Unit 7

TITLE: THE TECHNOLOGICAL INNOVATION PROCESS

PURPOSE: The purpose of this unit is to provide an overview of the technological innovation process as it occurs within the private sector. An understanding of the process will assist Federal laboratory personnel in transfer efforts directed toward commercialization, since they will have an insight into the overall dimensions of the process to which they will be contributing.

OBJECTIVES: Upon completion of this unit, participants will:

- Have attained a good understanding of the formal dimensions of the technological innovation process
- Have focused on the centrality of adoption in the marketplace
- Have been introduced to the fundamental concept of design
- Have reviewed the historic dimensions of innovation, with particular emphasis on how products develop incrementally after market introduction.

MATERIALS:

Transparency 7-1: The Technological Innovation Process
Transparency 7-2: The Xerox Machine
Transparency 7-3: So Why Should I Care?
Transparency 7-4: Technological Innovation Process
Transparency 7-5: Adoption
Transparency 7-6: Adopters
Transparency 7-7: Adoption and Diffusion
Transparency 7-8: Social Dimensions of Innovation
Transparency 7-9: Direction
Transparency 7-10: Need
Transparency 7-11: Creative Act
Transparency 7-12: Creation As A Process
Transparency 7-13: Objections
Transparency 7-14: Developmental Process
Transparency 7-15: Technology and Products
Transparency 7-16: Development as Design
Transparency 7-17: Production and Marketing

Transparency 7-18: Historic Dimensions of Innovation

Transparency 7-19: Incremental Innovation

Transparency 7-20: Technology As A Stream

REQUIRED READING:

1. Review pages II-22 through II-34 (the section on the Technological Innovation Process) of Issue Paper II--The Technology Transfer Process.

2. Donald G. Marquis, "The Anatomy of Successful Innovations," pages 42-50 in Michael L. Tushman and William L. Moore, eds., Readings in the Management of Innovation, Pitman Publishing Inc., Marshfield, Massachusetts.

3. Donald A. Schon, Technology and Change, Chapters I (The Process of Invention) and II (Innovation, Uncertainty and Risk), Delacorte Press, New York, 1967.

OPTIONAL READING:

1. P. Ranganath Nayak and John M. Ketteringham, Breakthroughs, Chapter III (3M's Little Yellow Note Pads: "Never Mind. I'll Do It Myself"), Rawson Associates, New York, 1986.

2. Tracy Kidder, The Soul of a New Machine, Avon Books, New York, 1982.

3. Richard C. Bourne, "Development of a Circular Strike Plate," Case 9 (pages 327-371) in H. O. Fuchs and R. F. Steidel, eds., 10 Cases In Engineering Design, Longman Group Limited, London, 1973.

NOTES TO INSTRUCTOR:

1. This unit is dependent, in part, on the understanding of the nature of technology presented in Unit 3 (Technology). In Unit 3, emphasis was placed on the disembodied qualities of technology. In this unit, however, the emphasis shifts to embodiment, since the innovation process is concerned with the development of products, which necessarily have a material form.

2. This unit presents the innovation process in a formal manner. The theme is picked up in Unit 8 (The Innovation Process in the Company), which places the formal process in a company setting. Unit 9 (Technology Transfer and the Private Sector) then carries the theme forward by focusing on the

innovation process in the private sector in its relation to technology transfer.

3. The required reading by Marquis provides a brief introduction to the innovation process along with a model that has achieved widespread acceptance. The required reading by Schon presents a provocative view of the non-systematic aspects of the innovation process.

4. It is difficult to get a feel for the innovation process unless one has personal experience or a fully documented case study. Unfortunately, there are no case studies describing the entire process from invention through market introduction of a product. The optional readings by Nayak and Ketteringham and by Kidder concentrate on the invention end of the spectrum, but both provide exciting reading. The optional reading by Bourne is a case study in design, which is a fundamental feature of the innovation process. It shows that the creation of even a simple technology such as a door strike plate is a complex, time-consuming, and creative process.

3. In the absence of an innovation process case study, the instructor may wish to develop one over time to illustrate (or modify) the description of the formal features of the process presented in this unit. Since this would require investigation of documentary materials, the instructor should choose an important innovation such as the Xerox machine, or perhaps the series of inventions by Charles Kettering that gave rise to the automobile ignition system (which is partly documented in Stuart W. Leslie, Boss Kettering, Columbia University Press, New York, 1983).

ESTIMATED TIME:

30 minutes for presentation
50 minutes with discussion

Unit 7

THE TECHNOLOGICAL INNOVATION PROCESS

Transparency 7-1: The Technological Innovation Process

> NOTE: EXPLAIN THE PURPOSE OF THIS UNIT AND WHAT PARTICIPANTS SHOULD HOPE TO ACCOMPLISH.
>
> NOTE: IF NECESSARY, REVIEW THE BASIC CHARACTER OF TECHNOLOGY PRESENTED IN UNIT 3.

INTRODUCTION

First, let's clarify what we are going to be describing today. We will not be talking about the innovation process per se, but about the technological innovation process.

We can speak about the innovation process with respect to anything that comes into existence and is developed, adopted, and spreads. A religion like Christianity, for example, can be spoken of in these terms.

However, what we will be addressing today is the technological innovation process, which is concerned with how useful, or utilitarian, things are created, developed, and adopted.

In our review of the nature of technology (in Unit 3), we found that some technologies have a material embodiment. Tools, industrial processes, and products are examples. But others such as techniques and methods are not physical things.

Unfortunately, we will have to exclude non-physical technologies from the present effort to describe the innovation process. In spite of their importance, there are no adequate models to display how such things as management techniques emerge out of practice; and it may be that non-physical technologies are too varied and complex to be understood in terms of a common form of development.

Products and processes are the two major types of tangible technologies, and a few decades of effort have been devoted to modelling the innovation process for them. We will be concentrating on product innovation; and, in order to get an overview of what we will be talking about, it is best at this point to introduce an example.

Transparency 7-2: The Xerox Machine

The Xerox machine began as an invention, which is illustrated at the top of the transparency by Chester Carlson's patent drawing. In order for that patent to result in something that could be used, a long period of experimentation and development ensued, which is briefly illustrated by the photographs in the middle of the transparency. Finally, a product was developed that was introduced to, and accepted by, the consumer.

When we speak of the technological innovation process, we are referring to this whole process by which a technology is created and developed and accepted (or adopted) in the marketplace as a product that is put to use.

In our earlier discussion of technology, we suggested that a technology precedes any physical embodiment, and that's true. Photoduplication technology--what we have referred to as the functional essence of a technology--is revealed in Carlson's patent.

However, a patent can't make copies of letters. In order for the technology to be used, there must be a material manifestation. The innovation process includes invention, but brings the technology through development into a concrete product that is adopted in the marketplace.

ARE THE PARTICIPANTS CLEAR ABOUT THE PARAMETERS OF DISCUSSION?

NOTE: IN ATTEMPTING TO ILLUSTRATE JUST HOW FAR A TECHNOLOGY IS FROM A PRODUCT, THE INSTRUCTOR MAY WISH TO DISTRIBUTE COPIES OF CHARLES KETTERING'S INITIAL SKETCH OF WHAT EVENTUALLY BECAME THE AUTOMOBILE IGNITION SWITCH (WHICH CAN BE FOUND ON PAGE 136 OF FRANK DONOVAN'S WHEELS FOR A NATION).

RELEVANCE

Transparency 7-3: So Why Should I Care?

Before describing the process itself, it's best to address a question that is probably on your mind. Why should Federal laboratory personnel be interested in how products and processes are created, developed, and adopted?

There are two important reasons:

1. First, most Federal laboratories have been created for the production of useful things and therefore are engaged in innovation processes. Some of the useful things created are intangible (for example, a measurement standard or a new form of contour plowing). Others are destined for the production of tangible things. Laboratories generally don't make these things themselves, but place this responsibility in the hands of contractors. In such cases, laboratories are involved in innovation processes that are carried out by more than one organization. The intended adoptors are many and include Federal, state, and local government; institutions; companies; and individuals.

   If laboratories understand the innovation process better, they have a better understanding of what they in fact do. In addition, Federal laboratories have been subjected to a lot of criticism for having joined in the development of some expensive things that haven't proven to be very useful. Generally, this has happened when laboratories have become too enamoured of their technologies and haven't set their eyes firmly on the intended use. With a better understanding of the innovation process, and particularly its orientation toward the production of useful things that are to be adopted, they can do a better job of fulfilling their primary missions.

2. Second, Federal laboratories have been given a secondary mission of technology transfer that places heavy emphasis on commercialization. If laboratories know more about the innovation process in the private sector, they will be in a better position to respond to private-sector needs and to work with the private sector to commercialize technologies.

DO THE PARTICIPANTS UNDERSTAND THEIR PRIMARY MISSION ACTIVITIES AS PART OF INNOVATION PROCESSES?

<u>NOTE:</u> THE ROLE OF TECHNOLOGY TRANSFER IN INNOVATION PROCESSES IS ADDRESSED IN UNIT 10 (MANAGEMENT OF TECHNOLOGY TRANSFER).

PROCESS ELEMENTS

Transparency 7-4: Technological Innovation Process

We have defined the technological innovation process as the process by which useful things are created, developed, and adopted. This definition can be used to begin our description of the process by simply placing the three elements in sequence.

This simple rendition displays the basic steps by which a product-embodied technology or an industrial process becomes an innovation; that is, the technology must be created, developed, and adopted. Through adoption the technology becomes an innovation.

Adoption

Transparency 7-5: Adoption

Most discussions of the innovation process begin at the beginning and proceed step by step to the end. However, if we understand a process as an ordered series of events directed toward a particular end, it's obvious that the end towards which the process is directed is the first thing that needs to be discussed.

Transparency 7-6: Adopters

The technological innovation process ends with use of the technology. If we are looking at industrial process technologies, there may be only one user: the institution that creates and develops the industrial process. However, the industrial process may be adopted by other institutions through natural diffusion, or it may be treated as a saleable item by the originating institution and offered to other institutions at a price.

If the technology is embodied in a product, the users will be outside of the originating institution and would include such groups as consumers, companies, and government. In these circumstances, there's a radical discontinuity in the innovation process, since different entities are responsible for creation and development on the one hand and adoption on the other.

Transparency 7-7: Adoption and Diffusion

The innovation process could be said to end with a single adoption. However, with respect to product-embodied technologies, the originating institution will obviously be interested in multiple adoptions, since that is the only way in which money can be made on a product.

The innovation process is often said to end with widespread adoption in which a technology is used on a scale having substantial societal impact. This is sometimes spoken of as diffusion, which can take place through many initial adoptions, or through the spread of a technology when initial users demonstrate the value of a technology to other potential users.

Transparency 7-8: Social Dimensions of Innovation

The adopted technology often has a dramatic effect on the adopting organization or society. The adopted technology is also adapted to specific conditions of use. In addition, a revolutionary technology like the automobile or jet airplane can induce a whole new set of innovative activities, since economic and social systems must be developed to make the technology fully functional. These adoption/adaptation responses are referred to as the social dimensions of innovation.

Transparency 7-9: Direction

In the light of this brief description of adoption, it is already apparent that there is something wrong with our simple diagram of the technological innovation process.

The blocks suggest that we are dealing with discrete elements in which one step leads to another and that adoption is but one element in the process. However, if adoption is the end toward which the innovation process is directed, then it governs all steps and should be understood as suffusing and animating them.

NOTE: ALTHOUGH A TECHNOLOGY MUST BE CREATED, DEVELOPED INTO A PRODUCT, AND ACCEPTED IN THE MARKETPLACE FOR THE INNOVATION PROCESS TO BE COMPLETED (WHICH IS ILLUSTRATED BY THE SMALL, DESCENDING ARROWS IN THE TRANSPARENCY), THE PERSPECTIVE ON MARKET ACCEPTANCE NEEDS TO GOVERN THE WHOLE PROCESS (WHICH IS ILLUSTRATED BY THE LARGE, ASCENDING ARROW). SINCE THIS IS A NEW MODEL OF THE INNOVATION PROCESS, THE INSTRUCTOR MAY WISH TO DISCUSS IT WITH THE PARTICIPANTS.

Creation

From this perspective, it is easy to see why most studies have found that creative activity in the technological innovation process is generally initiated by a concept of need.

Transparency 7-10: Need

If a company is developing an industrial process for internal use, the need is apparent, and so are the desired performance qualities. Satisfaction of internal process needs is a fairly straightforward operation. However, if the intended user is external to the organization that creates the technology, need is indeterminate and satisfaction is more complex and difficult.

This is generally the case with technologies that are to result in products. If need for a product was quite specific and easily seen, the product would be designed to meet the need and would achieve an easy success in the marketplace.

The primary reason that there are so many product failures is that need is usually indeterminate. It reaches a high state of determination only when the need is well articulated, which happens when a company has secured a delivery contract for a product that has not yet been developed, or when a company receives strong signals from its customers for modifications to an existing product.

In normal circumstances, however, the concept of need that gives rise to the act of creation is merely a shrewd hunch that the product will be found desirable in the marketplace. Such hunches may lead to the creation and development of products that prove to be market failures even when the hunch is well founded and based on a lengthy market analysis, as happened with the synthetic leather Corfam.

HOW WELL DO THE PARTICIPANTS THINK NEED IS USUALLY ARTICULATED?

Transparency 7-11: Creative Act

<u>NOTE</u>: THIS IS A CARTOON TO ILLUSTRATE A POINT AND MAY NOT BE A FAITHFUL REPRESENTATION OF HOW THE PIPE LIGHTER CAME INTO EXISTENCE. THE CONCEPT OF FUNCTION IS ADDRESSED IN UNIT 3 (TECHNOLOGY).

The creative act in successful technological innovation is usually a synthesis of three different elements:

1. A concept of need;
2. A concept of function to meet the need; and
3. A concept of the technical satisfaction of need and function.

Need and function are closely related but should be sharply distinguished. The concept of need is, as we have just said, an anticipation that something will be found desirable in the marketplace. Function is what we have referred to as the essence of a technology: what it is capable of doing.

We can certainly create things with certain functional abilities for which there is no need. A device for extracting tap water from champagne would be an example. And, it should be realized that most patented inventions will never become innovations. Although they embody concepts of function and need, the need is not strong enough to induce market acceptance.

A concept of technical satisfaction is the third element in the act of technological creation. We may have a concept of need and of some functionality to meet that need, but no solution may be available. Leonardo da Vinci's notebooks are filled with examples.

When we are considering things that are made, technical satisfaction implies material satisfaction, since some tangible thing must be created. No material thing can be created out of nothing. As a consequence, most new technologies are composites of existing technologies.

The creative act in technological innovation is a goal-directed synthesis of existing technologies that serve as components. Each of the component technologies is a subfunctional element that must be organized and modified as needed to achieve the desired effect. At times, new subfunctional elements must be created when the pool of available components is deficient.

Transparency 7-12: Creation as a Process

The creative act is itself a process. A need is identified, which is usually formulated as a problem. One begins to form a concept of the particular operational characteristics that would resolve the problem. Generally, many different courses of action are open, each of which has various advantages and disadvantages. One or more is tried, with combinations of various elements, modifications, and new subcreations in a complex, frustrating, and repetitive process until the desired effect is demonstrated.

The process of creation is a design process. Design is concerned with how a thing is to be structured and what it is to look like. Need establishes the performance criteria that must be met through the assemblage and modification of components and serves as a continuing focus for the emerging creation. Each change to a component requires changes to other components, since everything must work together to achieve the desired effect.

Transparency 7-13: Objections

It is sometimes objected that the process of creation isn't always initiated by a concept of need, since creation may begin through the suggestion of a scientific idea or through the identification of a new phenomenon. The objection is correct, but the implications are not all that dramatic.

If the scientific idea originates in an industrial research laboratory, it usually does so within the context of applied science activities that are directed toward a range of needs identified by the company. In the case of the results of pure science, the scientific idea is a necessary, but not a sufficient condition, for technological creativity. The discovery of the structure of genetic material, for example, was necessary for biotechnology to be, but it doesn't tell us anything about how biotech products come into existence. In any case, knowledge must be translated into design.

The accidental creation of a new material is often used to illustrate creativity that begins in the identification of a new phenomenon. However, an accident is merely an accident unless it happens to a prepared mind that can envision its utility; and, the words "new material" themselves contain a concept of use. The important point is not what occurs first in the process of creation, but the criteria that must be met for the technological creation to be achieved.

NOTE: IN THE REQUIRED READING BY SCHON, THE IRRATIONAL ELEMENTS IN CREATION ARE EMPHASIZED. DISCUSS WITH THE PARTICIPANTS THE CONTRAST BETWEEN SCHON'S VIEW AND THAT PRESENTED IN THIS UNIT.

Development

Transparency 7-14: Developmental Process

We have described adoption and creation and have asserted that the essence of a technology is in its function rather than in its material embodiment. Since a technology exists through its creation, why is it necessary to incorporate a development phase in the innovation process?

For the simple reason that a technology is not a product. Technological creation is largely an intellectual process, though it often involves tinkering and the construction of models. At the end of the creative process there are sketches and drawings and sometimes rudimentary models that demonstrate the validity of the design concept. These are in no condition for use by anyone.

The identification of a technology with its functional capacity should not be used to denigrate the material manifestation. Obviously, the functional essence of products and industrial processes would not be operational unless they were embodied in matter. A technology that is destined to become a product can't do anything unless it becomes tangible.

A product is a technology dressed for market; that is, a function placed in a physical envelope that makes it operational and acceptable. Part of the technological innovation process is concerned with how a technology comes into existence; but most of it is concerned with how the technology comes to be dressed for market. This latter element constitutes the development phase.

At the end of the creation phase, there is a skeleton of a technology, most of which is on paper. The skeleton is simple, lacking a full bone structure. Some pieces are missing, and there are a few bent bones. The skeleton has no flesh and is not dressed.

Development is the process of filling out the skeleton. Decisions must be made about which bones are needed, then the skeleton must be given flesh and clothing. Development generally involves the preparation of detailed designs, the construction of prototypes, and the performance of tests. At the end of development, the final design is ready to go to production for the duplication of copies.

A technology, in itself, has little economic value unless it serves as the basis for products or industrial processes. Most inventions never proceed to development; and of those that do, most never emerge from development. Many that emerge from development never become products; and of those that do, many fail. The cost of invention is small compared to the cost of development, and the time involved in invention is brief compared to the time involved in development.

Transparency 7-15: Technology and Products

Products are things that are offered for sale. To be acceptable, they must meet the needs and desires of particular groups of purchasers. Each of these groups must deal with a technology under specific conditions of use. As a consequence, development work is market specific and must segment and refine the general utility embodied in the created technology into the specific requirements of potential buyers.

At times, a technology that emerges from the creative process has a high degree of market specificity and development work is fairly straightforward. At other times, however, the identified need that gave rise to an invention may provide a range of utility that is not product specific.

Computer technology, for example, has many different product applications. In addition, the sense of potential use contained in a technology may be vague, as was the case with the failed glue that eventually resulted in Post-It note pads. Here, a technology was looking for a specific market application. On the other hand, use may be specific, but not formulated in terms of the requirements of a particular customer, as was the case with microwave technology before an appliance manufacturer envisioned a product in terms of the housewife's needs. Lastly, envisioned use may be specific, but the target audience ill conceived, as was the case in Sperry's initial attempt to sell his gyroscope to the circus for balancing acts.

The development effort forces these issues because development must be concerned with a target audience. This often requires a second invention--the conceptualization of the specific product form that the technology will take. This second invention is generally much more important than the first invention, because products are more important than technologies in the innovation process.

NOTE: THE SECOND INVENTION MAY BE A NEW CONCEPTUALIZATION OF THE PRODUCT, WITH REQUISITE MODIFICATIONS, OR IT MAY BE A NEW MARKETING APPROACH. XEROX BECAME A COMMERCIAL SUCCESS WHEN IT WAS REALIZED THAT CONSUMERS WERE INTERESTED IN PURCHASING COPIES RATHER THAN IN PURCHASING THE MACHINES THAT COULD PRODUCE THEM.

Transparency 7-16: Development as Design

NOTE: DESIGN IS CENTRAL TO THE INNOVATION PROCESS. IT OCCURS IN THE INVENTION STAGE, MOST IMPORTANTLY IN THE DEVELOPMENT STAGE, AND EVEN THEREAFTER. THE OPTIONAL READING BY BOURNE (IF USED) CAN SERVE AS A GOOD ILLUSTRATION AND BASIS OF DISCUSSION FOR THIS POINT.

Development is essentially a design process that determines the structure and appearance of the emerging product. It usually extends the design begun in the creation phase, but gives it much more concreteness. In development, design moves toward market specification, which generally involves important changes to the preliminary design and may involve scrapping the preliminary design and picking up on a previously rejected alternative.

Technological products are usually composed of many different technologies. A bicycle, for example, is a composition of wheels, sprockets, chain, saddle, and frame, each of which is a component function contributing to the function of the whole. And within these major parts there are subfunctionalities, such as the tire, rim, and spokes contained in the wheels, and beneath that the components of the spokes, down to the material base.

Since technological products are functional complexes, they must be designed as systems. As a consequence, development must approach the emerging product holistically. During development, every change to an emerging component refracts throughout the system, giving rise to a need for other changes. At the end, all of the parts must work together to achieve the desired effect.

Development cannot be concerned with technical perfection. It is a satisficing activity that must bring into balance many different factors to produce an acceptable product. Two of the major considerations of development are the performance criteria that must be displayed in the product and the cost of the product. Higher performance can usually be obtained at higher price, but higher price may not be acceptable to the purchaser. Thus, performance may have to be reduced. Design in development is necessarily a tradeoff activity that must keep one eye on the emerging technology and another eye on the potential market.

WHAT DO THE PARTICIPANTS THINK ARE THE IMPLICATIONS FOR TECHNOLOGY TRANSFER OF THE CONSTRAINTS ON DEVELOPMENT IN THE PRODUCTION OF A PRODUCT?

Production and Marketing

Transparency 7-17: Production and Marketing

There are two additional steps in the innovation process that can be covered briefly. The first of these is production.

The development phase ends with a fully fleshed technology, which may take the form of a full-scale model. However, one instance does not make a product. Since products are offered to customers, they must appear in multiple instances. This making of multiples is the function of production.

The introduction of a new technology may require a new production facility. If not, adjustments to the existing production processes will be needed. In addition, further design work may be undertaken as the costs of adjustments become clearer and the manufacturing process reveals unsuspected problems in the final design.

Lastly, marketing introduces the product to the customer, often on a test basis with subsequent modifications. The fate of the product is now largely in the hands of users, but can be affected by advertising. If widespread adoption is achieved, the innovation process is completed.

NOTE: PRODUCTION AND MARKETING ARE DESCRIBED HERE AS STEPS IN THE INNOVATION PROCESS AND NOT AS COMPANY FUNCTIONS. WITHIN THE COMPANY, THE MARKETING FUNCTION (OR GROUP) ASSUMES A MUCH LARGER IMPORTANCE, SINCE ALL INNOVATIVE ACTIVITY IS DIRECTED TOWARD MARKET ADOPTION (WHICH WAS THE POINT MADE PREVIOUSLY IN THE DISCUSSION OF THE BASIC STRUCTURE OF THE INNOVATION PROCESS).

HISTORIC DIMENSIONS OF INNOVATION

Transparency 7-18: Historic Dimensions of Innovation

After the various steps in the innovation process have been described, is this all that can be said about innovation? Certainly with the introduction and diffusion of a new technology in product form we can say that the innovation process is completed in some sense. However, innovation has an historic as well as a time dimension.

Most new technologies are based on previous models. Watt's steam engine, for example, was a modification of the Newcomen engine. Most new technologies also emerge from a stream of previous failed attempts at invention, and from attempts parallel to the one that proves successful. And, all technologies are composites of existing technologies. As a consequence, a new technology does not appear from nowhere but emerges from a longstanding series of technical developments.

At the other end of the innovation process, a newly introduced technology seldom achieves the full dimensions of its functional potentials. Work still needs to be done. Part of the needed work is obvious from an engineering perspective, as, for example, in the quest to achieve smaller and faster in transistor technology. Customers provide feedback, which leads to product improvement. Old components are improved and new components are introduced. Some of these new components, such as the introduction of jet engines in airplanes, dramatically transform the potentials of the existing technology.

Transparency 7-19: Incremental Innovation

We tend to identify technological innovation with major product and process novelties. However, the newly introduced technology is often quite crude. Evolution takes place over long periods of time with incremental improvements that contribute significantly to technological progress.

We are all acquainted with the changes that have taken place and are taking place in such things as computers and automobiles. Studies have also shown that incremental improvements to such industrial processes as catalytic cracking in the petroleum refining industry have produced cost reductions that exceed the effect of the process when it was newly introduced.

Incremental improvements, which may be infinitesimal and introduced on a daily basis, could be conceived of as instances of innovation. So could the introduction of an improved product as a new model. The important point here is not whether we choose to call these innovations, but rather to recognize that technological innovations are in a constant state of development in which their essential qualities are progressively realized. Cumulative minor changes produce major changes in usability.

Transparency 7-20: Technology as a Stream

If we look at the beginning of a technological innovation, we find antecedents that are themselves based on antecedents. And, if we look at what happens to a technology after it is introduced, we find a long trail of subsequent improvements and that the technology itself serves as a basis for new innovations. In addition, social systems are developed to enable the technology to reach the full dimensions of its use potential.

Thus, both technology and the innovation process should be thought of as streams of development with historic dimensions. The creative act, though important in itself, rests on many different contributions and is completed through many different contributions. Thus, innovation is a social activity that points backward in time to the first thing made and forward in time to an indefinite future.

<u>NOTE</u>: REMOVE TRANSPARENCY FROM SCREEN AND ASK FOR ADDITIONAL QUESTIONS AND COMMENTS.
