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TECHNOLOGY TRANSFER FOR PRODUCT LIFE CYCLE EXTENSION: A MODEL FOR SUCCESSFUL IMPLEMENTATION

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Abstract: This paper examines the logistical and operational issues relating to technology transfer. It documents the specific problems encountered as well as the solution designed to overcome these problems. The paper presents a model for technology transfer that incorporates a sequence of stages or steps that should be considered when planning, scheduling and executing a transfer from one location to another. The model ensures that roles are clarified, appropriate training is undertaken, validation processes are considered, supply to the market is maintained and all relevant information and equipment is transferred in a controlled, timely and cost effective manner.

Key Words: Technology Transfer, Product Transfer, Best Practice Model

1. Introduction

The current economic environment is characterised by a phenomenal rate of technical advances coupled with intense global competition. Knowledge intensive products are being developed at increasingly rapid rates. Product life cycles are becoming shorter [Cormican and O'Sullivan (2004); Golder (2004); Lee (2002)]. This puts pressure on companies to bring new products to market faster, cheaper, smarter and better than their competitors. Organisations need to plan for the introduction of new products. Companies must ensure that they have a portfolio of products at different stages in their lifecycles so that they maintain a constant income stream. The product life cycle is a descriptive framework that classifies the evolution of products into four discrete and temporary stages [Levitt (1965); Emblemsvag (2003); Moon (2005)]. These are the introductory stage, growth stage, mature stage and decline stage. These stages are distinguished by the levels of demand and competition [Wong and Ellis (2007); Moon (2005)]. Throughout the introductory stage the market begins to grow and there are few competitors. In the growth stage, sales increase and this attracts many new entrants. Sales begin to taper off as the market enters the mature stage. The decline stage of the cycle arrives when sales begin to fall. During this stage the level of demand is low and products are withdrawn from the market.

Companies can either make or buy new products to replace their products that are going into decline [Lawton-Smith (2000); Afuah (1998); Muir (1997)]. In other words, they can develop products internally through knowledge generated from research and development or they can purchase knowledge, insight and technology externally using mechanisms such as license agreements, joint venture or acquisition. Acquiring technology from external sources and applying it in a new system is called technology transfer. Many organizations use these commercial arrangements to transfer technologies from one location to another in an attempt to extend the product lifecycle and maintain income streams. The acquisition of designs, specifications, process know-how and sample products simplifies the product launch and facilitates swifter market entry. Other benefits of technology transfer include the ability to [Lawton-Smith (2000); Lowe (1995)]:

- exploit rapid changes in technology,
- reduce the time and costs of new product development,
- minimise the risk of research and development failure,
- compensate for the lack of qualified/experienced technical people.

Consequently, technology transfer has become part of many organisations' business strategy and the ability to manage the transfer process has become a critical competence. According to Burgleman *et al.* [2004] technology transfer enables organisations to extend their product life cycles when older technologies mature. It can also enable '*technology followers'* to become '*technology leaders'* [Forbes and Wield (2002)], making the company more competitive in the global marketplace and more capable of innovation.

However, technology transfer is a complex process fraught with numerous operational difficulties. Published literature does not address the logistical and operational issues that are encountered during this process. There are no guidelines for planning, managing and executing technology transfers. This paper seeks to address this deficit. It defines and classifies the concept of technology transfer. Particular attention is then paid to product transfer. Problems with the product transfer process are identified and discussed. The paper then presents a model for product transfer based on best practice and case study analysis. This model incorporates a set of guidelines and tools for managers to plan, schedule and execute a successful product transfer. It is considered suitable for transfers that take place within and between organizations to extend the product life cycle. For example, a company may move a product from one location to another to provide capacity for new product innovations at a particular site. It may also move a cash cow from one facility to another to avail of lower manufacturing costs. These intra company transfers are about moving the results of innovation from one place to another rather than delivering mechanisms that would result in innovation in the new location [Afuah (1998)]. A product or technology can also be sold to another company in a low cost economy or to in a developing country. In this instance the product may have reached the end of its life cycle in one geographic region but may be new to the market in another.

2. Technology Transfer

The term 'technology transfer' has been used by many disciplines to describe and analyze a wide range of technology issues. Consequently, it is used in several different ways in the literature. Some authors adopt a philosophical approach. For example, Autio and Laamanen [1995], maintain that technology transfer refers to '*intentional, goal oriented interaction*' between groups and/or organisations in order to exchange technological knowledge, artifacts and rights. Many authors adopt a more tangible, process oriented approach. For example Muir [1997] and Dakin and Lindsey [1991] talk about '*the process of bringing new products to commercialisation'* and Jones-Edwards and Kloftsen [1997] refer to '*the acquisition, absorption and dissemination of technology*'. Other researchers suggest that technology transfer should be considered in terms of achieving certain outputs or objectives. For example, Wittamore et al [1998] define technology transfer as '*the transfer of new knowledge, products or processes from one organisation to* *another for business benefit*'. Gruber and Marquis [1969] note that the technology transfer process should be for '*economic gain*'. Gee [1981] also highlights the importance of '*economic or productivity gains*'. Many authors stress that effective knowledge management is central to technology transfer [e.g. Li-Hua (2006); Amessea and Cohendet (2001)].

Technology transfer implies the movement of technology from one place to another. Much work has focused on the concept of transferring inventions from research laboratories and Universities to industries and markets [Mosey *et al.* (2007); Rahal, and Rabelo (2006); Elmuti *et al.* (2005); Bozeman (2000); Souder (1987)]. Technology transfer is also analysed and discussed in terms of moving technologies or products from one organisation to another. For example, Madu [1989] analyses the transfer of knowledge, technology and products from multinational corporations to less developed countries. Quinn [2000] considers '*systematic outsourcing*' while many others examine '*international technology transfer*' [Nahar *et al.* (2006); Giroud and and Mirza (2006); Balachandra (1996)]. Consequently, many types or classifications of technology transfer have been suggested in the literature. Table 1 synthesises some of the work done in this area.

Table 1 Classification of Technology Transfers

Classification	Descriptor	Reported By
▪ Transfer from universities and research laboratories to industrial companies ▪ Transfer between firms in advanced industrial countries ▪ Transfer from an advanced country to a developing country	Location of transfer	Lowe [1995]
▪ Market mediated transfers ▪ Non-market meditated transfers	Contractual arrangement	Kim [1997]
▪ Transfer within an organisation from research to commercialization ▪ Transfer from one company to another ▪ Transfer between countries	Location of transfer	Afuah [1998]
▪ Transfer through sales of products that embody the technology ▪ Transfer through contractual arrangements including licensing, co-operation and sharing among firms as part of strategic alliances ▪ Transfer through acquisition	Mode of transfer and contractual arrangement	Bonomo et al [1998]
▪ Transfer tangible assets such as new products, plants and equipment ▪ Transfer intangible forms through formal mechanisms such as patents and licenses ▪ Transfer informally through knowledge and information flows	Mode of transfer and nature of asset	Howells [1998]
▪ Managing innovation ▪ Contracting out R&D and outsourcing ▪ Transferring to divisions or subsidiaries ▪ Buying or selling proven technologies	Nature of technology and location of transfer	Amessea and Cohendet [2001]

▪ Non-commercial transfer ▪ Commercial transfer ▪ New company generation	Mode of transfer	Upstill and Symington [2002]

It seems that technology transfer can be defined in many different ways depending on the discipline of the researcher and the purpose of the research. It is also clear that technology transfer has been used by many disciplines to analyse a wide range of technology issues. This paper focuses on the transfer and integration of external product technologies. Product technology transfer is a '*dyadic process'* between source and recipient firms [Tatikonda and Stock (2003)]. It involves the movement of product technology and all the knowledge about it from one location to another. The activities in this process include the analysis, selection, adaptation, integration and absorption of the technology into a new system [Bozeman (2000); Souder (1987)]. The technology transfer process begins at the point where the receiver commits to a specific technology and ends when that technology has been successfully incorporated into the receiver's system as part of a product development effort. Careful integration of product technologies from external organizations is an essential competence for new product development organizations [Tatikonda and Stock (2003)]. Research suggests that companies skilled in the product transfer process have access to more technological options and are also able to optimise their limited R&D resources [Miller *et al.* (1995)]. However, it is an expensive and difficult process [García Muñoz *et al*. (2005); Iansiti (1998)]. It is often performed in '*an ad-hoc manner*' [Sheridan (1999)]. Furthermore commentators have noted that the literature on the area of technology transfer focuses on strategic options but does not address project level activities and details [Tatikonda and Stock (2003); Cusumano and Elenkov (1994)]. The principal goal of this paper is to gain insight into the product transfer process so that organisations can manage this process more effectively and so that researchers can investigate this critical activity further.

3. Research Problem

Product transfer for life cycle extension is a complex activity and companies face many problems in this regard. Factors such as the nature of the technology, the stage that the technology is at in its life cycle, the absorptive capacity of the receiver, geographic distance and cultural differences between the parties receiving and transmitting the technology can affect the process [Afuah (1998)]. The availability of suppliers, customers and complimentary innovators are other factors that impact the technology transfer process. Organisations must understand how to transfer the technology and the critical knowledge associated with the technology to their facility so that they can operate it and supply it to the market or combine it with existing knowledge and technologies for use in future innovations. In order to do this, they must attempt to identify and capture critical knowledge and information from workers in the transferring site, move it to the receiving site and embed it there so that it is not forgotten or lost.

A key problem to overcome in the transfer of an established product is ensuring continuity of supply during the transfer period. Companies cannot risk allowing customers to move to competitors' products during this period. As the technology is being obtained to generate new products it will have to be transferred within a pre-defined time period to ensure product launch dates are not compromised. The roles of individuals involved in the transfer have to be clearly defined to avoid duplication or failure to transfer any part of the process. Companies involved in technology transfer need to plan for training of their staff. Staff at the transmitting plant must be retained in their positions in order to carry out this training. In addition to overcoming time, cost and training constraints which apply to any industry, many organisations must plan for validation work to be undertaken in order to satisfy company, industry or regulatory requirements which call for some companies to demonstrate that product produced complies with their regulations. Companies undertaking transfers of technologies need to address time, cost, training and validation requirements. Therefore in light of this, products and processes must be transferred in a timely and cost effective manner without any changes. The model outlines how to plan, schedule and execute a transfer to ensure that:

- The time frame for the transfer is determined
- The cost of the transfer is established

- The roles of individuals involved are clearly defined
- Comprehensive training is undertaken
- Validation of process and product is completed
- All aspects of information are transferred i.e. codified and tacit
- Supply to market is maintained
- Equipment is transferred in a controlled and planned manner.

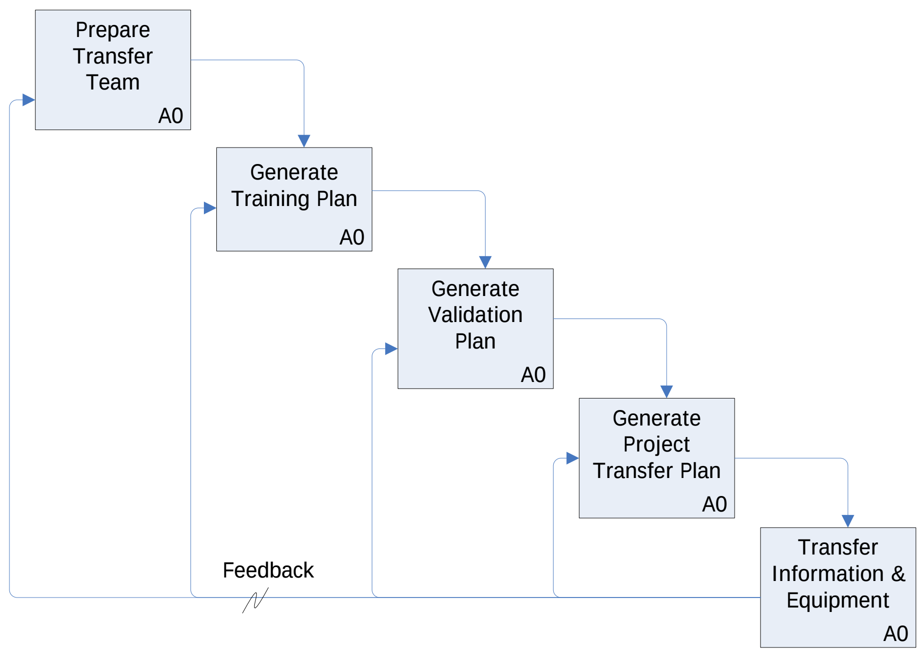
4. Research approach

The lack of published work in the area of product transfer motivates exploratory research. Case studies are suitable for performing this research because they allow for an in depth analysis of a particular context **[**Baskerville and Myers (2004); Reason and Bradbury (2001); Yin (2002); Eisenhardt (1989); Patton (1990)]. This paper uses case study research methods. The case examined is a large multinational healthcare organisation. The company has grown by acquisition and has many subsidiaries overseas. It is also bound to adhere to Food and Drug Administration (FDA) regulations. The organization has a history of transferring products, technologies and know how from one location to another. Qualitative research techniques were used to uncover the context specific knowledge that was embedded in the organization to develop our model. Empirical data was collected via open-ended semi-structured interviews from multiple units of analysis. Each interview was adapted to the position and role of each interviewee. The interviewees include members of the core project teams as well as the extended team [Ulrich and Eppinger (2003)], such as product managers, process managers, project leaders, team supervisors, technicians, operators, trainers, mechanical engineers, quality engineers, etc. This qualitative analysis helped us to understand and explain the product transfer process i.e. what happened, why it happened and how it happened. Additional sources of data such as project and product specifications, minutes from meetings, drawings, blueprints etc. were collected and analysed to ensure internal validity. This helped us to avoid traps that can be associated with case study research such as bias and the tendency to generalise. The data analysis process followed a three-phase procedure as recommended by Miles and Huberman [1994]. The first phase consisted of selecting, focusing, simplifying, abstracting and transforming the data. The second phase focused on organising and compressing the data. The third phase concentrated on drawing conclusions and extrapolating meaning from the data.

5. Technology Transfer Model

Technologies obtained externally must be transferred from one location to another in a systematic, timely and cost effective manner if they are to be used in launching successful new products. The technology transfer methodology presented here was developed to help to simplify, categorise, structure and give coherence to a complex process. It is based on best practice and can help organisations to understand and develop a strategic, well defined, controlled and audited transfer processes. The methodology consists of five key stages namely; (a) prepare transfer team; (b) generate training plan; (c) generate validation plan; (d) generate project transfer plan and finally (e) transfer information and equipment (see Figure 1). Each of these stages is presented in more detail below.

Figure 1: Technology Transfer Model



5.1. ***Prepare Transfer Team***

A cross-functional team is formed to undertake the technology transfer. The team comprises a project manager, manufacturing and quality engineer(s), production supervisor, process technicians and operators as well as representatives from training and information technology. Ideally this group travels together to the plant from which the technology is to be transferred so that they all view the same activities simultaneously. The team views the physical size of the operation, the number and type of machines involved and the number of people in the operation. They get an initial impression of the complexity of the task to be undertaken. They can at this stage develop a comparison between the operation being transferred and their existing manufacturing operations. The team should review information such as yield analysis and failure data in order to establish what type of problems occur during the operation and how they are resolved. Production information such as cost and lead times should also be evaluated at this stage.

The transfer of electronic information must also be considered and evaluated at the earliest possible stage in the technology transfer. Companies will have their operating procedures, routings and bills of materials, yield data, fault analysis data and labeling programs stored electronically. Ideally for the receiving plant this information should be compatible with their existing databases as this guarantees no issues with supplying of the product.

The initial visit to the facility from which the operation will be transferred transfer will involve hands-on, person-to-person contact in order for the transfer team to understand the process, its' intricacies and complexities and also for them to compare and contrast it with their existing operations. After this initial visit, the following activities should be undertaken:

- A process flow chart should be generated listing all manufacturing operations and quality inspections which make up the manufacturing operation. The number, models/types of machines and pieces of test equipment should be established and documented. This will assist in determining the sequence in which the transfer of equipment will be undertaken and if there are similarities with existing equipment.
- A layout drawing for the equipment in its new plant should be generated. It should include all equipment which is being transferred from the transmitting plant and equipment which is being

purchased externally. The drawing should be posted in the manufacturing area and can be used to monitor progress of the transfer.

The transfer team must meet on a regular, pre-determined basis to plan the transfer. They should arrange to speak to their counterparts in the transmitting plant at regular intervals via conference calls. There should be clear and frequent written communication between the parties using e-mail. After creating the flow chart and the layout drawing the team should develop the training plan, the validation plan and the project transfer plan.

5.2. *Generate Training Plan*

A training plan must be generated to include details of training to be undertaken by operators, inspectors, technicians and engineers. Training is undertaken at the transmitting company in advance of transferring equipment. It is preferable to use lead operators at the transmitting company to carry out this training. The plan must also allow training to be undertaken by the same personnel overseen by the same lead operators from the transmitting plant after the equipment has been transferred. The expected start and finish dates of training on each piece of equipment in both plants must be determined, coupled with the cost of air fares, accommodation and living expenses. Also, if production operators are to be out of the plant or out of the country training, provision must be made for cover for the activities which they generally carry out. The training plan must also identify if new people need to be hired to operate new equipment post transfer.

5.3. *Generate Validation Plan*

The objective of technology transfer is to be able to make a product after the transfer in the same way that it was manufactured in advance of the transfer. Companies must be able to demonstrate to themselves and their customers that there is no impact on product quality or performance arising from a technology transfer. For that reason one of the first steps undertaken in advance of transfer of a line from one location to another is to establish what process validations have to be undertaken to ensure process output is repeatable, how long this will take and what resources are required in order to undertake this work. This will impact the time required for the transfer to be completed. Validation activities specific to the manufacture of medical devices are as follows:

- Installation qualification/software validation: an initial assessment of the equipment used and the services and software required to operate that equipment.
- Operational qualification: a demonstration that the process will produce acceptable product at the limits (worst case scenario) of the process parameters.
- Process qualification: confirmation of long-term process stability,
- Product qualification: confirmation that the product produced on the installed equipment as per established process procedures meets product performance specifications.

5.4. *Generate Project Transfer Plan*

The project transfer plan will normally focus on four key activities. These are (a) determine time lines; (b) undertake training; (c) determine sequence of transfer and (d) generate budget.

5.4.1 Determine time lines

The duration of the technology transfer will impact its cost, the amount of inventory which must be built up in order to cover the transfer period, and the amount of people that are working on the transfer. It is therefore important to predict in advance how long the transfer will take. This can be established by determining the time it will take to transfer each piece of equipment and what down time will be encountered. The time required to train operators, transfer and modify equipment and validate it in its new location are the main elements of the time required to transfer each item of equipment in the transfer.

5.4.2 Undertake training

Training activities do not necessarily contribute to down time in the transfer process. Training can be undertaken at the transmitting plant pre-transfer before any equipment is taken out of operation. This period of training can be used as part of the inventory generation in advance of the transfer. Therefore it is important that personnel at the transmitting company are retained until completion of the transfer. Continuity of supply can also be ensured by having product part made at the transmitter's site and finished at the receptor's site. During the transfer neither site will contain a full complement of machines or equipment so it is important to organise the transfer of machines in such a way that continuity of supply is ensured.

5.4.3 Determine sequence of transfer

The sequence of transfer must also be determined. In the case of a non-regulated industry such as textiles or cutting tool manufacture the most logical manner in which to schedule the transfer of machinery from the transmitter to the receptor is to move equipment from the end of the process first and work back to the start of the process. This ensures that product manufactured during the transfer period can begin to be processed at the transmitter and can be finished at the receptor without any need for any additional movement between the two centres. This concept is shown in Table 1.

Table 1: Sequence of Transfer for Non Regulated Industry

Stage	**Transmitter**	**Receptor**
1	Product produced at transmitter Implement Process 1, Process 2, Process 3	Product not produced at receptor
2	Start of Transfer: Continue implementing Process 1, and Process 2	Process 3 transferred to receptor Implement Process 3
3	Continue implementing Process 1	Process 2 transferred to receptor Implement Process 2, Process 3
4	End of Transfer Product not Produced at transmitter	Product Produced at receptor. Implement Process 1, Process 2, Process 3

In the case of an industry regulated by for example the FDA the transfer cannot be undertaken in such a manner. Product cannot be part manufactured at one site and finished at another without validations being undertaken and approval being granted by the regulatory body. Each site which is involved in the manufacture of a product applies for a license of its own to manufacture the product. Therefore if the manufacture of a product is being transferred from one location to another (from transmitter to receptor) it is generally the case that sufficient inventory is built at the transmitter to ensure continuity of supply during the transfer. This differs significantly from the example of a non-regulated company outlined above.

In order to ensure that product is not part manufactured at both sites it is best practice to move equipment from the start of the process and progress sequentially through the process to the last operation as outlined diagrammatically in Table 2.

Table 2: Sequence of Transfer for Regulated Industry

Stage	Transmitter	Receptor
1	Product produced at transmitter site Implement Process 1, Process 2, Process 3	Product not produced at receptor site
2	Start of Transfer: Continue implementing Process 2, Process 3	Process 1 transferred to receptor site Implement Process 1
3	Continue implementing Process 3	Process 2 transferred to receptor site Implement Process 1, Process 2
4	End of Transfer: Product not Produced at transmitter site	Product produced at receptor site Implement Process 1, Process 2, Process 3

5.4.4 Generate budget

The next step is to generate a budget for the transfer outlining what expenses will be incurred and when they will be incurred. Expenses likely to accrue during the transfer include:

- Purchase of machinery, equipment, jigs and fixtures
- Freight charges for movement of equipment
- Air fares, hotels and living expenses for training and installation at both sites and any additional travel required by the Transfer Team
- Labour costs of all the transfer team members (full-time and part-time)
- Costs of modifying machines as required
- Cost of validation product builds
- Contingencies

The project plans for a technology transfer must include a full list of all activities involved in the transfer of all equipment and information from the transmitting plant to the receiving plant and for the commissioning of equipment purchased from machine manufacturers. The plan will have two key elements namely the transfer of information and the transfer of equipment

5.5. ***Transfer Information and Equipment***

Information can be transferred orally, in writing, or in a graphic. Moreover, the transfer of written and graphic material can take place in hardcopy or softcopy formats, using many different media and technologies. Transfer of information can be undertaken in one block of activity as it is not dependent on the sequence in which equipment is transferred. Care must be taken to ensure tacit information, i.e. information relating to the process which is not easily documented and which is generally held by trained operators with years of experience, is related to personnel from the receptor during the transfer. This transfer of information can be undertaken effectively during the training period when personnel relocate temporarily. A company which strategically decides to grow by acquisition must have in place a Product Data Management Database in which the following items are located:

- Operating Procedures
- Bills of Materials
- Product Routings
- Manufacturing Lead Times
- Product Specifications
- Change Requests

An audit of documented procedures is advisable to ensure that all information required to start, set-up, operate and shut down each piece of equipment is documented. Any omissions must be documented in advance of deciding to transfer the piece of equipment. Before a machine can be used in the receptor's plant the following sequence of events must be undertaken. Table 3 is a checklist that presents a sequence of activities for cross border transfer.

Table 3: Sequence of Activities for Cross Border Transfer

	Activity	Yes	No	Comment
1	Select machine operator to train on the machine pre-shipment	□	□	
2	Train operator in transmitter's plant	□	□	
3	Build inventory as required	□	□	
4	Order crate for the machine to be shipped in	□	□	
5	Disconnect electricity, compressed air, gas and water as appropriate	□	□	
6	Send machine to the warehouse or shipment depot for shipment	□	□	
7	Organise purchase order for shipment	□	□	
8	Organise customs clearance	□	□	
9	Collect machine at port of entry and transport to receiving plant	□	□	
10	Rewire equipment if operating voltage is different in new location	□	□	
11	Modify machine safety features to adhere to local health and safety regulations	□	□	
12	Place machine in pre-designated location as per plant layout drawing	□	□	
13	Complete training if required	□	□	
14	Undertake validation	□	□	

This sequence of events is repeated for all pieces of equipment in the manufacturing process. When all equipment has been transferred and all validations have been undertaken it is advisable for the transfer team to review their three plans, i.e. training, validation and transfer project plan to ensure that all activities have been undertaken as planned. At this stage the equipment is available to be used by the receptor to supply product or to be incorporated into future innovations.

6. Problems addressed

As mentioned earlier, factors such as the nature of the technology, the stage that the technology is at in its life cycle, the absorptive capacity of the receiver, geographic distance and cultural differences between the parties receiving and transmitting the technology can affect the process. The technology transfer model outlined in this paper addresses the generic problems and operational issues associated with technology transfer outlined earlier. These are discussed in more detail below:

6.1. *Nature of technology*

If a technology being transferred is similar to the existing technologies of the receptor then it should be relatively easy to move. If, on the other hand, the technology is new to the receptor the process will take longer. We learned that problems arising from the nature of the technology to be transferred can be overcome by selecting the appropriate people for the transfer team. For example if the technology is very complicated it will require more senior technical people to work on the transfer. We also found that the more time that people from the receiving plant spend at the transmitting plant the easier it will be to overcome the problems associated with the nature of the technology.

6.2. *Stage in the product life cycle*

This study discovered that the stage of the technology or product in the product life cycle determines how much information there is relating to its design, development and maturity. In general, the less mature the process, the less established information there is, and vice versa. The less that is written down about the process the more personal intervention will be required to collect all the relevant detail in a transfer situation. This will invariably require more training.

6.3. *Absorptive capacity of the receiver*

We found that the relocation of personnel from the receptor to the transmitter and vice versa is essential in ensuring that information is absorbed and understood by the receptor. This contact arises from the generation of the training plan and results in staff of all levels from the receptor spending time at the transmitting plant in advance of transfer taking place. We also learned that selecting experienced people who have worked on previous transfers also helps to increase the absorptive capacity of the receiver.

6.4. *Geographic distance*

Issues relating to geographic distance between the receptor and transmitter can to some extent be overcome by travel, temporary relocation and communications. Successful technology transfer requires regular meetings and conference calls between the transfer team and their counterparts in the transmitting company.

6.5. *Cultural difference*

We learned that the personal contact which arises from plant visits and from staff from both plants undertaking training or validations together will help to overcome cultural differences. People get to know each other on a personal basis and build working relationships. They get to know how to deal with each other and how to communicate information effectively to each other.

6.6. *Operational issues*

The operational difficulties encountered in planning a technology transfer listed above are overcome by the technology transfer model as follows:

- In order to ensure that the roles of individuals involved are clearly defined a cross functional transfer team is established from the outset. These teams incorporate representatives from all the relevant functions in the process and can ensure that problems can be anticipated in advance.

- Organisations need to know how long transfer will take as product launch date may be impacted. Therefore the model recommends that transfer lead times are calculated and that a transfer plan is developed to help guide and control critical activities.
- The model also recommends that costs associated with the transfer are identified and specified. To do this the transfer lead time (which ultimately will have an impact on the overall cost) is established and re-location costs for people and equipment are determined and validation expenses are considered.
- A training plan is produced which includes details of training to be undertaken, location of training and duration. This is done to ensure that that the technology can be operated when moved to the receiving plant.
- Validation plans are also produced which includes details of product builds, time required and validations to be undertaken.
- Training plans detailing the nature of training to be undertaken as well as the location and duration of these sessions together with personal contact at site visits ensures that both tacit and documented or codified information is shared among the transmitters and receivers. Furthermore comparative analysis of procedures and practices are also encouraged.
- Establishing transfer lead time enables required inventory cover to be calculated. Furthermore, determining the appropriate sequence of transfer ensures that everything is done to ensure that supply to market is maintained.
- Finally the technology plan listing timelines for transfer of information and equipment ensured that all equipment is transferred in a timely and co-ordinated way.

7. Discussion

The technology transfer model can be used by organisations to extend the product life cycle of its products. We found that companies can reduce overhead and consequently generate additional demand for products by transferring their manufacturing operations to low-cost economies. This is supported by other studies [e.g. DeGarmo *et al.* (2007); Zangwill (1993); Rosenthal (1992); Sheth and Ram, (1987)]. Companies can also use the model to sell technology to less developed countries in order to generate substantial cash rewards. In this instance the product may have reached its end of life in one geographic region but may be new to the market in another. Many researchers contend that technological advance in developing countries stems largely from the acquisition, assimilation and improvement of foreign technology [Forbes and Wield (2002); Kim (1997)]. The effect of technology transfers to low cost economies is increased economic activity in those regions. Therefore technology transfer is crucial to the economic development of these countries. Companies and countries can use imported technology to generate economic activity and commence their progression up the technological ladder as outlined by Bell [1999] and Mac Laughlin [1999].

8. Conclusions

Product innovation results from a conscious, purposeful search for innovation opportunities. Research suggests that most successful product introductions are built from an existing product or platform [Ogawa and Piller (2006); Yang *et al.* (2006); Catalone *et al.* (2006)]. In the current economic environment it is imperative for companies to plan the development and introduction of new products. Increasingly rapid rates of technical innovation coupled with intense global competition means that in order to survive companies must have a continuous supply of new products and technologies to bring to market. One option for a company seeking new technology is to acquire it externally and transfer it to their organisation. This process is referred to as technology transfer. Technology transfer can be defined as the process of transferring knowledge or expertise related to some aspect of technology from one user to another. It is a complex activity and companies face many problems in this regard. Organisations must understand how to transfer the technology to their facility so that they can embed it into their existing processes and supply it to the market or combine it with existing knowledge and technologies for use in future innovations. Technologies obtained externally must be transferred to the receiving company in a systematic, timely and cost effective manner if they are to be used in launching successful new products. In order to do this, they must attempt to identify and capture critical knowledge and information from workers in the transferring site, move it to the receiving site and embed it there so that it is not forgotten or lost.

This paper focuses on the transfer and integration of external product technologies. It examines the logistical and operational issues regarding technology transfer in a large multinational organisation. The principal goal of this paper is to gain insight into the product technology transfer process so that organisations can manage this process more effectively and so that researchers can investigate this critical activity further. The paper documents the specific problems encountered as well as the solution designed to overcome these problems. It presents a model to guide such a technology transfer based on best practice. The model incorporates a sequence of stages or steps that should be considered when planning, scheduling and executing a technology transfer from one location to another. The methodology ensures that roles are clarified, appropriate training is undertaken, validation processes are considered, supply to the market is maintained and that all relevant information and equipment is transferred in a controlled, timely and cost effective manner. While the model was developed for the healthcare industry, it can also be used by other industry sectors. It can be used by companies to transfer technologies, products and manufacturing operations to low cost economies, thereby reducing manufacturing costs and stimulating demand. It is clear that the ability to undertake such a transfer is an important capability for a company to possess.

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