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Paper Session I-A - Technology Transfer in the Space Sector: Implementation and Issues

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TECHNOLOGY TRANSFER IN THE SPACE SECTOR: IMPLEMENTATION AND ISSUES

Vijay Krishen¹ and Trung T. Pham²

Abstract. Technology transfer is the process of bringing technology from one sector to another in order to satisfy certain demands. Traditionally, technology is developed to address one specific problem. However, it can also be modified and reused for another problem. This paper examines the transferring process of technology: its implementation procedure, the benefit vs. costs, and the technological/managerial obstacles. Examples in the space sector were given in the analysis of technology transfer process.

1. INTRODUCTION

Technology transfer is the process of incorporating technology developed from one sector into practical application in another sector. The transferring is triggered either by a difference in technological levels between two sectors, or by a specific demand addressable by an existing solution of another application/problem.

It is often perceived that advanced technologies were often developed in the space industry and transferred to other industries in the commercial sector. This fact is understandable because space is a unique environment that space-related problems normally require specialized (and sometimes unique) approaches and solutions. Some of these solutions will gradually find practical applications on earth such as efficient solar power cells, heat shield tiles, clean and efficient fuel, etc. However, this technological flow only represents half of the technology transfer process in the space industry: there have been technologies developed elsewhere and transferred into the space industry. For example, computer technology has been developed in the business sector and utilized in space-crafts as onboard hardware/software normally to provide computation for automatic guidance and control.

Technology transfer occurs to mutually benefit both the originating and the receiving sectors. It will either bring additional revenues to the receiving sector in form of a new competitive product (seizing major share in a new market), improvement to quality of existing products (gaining share in a competitive market), or reducing cost to manufacture existing products (establishing competitive edges). The technology providers will enjoy additional revenues in form of royalties, licensing fees, and consulting contracts.

However, there are obstacles in the technology transferring process that prevent spontaneous transfer addressing a demand. The two major obstacles often recognized are: (i) lack of technical understanding, (ii) strategic difference in the managerial decision process. Lack of technical understanding often leads to failure to implement customized solution, disruptive maintenance, and/or shortened life-cycle of a product. Strategic difference in managerial decision process might cause aborted attempts, inappropriate utilization, and/or added hidden costs.

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This paper will provide the basic insight into the technology transferring process, its implementation procedure, and major obstacles normally encountered in the transferring process. Solutions to resolve these obstacles are also proposed, and their strategic effects examined. Examples are also provided in the analysis of these scenarios and proposed solutions.

2. TECHNOLOGY TRANSFER

Technology is normally developed to address a strategic demand in a business sector. The objective of this development is to generate revenues either directly (in form of a new competitive product) or indirectly (in form of a value-added option to an already existing product). Transferring is normally an optional step in the life-cycle of a technology. This cycle, depicted in Figure 2.1, consists of the following four main stages: (i) research, (ii) development, (iii) application, and (iv) marketing.

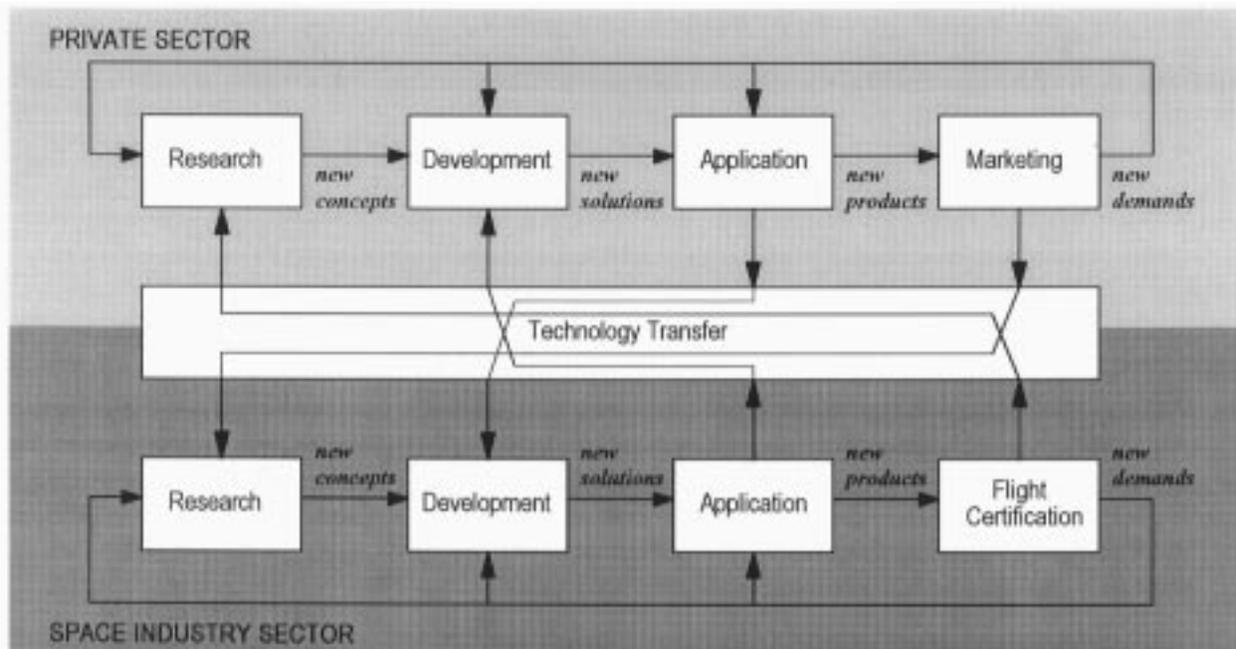


Figure 2.1. Typical Life-Cycles of Technologies and Their Transferring Between Two Sectors.

Research is the stage where ideas and concepts are conceived. There are two kinds of research: theoretical research, and application research. Theoretical research is conducted to advance the technology. Application research is investigated how to utilize a new technology into practical usage. Research is traditionally done at academic institutions and major corporate. However, the recent downsizing and cost-cutting trends in the American corporate have reduced corporate research significantly and consequently delegated the research responsibilities to academic institutions. This delegation widens a gap between theoretical development and practical applications due to academic freedom and minimal insights to the real-world applications that researchers face at these academic institutions.

Development is the stage where a practical solution is derived based on the result of theoretical research. The development brings a theory into solving a particular well-defined problem. The output of this development is a technique (or a process) that solves this well-defined problem. The development stage brings theory closer to real world.

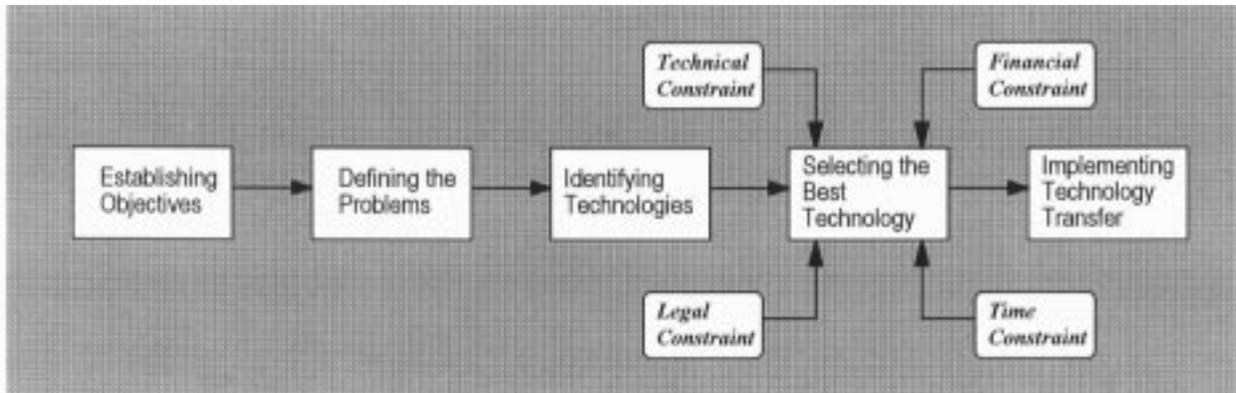


Figure 3.1. Decision Process to Implement Technology Transfer: Technical, Financial, Time, and Legal Constraints Must Be Considered.

Application is the stage where a new product is manufactured based on the solution derived in the development stage. This new product is ready for usage and will be packaged for consumption. The packaged product is viewed as a final product, pending new improvement (for substitution) or new product (for replacement).

Marketing is the stage where a new product is brought into final consumption. This stage consists of distribution, market positioning, and analyzing consumers' feedback for future demand. Distribution is bringing the product to consumer, either directly from manufacturers, or via a distribution center. Market positioning is the action to maintain a steady base (as a leader) or to gain market share (as a follower) of consumers for a product.

Technology transfer is the process of bringing new technology from other sectors to quickly address a demand. The advantage of this process is the saving in time, mostly in the research (and sometimes development) stage of a technology's life cycle. This time-saving is translated into saving in costs associate with supporting research activities. However, there exists a hidden cost in this technology transfer: cost of understanding the technology. This cost consists of feasibility study, consulting fees, licensing fees. There is also a risk involving: risk of not successfully marketing the final product(s). This risk is often objectively ranked between the risk of researching and the risk of marketing.

Sometimes technology is thought of as the extension of application and marketing. This comparative thought merits because the transfer involves finding a good application and marketing it to users. There are two theories about the triggering factor that initiates the technology transfer: Push Theory, and Pull Theory.

Push Theory. Technology transfer is the result of a demand. This demand can be in form of an unsolved problem that hold a great expected value of returns.

Pull Theory. Technology transfer creates demands. This creation can be in form of a new product in a new market.

3. IMPLEMENTATION PROCEDURE

A decision to implement technology transfer procedure is made with the following steps: (i) establishing objectives, (ii) defining the problem, (iii) identifying possible technologies, (iv) selecting the best technology, and (v) implementing technology transfer. In order to rationally select the best technology, one must also consider technical, financial, time, and legal constraints. Figure 3.1 illustrates these decision steps.

Once a decision is made to transfer technology, the following implementation procedure can be employed: (i) licensing, (ii) teaming arrangement, (iii) feasibility study, (iv) prototyping, (v) market survey, (vi) fabrication process, (vii) pricing, and (viii) manufacturing & marketing.

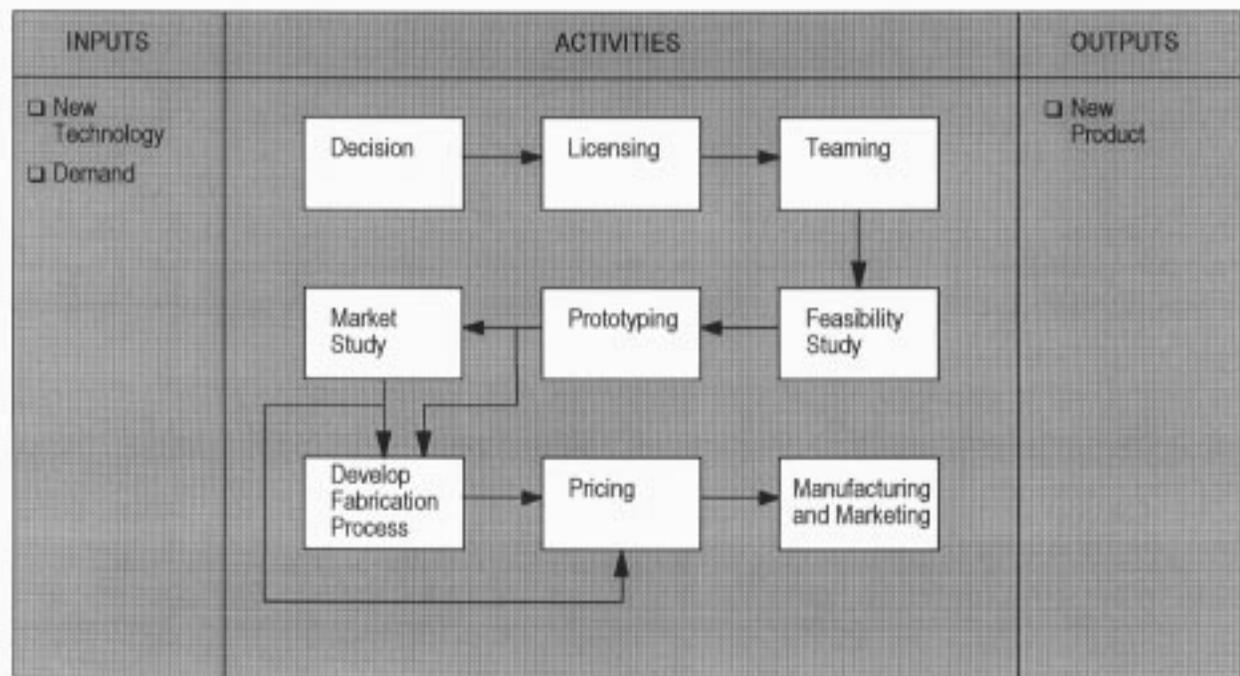


Figure 3.2. Technology Transfer Implementation Steps: From Decision to Marketing.

Licensing is the acquisition of a permission to use a certain technology. Licensing can be either exclusive or non-exclusive. This aspect will be decided by both parties involved: the technology developer and the technology utilizer. Normally associating with a licensing agreement will be some teaming arrangement so that the developer will provide some consultation when required.

Feasibility study is the derivation of a particular solution based on the new technology to address a specific problem. The objectives of this feasibility study are to verify that there is a solution, and to investigate the characteristics of this solution. The characteristics can be uniqueness, advantages, disadvantages, long-term effects, etc.

Prototyping is the development of a specific unit of commodity. This commodity can be tangible (product) or intangible (service). The commodity should be in the final form ready for market survey. This form is assumed to be market ready. Market survey is the study of potential demand (if the product is new), or potential market share (if the product is intended to replace another product). The purpose of this market survey is to determine if the prototype is worth further pursuing.

Fabrication process is a technique that produces the prototype in mass quantities at efficient costs and in reasonable time. The product manufactured from this fabrication process must meet specific quality similar to that of the prototype. Pricing is the determination of what a unit should cost in a competitive market. Manufacturing and marketing is the process of gathering capital and resources to produce the final product in mass quantities and distributing them to consumers. This step includes quality control to ensure that each unit produced in mass quantities meets the specifications of the prototype.

4. OBSTACLES AND ISSUES IN TECHNOLOGY TRANSFER

Technology transfer is normally obstructed by two main obstacles: (i) lack of technical understanding, (ii) strategic difference in the managerial decision process. These obstacles will systematically lead to unfavorable consequences for both the technology provider and technology utilizer.

4.1. Lack of Technical Understanding.

A lack of technical understanding can occur with the providers or utilizers. The providers, if lacking the understanding of the application, will provide inadequate consultation (that leads to failure to implement) and inappropriate advises (that lead to disruptive maintenance and shortened life-cycle). The utilizers, if lacking the understanding of the technology, will incorporate the technology inefficiently, inappropriately, and/or insufficiently. In this case, if technology is utilized, it might result in excessive usage of high technology for a comparatively simple problem. This happening will increase costs and make the product cost-ineffective.

In the space sector, if the direction of technology transfer is toward commercial sector, then a lack of technical understanding of a technology will discourage the commitments even to the first phase of the decision process (illustrated in Figure 3.1). When no commitments were made, opportunities (for profit) were lost. Such non-commitments were often attributed to the intimidation inflicted by the perception of high technology in the space sector.

If the direction of technology transfer is toward the space sector, a lack of technical understanding of a technology will also cause management to be non-committed. In the space sector, human safety is one of the top concerns that management must address. Lack of understanding of a technology will significantly reduce confidence in using it. When no confidence exists, it is reasonable to conclude that the technology might not be safe to try on situation when safety is a major concern.

4.2. Strategic Difference in Managerial Decision Process.

The space industry depends on annual budget approved by the U.S. Congress. This dependence has caused managerial decision to focus on short-term objectives and quantitatively based on local optimization in time domain. The objectives are normally specific for the duration of one year. Decisions are therefore made quantitatively by optimizing the objectives for the one-year time interval. This piece-wise process often provides sub-optimal solutions, i.e., solutions that are slightly less effective than solution optimized in an indefinite time interval.

As the result of this piece-wise decision process, technology transfer from private sectors into the space sector will suffer when budgetary constraints are severely applied. Management often defers the transferring process to another point in the future as a trade-off to protect the everyday operation and maintenance. On going transferring processes are often aborted. Planned transferring processes are delayed indefinitely. In the first case, the accumulated cost will be lost and there will be additional cost to restart the effort. In the second case, opportunity cost will be subjectively assessed for not using newer technology in the long run.

5. PROPOSED SOLUTIONS

The research effort in the US has stabilized to a constant level (measured by the amount invested in terms of percentage of the GNP). However, the transferring effort has fluctuated in the space sector. In order to minimize this fluctuation (and maintain constant effort), we propose the following:

5.1. Combine Research and Technology Transfer Effort.

By combining the transferring effort to research, we might set the decision independent from conflicting with operation and maintenance. Federal funded research will require investigation of technology evolution path into federal space programs. Most of these research programs are normally based on multi-year basis. Thus, combining them with the technology transfer will escape the single-year decision making process.

5.2. Encourage Academic and Industry Research Teaming Arrangement.

By pairing academic research and industrial partnership, we help provide a bridge between theory and application. Academic research will have better understanding of the industrial demands and therefore will steer the investigation to address practical problems. Industrialists will have better understanding of new technologies developed by academic researchers and therefore will be in good technical position to implement the solutions into a final product.

5.3. Protect the Technology Base.

By contracting advance technology work to US based companies, we are providing a steady effort to develop technology and maintain a competitive edge in the global community. Furthermore, we will encourage future (young) generation to commit to the research with this stable job market. This influx of new researchers will replace the retired ones and maintain a steady human resource in the field.

5.4. Link Manufacturing and Development Processes.

The U.S. has been known for its excellence in research while Japan was known for its utilization of new technology into manufacturing and development. These two models must be linked together into one cohesive unit that provide feedback to the direction of new research, feedforward to the modernization of manufacturing process and development of new products.

6. CONCLUSION

Technology transfer is a process of reusing technology developed for one demand in another application. This reusing concept will reduce costs normally accumulated in the research and development stages. However, there exists a hidden cost in technology transfer: cost of understanding the technology and feasibility study. If the cost for research and development outweighs this hidden cost, then technology transfer is cost-effective. It has been demonstrated that there are obstacles to this technology transferring process, and these obstacles can potentially inflict costs and liabilities. Strategic decision therefore must be made to effectively and efficiently utilize technology transfer for optimization of a well-defined set of objectives.

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