INNOVATION FOR BUSINESS GROWTH

A fourth generation of innovation management broadens the scope of innovation to produce not just new products and processes but also candidates for new dominant designs. Are you developing a chief innovation officer?

William L. Miller

OVERVIEW: *Profitable business growth that creates shareholder value is restricted by core barriers and gaps in the third generation (3G) of innovation management currently practiced by most industrial organizations. The barriers and gaps are: (1) the basic principles of current innovation management which limit its scope and strategy; (2) the current organizational capability and architecture for innovation; (3) current "best practices" which restrict innovation, including marketing and R&D, to what the customer perceives is needed. Twelve new principles and practices define a 4G management that helps overcome these limitations in current practice.*

The most important issue facing business leaders who wish to maximize shareholder value is how to achieve sustained profitable business growth (*1*). Indeed, "managing R&D for business growth" has for several years been at or near the top of the list of "biggest problems facing technology leaders" in the Industrial Research Institute's annual poll of its members.

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Management's ability to generate profits has been undergoing an evolutionary change over the past 10 years, from the so-called third generation, in which R&D focused mainly on product and process innovation, to a fourth generation of innovation and R&D (*2*). In this new "4G" model, industry structure is presumed to be more dynamic, and the scope of innovation management is broadened to include not just products and processes but business and market models that encompass the management of knowledge, technology, and market/industry infrastructure.

Even companies with world-class third-generation R&D organizations like Gillette, Lucent Technologies (*3*) and Xerox have recently had difficulty producing sustained business growth because of the core barriers and gaps inherent in 3G innovation management. These barriers and gaps are:

- Current principles of innovation management that limit the scope and strategy of innovation and focus strategic planning, marketing, R&D, and investment inside models which are the current dominant designs for "best practices," products and services, businesses, industries, and markets.

- Current organizational capability and architecture for innovation management that restricts leadership, organization, business processes, collaborative learning with customers and other suppliers, partnerships, funding and other resources, incentives, and cultural transformation.

- Current "best practices" of innovation management that create the classic innovator's dilemma (*4*) and restrict innovation, including marketing and R&D, to what the customer perceives is needed. These practices also create a collaborative knowing–doing gap (*5*) that prevents marketing and R&D in a group of suppliers from learning effectively with customers through iterative experience about what's possible and mutually valued as a new scalable, sustainable and competitive capability and architecture targeted to becoming a new dominant design.

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As Clayton Christensen has said, "It's no wonder that innovation is so difficult for established firms. They employ highly capable people—and then set them to work within processes and business models that doom them to failure" (*6*).

To a great extent, 4G management overcomes the core barriers and fills gaps in today's business system by relying on the 12 basic principles and practices outlined in the remainder of this article.

1. A Broader Definition and Scope of Innovation Is Required for Effective, Sustained Growth in Business Value.

Sustained profitable growth is a primary factor in determining business valuation. With competitive markets in developed countries becoming saturated and driven by weak demographics, growth in business value ultimately depends more on creating and delivering the new customer value propositions that transform and form new markets than on increasing market share, improving branded product performance, reducing cycle time, or cutting costs. Technology is an enabler, but only as part of a business system challenged with growing through innovation. To produce growth in business value, the scope of innovation management must be broadened to change the business system along the following nine dimensions.

■ *Competitive Analysis and Strategy.*—Sensing and responding to the development of the global economy, markets, industries, business models, and products/services requires not just an analysis of individual competitors and industry structure (*7*) but an analysis of the scalable, broadened capability formed by groups of suppliers called "galaxies" in 4G. These galaxies are enabled by a layered architecture and build candidates for new dominant designs attempting to "lock-in" a market (see Figure 1). The flow of value in 4G is aggregated by capability and architecture into a series of dominant design cycles for products that feed business cycles to an industry and then industry cycles to the economy. (The dominant design of the economy has evolved from agricultural and industrial to the information age and is now entering a "bioinfotech fusion" age exemplified by digital convergence.)

■ *Targeted Customer Needs.*—Resolving "the innovator's dilemma" requires a new type of business process

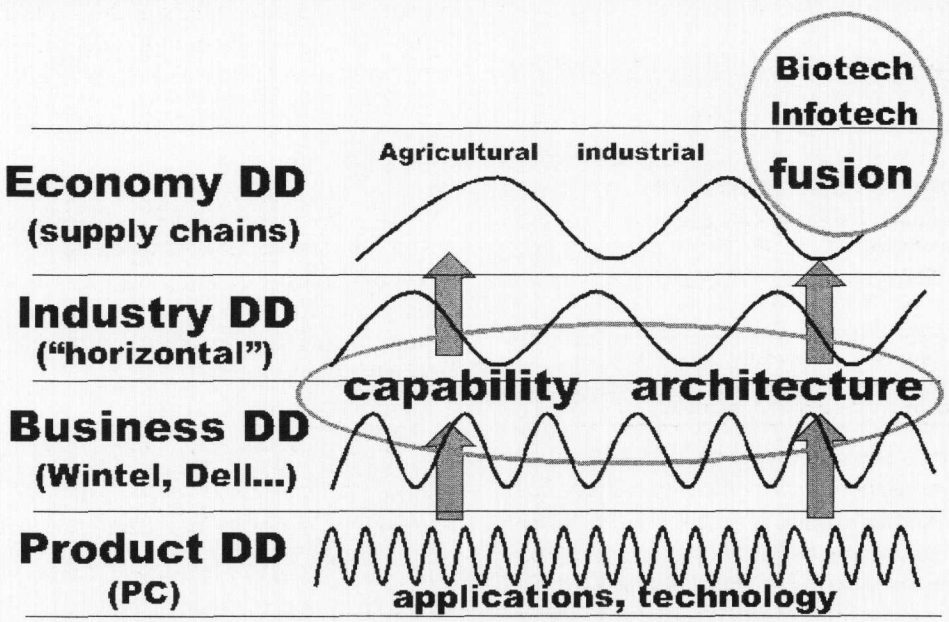

Figure 1.—The global economy can be visualized as a layered architecture with product, business and industry layers. Value flows up from the bottom layer. Dominant design cycles occur at and transform each layer. At the product layer, technology and knowledge create new capability which enables new applications for customers. Value flows up from the new dominant design at the product or service layer into the business layer, eventually changing its dominant design and, ultimately, transforming the industry layer, as the PC transformed the computer industry. Wintel refers to the combined architecture of the Microsoft family of Windows operating systems and Intel's family of Pentium microprocessors. Dell's direct "build to order" model is part of the horizontal architecture forming the dominant design at the business level.

with a scope broadened through customer and supplier trials to discover both the perceived and latent needs of existing and new customers, as new value propositions that can be effectively served by groups of suppliers (see Figure 2).

■ *Customer and Supplier Value.*—Customers and suppliers find value in products or services as part of a new capability for them to do or experience something valuable. They develop this capability in the context of an architecture, defined by the market as dominant designs for knowledge, technology, practices, processes, tools, business models, industry structures, and the combination of industries into new supply chains. An example is the integration of cars and information services represented by GM's OnStar™ as "atoms and bits." Cars are built from atoms and OnStar is produced from bits contained in information services.

■ *Implementation of Business Value.*—The collaborative knowing–doing gap in 3G suffers from the stage–gate translation of knowledge through actionable projects into products and services; these frequently fail because the projects (including venturing of start-up businesses) target the context of an old dominant design or miss having the right value proposition enabled by an architecture targeting a new dominant design and a new capability from a galaxy of suppliers.

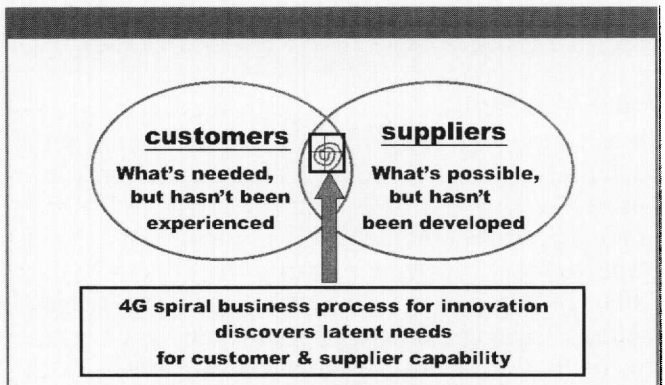

Figure 2.—The fourth generation (4G) of innovation management solves "the innovator's dilemma" with a new spiral business process for capability and architecture development. The principles of knowledge and technology management are combined to create new learning experiences for customers and suppliers. The process iteratively creates, tests and analyzes experiences to fill gaps and eliminate errors. Categories of stakeholder value are mapped into application scenarios which are translated into capabilities for customers and suppliers. The capabilities are structured by an architecture as a candidate for a dominant design.

Resolving "the innovator's dilemma" requires a new type of business process.

■ *Leadership of Innovation.*—Effective innovation needs new, broadened leadership; specifically, "T-shaped" people who direct teams and occupy new executive positions (a chief innovation officer) and understand the business system and can direct learning that extends functional business processes and practices including strategic planning, business development, venturing, corporate and funded university R&D, marketing, operations, human resources, and finance.

■ *Management and Scope of R&D.*—4G includes all previous generations of R&D (Figure 3) and combines the management of knowledge, technology and innovation such that R&D becomes a T-shaped function: horizontally broad in business and technical innovation and vertically deep in understanding science and technology. Each new generation augments rather than replaces the previous one. The most significant changes occur in planning, resource allocation, leadership, organization, and processes.

■ *Technology in R&D.*—The CTO's scope expands to include the development and acquisition of information technology in order to create new dominant designs. The CIO still runs operations and is a partner in innovation. Information technology (IT) enables innovation that broadens the scope of business value within and across industries. The increased scope occurs as the convergence of "atoms and bits" in many forms including customer relationship management (CRM) and supply chain management (SCM). With e-business, the ubiquitous Internet, and low-cost, networked, sensor-based information appliances, IT now allows innovation to change core business models. Customers want solutions anywhere and anytime from a supply chain that integrates products and services from multiple industries.

■ *Collaborative R&D.*—The strategy of business is shifting from a focus on internal distinctive-core competency to leveraging that competency with external partners to deliver solutions as a new capability for customers.

■ *Innovation in the Expanded Enterprise.*—Suppliers from different industries can partner to form a "galaxy," thereby increasing the scope of a new value proposition

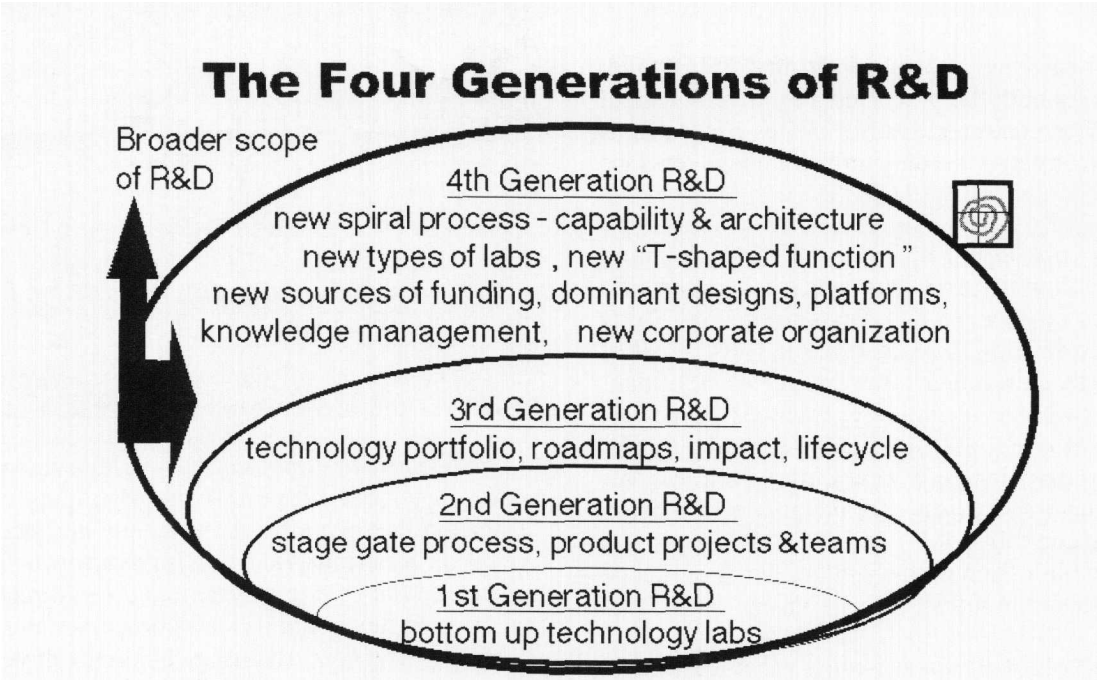

Figure 3.—Each generation of R&D builds on the preceding generation and changes planning, resource allocation, leadership, organization, and processes. The first generation began around 1900, the second around 1950 and the third about 1985. In 4G, new funding sources such as venturing and acquisitions enable more R&D to accelerate innovation of new dominant designs. "T-shaped" R&D is broader and deeper. The spiral process resolves the innovator's dilemma and broadens the R&D capability into knowledge management, including discovering latent customer needs through experimentation that generates and tests new experiences.

for a business with new capability. The galaxy uses a supply chain with a sales and a 4G knowledge channel to interact with customers while they are using a product and/or a service.

GM's OnStar in-vehicle communication system is an example of this first principle. It increased the scope of innovation, including the value proposition offered and delivered by the business (and the industry), to include information services. The new proposition created a new and larger industry with the potential for much higher, sustained profit margins than the "mature" automobile industry. OnStar is a candidate for the new dominant design combining cars with personalized, situated information services delivered via a 4G knowledge channel.

2. A Strategy of Targeting Dominant Design Lifecycles Is Required for Profitable, Sustained Growth.

The strategic rules for investment change in every market, especially in "mature" markets, by understanding that the life cycles of industries and markets are driven by new dominant designs. Growth that was nearly impossible to achieve in "mature" markets using 3G can now be enabled by 4G innovation.

A dominant design begins as a new product or process with a new architecture that creates new value for customers and will eventually expand to transform business models and entire industries. In 3G R&D, technology portfolios and roadmaps focus evolutionary improvements on the existing dominant design. Although portfolios help manage technology development, the planning process still implicitly assumes that the technologies are aggregated into the existing dominant design. 3G marketing implicitly uses the existing dominant design to define the context for a customer's needs.

Technologies, including the disruptive technologies described by Christensen, form part of capability and are brought to market through an architecture that should allow an evolution or migration of a scalable capability for customers and suppliers. If the architecture for a new product or system combines the right mix of valued capabilities and provides for the right evolution of capabilities, it has a chance to become a new dominant design. In 3G, the growth of suppliers is eventually blocked by the performance limitations in existing dominant designs. Only the suppliers of new dominant designs will eventually survive and grow in a transformed industry.

The concept and history of dominant designs—thoroughly researched by Utterback (*8*)—applies to all industries and follows a predictable pattern over time, as shown in Figure 4. As architecture, dominant designs give both customers and suppliers an evolutionary path to more valuable, new capabilities. New capability doesn't necessarily mean higher levels of technology components. For the introduction of the personal computer, for example, the technology of an interactive user interface was more important than the relative technology of processor speed.

3. Dominant Designs Are Defined as Layered Architectures with 3 Parts: Product/Process Platforms, Business Models and Industry/ Market Models.

Dominant designs are the specific combination of product and service features, business models and industry/market structure that customers overwhelmingly prefer. Normally, dominant designs emerge out of a period of chaos, during which many combinations are offered. A dominant design begins as the architecture that structures a new capability serving latent customer needs and provides an evolutionary path for the valued capability. New product and (knowledge) services form the core of the new capability. But the architecture for a dominant design needs to specify how the capability for suppliers is assembled to build and supply the product and services. Therefore, it also includes rules for building the supplier business models and assembling these businesses into a supply chain to serve a transformed market and industry. Because the dominant design will evolve, what's more important for business value is being the core suppliers who control the critical parts of the dominant design. First-mover advantage is critical since business models and other capability such as technology can be patented and licensed.

The dominant design evolution begins in a period of chaotic product or process development leading to a standard accepted by customers and suppliers that eventually restructures business models and the entire industry. For example, when the PC became the new dominant design in the computer industry, the product model, business models and the industry architecture changed. IBM had been vertically integrated as the leader in mainframe computers, and the PC changed the industry to a horizontal structure for business models. IBM wasn't first with the PC—Apple was the early leader and introduced the graphic user interface on the MacIntosh. But Wintel became the core of a galaxy with the Microsoft Windows operating system and the Intel Pentium microprocessor, and won the architecture for the dominant design by offering scalable performance for current and future generations, and by being

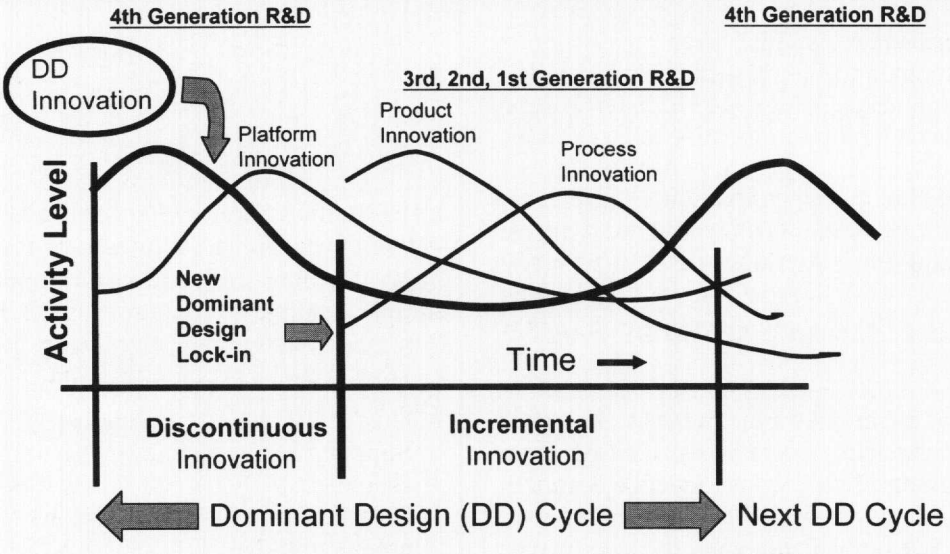

Figure 4.—Industries have dominant design (DD) lifecycles and become "mature" when the limit of value in a DD has been reached. As a new DD emerges to create new sources of value for economic growth, the highest level of activity focuses on determining the design. The market (customers and suppliers) experiments with different product, business and industry models. After locking-in a DD, the main activity shifts to determining specific platforms for the DD. With a platform established, the activity shifts to producing generations of products with increasing value. Finally, process innovation becomes the highest activity. Then the cycle repeats. Only those very few suppliers that introduce or quickly adopt the dominant design will survive.

open (*horizontal*) to create a larger galaxy of suppliers but *proprietary* to capture sustained profits. Dell also built a valuable, scalable business model as a PC supplier with a build-to-order capability but had to accept lesser profit margins.

Higher margins for suppliers are counterintuitive to manufacturers in some industries, such as automotive where the highest margins normally go to the integrator at the end of the chain who adds the most value and also controls the brand. Lower margins go to the suppliers. But both Microsoft and Intel have great brand visibility with the customer, govern the evolution of the architecture to meet customer needs, and supply the critical proprietary components where most of the value is added. To enable the horizontal business models that form part of the dominant design, an architectural 3G "stack" of layers describes the PC as a product with a hardware layer for the microprocessor at the bottom, the PC motherboard and peripherals in the next higher layer, then the operating system and user interface layers and, finally, applications. 3G focuses on the product and/or service.

In a 4G system of "atoms and bits" such as represented by GM's OnStar, the architecture for the business model splits into two dyadic "stacks" as (1) a manufacturer supplying the sales channel for cars, and (2) an application service provider supplying the knowledge channel, with information delivered to the point of product use. The 4G architectural stack for the service provider has a product stack on the bottom (representing a device as a car or a person with a cell phone, PC or PDA). Then it adds a device-independent middle layer for *capability and architecture* to integrate networked business models into a galaxy of suppliers, a contextual user interface and profile layer, and a contextual application layer. Finally, the top layer is a value proposition describing the industry or market. The 4G stack describes scenarios for new value propositions for mobile users moving from car to home to work and shopping sites.

4. Capability and Architecture Are the Building Blocks of Value.

The composition of the market value of the businesses in the Dow Jones Industrial Average has shifted from mostly tangible assets (book value) in 1980 to about 75 percent intangible assets in 1997 (*2*). The crossover point was 1988. Clearly, business value is being driven by assets that include intellectual capital and that 4G defines as capability (see Figure 5).

Delivering capability to people generally means supplying both new products and/or services and knowledge on how to use these products and services in their context. 4G "contextual" marketing deals with this issue by defining an architecture for supply and personalized use.

Business value is driven by assets that include intellectual capital and that 4G defines as capability.

Capability has four parts: (1) people with knowledge (explicit and tacit, individuals and groups); (2) tools such as products and services plus all other assets; (3) technology; (4) process and practice. Capability can be directly mapped to new models of intellectual capital accounting.

Architecture consists of structure and design rules for aggregating capability and for enabling the valued evolution of capability. Dominant Design is an architecture preferred by the market that "locks-in" standards enabling new value propositions serving new needs and the evolution of capability to serve those needs. Suppliers of the critical dominant design components (the "choke points") generally enjoy the largest profit margins.

Architecture exists for both suppliers and for customers but is distinctly different. Supplier architecture is outlined in the following paragraph. For customers, the middle layer of their dominant design becomes a Lifestyle Architecture that defines how the capabilities of products and services get combined and applied in their daily lives and defines their context.

Architecture (as dominant design) consists of three layers:

1. *Market and Industry Architecture.*—Market dominant designs, including:

- Supplier architecture—structure of supplier capabilities as value propositions including relationships, brands, tools, technologies and processes, infrastructure.
  Supply chains including the sales and knowledge channels.
  Galaxies of suppliers as partners to create new value propositions.
- Customer's architecture—values, needs, structure of capability as relationships, activities, locations, assets, income and spending patterns, personalization, profiles, privacy, infrastructure.
  Customer segmentation models.
  Categories of value.
  Capabilities that map to categories of value.
- Marketplaces—physical, electronic and linkage.

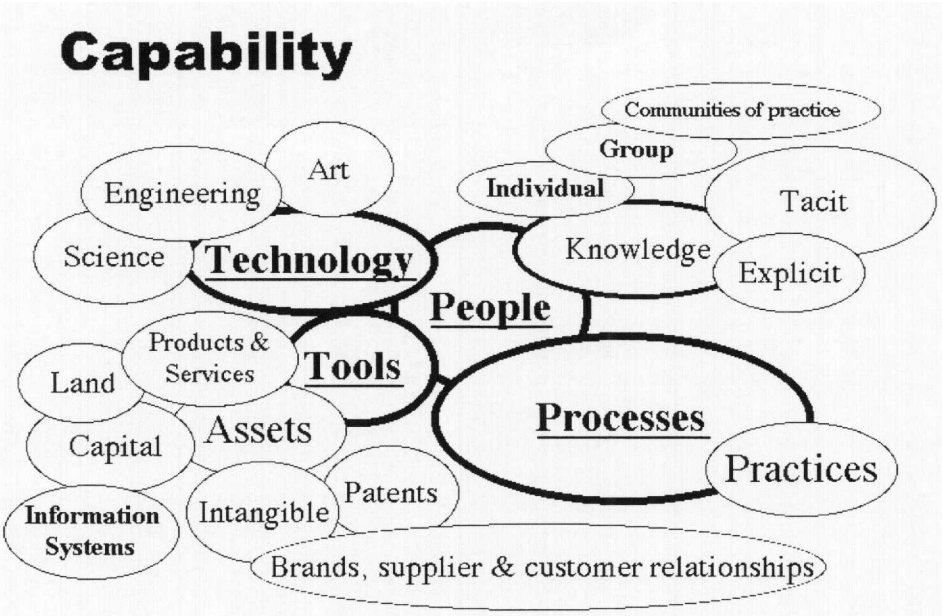

Figure 5.—Capability is a core building block of a market and business system that represents value for both customers and suppliers; it is the combination of people (with knowledge), tools, technology, and processes. Capability evolves with improved knowledge, tools, technology, and processes. Products and services are tools; delivering capability to customers (people) means delivering products and the knowledge to use the products. To learn and apply new capability, people join groups such as communities of practice. Effective learning depends on overlapping communities of practice with people moving around to have dialogue and share experiences. A marketplace overlaps customers with suppliers. Capability can be directly mapped into financial accounting terms including both tangible and intangible assets. Customer value propositions can be mapped into capability and structured by architecture.

- Industry structure—Porter's Five Forces model (*7*), competitors, customers, suppliers, substitutes.
- Distribution models.

2. *Business Architecture for suppliers.*—Business dominant designs, including:

- Business models (in markets) for generating value.
- Organization of internal and external business capability.
  Business organization, leadership roles, business development.
  Business process model, served markets, e-business.
  Relationships with galaxy of partners.
  Alliances, partnerships with suppliers and customers, venturing.
  Communities of practice, projects, teams.
  Architecture of core competencies, intellectual property.
  Architecture of the installed base of products, assets.
- *The model (generation) of innovation management.*

3. *Product/Service or Technology Architecture.*—Product/service and technology dominant designs, including:

- Product and service platforms as existing and new dominant designs.
  Hardware, software, materials, molecules, proteins, processes.
  Information systems.
- *The model (generation) for R&D, marketing*
  Knowledge maps, organization of labs, partners, suppliers.
  Patent maps, technology roadmaps, portfolios, life-cycles.

5. Markets Have a Distribution and Supply Architecture with Two Types of Channels: Sales and Knowledge.

Figure 6 shows both channels in a 4G market architecture. Products and services are both sold through a sales channel with distribution partners such as consultants, agents, system integrators, value-added resellers

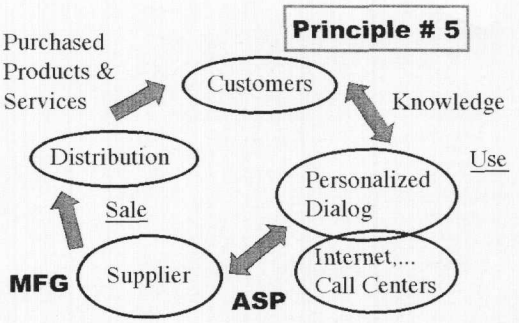

Figure 6.—In 4G, the scope of the market architecture expands to include two types of distribution channel: sales and knowledge. On the right side of the diagram is the Knowledge Channel (Principle 5.) 4G innovation is defined as new, valued capability delivered to customers. Capability includes tools such as new products or services sold through a sales channel illustrated on the left side of the diagram. The manufacturing (MFG) part of a business model would perform order fulfillment for products using the sales channel. Since 4G defines capability as including knowledge, the knowledge channel would deliver knowledge to the customer in the form of services at points of sale and use. The application service provider (ASP) part of the business model operates the knowledge channel. In 3G, innovation is generally defined as the delivery of new products (not capability), and the customer's need for knowledge such as how to effectively use (or support) the product is unsatisfied. As an example, GM delivers the information part of its OnStar™ through the Knowledge Channel to the customer using the car, and the product part of OnStar as electronics in the car delivered through the sales channel.

(VARs), OEMs, dealers, and distributors who manage customers, accounts, orders, and transactions. The sales channel is concerned about customer satisfaction with the purchase transaction at the point of sale and the delivery of the product and/or service. After the sale, the knowledge channel permits a dialogue with the customer and the delivery of services at the point of product and/or service use. Value in the knowledge channel depends on personalization, profiles and a situated, semantically understood context that identifies a customer need and delivers required knowledge. Knowledge transfers occur using call centers and other agents.

As the economy shifts to more services, more value flows through the knowledge channel than through the sales channel. Business models for manufacturers become dyadic hybrids with a manufacturing model supplying products that flow through the sales channel and generally an application service provider (ASP) model supplying services that flow through the knowledge channel. GM's OnStar is an example of applying the knowledge channel to change the dominant design.

6. A New Spiral Business Process Is Required for Capability and Architecture Development.

Customers and stakeholders, who include end users and channel partners, need to experience a new dominant design to appreciate the value proposition, help develop it, and know they want it. The four-step spiral process for capability and architecture development is shown in Figure 7 as a 2 × 2 matrix that implements mutually dependent double-loop learning between suppliers and customers. The process is based on the application of the principles of knowledge management discovered by Ikujiro Nonaka and the principles of behavioral psychology and learning discovered by Chris Argyris.

Beginning with step 1 in the lower-right quadrant, a candidate architecture is described that would enable new, valued scenarios for customers. This step combines explicit knowledge with other explicit knowledge. Step 2 in the lower-left quadrant develops a capability for the new architecture by building a prototype that can be tested and used by customers in the application scenarios. Here, customers and suppliers create new tacit knowledge from explicit knowledge by using the prototype in the context of the architecture.

Explicit knowledge is made tacit when it is internalized through experience. Experience transcends descriptive language. Explicit knowledge gets close to actual experience with storytelling and acting scenarios. Step 3, in the upper-left quadrant, builds group tacit knowledge from individual tacit knowledge by conducting field tests in a shared group application. Step 4 transforms the tacit knowledge back into explicit knowledge. The new tacit knowledge can be captured by observation and other methods and used to reveal latent needs.

Experience suggests the process must complete the spiral about three times within the first year to develop an acceptable, valuable capability and architecture that can be sold to customers as a candidate for a dominant design. To complete the development of a dominant design, the spiral process should be completed each year for another two years for a total of nine iterations, three in the marketplace. The total time to lock-in a dominant design using 4G appears to be about four years. First-mover advantage applies to those using 4G.

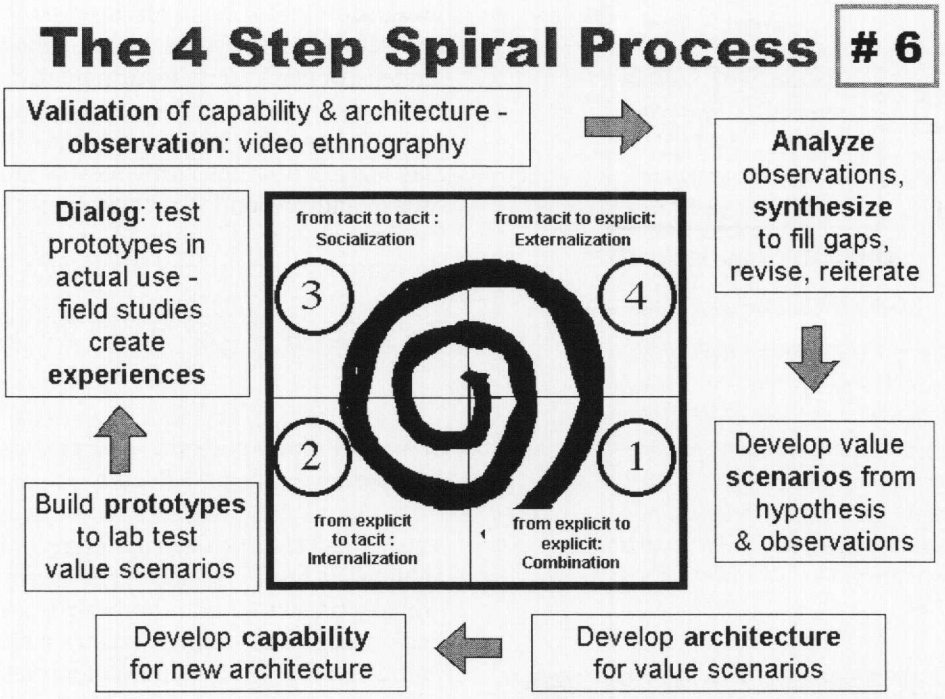

Figure 7.—As Principle 6, the spiral capability and architecture development process has four steps that repeat in sequential iterations. The process forms the core of 4G innovation management. The fuzzy front-end becomes clearer when using the new spiral process. For instance, video records customers using prototypes, and ethnographic analysis helps determine latent needs from customer behavior. For over 10 years, research on software engineering has recognized the unique value of a spiral process, and this insight is beginning to change standards. The capability maturity model (CMM) for software engineering was developed at the Carnegie Mellon Software Engineering Institute (SEI) and is used as a standard in many organizations. The CMM is based on a "waterfall" or linear process, but is being changed to recommend a spiral process when the requirements are not well known. The voice of the customer is limited by their experience, and surveys cannot be used effectively to determine latent needs and new dominant designs. The spiral process, in contrast, allows the customer to experience new capabilities structured by new architectures, and then to have an effective voice. Principles of knowledge management are used to design the spiral process and the experiments to be tested.

7. Strategic Planning Is Extended in 4G with New Principles, Tools and Practices.

Each business and market segment in the strategic plan will have traditional 3G growth plans for adding value to the current dominant design—incremental innovations for product/process, business and market models. For example, the plan could include product/process technology roadmaps, portfolio analysis, competitive analysis, and information technology for e-commerce, such as supply chain management. But long-term growth will depend on extending the overall strategic plan with 4G principles that plan for a new dominant design in each line of business; e.g., new models for product/process, business and markets. And the plan should include industrial sector convergence/fusion with information technology for e-commerce, e-products and e-services.

Another tool for planning is the matrix shown in Figure 8. For a period of time, 3G does a good job of adding value to existing dominant designs, which includes expanding into global markets. This is shown as the lower-left quadrant but labeled as "growth problems" because growth eventually slows and business value decreases. A 4G "new methods" strategy can help temporarily to sustain growth with existing dominant designs by discovering and serving latent needs with new complementary technology largely acquired externally through such activities as partnering, licensing, acquisitions, and venturing with minority equity investments.

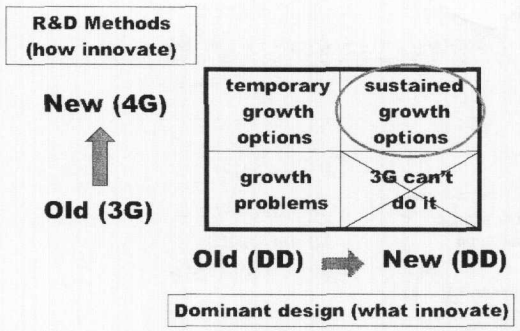

Figure 8.—This 2 × 2 matrix is a 4G planning tool that expands the perspective of innovation beyond 3G methods operating inside existing dominant designs (DDs). 4G can support adding value to both existing and new dominant designs. 3G eventually runs into growth problems trying to add value to existing DDs and cannot effectively discover and develop new DDs.

This is shown in the upper-left quadrant. Cisco and Intel have been leaders in this approach.

The 4G "new target" strategy of discovering and developing new dominant designs fits mainly in the quadrant labeled "sustained growth options." Both method and target strategies can be combined for even more aggressive "sustained growth options." Ted Lewis has described attempts to use both strategies at DaimlerChrysler's California research laboratory (*9*).

4G tools for strategic planning include a Strategic Cube (Figure 9) that helps manage technology by considering technology acquisition, lifecycle and application. The Cube helps plan where and how to apply 3G and 4G R&D. It has three labeled dimensions: (1) on the x-axis, technology application in either existing markets or emerging markets; (2) on the y-axis, technology lifecycle as existing technology or emerging technology; and (3) on the z-axis, technology acquisition. The surfaces are labeled with appropriate actions.

New dominant designs could be considered at the intersection of existing markets and emerging technology, or emerging markets and emerging technology. The intersection of existing markets, existing technology and internal source dictates "reengineering and (3G) R&D exit." The intersection of emerging markets, emerging technology and internal source says "4G R&D, latent needs, startups and venture capital." In other words, use internal 4G leadership to seed ventures that create the new dominant designs that grow as new businesses and as partners allow the internal organization to grow.

Vince Barabba describes the strategic planning that produced OnStar (*10*). He discusses how rapid change and the need for mass customization is shifting the strategy of many manufacturing businesses from "make-and-sell" to "sense-and-respond," but maintains that the best business designs are hybrids. "Make-and-sell" for cars has a profit focus driven by economies of scale, and "sense-and-respond" for OnStar has a profit focus driven by economies of scope. Business designs (part of dominant designs) and strategies are evaluated for various future scenarios, and outcomes are estimated. A design is selected for growth that is robust for many scenarios.

8. New Value Propositions Are Created with New Principles, Tools and Practices.

The Value Matrix shown in Figure 10 is used to build the application scenarios needed in the first step of the spiral process (Principle 6). The Matrix focuses attention on market segments and invariant categories of customer value. Existing dominant designs are plotted and evaluated on the Matrix. New candidate dominant designs are tested as scenarios evolving from product applications to new business models and then to market and industry designs.

The first step is determining the broad invariant categories of value that line the x-axis of the Value Matrix. Five categories seem to fit many businesses: (1) health, safety and comfort of individuals; (2) the productivity of individuals and organizations; (3) lifecycle costs of acquiring and maintaining assets; (4) information system integration and migration; and (5) design integrity. The next step is determining the y-axis, which is the migration path for the dominant design from the initial value proposition into adjacent market segments. Each evolution of the dominant design is a new row in the matrix and each row has a different weighted mix of the categories of value.

The methods used in the Value Matrix are similar to those described by Geoffrey Moore (*11*). They employ scenario concepts such as "a day in the life of a customer before and after the new dominant design." Architecture as dominant design enables what Moore terms "the whole product" that mainstream markets demand. Partnerships and alliances play critical roles in building "whole products" and those collaborative efforts are enabled by an architecture.

The new value proposition offered by OnStar integrates two industries. The strategy was attractive because it put GM in a much bigger market with higher margins. The 4G strategy attached the smaller competitive global market for vehicles ($400 billion) to the larger market for global information services ($1.6 trillion). The strategy

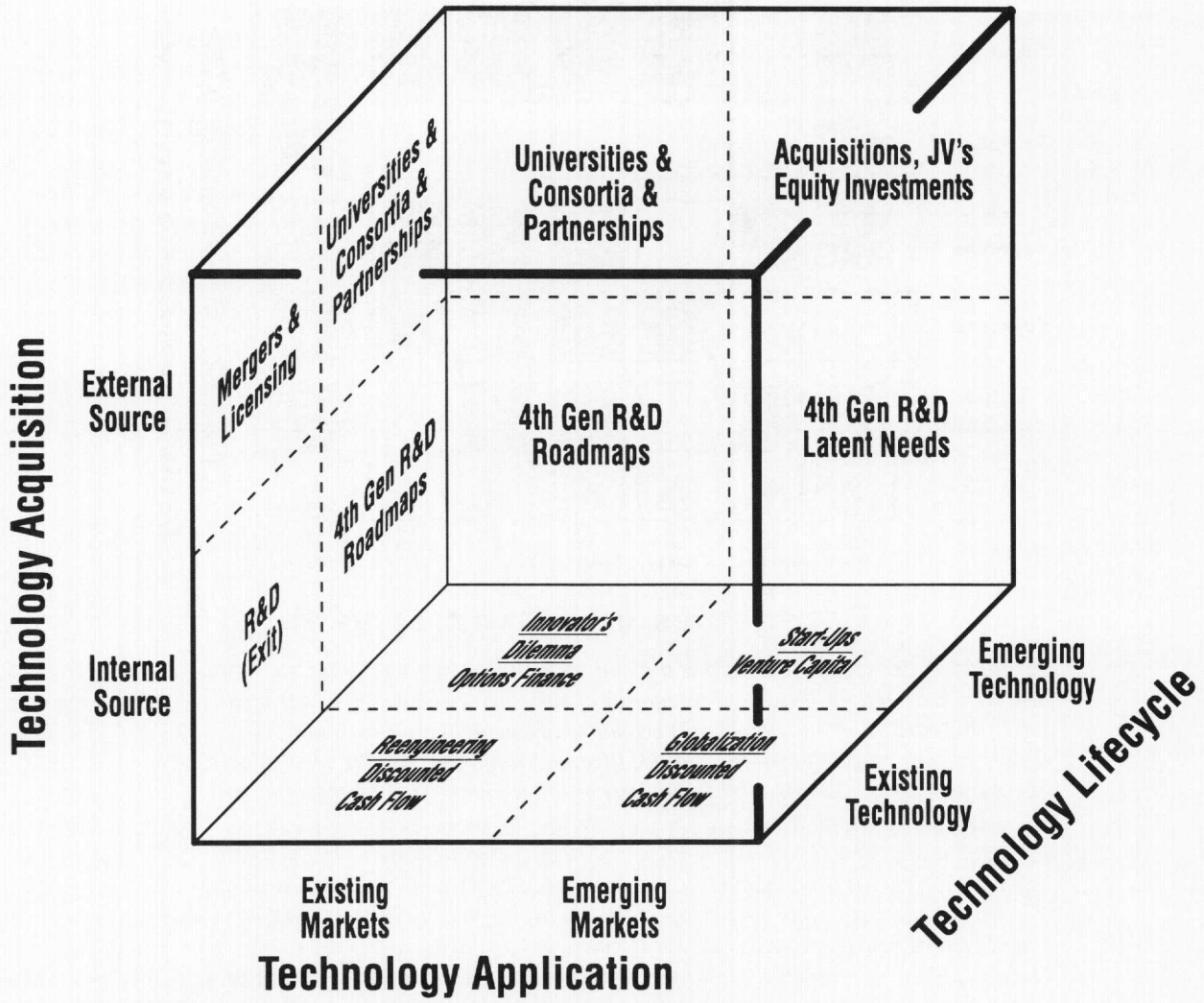

Figure 9.—The Strategic Cube helps to analyze and plan the acquisition, lifecycle and application of technology. At the intersection of emerging technology and emerging markets, the cube recommends start-ups and venture capital, plus acquisitions, joint ventures and equity investments to assist internal R&D. 4G R&D is recommended to discover latent needs.

offered a competitive advantage to GM compared to the providers of information services because GM had an installed base, brand identity and capability for designing and producing smart vehicles. Further, the strategy was attractive to GM's dealers who would benefit from more value-added electronics in vehicles and an increase in volume due to a probable increase in market share.

In addition, GM would be able to get direct marketing information from individual customers using vehicles and be able to practice differentiated, personalized "1-on-1" marketing without modifying the vehicle hardware. The differentiation was enabled by a software and services market largely governed by the economics of increasing returns on an infrastructure platform for an application service provider. GM with OnStar has gone past the breakeven point and licensed Toyota and Nissan.

9. New Types of "T-shaped" Innovation Leaders Have Greater Breadth and Depth.

Innovation has greater scope than any function such as R&D, marketing or strategic planning. Multifunctional teams are required to solve the complex problems in innovation. But what kind of leader is best for these teams?

Leaders should understand how the business system operates to create value. The functional practices of R&D and marketing require extensions called 4G R&D and 4G marketing to discover and develop new dominant

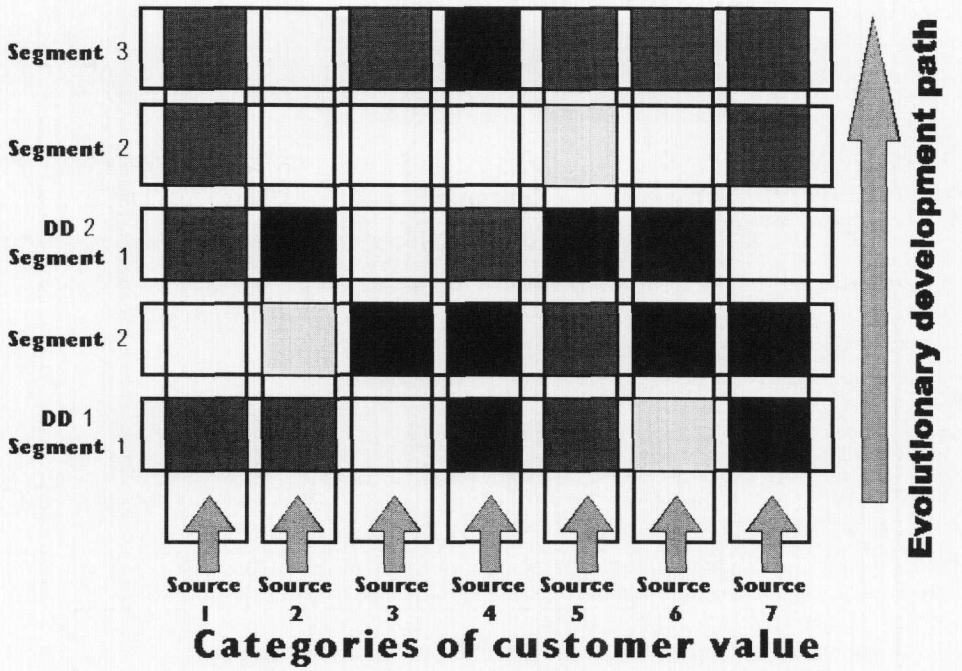

Figure 10.—The 4G Value Matrix is a planning tool for new value propositions and new dominant designs. Invariant categories of customer value could be: (1) health, safety and comfort of individuals; (2) economic productivity of individuals and organizations, including time-saving; (3) lifecycle costs of assets; (4) accommodating change with a flexibility for new technology as information system integration and migration; and (5) emotive design integrity. In the bottom rows are the current dominant design and served segments. In the rows above are the targeted initial segments for the new dominant design as a product, business and industry model. Partners are typically enlisted and operate as a "galaxy." For GM, the bottom rows would include just cars and trucks. The higher rows would be networked cars with OnStar, which is a candidate for a new dominant design that initially served a niche segment (navigation) but is evolving to include a new business model (e-GM) and new markets like mobile commerce using information services in cars as a platform. The shaded boxes in the matrix represent different weights of the categories of value in a specific segment.

designs as new models for products, businesses and industries/markets. The new principles and practices of 4G have to be taught and then learned by application on 4G projects under the guidance of a 4G coach. Teaching these 4G skills will create new types of effective growth leaders.

4G can be taught in a manner similar to Six Sigma. However, unlike Six Sigma, which in 3G focuses on the expressed "voice of the customer," 4G focuses on the latent or unspoken voice. 4G also uses a different process and set of functional practices.

Organizations have adopted business process models to describe their systems. The new process of capability and architecture is managed and applied by the T-shaped leaders who use the new process to change the system. T-shaped means being horizontal across the processes in the system and vertical into the depth of their functional specialty.

As an analogy, consider assembling a "team" of expert musicians into an orchestra. Without composers and conductors acting as the "T-shaped" leaders, the orchestra has difficulty playing. Good candidates for a conductor and/or a composer include those who have played in an orchestra. Jazz is played without a dedicated conductor, but the musicians act in turn as a combined conductor and composer and are all T-shaped.

T-shaped leaders must understand not just the business of their organization as a supplier but also the business of their partners and customers and be able to facilitate the mutually dependent, co-created, double-loop learning required in the new spiral process.

10. New 4G Innovation and Application "Labs"/Startups Overcome Barriers, Fill Gaps, Acquire New Funding for Innovation and Improve Yield.

New types of "labs" are created in 4G innovation to fill gaps between technical and market research, and between research and customer validation. New 4G innovation and application labs augment traditional R&D labs and use a spiral process for capability and architecture development. The concepts of T-shaped leadership and the new labs are highlighted in Figure 11.

An example of a new 4G lab as an innovation lab is Project Oxygen at MIT's Laboratory for Computer Science (*12*). Project Oxygen practices 4G top-down development and user testing of a new system with big goals, such as determining the future of computing that yields transparent, ubiquitous, productive, inclusive, ease-of-use for customers including users. Project Oxygen also practices 3G bottom-up development of technology. In a 4G lab, the system is built by developing a new architecture that defines a new infrastructure and a new aggregation of technology.

New "labs" are created in 4G innovation to fill gaps between technical and market research.

In 4G labs, the paired combination of a top-down customer or application view and a bottom-up science or technologist view is called dyadic development. Dyadic development involves overlapping the communities of practice of suppliers and customers. It involves using an effective spiral process in the front-end of research to

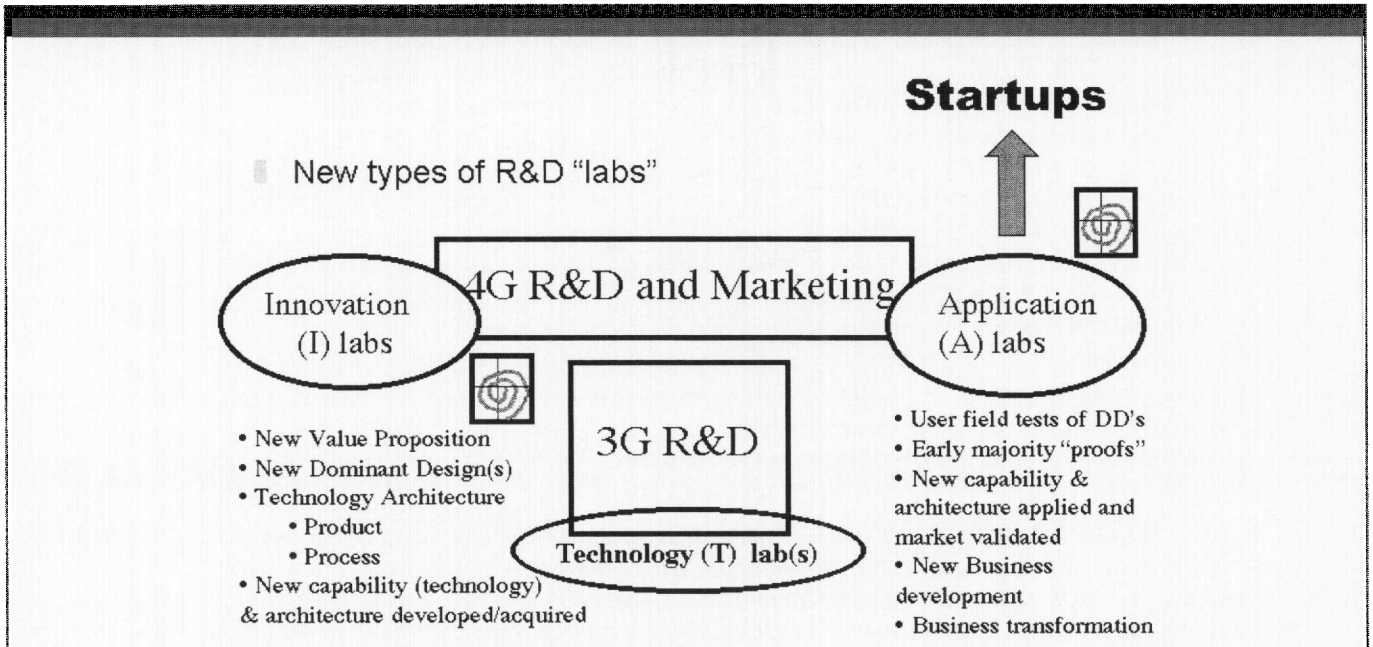

Figure 11.—Here, 4G Principles 9 and 10 are shown as "T-shaped" R&D and marketing functions and new types of "labs" that fill gaps in the 3G innovation process between research and the market. An innovation lab focuses on developing capability and architecture for new dominant designs and uses a spiral process to let customers experience the new value propositions as applications. The application lab focuses on taking the innovation to market and can act as an incubator for startups that participate in the lab. Typically, the innovation lab is a "public" consortium on a university campus and the application lab is a proprietary partnership off-campus that builds additional prototypes and conducts further tests of customer applications. An example of an innovation lab is Project Oxygen in the Laboratory for Computer Science, directed by Michael Dertouzos at MIT. The lab operates with a hypothetical system architecture for the future of computing and communications, has ambitious goals for customers, and tests complete new application environments with users.

discover and develop new dominant designs and capabilities that then drive an efficient stage-gate process for product development.

Donald E. Stokes proposed a similar dyadic model, called use-inspired basic research, to improve basic science and technological innovation and to change the Vannevar Bush model of R&D, which separated understanding from use and created the dichotomy between basic and applied science (*13*).

In funding 4G labs, more capital for innovation is allocated to external sources of R&D than to internal sources. A study of new sources of funding for innovation was reported by Ralph Wyndrum (*14*). Among 28 information technology companies, "5X" more funding was being spent on external R&D using acquisitions and minority equity investments (MEIs) than was being spent on internal R&D. In the first half of 2000, the increased funding of R&D as a percent of revenue was (1) MEIs for R&D—8.36 percent, (2) acquisitions specifically for R&D—11.0 percent, and (3) internal R&D—3 to 4 percent. That's 19.36 percent for external R&D compared to 3 to 4 percent for internal R&D and a total funding for all R&D of nearly 23 percent!

11. A New Corporate Organization and Leadership Is Required, Including a Chief Innovation Officer.

As shown in Figure 12, R&D and marketing activities split in the new 4G organization. 3G R&D and marketing organizations are mainly linked to operations for existing 3G businesses managed by the COO, and 3G businesses manage new capability development that adds value to existing dominant designs. In contrast, 4G R&D and

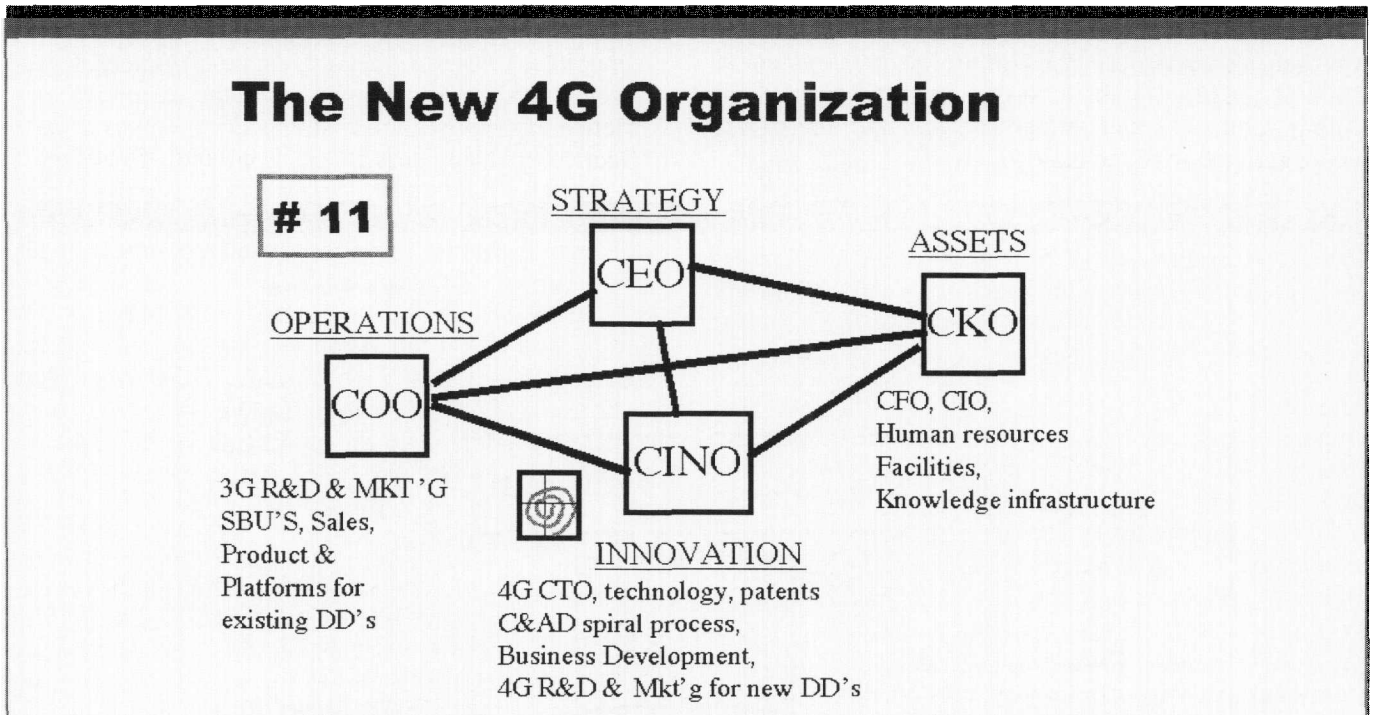

Figure 12.—With Principle 11, 4G innovation recommends a new organization and new leadership that includes a chief innovation officer (CINO), who manages the new spiral process for capability and architecture development (C&AD). The organization is networked. The COO manages the 3G model and stage-gate process of new product development within existing dominant designs. The COO is a customer for new capability and architecture, and 4G feeds new dominant designs to 3G using the "ABC" pipeline. "A" is existing capability in the core business, structured by existing architecture; "B" is capability and architecture in the pipeline intended to become part of "A" next year; and "C" is capability and architecture being researched and developed to become part of "B" next year and "A" two years from now. Because intangible assets such as intellectual capital now generate more shareholder value than tangible assets, the CFO, CIO and head of human resources all report to the chief knowledge officer (CKO). The CFO must also practice options finance in addition to intellectual capital accounting to support learning and innovation for growth. Facilities, information systems and human resources form a knowledge infrastructure. Knowledge infrastructure engineering expands and augments industrial and operations engineering.

marketing organizations are mainly linked to a chief innovation officer (CINO) who manages new capability development (which is part of new dominant designs) by funding and directing research and business development activities that include venturing.

The new spiral business process of capability and architecture development is managed by the CINO. The process feeds both internal and external customers. The responsibility of implementing new capability and architecture is shared between the CINO and customers. To link the spiral business process to individual creativity, group learning such as field trials and "trusted" operations, 4G uses a three-stage "ABC" pipeline of activities for the process and new management practices (*15*).

The ABC pipeline stores and incubates the flow of new capability and dominant designs into the existing organization and changes the culture. People become "Marco Polos" and work on projects in both 3G and 4G organizations to transfer knowledge and capability. "A" represents the existing capability managed by the COO based on current dominant designs. It forms the objectives, projects and performance reviews in most organizations. "B" represents new capability and architecture for new dominant designs that will become part of "A" next year. In most 3G organizations, "B" doesn't exist. "C" represents planning experiments and research for what will become "B" activities next year and in the years to follow. The CINO manages the "B" and "C" activities.

The 4G CTO leads development of technology for strategic capability in both existing and new dominant designs. When a business needs "smart networked products" such as OnStar, the 4G CINO and 4G CTO have the responsibility for the discovery and initial development of new *business and technical* capability and architecture, respectively.

12. New Extended Enterprise ("Galaxy") Model Spurs Innovation.

Capability for customer solutions can be effectively created and supplied by a galaxy of partners operating as an extended enterprise. A horizontal architecture enables them to effectively work together. As partners, they share both the sales and the knowledge channel to interact with customers.

The story of the Ford Tri-Motor illustrates the importance of starting with a customer value proposition for market development (a transportation business with cars and new commercial aviation) and then creating the capability and architecture for an extended enterprise as a solution (*2*). The Tri-Motor was the first plane to have a metal skin and the right mix of other critical features such as size, efficient and adequate payload capability, comfort, and reliability to become the first dominant design for passenger aircraft. These features included

The 4G CTO leads development of technology for strategic capability in both existing and new dominant designs.

having enough engines to sustain flight after an engine failure, an enclosed cockpit separate from a spacious enclosed passenger compartment with lavatory and uniformed flight crew including flight attendants.

So, the product and in-flight services were established as a dominant design with the right mix of features. But, Henry Ford also created dominant designs for the infrastructure, including airports, and advertising to create new demand for a compelling vision of air travel. Customers included newly created United Airlines. The Ford Aircraft Division lasted seven years before it was closed in 1932, largely because the Great Depression killed demand for air seat miles and Ford wanted to focus resources on defending the car business against a competitor with new strength in the market, GM.

The Potential of 4G

Technological innovation is the main driver for economic growth. It is like quality in the sense that it's an attribute of products and services, the business/university/government system, markets, an industry, and the economy. But unlike quality, the potential impact of innovation is open-ended and thrives on variation and divergent thinking. Quality culture can seriously retard innovation, especially when management fears losing control of the innovation process.

4G enables effective management of the divergent thinking needed for renewed growth; it introduces a new spiral process that can be easily controlled and executed many times per year. Venture capital and corporate venturing have different goals regarding the time frames for sustained growth, but 4G can improve the speed and yield for both kinds of innovation. The university/government/industrial R&D system created by Vannevar Bush after WWII needs a significant update, which 4G offers. Since about 1988, business value measured by stock market valuation has been primarily determined by intangible rather than tangible assets. 4G

includes system accounting variables (capability and architecture) that measure both tangible and intangible assets.

Limited growth challenges the leadership of industrial R&D to adopt new management principles and practices. To a great extent with 4G, industrial R&D can overcome the core barriers and fill the gaps in the existing business system that are restricting the potential of technological innovation to produce business growth. ◆

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