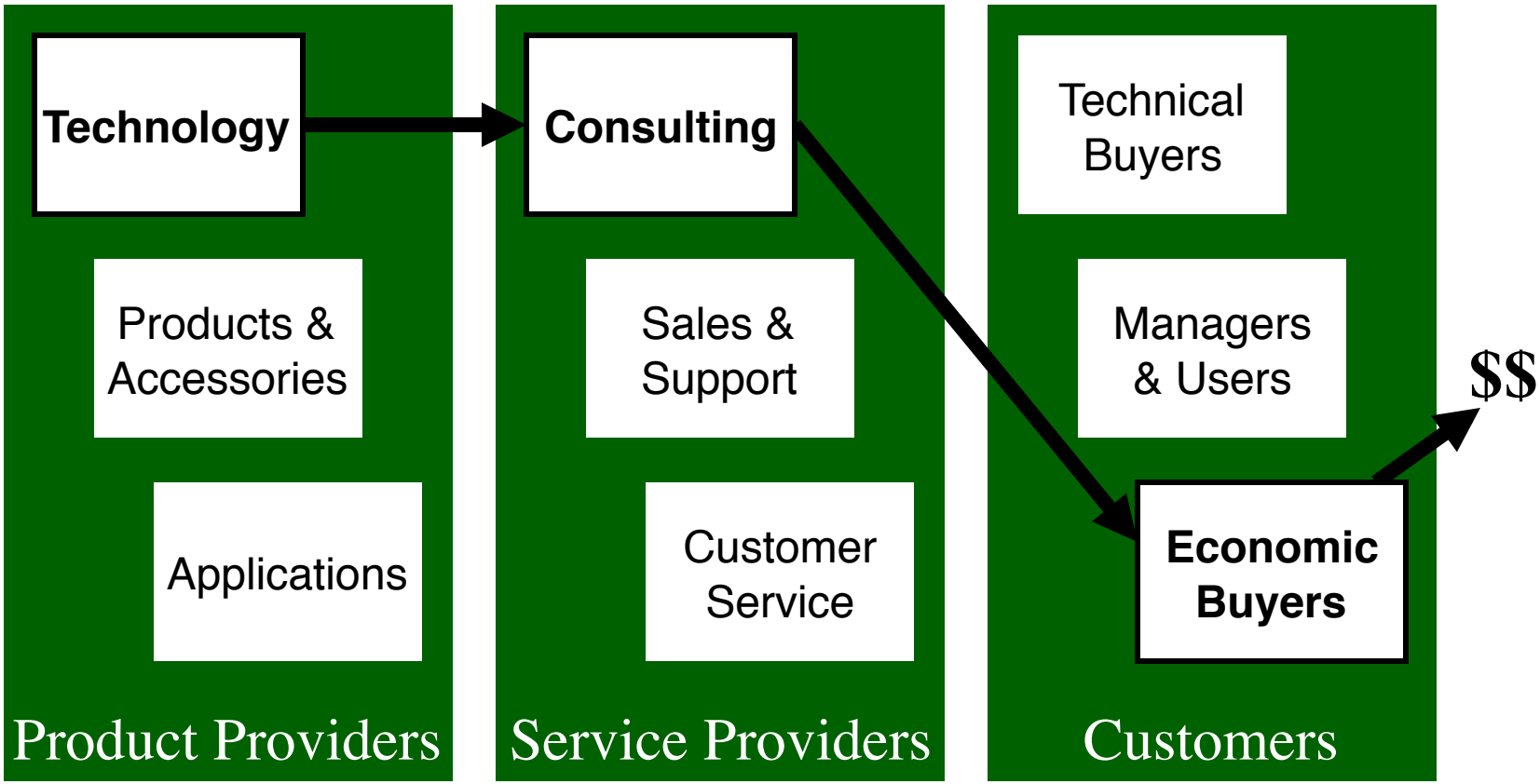
Implementation: Crossing The Chasm - Technology Adoption Life Cycle



Source: Geoffrey A. Moore, Chasm Group, "Living On The Fault Line: Managing For Shareholder Value In The Age Of The Internet.," Harper Business, HarperCollins Publishers Inc., New York, New York, Copyright 2000 by Geoffrey A. Moore, Page 143.

DFMA & BREAKTHROUGH INNOVATION TECHNIQUES

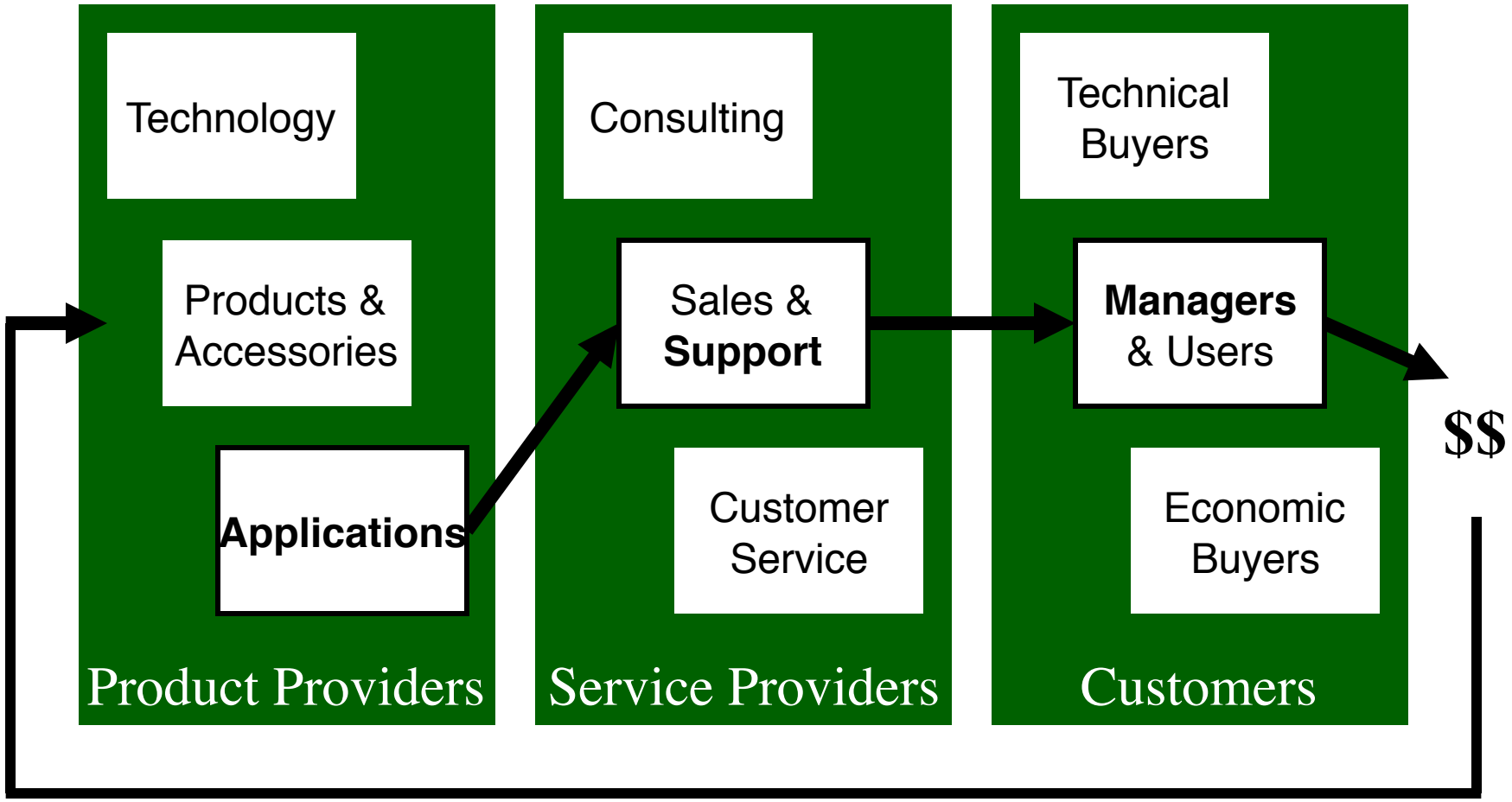
Implementation: Crossing The Chasm - Value Chain - Early Market



Source: Geoffrey A. Moore, Chasm Group, "Living On The Fault Line: Managing For Shareholder Value In The Age Of The Internet.," Harper Business, HarperCollins Publishers Inc., New York, New York, Copyright 2000 by Geoffrey A. Moore, Page 147.

DFMA & BREAKTHROUGH INNOVATION TECHNIQUES

Implementation: Crossing The Chasm - Value Chain - Bowling Alley



Source: Geoffrey A. Moore, Chasm Group, "Living On The Fault Line: Managing For Shareholder Value In The Age Of The Internet.," Harper Business, HarperCollins Publishers Inc., New York, New York, Copyright 2000 by Geoffrey A. Moore, Page 156.

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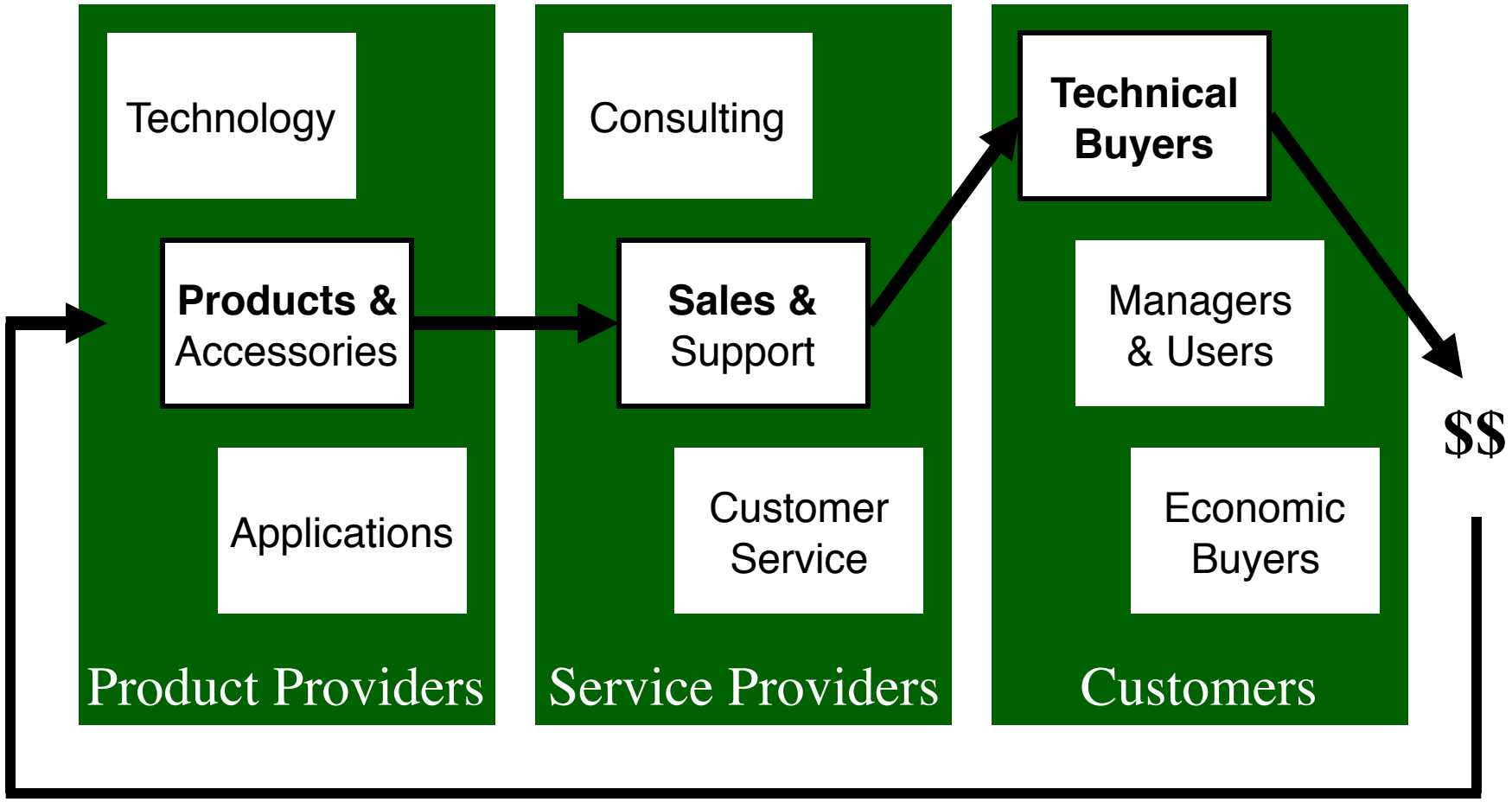
Implementation: Crossing The Chasm - Value Chain - Tornado



Source: Geoffrey A. Moore, Chasm Group, "Living On The Fault Line: Managing For Shareholder Value In The Age Of The Internet.," Harper Business, HarperCollins Publishers Inc., New York, New York, Copyright 2000 by Geoffrey A. Moore, Page 165.

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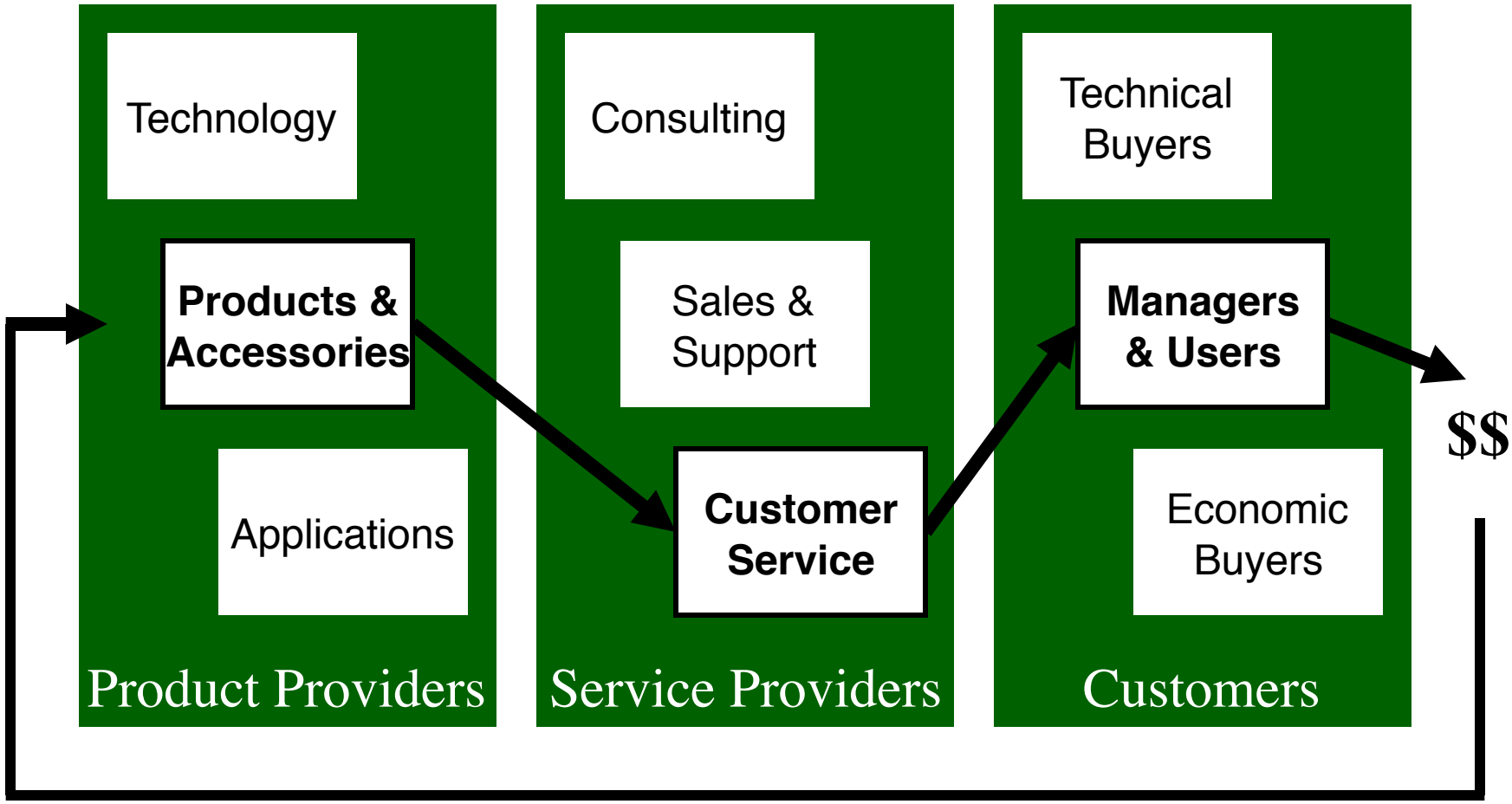
Implementation: Crossing The Chasm - Value Chain - Main Street

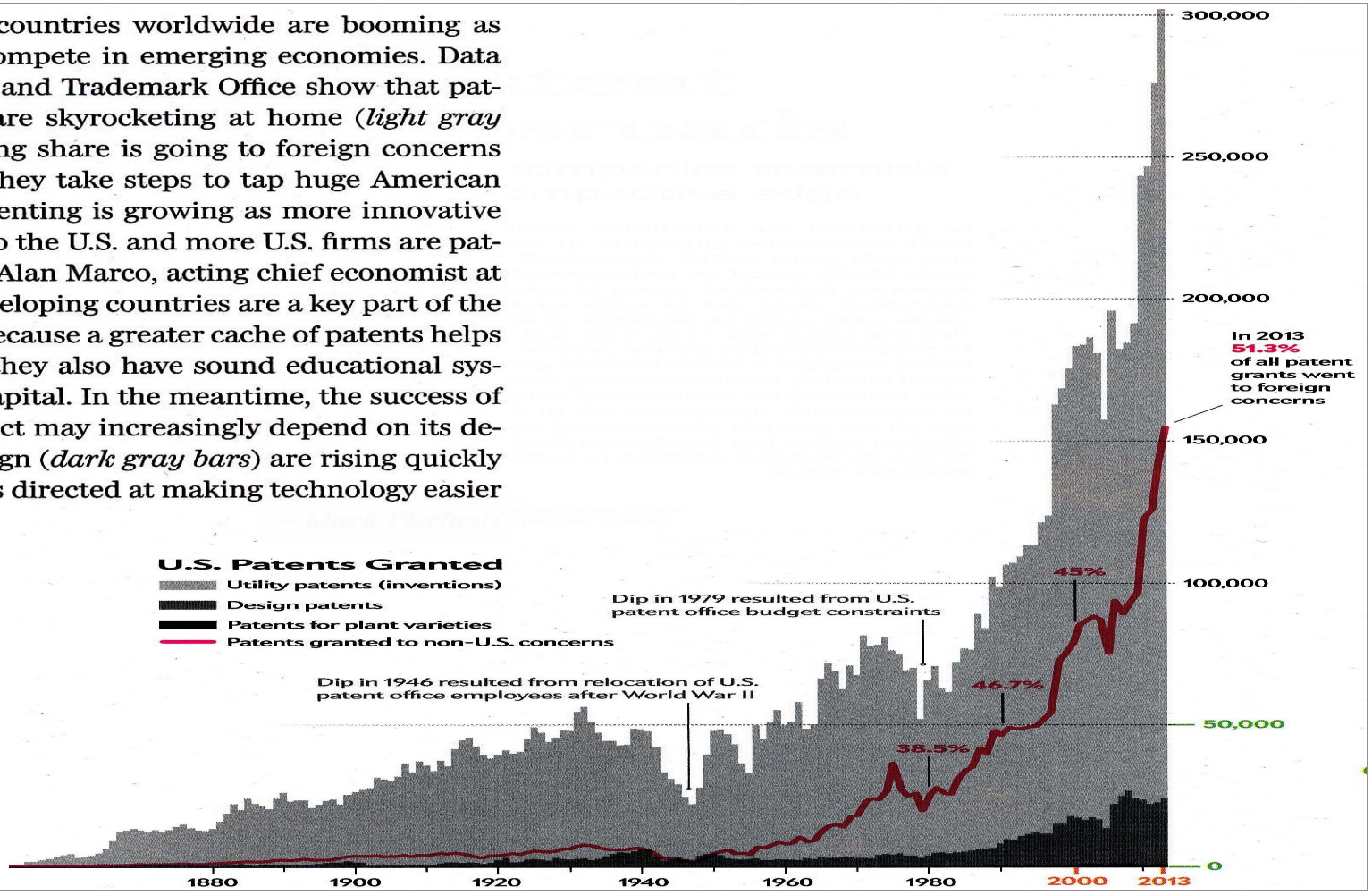


Source: Geoffrey A. Moore, Chasm Group, "Living On The Fault Line: Managing For Shareholder Value In The Age Of The Internet.," Harper Business, HarperCollins Publishers Inc., New York, New York, Copyright 2000 by Geoffrey A. Moore, Page 176.

DFMA & BREAKTHROUGH INNOVATION TECHNIQUES

Implementation: Patents Are Evermore Important - Protect The Breakthrough

Patents granted in countries worldwide are booming as companies race to compete in emerging economies. Data from the U.S. Patent and Trademark Office show that patents for inventions are skyrocketing at home (*light gray bars*) and that a rising share is going to foreign concerns (*dark pink line*) as they take steps to tap huge American markets. "Global patenting is growing as more innovative firms are exporting to the U.S. and more U.S. firms are patenting abroad," says Alan Marco, acting chief economist at the patent office. Developing countries are a key part of the expansion, he says, because a greater cache of patents helps them grow faster if they also have sound educational systems and available capital. In the meantime, the success of any individual product may increasingly depend on its design; patents for design (*dark gray bars*) are rising quickly as more innovation is directed at making technology easier than ever to use.



Source: Fischetti, Mark, "Patent Crossroads: Countries and companies scramble to gain a competitive edge.," *Scientific American*, Nature America, Inc., Nature Publishing Group, London, UK, July 2014, Page 96.

THANK YOU

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Biography – Bradford L. Goldense

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DFMA & BREAKTHROUGH INNOVATION TECHNIQUES

Biography: Bradford L. Goldense NPDP, CMfgE, CPIM, CCP

Brad Goldense is Founder and CEO of Goldense Group, Inc. [GGI], a thirty year old Needham, Massachusetts consulting and education corporation concentrating in advanced business and technology management practices for product strategy, management, development, and commercialization. Mr. Goldense has consulted to over 200 of the Fortune 1000 and has worked on productivity improvement and automation projects in over 500 manufacturing locations across North America, South America, Europe, Asia, and the Middle East.

Mr. Goldense is a retired member of the graduate engineering school adjunct faculty at the Gordon Institute of Tufts University in Medford, MA, after lecturing and teaching for nineteen years. He holds a BS in Civil Engineering from Brown University and an MBA focused in Cost Accounting and Operations from Cornell University. Brad is a certified New Product Development Professional [NPDP] by the Product Development and Management Association [PDMA], a Certified Manufacturing Engineer [CMfgE] by the Society of Manufacturing Engineers [SME], a Certified Computer Professional [CCP] by the Institute for Certification of Computer Professionals [ICCP], and is Certified in Production and Inventory Management [CPIM] by the American Production and Inventory Control Society [APICS].

Brad is Founder and past President of the Society of Concurrent Product Development [SCPD], the successor organization to the Society of Concurrent Engineering [SOCE] that spawned from IBM in the early 1990s. After fifteen years of volunteering to further the principles of concurrent engineering and product development, Mr. Goldense turned the organization over to a group centered in 3M in 2006. He retired from the board in 2012. A number of periodicals and international organizations spawned from SOCE and SCPD efforts that continue today. Many corporations have adopted concurrent values.

Mr. Goldense is a past member of the Board of Directors of the American Society for Engineering Management [ASEM], a past chapter president of SME's Computer & Automated Systems Association and a past SME regional officer. He was a member of SME's National Technology Council. In that capacity, he wrote much of today's CMfgT and CMfgE examination. Mr. Goldense served for six years on Cornell University's Technology Transfer Committee and the Cornell Johnson Executive Committee.

Brad has appeared on Alexander Haig's World Business Review, and on Public Television, PBS The Business & Technology Network, and CNBC. He has authored or been quoted in some three hundred articles on competitive product development and manufacturing with known industry publications such as Business Week, CFO, Design News, R&D Magazine, Product Design & Development, Purchasing, and others. He currently writes "Goldense On Product Development," the inside back page article for Machine Design, a monthly Penton Publishing magazine.

Prior to founding GGI in 1986, Mr. Goldense held positions at Index Group [the Cambridge-based think tank that spawned "reengineering"], Price Waterhouse Consulting, Texas Instruments, and his family's engineering business. Brad enjoys woodworking, landscaping, reading, boating, and is an avid fresh water fisherman.

END

DOCUMENT