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Technology Transfer

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Background

People engaged in research and development across government, corporate or university laboratories – as well as those working in their homes or garages – all work toward an explicit goal of moving from idea through application to beneficial impact on society. They discover new technology-based capabilities, embody their functional benefits in prototype inventions, and eventually manufacture innovative products. Matching those novel capabilities to extant needs in the marketplace is the challenge of technology transfer. The challenge is magnified by the array of extraneous factors that may act as barriers to a successful transfer, even for well matched needs and capabilities. Technology transfer brokers apply their expertise to mitigate these barriers, and organizations pursue technology transfer with expectations of success.

Technology-based devices for rehabilitation or daily living – hereafter referred to as Assistive Technology (A/T) – are great equalizer for millions of Americans with disabilities, increasing functional independence, earning power, and social opportunities (U.S. Department of Commerce 2003). Technology transfer is an important mechanism for transforming technological capabilities generated through research and development projects, into new or improved features and functions within A/T and even mainstream products. Making the technology transfer process more systematic and successful is critical to improving the number and quality of A/T products in the marketplace. Success typically requires the collaboration of multiple stakeholders (Muir 1998).

What is technology transfer? Despite the dearth of rigorous analysis and the absence of consensus on a single definition, one can readily focus discussion by identifying the unique value of "technology transfer" that differentiates it from related activities and initially prompted coining the phrase. For example, it is decidedly different than an intra-organizational movement of technology between departments or phases, because such activity evolved with modern organizational theory and practice. It is other than the passing of practical knowledge first formalized through medieval apprenticeships, and now practiced as education and training in formal and informal settings. It is more than invention, intellectual property protection, prototyping or production, although all of these are elements of the process.

Technology transfer does and should continue to represent a value-added process that encompasses a continuum of range of related activities from laboratory innovation through market consumption. The phrase "technology transfer" is operationally defined here as:

(*what*) the novel application of existing technologies or prototype devices,
(*who*) by members of multiple stakeholder groups,
(*where*) operating through Research and Development facilities,
(*when*) collectively viewing transfer as a feasible and attractive option,
(*why*) to commercialize an innovation or address an unmet need,
(*how*) through the synergistic matching of capabilities to needs.

Technology transfer's unique promise is in gaining access to a technology with significant value for a new market, without having to replicate the initial development effort and associated cost for the original intended

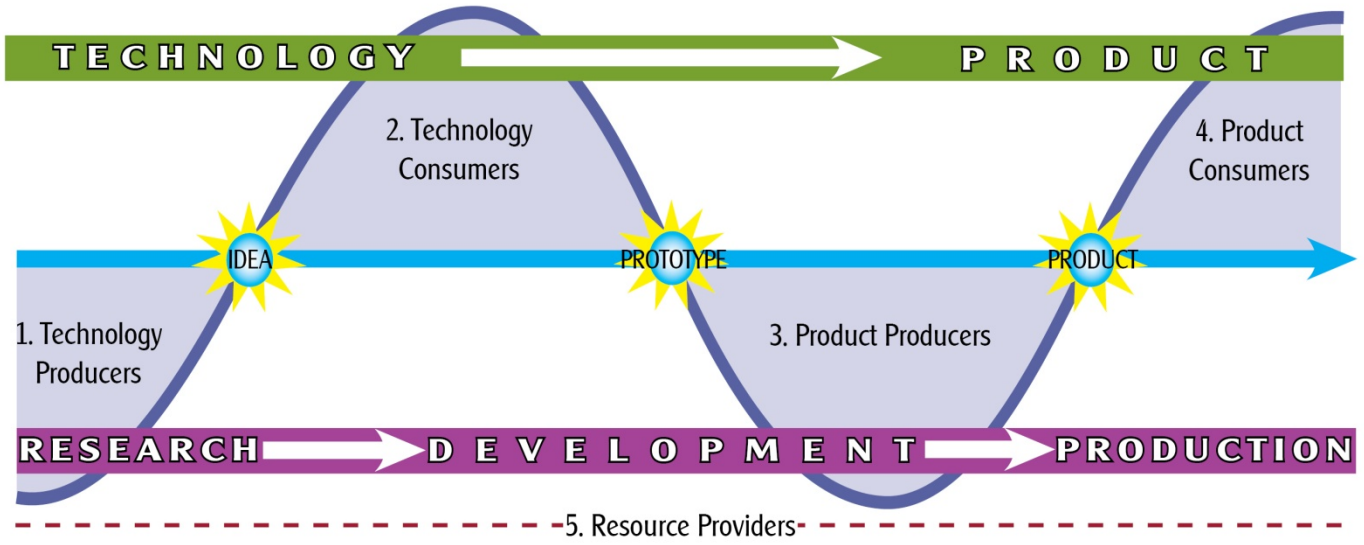
market. It offers a "win-win" situation for the participants. By implementing an already developed (and already financed) technology in a new and novel application, the originators gain returns from a new market and the appliers meet a need while avoiding the cost of development.

Technology transfer is an appropriate tool for both large and small markets. Larger markets translate into larger returns, so participants will always seek the broadest applications possible. The promise of large returns may expedite decisions to proceed or secure needed resources. Although the economic incentives are less for smaller markets, technology transfer may be the most feasible option for small companies. Lacking internal resources or expertise, small companies may innovate rapidly through technology transfer. The concept of "spin-off" enterprises derives from people who see a new application for an existing technology/prototype, and leave a larger resource-laden environment for a small resource-constrained venture, based on the innovation's expected value in the market. Assistive technology for people with disabilities was traditionally dominated by niche or orphan markets served by relatively small manufacturers with limited development capital. The demographics of the aging Baby Boom generation are shifting the socio-economic factors toward more mainstream applications of interest to increasingly larger companies.

Technology Transfer as One Process

Technology transfer is really one overall process encompassing multiple elements that collectively transform technologies into products. The elements comprising technology transfer are routinely viewed as discrete activities, but it is more constructive to treat them as a continuous process from technology discovery through product consumption. Technologies enable a product's features and functions. For example, the manufacturer of a non-stick frying pan incorporates multiple technologies (e.g., metals, ceramics, plastics, and bonding agents), while the consumer only buys one product -- a frying pan with the desired non-stick feature (Camp and Sexton 1992).

A generic model of technology transfer characterizes the key elements of technology transfer within a single overarching process. As shown in the following Figure:



Two Forces Initiate the Technology Transfer Process

Technology transfer commences through one of two initiating forces. Forces at either the technology discovery end, or at the product consumption end, can initiate the technology transfer process. "Supply Push" is a process

by which the technology transfer process is initiated through an effort to apply a technology's utility within a new product -- the technology supplied is pushing toward the marketplace to address an assumed unsatisfied demand (Paul 1987). For example, a nursing home senior was falling when he rose from his wheelchair, because he had difficulty engaging the wheel locks. A therapist prototyped a device that automatically engaged the wheel locks as he rose. The device worked for the senior so the inventor then sought a broader commercial market for the invention through license or sale. (The Wheelchair Braking System was licensed to AliMed Inc. in 2002.) A classic case of Supply Push transfer; an invention intended for a limited application is assumed to be applicable to a larger population, without a validated expression of the market's need for their perceived solution. It is a gamble that may prove right or wrong.

Conversely, "Demand Pull" means that the technology transfer process is initiated in response to a validated market demand for a product feature or function. Companies may seek a solution to a problem articulated by their customers (Von Hippel 1986). As an example, the T^2RERC determined that wheelchair manufacturers and people with mobility impairments were dissatisfied with the inefficient battery charging process that often left them stranded with dead batteries. Once the market demand was articulated, we were able to identify a device in the automobile industry that enhanced the battery charging process and rapidly transferred the technology to the major wheelchair manufacturers (transferred from the University of Wisconsin to multiple wheelchair manufacturers.) Another source of demand pull activities can be found in the technology requests from manufacturers or NASA specifications circulated through the SBIR program, because they are market problems seeking a technology solution.

In some cases, breakthrough technologies (e.g., telephone, integrated circuits) enter the market through Supply Push activities and then Demand Pull forces expand their applications. Identifying the initiating force as either Supply Push or as Demand Pull helps validate the transfer opportunity, estimate market value, and assess the likelihood of future success.

Three Critical Events in the Transfer Process

The transformation from core technology to commercial product passes through three critical events: 1) Idea Event; 2) Prototype Event; 3) Product Event (Rogers, 1995). The Idea Event is the conceptual awareness that an existing technology might be applied within a new field. The Idea Event does not involve any tangible development. For example, an engineer thinks that composite materials used in aircraft could be transferred to improve consumer goods, by reducing weight while increasing strength and flexibility.

The Prototype Event occurs when a working model demonstrates that the idea functions as expected in an actual application; where the idea is "reduced to practice" in legal parlance. In our example, a prototype event is when bicycle and wheelchair frames formed from composite materials passed basic performance tests. The ensuing transition from feasible prototype to market product is the crux of technology transfer, because a manufacturer must decide to engage/invest in product development (Krishnan and Ulrich 2001). This decision is required whether the prototype is developed inside or outside a company.

From the manufacturer's perspective, assessing the prototype's commercial viability includes internal manufacturing capabilities, sales and marketing expertise, and product planning horizons (Day and Shoemaker 2000). Even then, the manufacturer's involvement requires successful negotiation of intellectual property, financial compensation, and due diligence terms with the prototype developer (Gutterman and Erlich 1997). Problems in any area will likely result in project termination. Manufacturers maintain an especially low rejection threshold for external projects.

The Product Event is when the first production quality unit leaves the assembly line for the marketplace. In our example, the proliferation of bicycle and wheelchair frames made from composite materials—along with limb

braces, tennis rackets, and golf club shafts— demonstrates the range of Product Events that can result from an initial Idea Event. It also shows the power of one technology to enhance the lives of people with and without disabilities.

The Product Event is the culmination of an arduous journey through the product development "valley of death," a series of gaps that must be bridged to achieve success (Rosenau 1996). The transition from prototype to product requires bridging three crucial gaps: 1) the Funding Gap between government and commercial support; 2) the Value Gap between academic knowledge and market potential; and 3) the Information Gap between technologists and marketers (Hartman and Lakatos 1998). Successfully bridging all three gaps leads to the further challenges presented by the tasks associated with product introduction. These include production, distribution, sales, marketing, and support activities (Jolly 1997).

Technology transfer managers and brokers must be mindful of all three critical events in the technology transfer process. The fact is that no matter how great the need, not all prototypes culminate in products with value to the marketplace. Market failures can often be traced back to activity preceding the Prototype Event, such as improper assumptions about ideas, incorrect information about markets, interpersonal conflicts, or the trajectory of parallel research making current work obsolete. Early decisions or actions by any stakeholder group should be considered as they may have grave consequences later in the process.

All of these activities must be considered in the developer's earliest transfer plans, because manufacturers will consider the cost of these activities in their transfer decision. These activities must also be tracked, quantified and budgeted -- they must be managed. As they are being managed they also have to be evaluated for their efficiency, effectiveness and added value for the business enterprise.

Five Stakeholder Groups Involved in Technology Transfer

The various stakeholders can be categories according to their functional roles in the process, which helps to determine where their input is needed and when they should cease involvement:

1. Technology Producers include the inventors and researchers who literally create new core technologies and the "know how" that permits their application;
2. Technology Consumers and
3. Product Producers include manufacturers and their partners who identify applications for technology and generate products that embody them (Pajer and Gibler1990);
4. Product Consumers are people with disabilities who are the end users of A/T, their family members, and professional intermediaries, who recommend or acquire products for use (Ulrich and Eppinger 1995);
5. Resource Providers consist of government agencies, third party payers, and process intermediaries who furnish funding and expertise for the competitive marketplace or furnish the requisite product demand in the absence of competitive market incentives (Prosser 1995).

Although all stakeholder groups play important roles in the transfer process, the manufacturers are critical as they are uniquely positioned to turn a prototype into a commercial product, while they are pivotal to the roles of other stakeholders (Scadden 1987). Manufacturers mostly rely on Product Consumers, including people with disabilities, as the customers for their products. To a lesser extent, manufacturers also rely on Technology Producers as a source for innovations in core technologies. For small markets like A/T, manufacturers also need the support of Resource Providers, like Federal agencies, because they fund development projects, regulate new products, or set reimbursement levels. Therefore, all of these stakeholders are considered target populations with manufacturers in the pivotal role.

Facilitating the process of moving prototypes to the marketplace – particularly in the field of A/T – must address the collective roles of all stakeholder groups across the entire technology transfer continuum (Mock et al 1993). To improve the process, one must consider the Technology Producers who create new technologies and enable their application and the Product Consumers who create the market for new products (Sheredos and Cupo1997). One must also consider the Resource Providers that support the early stage transition from idea to prototype and may later provide funding for product acquisition.

Overcoming Barriers to Transfer with the Application of Carriers

The transformation from invention to innovation contains numerous barriers and the challenge is to create carriers that overcome them. These barriers embody the "risk" associated with new ventures because they cause projects to fail. The following section describes some of these barriers and how to manage the associated risk by overcoming them by applying carriers (Auerswald and Branscomb 2003).

Communication barriers arise from the cultural context in which information is stored and retrieved (e.g., academic versus industry cultures). A carrier may consist of a description of a problem or solution in words, or at a level, common to both cultures. For example, technical specifications for a requirement may be described without reference to the field of application which may be assistive technology or kitchen appliances. The interaction of technologists and marketers may be a carrier (marketers are close to the market and know requirements for successful commercialization), or a barrier (marketer's satisfaction with existing business model and products may suppress innovation). Specifications provide a common platform for communication. However, even these specifications may change as a result of other advances.

Expertise barriers are asymmetries in the knowledge and experience held by partners, which is required to accomplish their shared objective. The partners need to ensure the recipient organization has the technical competence to implement, produce and then support the transferred technology within a new product. Technology transfer is getting more complex because it demands a thorough understanding of both technologies and markets. The most critical fixed factor is the time of the few individuals with the skills to assess and address both.

Time barriers include disparities in time required to accomplish actions (e.g., securing internal approval), in universities that operate on semesters, versus small companies that operate on product cycles. A carrier may be a jointly created timeline with agreement from management in both organizations to adhere to that timeline.

Financial barriers include constraints on resources allocated to the project. For example, a government operated laboratory may allocate resources to participate in a project through the technology performance validation stage, while a corporation may budget to participate through product design and fabrication. Carriers include performing due diligence on the project plan to ensure that resources commitments are sufficient to bridge gaps in activity by the respective partners.

Opportunity barriers are decisions to proceed with some projects that preclude proceeding with other projects. The carrier is validated information shared with all decision-makers. Market forces drive technology decisions toward areas of highest potential return, which may be countered by financial incentives from government agencies addressing areas of lower return. The traditional "Valley of Death" analogy may be replaced with a "Darwinian Sea" analogy (Auerswald and Branscomb 2003). Resources are present but the struggle is to secure them for a specific project and then to negotiate the barriers threatening survival.

Return on investment barriers arise from inequities between participants in the risk/return ratio. Applying existing technologies in existing markets (evolutionary change) has lower risk than applying new technologies in existing markets (leverage base change), while applying new technologies in new markets (radical change)

has the highest risk. To entice companies into higher risk ventures, technology producers may have to offer them a higher share of future returns.

Capabilities barriers result from limitations in access to the entire value chain or in market readiness for the features/functions of the new product. These capabilities barriers may cause a transfer to fail at the back-end of the process, even if all prior barriers are overcome. A thorough business plan addresses the value chain requirements for production, function, quality, price, service, training, distribution and marketing. Ensuring market readiness requires a SWOT analysis (strengths, weaknesses, opportunities, threats), and comprehensive input from the target customer group.

Conclusion

Technology Transfer is a process. The process is used to transform concepts into applications. The process spans a range of activities typically requiring input from experts representing multiple stakeholder groups. The bottom-line is the eventual outcome not the process itself. All stakeholders involved need to stay focused on the eventual outcome.

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