Project Number: ZUR4

PROJECT PROPOSAL FOR:
WPI TECHNOLOGY ASSESSMENT AND TRANSFER

An Interactive Qualifying Project Report

Submitted to the Faculty

Of the

WORCESTER POLYTECHNIC INSTITUTE

In partial fulfillment of the requirements for the

Degree of Bachelor of Science

By

Stuart C. Howes

Mereen S. Mammen

Jennifer L. Reid

Date: December 10, 2003

Approved:

Professor Robert Krueger, Advisor

Table of Contents

List of Figures

List of Tables

Executive Summary

The Swiss Federal Institute for Snow and Avalanche Research is a highly recognized leader in its field. Located in Davos, Graubüden, it is headed by Doctor Walter Ammann. The institute hopes to expand its operations by transferring its technologies to countries that could benefit from their expertise. The purpose of our project was to develop an understanding of international technology transfer in terms of SLF research and technology.

For our project, we concentrated on the factors associated with technology transfer and the methods used to assess these factors. We found technology transfer to be a highly social process requiring a multidisciplinary analysis of the process. Differences exist between societies causing technology transfer to be more complex than a physical relocation of a technology. Not every technology is appropriate for every society. A technology intended to benefit a society can also be harmful if the different social factors are not properly assessed.

To communicate our findings on technology transfer, we created a theoretical decision tool designed to mimic the transfer process. The process was based on previous technology transfers and our own empirical research. The main necessary steps are outlined when transferring a technology. Each step is imperative to the success of the transfer and must be followed sequentially.

Before we could choose the technologies to focus on for transfer, we had to first gain an understanding of the technologies available at the SLF. To do this, we created a database of SLF technologies via interviews and archival research. The database itself is divided into four categories. They are: hardware, software, applied knowledge and research. All of the SLF technologies we researched fit into one of the four broad categories.

From our database, we chose two SLF technologies and a complete system of technologies to theoretically transfer using our process. Each technology demonstrated the main points of our literature review. The technologies were analyzed in terms of technology transfer and the transfer differences between the technology categories were emphasized. These provided examples of how the process is used.

Our findings can be viewed in the Data Analysis chapter of our report.

Chapter One: Introduction

Countries around the world have achieved different levels of technological capability. Technology has a tendency to become concentrated in certain locations, leaving others with a relative deficiency. This differential creates the opportunity to significantly help less advanced countries through a technology transfer. However, all technology is embedded in society and cannot simply be relocated from one society to another. The social and cultural differences between societies force the geographic transfer to be a social process.

Striking differences exist in the abilities of particular countries to protect themselves from natural disasters. In many cases, the knowledge, expertise and hardware to manage disasters has been developed but not globally applied. Many lives could be saved, not from further research, but from a wider application of existing technology. The Swiss Federal Institute for Snow and Avalanche Research (SLF) has developed a range of technologies to deal with snow and avalanche hazards. This knowledge and expertise has the possibility of being implemented in other countries dealing with similar hazards.

Technology transfer is a complicated process with many multidisciplinary considerations to consider for success. Previous literature has approached the problem from many different perspectives, yet each perspective recognizes the importance of the societal differences, regardless of the particular technology. Previous research emphasized the careful selection and adaptation of technology to suit a new society. The social differences of technology transfer have been extensively compared and contrasted in various sectors, for example: agriculture and health. The affect of the agent of transfer is also thoroughly examined.

Multinational corporations (MNC’s) are responsible for much of the occurring technology transfer. Previous literature stressed the relationship between the transfer process and MNC's. The SLF is a research institute wanting to conduct a transfer differently. Research institutes are usually involved in the transfer of research to industry, but not as international technology transfer agents. The type of technology transferred heavily influences the process. Technology relating to natural hazards is very specific and is not found in the literature.

Every transfer is unique, requiring an individualized analysis of relevant factors. The differences between the sending and receiving societies cause the transfer to be unique. Our research focused on SLF technology and how to transfer it. To conduct a transfer, the SLF needs to understand the relevant transfer factors and the affect of the destination on the process. An emphasis was placed on developing countries. Our research was guided to supplement the SLF’s education of technology transfer and provide an outside perspective on SLF technologies.

Chapter Two: Literature Review

Introduction

Technology transfer is a social process. Though ultimately designed to improve the quality of life of people, not every technology has the same effect on every society. Each society and culture contains a different set of beliefs and social structures. These beliefs and structures can cause the introduction of a new technology to be harmful instead of beneficial. The beliefs and structures determine the overall success of the technology. The resources provided by the society are crucial to the transfer process and the ultimate benefit of the technology.

To demonstrate the relationship between technology, society and the process of technology transfer, we discuss three main points in this chapter. They are (1) the concept of appropriate technology, (2) factors surrounding technology transfer, and (3) sociological methods used in technology assessment. These three concepts illustrate the extensive underlying relationship between society and technology. Appropriate technology specifically examines the relationship between society and technology. It discusses the “best” technology to transfer based on the effect and need of the new society. Technology transfer highlights many important issues to consider during the transfer process. Each factor affects a society differently which is determined using tools discussed in the technology assessment section. The technology assessment section provides social tools used to gather information on the technology’s effects. Before the social and technical relationship can be examined, a solid understanding of technology is necessary.

2.1 Technology

Introduction

Webster's Dictionary defines technology as "the science of the practical or industrial arts," (1990, 606). For this project, technology is defined as any innovation that changes a people's quality of life. We divide technology into two types: hard and soft. Hard technology is a tangible object, device, or a software program. Soft technology is knowledge and expertise. It is not a concrete object that can be constructed. The SLF has developed both types of these technologies. For example, SLF experts are researching the effect of permafrost on snow support structures. These structures are very important to the protection of citizens. Permafrost has the ability to reduce the protection level of snow support structures (Phillips 2003). The SLF also helps develop and deploy hard technologies such as these snow support structures that prevent avalanches in the starting zone. Often technologies are a mixture of both, hard and soft technology.

Technology is embedded in society and therefore not every technology may be transferred to a location. Therefore, before the transfer can take place, the question of appropriate technology must be raised.

2.2 Appropriate Technology

Introduction

Every technology is unique in how it affects a society. The effect of a new technology varies with each type of technology chosen for transfer. In any transfer process, an emphasis exists on transferring the best technology to the location (Bull 1999). The technological change produced by the introduction of a technology can be beneficial or harmful to the new society. Therefore, the right choice of technology is a crucial step in the transfer process. This section of our report discusses the choice of appropriate technology and some dimensions of technology found to play an important role in the decision process.

Appropriate technology is the choice of technology that considers the people's needs and, at the same time, is least harmful to the environment. Appropriate technology is designed to help choose the best technology to transfer. In most cases, different alternatives exist that satisfy the same requirements for the host country (Clarke 1973). The various considerations for each alternative have to be analyzed until a consensus is reached on the most appropriate technology to transfer.

Two possible ways to increase land productivity in a farming community provide an example of these alternatives. The first method transfers mechanized agricultural tools with chemical fertilizers. The second increases production by introducing the standard tractor and simple tools with natural fertilizers. The first approach yields faster results but may require more money to be spent on the supporting infrastructure these tools require. The second approach is more environmentally friendly but may require more time for effective results to become apparent (Bull 1999). Here, the appropriate technology depends on the society's needs and resources and what is more likely to succeed. The main idea of appropriate technology to remember during the decision process is the technology transferred should generally be a small scale, energy efficient and an environmentally sound technology controlled by the local community (Bull 1999). The conditions depend on the type of technology and the society it is being transferred to.

To satisfy these conditions, the most appropriate technologies are more likely to be a range of intermediate technologies. Intermediate technologies are not highly sophisticated systems but are more technically or conceptually advanced than current technologies. Intermediate technologies reduce the possible choices by excluding more advanced options. They are more effective than the existing traditional technologies and more manageable than large scale, capital-intensive technologies (Evans 1979). The SLF may need to reduce the technological level to gain more intermediate technologies. This increases the number of choices of technology and produces a wider range of choices for appropriate technology. The type of technology itself plays a huge role in determining the transfer's success. Some of the attributes of technology are explained in the next section.

Dimensions of Technology

Every newly introduced technology has direct consequences. These consequences depend on the type of technology, whether soft or hard. Certain attributes, or dimensions, of the technology help choose appropriate technology. These dimensions help determine the success of the technology after it is complete. Robinson (1988) suggests different dimensions of technology influence the mode of technology transfer.

The first dimension of technology is maturity. Technological maturity measures the technological age and how it had survived in the new country (Robinson 1988). A more mature technology is more likely to adapt, depending on the level of technological advancement in the new country.

Dynamic quality is another dimension of technology. Dynamic quality indicates the possibility of upgrades to the existing technology, helping to predict its influence on the new society (Robinson 1988). The dynamic level of the technology affects the choice of the stakeholders at the receiving end. Quickly advancing technologies adjust better to the new society. Therefore, it is a key factor to assess before the transfer process.

Appropriate technology represents a choice that matches technology with the needs of a host country. It looks at the future of the introduced technology for its survival (Bull 1999). Appropriate technology answers the problems people might encounter while working with the new technology. The concept of appropriate technology is a reminder to consider the range of factors when choosing a technology. Since the transfer involves input from stakeholders of the host country, any differences between the host and the sender must be considered while choosing the most appropriate technology for transfer. These differences are evaluated on the basis of the various factors of technology transfer discussed in the next section.

2.3 Technology Transfer

Introduction

Determining a technology's appropriateness for a society requires the careful consideration of many factors. The following section highlights macro-scale factors useful in determining the suitability of a technology for a particular society. Each of these issues relates to the social process of technology transfer and is important for the ultimate success of the technology. Issues relating to the transfer process are also raised in this section.

The impact a new technology will have on a society must be carefully analyzed and predicted before the technology is transferred. Innumerable differences exist between any two given countries. The cultures of the countries will not be the same and will affect the choice of technology and the method of transfer. The relevant differences must be considered to determine the appropriateness of the technology and to select the method of transfer.

Technology transfer itself has many different definitions. Madu (1992, 2) for example, identifies technology transfer as the “acquisition, development, and utilization of technological knowledge of a country other than that in which this knowledge originated.” It has also been described as the use of inventive activity by secondary users in another country. One definition includes “the purpose, applications, and justification of the technology. It is what to employ, how, when, and why” (Dean 1995). For the purpose of this project, technology transfer is defined as the adaptation, relocation, and implementation of a new technology from a parent organization (SLF) to a new location. The first aspect of technology transfer to recognize is whether the transfer is active or passive.

Active and Passive Transfer

Technology transfer is divided into active and passive technology transfer. Passive technology transfer (PTT) is a problem that usually arises when technologies are moved to countries lacking their own industrialized economy. PTT occurs when capital goods and whole systems are imported into a new country without any serious involvement on the part of the receiving country. The new host does not explore the incoming technology. They do not consider if other technologies fulfill the same need or if the new technology will create more problems than it will solve. Furthermore, the new host does not conduct any research or development on the newly acquired technology. The knowledge and expertise behind the technology is never revealed to the native people and the technological capability of the country is not increased. The country remains dependent on the original owners, in terms of the specific technology, after the transfer. The technology is never fully assimilated into the structure of the new country rendering it an unsuccessful transfer (CTC UN 1987).

Active technology transfer occurs when the receiving country actively explores and selects the relevant technology. The possible effects of the technology in its new location are fully examined. The terms of transfer are negotiated between the new host and the owner until a satisfactory deal is reached. The SLF will have to adapt the technology to function in the new location while involving the local people. By doing this, the receiver does not remain dependent on the original owners. The technology is assimilated and new research is conducted by the host to further develop it for their own purposes. This increased knowledge and technology stimulates other areas of the country, thus improving overall conditions (CTC UN 1987).

The active transfer of technology requires a close connection and interaction between people from different societies. It is impossible to separate the technology from the society. With this in mind, the model for technology transfer will next be discussed. It provides a basic description of a complicated process.

The Basic Model of Technology Transfer

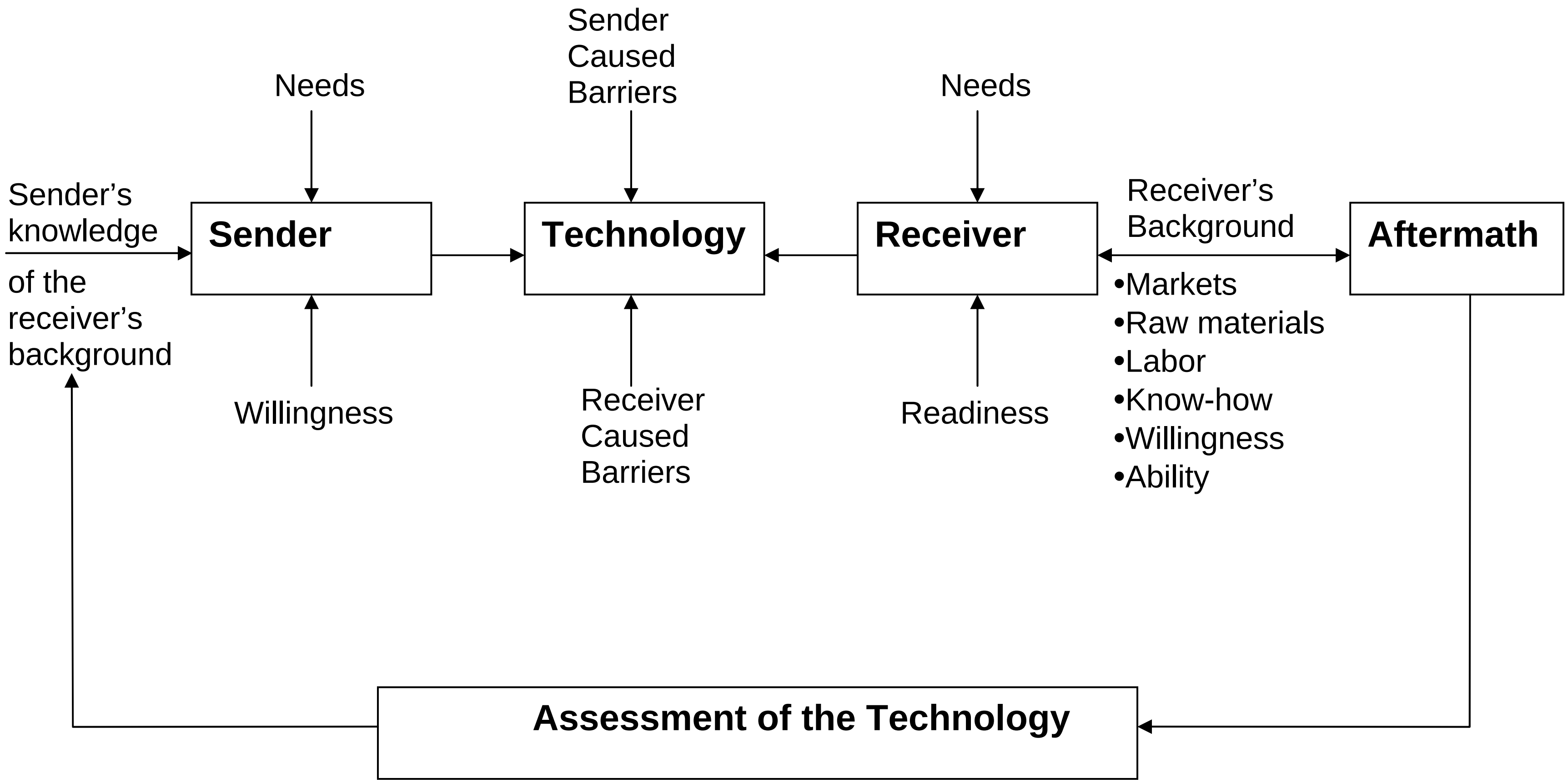
In order to consider technology transfer, previous technology transfer models were critiqued and modified. Samli (1985) proposed his generalized model for technology transfer in his book *Technology Transfer* (see *Figure 2.1*). The generic nature of the model allows it to be considered for a wide variety of transfers. Each technology transfer is unique based on the technology and differences between the sender and the receiver. A new process has to be developed each time regardless of the technology and how many times it has been previously transferred. This is due to particular differences in the societies involved and the change in societies over time. Specific details of the technology also necessitate individualized processes. This model provides a base on which to build an understanding of the problems of technology transfer as social problems.

The sender's thorough understanding of all the relevant aspects of the receiver's background is crucial in determining the success of the transfer and consequently, is a crucial part of the model. Of the items listed as part of the receiver's background, the only one not directly related to societal aspects is raw materials. All the others are products of the social situation in the new country. This illustrates technology transfer as a social process. The receiver's background and the two types of barriers shown are the same as the transfer factors though they are framed in different terms. Briefly, sender caused barriers are due to a lack of understanding of the new location while receiver caused barriers are usually due to a lack of resources, both physical and human.

The transfer should be mutually beneficial to both the sender and the receiver (Samli 1985). This creates the sender's willingness to expend the resources to move the technology and the receiver's readiness to accept the new technology. Through a common process, both sides must work to achieve their own goals and to satisfy their own needs. Both parties should gain from the transfer. The aftermath assessment of the transfer will not be the focus of this project, and is included here only for completeness.

Figure 2.1
The Basic Model of Technology Transfer

Samli (1985 9)



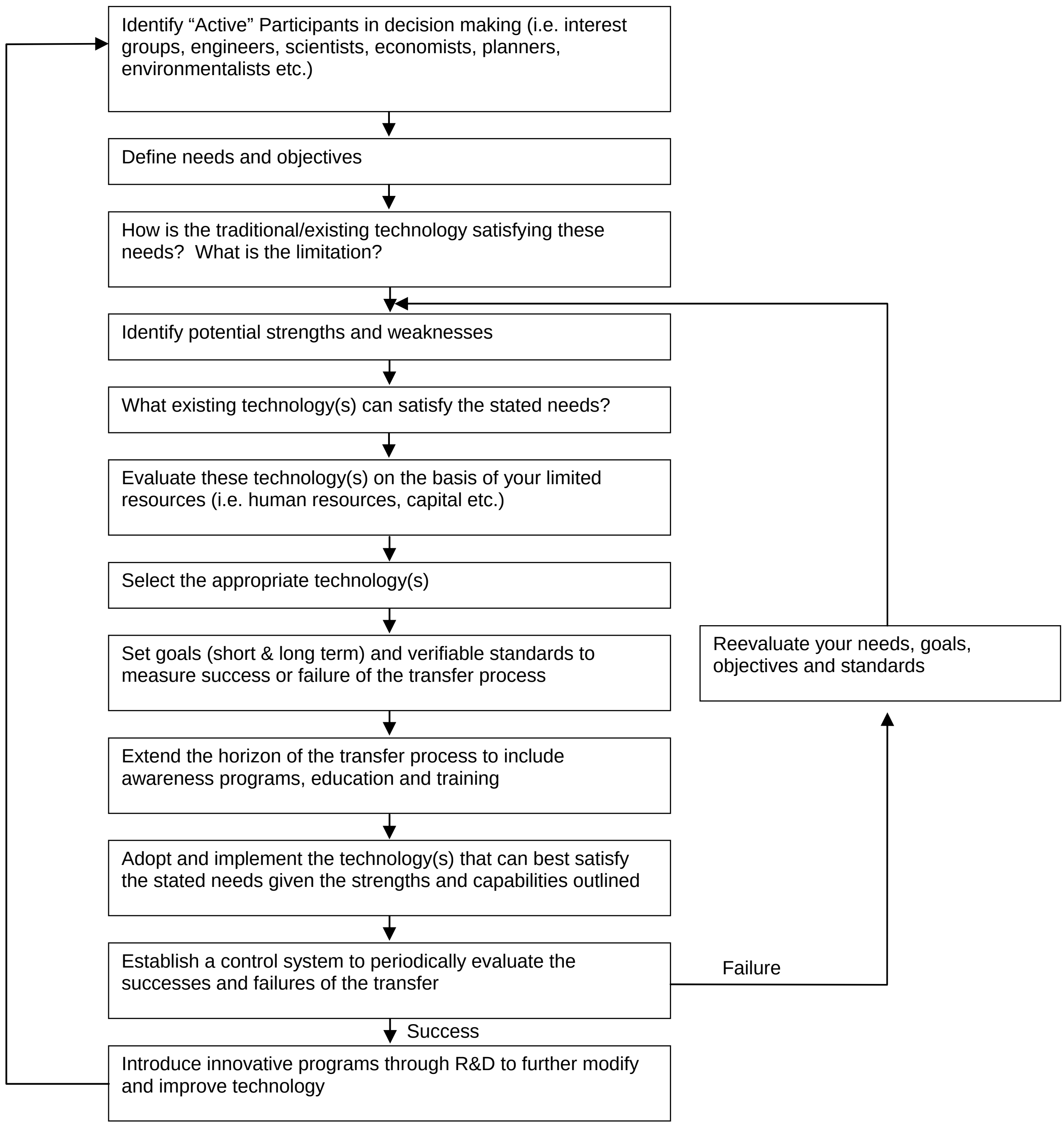
The Transfer Process

Madu (1992) presents another description of the transfer process. This depiction is more detailed than Samli's and plainly shows the steps involved in the transfer. It is taken from the view of the receiver and outlines the necessary transfer stages. It includes more practical details and is less abstract. However, it does not explicitly show where and how the various factors fit into the transfer process. They are implied throughout the process, especially in the sixth and seventh steps, "Evaluate these technology(s) on the basis of your limited resources (human resources, capital etc.)" and "Select the appropriate technology(s)" respectively. The representation's broadness again allows it to be used for this project.

The social implications of technology transfer are also shown in this model. The appropriateness of the technology depends on the society. Many of the aspects to consider for transfer are consequences of the society's beliefs and structures. The "Active" participants, also known as stakeholders, are people from different societies that must work together across a social divide to move the technology. They are considered in the next section in more detail.

Figure 2.2
The Technology Transfer Process

Madu (1992 107)



Stakeholders

A stakeholder is any group or person affected by the new technology or whose input will influence the transfer decisions (Madu 1992). Important stakeholders are the government, entrepreneurs, the technology users and the technology experts (Ramanathan 2002). Each stakeholder group typically consists of more than one member. It would be of little use to consider the opinion from just one person of each type of stakeholder.

The government of the new country is an influential stakeholder because it frames the public policies and controls the conditions in which the transfer occurs. The government is a result of the way the society has chosen to govern itself. In most cases, they assume a large part of the financial responsibility for transfer projects. The transfer could not be completed without their cooperation and willingness. Their authority also provides legitimacy to the technology making the other society members more receptive to both the technology and the changes it will bring.

Facilitators and investors, while not direct stakeholders, are important to the transfer process, especially in developing countries. In some cases, they are involved in matching technologically advanced organizations with potential recipients (Minchener 2000). Funding agencies, such as the World Bank and Asian Development Bank, supply the financial resources when local governments and technology owners cannot. Their participation is beneficial to the relocation.

Identification and involvement of the stakeholders from the beginning of the transfer process will ensure input and feedback from all relevant parties. Through communication between these stakeholders, the senders learn about the recipient society and the receivers learn about the technology. Ensuring these parties communicate and work together effectively is fundamental to the transfer process. It is not always straightforward given the different cultural and social backgrounds of each stakeholder. Equal consideration of their input will ensure informed decisions are made. This also minimizes the negative impacts on the new society and reduces the wasted time, energy and resources.

Resources

Technology requires many different types of resources during and after the transfer. Resources are both physical and human. Each should be considered because resources are limited and should be allocated and utilized as efficiently as possible. This is only achieved when adequate management is in place. Resources should be spent only when necessary. For this reason, technologies are often sub-divided into their separate components.

If the technology is separated into its core and peripheral components, the importer has the ability to select and transfer only the core technology (Wie 1995). This reduces the required resources by removing unnecessary parts and transferring only the piece solving the problem. It is much simpler to transplant a single technology than an entire system requiring an extensive infrastructure to support them.

Physical Resources

Raw materials for construction and maintenance as well as energy requirements are part of the physical resources. The amount and type of raw materials present in the new country is one of the few factors independent of society. However, the availability and pricing is heavily influenced by the society. The physical resources must be available and affordable. The same resources have different values in different parts of the world (Robinson 1988). The rarity of resources in certain locations increases the value. If resources are not readily available, the transfer process will require extra expenditure. The use of local resources reduces the overall cost by eliminating importation costs (Hay 2000).

Human Resources

Human resources include labor, management capabilities and technical skills. The labor required to use and maintain the technology must be available. The ability of a country to accept a technology transfer depends on the people using the technology. Their ability to effectively utilize a new technology can be referred to as "absorptive capacity" (Stewart 1987, 5). A country can import more technology if a high absorptive capacity exists. Absorptive capacity is divided into two areas; "the supply of workers with the general education appropriate for hiring and technology-specific training ... [and] the state of the legal-social-economic infrastructure" (Stewart 1987, 5).

The new personnel's background education determines the amount of feasible training. The level of background education is determined by the educational system of the host country. Technology specific training can only be supplied once the general education is in place. The general education necessary depends on the technological requirements. It usually includes engineering and managerial competencies. The management resources in the host country play the largest part in determining the way the new technology is assimilated (Mukherjee 1984). The effort of the management to understand and adapt the technology to their needs through research and development is crucial for the assimilation. Assimilation also reduces the dependency of the new host on the original sender. The transfer cost may become too great if the required training during the transfer must cover both background and technology specific knowledge.

The second area of absorptive capacity deals with the legal-social-economic infrastructure. These social structures are institutional instead of individual and separate from the physical infrastructure discussed later. This institutional infrastructure relies on the availability of individuals with the necessary general education (Stewart 1987). This area provides services to those importing the new technology, such as supplying information and administering the social-legal environment (Stewart 1987). Deficiencies increase the cost of the transfer as well as the cost to use the technology. The technology cannot be transferred if these costs are too great.

The absorptive capacity of a country measures the readiness of a country to use the new technology. A certain level of education and institutional support is required for the technology to survive. The technology also requires other physical support services. These will be supplied by the physical infrastructure of the country.

Infrastructure

The support systems and services necessary for the technology to survive in its new location need to be considered. Supports systems comprise of transportation networks, electrical grids, and other maintenance networks. The transportation of materials to the construction site as well as maintenance must be possible. If support systems are not solidly in place, the technology will not succeed. For many countries, the lack of support systems coupled with a lack of expertise creates a poor technology transfer foundation. The current support systems may need to be upgraded to ensure future technological compatibility (Joyner 2002). The newest and most sophisticated technology is not always appropriate to transfer because of the high support levels it requires.

One of the aims of technology transfer is to improve the technological capability of a developing country (Putranto 2003). A gradual increase in the technological level of the host country is generally more desirable so the infrastructure has time to increase with it (Madu 1992). This increase may be achieved by the diffusion of a technology throughout the new economy. Technical assistance extended by the newly trained experts, as well as personnel turnover, contributes to the diffusion of knowledge (CTC UN 1987). Without diffusion, the country does not advance its technological capability.

Public Policy

Governmental regulations, political history and economic stability play a significant part in determining the technology transfer outcome. The public policies adopted by the local government strongly influence the success of a transfer. These policies must be consistent and conducive to active technology transfer. For example, successful policies in Japan reduce the dependency on the original owner by forcing the new owners to independently utilize the technology (CTC UN 1987). Public policies should include requirements for the careful search and selection of appropriate technology to prevent transferring an inappropriate technology. A minimum level of education and training should also be included in the public policies to facilitate the technology's diffusion. Requirements for research and development using the new technology should also be incorporated into the policies.

The active contribution to the process by the government is a part of the active transfer of technology the SLF must perform. While the SLF does not have direct control over these policies, carefully considering them helps the transfer. Continual governmental involvement allows policies to change and adapt during the transfer process to obtain the maximum benefit. It is not enough for the government to construct policies and hope the transfer occurs smoothly. Unforeseen circumstances must be dealt with. The adaptation of policies during and after the transfer requires input from the stakeholders and sufficient management resources.

Cultural Factors

It is difficult to completely distinguish between the social and cultural aspects of technology transfer. The cultural beliefs influence the various ways people react to a new technology, from the highest government official to the lowest laborer. Reactions to a new technology may not be favorable if the host alters the structure of their society. The introduction of technology will have implications on the society; problems will be minimal if the society is willing and open to change. The technology would not be helpful if it created cultural problems, destabilizing the country (Madu 1992). The effects may take years to become apparent and are often difficult to predict. Strategies must be developed to minimize the damage and to manage the problems as they occur.

The SLF will not be able to consider the cultural implications until both the location and the technology have been chosen. Consensus conferences and other assessment tools discussed later help determine the results the technology's introduction might have on the society and its environment.

Environmental Factors

It is essential to carefully evaluate and anticipate the environmental impact of the transferred technology. The introduced technology should not pollute or harm the environment. Acceptable and unacceptable treatment and uses of the environment are defined by the society's view. These definitions dictate the allowable environmental impact of the technology during and after the transfer. The sender should be careful not to impose their views of the environment on the receiving country.

The environmental effects on the original country may not be the same as the effects in a new location. The pressure the technology places on the new environment should be examined to consider the environmental effects. These pressures, both direct and indirect, would derive from the resources and space the technology uses, as well as the waste it produces. It may disturb the native ecology. The environmental consequences of the technology's entire life cycle should be considered before it is transferred.

The environmental consequences of hard technologies are obvious and easy to determine. Soft technology has indirect consequences appearing through the decisions based on the new knowledge. The new host must consider them before they implement any decisions. They are more difficult for the SLF to determine.

Information Paradox

The receiving country will not fully understand the technology and the consequences of what they are importing until the transfer is complete. Without full knowledge of the technology, the receivers cannot consider all the social implications of the transfer. Their input will always be based on an imperfect grasp of the technology. Likewise, the exporters, who understand the technology, do not know the details of the location which it will be implemented in. Following the Centre on Transnational Corporations, UN (1987) this is referred to as the "information paradox." It is highly improbable that all the repercussions will be identified even with complete knowledge on both sides of every possible aspect.

This paradox adds to the complications of technology transfer. The decision process developed for the SLF will need to take into account this informational barrier. Allowances must be made during the transfer to deal with changing input from the sender and receiver as both come to understand the society and technology.

2.4 Technology Assessment

Introduction

Technology assessment is a social process. A technology only survives in a location if it suits the people. Therefore, technology assessment is crucial for a successful technology transfer. It assesses the societal impacts of the factors mentioned in the previous section. This section will outline the methods and concepts used in a technology assessment. The terms of assessment need to be defined for each specific transfer before determining the best methods to use. For this paper, the technology assessment method examines how a technology works in its home culture of Switzerland, and how it will survive and change in a new location.

Social Shaping Concept of Technology

The concept of social shaping is “a process in which there is no single dominant shaping force“ (Mackenzie 1999, 16). It utilizes all platforms of society such as professional, public, or educational (Hansen 2003). Social shaping uses these platforms to gain a cultural viewpoint on the effects of technology. Each of the platforms of society can be used to gain an understanding of the technology's future. It is, however, a reciprocal relationship as the technology also helps form society.

Technology has shaped society for better or for worse. "[I]t is inescapable that every culture must negotiate with technology, whether it does so intelligently or not," (Postman 1992, 5). To understand the interaction between technology and society, both negative and positive technical effects must be considered. Consideration of these ensures a successful technology transfer. The introduction of a new technology has the power to bring about a significant change in a society.

Consider the effects of the transportation revolution. By making it convenient for people to travel, it became easier to leave and live farther away from one's home. This migration is a type of societal change. It changes the base unit of society, the family, by allowing offspring to journey farther from home. This relocation spurred a communication revolution. Relatives desired to communicate at a faster pace. Communication devices such as the telegram and the telegraph were invented. Now in the information age, it is possible to communicate with others instantaneously, either through telephone devices, electronic mail, or instant messaging.

It is unlikely SLF technology will have such dramatic consequences. The effects of the new technology must still be carefully considered. Several tools are available for the SLF to examine these consequences before a transfer process begins.

Methods & Tools for Assessing Technology

The societal beliefs influence the various ways people react to new technology. Reactions to a new technology may not be favorable if the host has to alter the social structure. The SLF will not be able to consider the cultural implications until both the location and the technology have been chosen. Consensus conferences and other assessment tools discussed later would be used to determine the results the technology's introduction might have on the society and its environment. The economics of the transfer must also be considered.

Economic Tools and Assessment

Economic analysis is a crucial part of technology assessment. The economic analysis will determine if the host country can afford the technology transfer and how much outside funding will be needed to supplement the host's deficit. They also quantify the benefits obtained from the technology. Morgall (1993) outlines two common forms of economic analysis: cost-benefit analysis (CBA) and cost-effectiveness analysis (CEA).

Cost Benefit Analysis

Cost benefit analysis compares the cost and the benefit of a technology based on the same scale, usually monetary. CBA predicts the potential profit of the technology, to see if it is greater than the investment. It is usually used in a business environment. This analysis determines the actual value of the technology.

Cost Effectiveness Analysis

Cost-effective analysis compares the cost of technology and its benefits on two different scales. The cost is usually monetarily based, however the benefits are expressed in terms such as lives saved or accidents avoided. CEA focuses on finding the most effective technology for the provided resources (Morgall 1993). A CEA assessment of SLF's technology will be used in this project since the technology to be transferred has been developed to save lives and prevent accidents instead of generate profits.

A cost-effective analysis is most usefully seen in a ratio. The ratio displays the cost of the technology over the unit of effectiveness. The ratio is usually measured in the cost per death for every 1000 people per year. However, the unit of effectiveness changes for each technology. For avalanche barriers being built in high risk zones, the effectiveness could be measured in terms of reduced risk. An equation, shown below, was adapted from a United States Office of Technology Assessment report to measure the cost-effectiveness of SLF technology (Bentkover 1981, 10).

$$C/E = (C_T - C_S + C_M)/(E_A - E_B)$$

C/E = net cost effectiveness ratio
C_T = cost of transferring technology (including building, implementation, etc.)
C_S = cost saved by transferring the technology
C_M = cost to maintain the technology
E_A = level of risk after the technology transfer is complete
E_B = level of risk before the technology transfer

The overall cost of the technology is measured in the amount of money spent to transfer and maintain it minus the amount of money saved by transferring the technology. The effectiveness is measured by the change in the level of risk after the technology was transferred. SLF will need to determine how the risk, or some other factor, is measured for each technology it transfers. Since they are most knowledgeable of their own technology and its effects, it is easier for them to determine this term in the equation.

Communication Tools

Communication between the stakeholders must occur in order for the transfer to occur. The necessary information is obtained from the beginning from the stakeholders. Below are some methods that could be used to open up the dialogical between stakeholders,

Delphi Method

The Delphi method was originally developed by Olaf Helmer and Norman Dalkey in 1953 at the RAND Corporation in the United States (Lang 1998). It has undergone much development since its original creation. The Delphi method structures the communication between large groups of individuals so the group is efficient and effective in solving complex problems (Turoff 1975). It is used when face-to-face meetings between the participants are not feasible or desirable. The method allows participants to contribute to the problem solving without any problems normally associated with groups.

The method has been modified numerous times and many versions of the original method now exist. Three main categories of these methods are: conventional, policy and decision Delphi. The conventional Delphi is used in circumstances closest to the original purpose; to determine a consensus in forecasting and estimating unknown parameters (Lang 1998). The policy Delphi elicits the highest number of opinions possible from the participants for the discussion of these ideas. It does not seek to form a consensus. The decision Delphi is used to form a consensus among the participants on the best solution to the problem. It is used when participants have varying backgrounds and interests in the solution to the problem (Lang 1998). During a technology transfer, the decision Delphi ensures the best decision is made with input from all the stakeholders.

The entire Delphi process is controlled by a monitoring team. The monitoring team should comprise of at least one person familiar with the subject being discussed. Other members of the monitoring team should be familiar with the Delphi process to ensure the process occurs smoothly. The team is responsible for keeping the group focused by eliminating irrelevant information from the discussion.

Participants should be carefully selected to ensure each stakeholder is accurately represented. They usually come from varying backgrounds and interests. All are interested in the solution to the problem. They communicate indirectly through the monitoring team to discuss and solve the particular problem.

The Delphi method occurs through successive rounds of questionnaires distributed to the participants. The questionnaires ensure the group is focused on specific questions and also coordinate group interaction. The questionnaires become more specific as the rounds progress. Every questionnaire, except the first, is based on the previous results. The responses define how the method proceeds and the areas that are pursued. The group still controls the discussion and decides what the most important issues are.

The first round is the least structured and usually explores the particular problem (Turoff 1975). The participants are open-endedly asked for their opinions regarding the particular problem (Lang 1998). The monitoring team analyzes the information gathered from this round. Responses to the first questionnaire identify issues and problems that must be addressed. The monitoring team formulates a second questionnaire. The second questionnaire pursues important points or reveals the reasoning behind the opinions based on the first round information.

The participants are supplied with the results of the first round to allow them to consider their own thoughts in comparison with the other participants' ideas. The second questionnaire is distributed to the participants and again, the monitoring team analyzes the responses. A new questionnaire is constructed. As before, this is distributed with feedback from the previous round. Subsequent rounds of questionnaires and feedback are used to continually discuss the problems until a consensus has been reached. The number of required rounds depends on how quickly a consensus is formed.

The Delphi method has many advantages and disadvantages. The requirement of questionnaires construction is one disadvantage. The monitoring team may introduce a bias through the formulation of the questionnaires. Their analysis and feedback of the information may also unwittingly introduce bias (Linstone 1978). Another problem is the increasing specificity of the questions with each round. Questions seeming unimportant at the study's beginning were not asked and cannot be added once the process is underway (Simmonds 1977). The extreme flexibility of the technique widens it applicability and also makes it vulnerable to poor execution (Amara 1975).

The advantages of this technique outweigh the disadvantages. It allows problems to be discussed amongst large groups that could not otherwise effectively communicate on a face-to-face basis. The process also allows the anonymity of the participants. They can express extreme points of view without any pressure. The members can choose the parts of the problem they are most suited to solve (VTET). The participants' cultural backgrounds are removed as a barrier because there is no direct contact with other group members. The process is especially useful in situations where the "problem does not lend itself to precise analytical techniques but can benefit from subjective judgments on a collective basis" (Turoff 1975). The SLF will encounter this type of problem when conducting a transfer.

Many stakeholders from diverse backgrounds will exist whose opinions must be equally considered. This may not happen in a group situation where the discussion is controlled by dominant individuals (Lang 1998). In some cases, too many stakeholders will exist to meet effectively during the transfer process. The costs of such meetings will add to the expense of the transfer.

Environmental Assessment Tools

Many methods have been developed to determine the impact a particular technology on the environment. The Environmental Technology Assessment and the Life Cycle Assessment are two methods that are useful for the SLF. They both describe the pressures of the technology on the new location. The two methods differ slightly in their approach and, therefore, different information can be gained from each.

Environmental Technology Assessment

The environmental technology assessment tool was developed for the United Nations Environmental Programme Division of Technology (Hay 2000). This assessment tool guides the choice of technology when multiple options exist. It is designed to consider multiple stakeholders' opinions and the method is used as a scoping tool before a full proposal is written. The following is a brief summary of the overall process. The steps are displayed sequentially but the method does not have to be conducted in such a rigid manner. There is some flexibility in the process.

The five-step process begins by describing the technology being assessed. The function of the technology and the characterization of its operation and development all take place in the first step. All the inputs and outputs of the entire technological use should be determined in this step. A visual representation would be beneficial.

Once this is complete, the pressures resulting from the use of the technology must be determined. The many environmental pressures are systematically identified by listing the various technological requirements and the outputs. Secondary pressures from supporting technologies are also considered. This step provides the information necessary for the third step.

The impact associated with each pressure identified in the previous step is judged for its severity in the third step. Each pressure is grouped into various categories based on the extent of its damage. Environmental laws are considered when making these judgments. If the pressures and impacts create a situation of non-compliance, the category would be more severe. A judgment is based on the many different aspects of the surrounding conditions, such as the local and global environment, human health and safety, and the sustainability of resource use. The economic viability of the proposed technology is also considered in this step.

The fourth step compares the technology being assessed to other possible technologies. This determines if another technology satisfies the same needs with a lower environmental impact. The extent of the assessment of each alternative technology depends on the technologies involved. If one technology has a clear advantage over another without a complete assessment, then a complete assessment does not need to be performed. However, if the technologies are similar, a complete assessment will determine the better choice.

The final step of the process is evaluating the gathered information. Any uncertainties and knowledge gaps should all be identified. If these are not significant, the stakeholders can form a consensus and the preferred technology selected. The suitability of the technology should also be summarized. Lastly, the level of certainty of the overall assessment should be described.

These outlined steps will help the SLF and other stakeholders cooperate to determine which technology would be less harmful for the environment. The Life Cycle Assessment tool may be more appropriate to use if only one technology is being considered.

Life Cycle Assessment

The Life Cycle Assessment (LCA) method is used in a similar manner as the environmental technology assessment. It explicitly considers the impact over the different life cycle stages of the technology. The overall process is iterative. As more information becomes available other parts of the process are reconsidered and described in more detail. LCA does not consider the economic viability as the environmental technology assessment does.

Defining the scope and goal of the particular assessment is the most important part of LCA (EPA 2002). The specific technology or system to be assessed should be clearly defined by the types of information and the level of detail required for the study. This directs the study so useful results can be obtained.

LCA requires an inventory of the different process within the technology or system, such as stages in manufacturing or assembling. The processes involved during the construction, utilization and decommissioning must be inventoried. This inventory defines the components of the technology. The resource requirements, such as energy and raw materials, for each item in the inventory must be quantified. Substances released into the environment as waste or by-products must also be quantified (EPA 2002).

Once the inventory is complete, the impact of resource usage and environmental releases must be determined. Impacts are normally grouped into categories such as global warming, acidification or resource depletion (SETAC 1998). They can be defined depending on the requirements of the study. Each impact category requires an indicator or index to determine the magnitude of the impact (SETAC 1998). The inventory items are placed into these categories to determine the technology's impact on the environment.

The results of a life cycle assessment allow decision makers to quantify the technology's impact on the environment. The evaluation and interpretation of the results allow the stakeholders to predict the technological impact on the new environment before it is relocated. It is also used after the technology is transferred to determine if its actual impact, rather than predicted impact, is acceptable. If the impact is unacceptable the results will highlight specific areas to be address for the technology to remain.

2.5 Summary

Technology and society have a codependent relationship. Neither can exist without the other. In order for a technology to survive, it must be accepted and used by the society in which it is placed. The concept of appropriate technology attempts to answer the question of what the "best" technology is for a society. The factors listed in the technology transfer section help determine what is “best”. If the factors are not considered when deciding which technology to transfer, the society itself will not be considered. Thus the transfer process could harm to the society when the intention was to aid it. The tools outlined in the technology assessment section work towards preventing a potentially harmful technology from being transferred. From these three sections, the close-knit relationship between technology and society is very apparent. This relationship must be taken into careful account during our procedure and final decision tool.

Chapter Three: Procedure

Introduction

This chapter outlines the methodology used to gather information while in Switzerland. The main methodology tools used were semi-structured interviews and archival research. Using these two methods, we compiled an inventory of technology and knowledge developed at the SLF. The inventory provided an understanding of SLF technology and its uses. Next, a theoretical decision process was developed based on the SLF technology and our knowledge of other technology transfers. The decision tool and literature review were used to conduct theoretical transfers.

3.1 Inventory of SLF Technology

An inventory of SLF technology was an essential first step because a comprehensive list of SLF technology did not exist. It was necessary to view the existing SLF technologies available for transfer. A graphical representation of this procedure is shown in *Figure 3.1.* An inventory was crucial to develop a base understanding of the expertise at SLF and its various uses. Information gathered on each specific technology answered our research questions about the specific aspects of the technology.

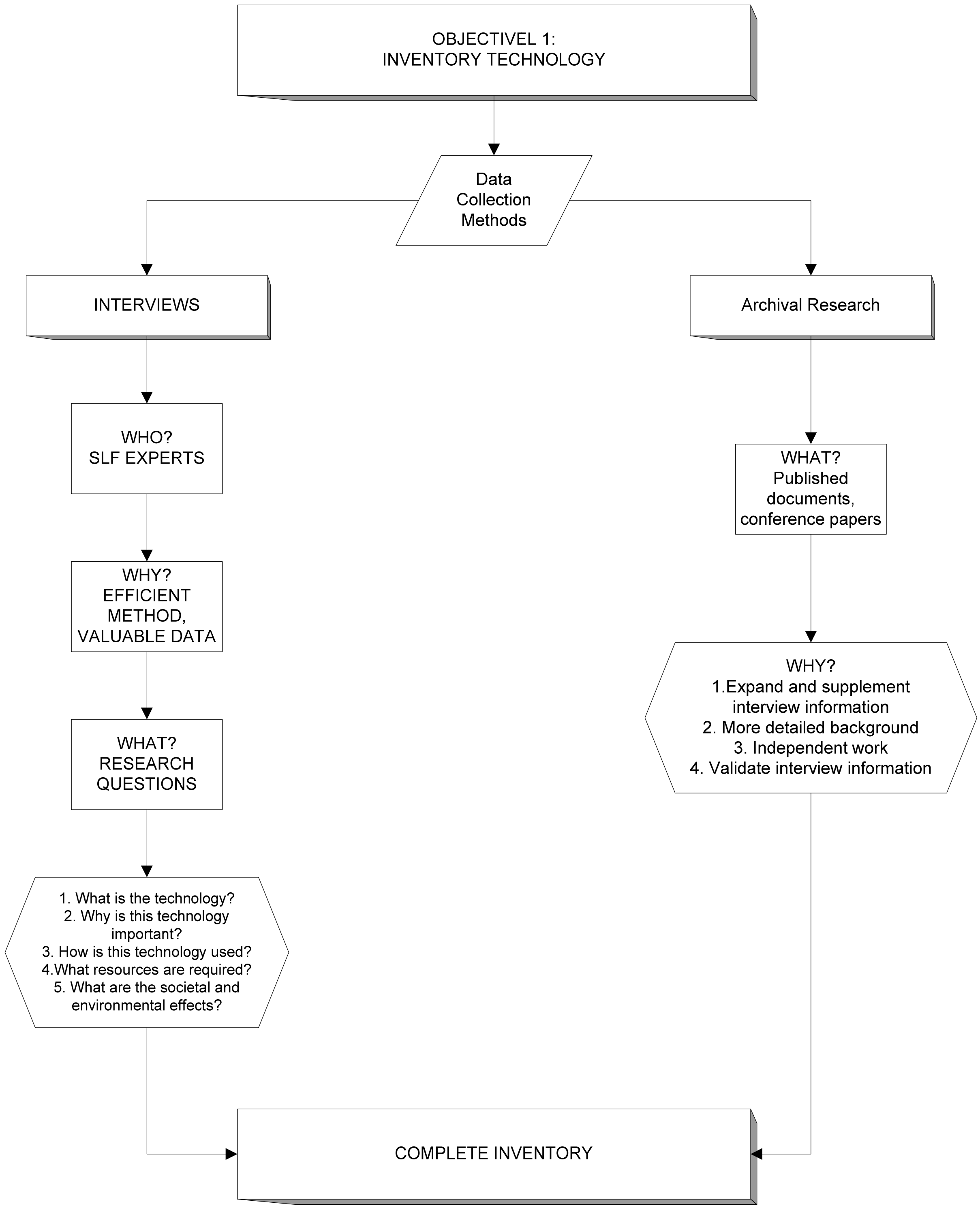
Semi Structured Interviews

A semi-structured interview was the main method used to gather information on SLF technology and research. The interviews were conducted with SLF scientists who developed and designed the technology. Interviews were an efficient method to fulfill this task. At times, a language barrier existed that needed to be overcome. Most of the people we interviewed had conversational English while other people did not have as firm a grasp on the language. We managed to gather information by being understanding and trying to help them form their thoughts in English. It also helped to talk slowly. In the end, the interviews achieved their purpose of answering our research questions. These questions were based on the technology or research, its uses and applications, the knowledge needed to run them, and whether or not it had been marketed. The answers to our questions provided an understanding of the technology necessary for completing the inventory and conducting the theoretical transfer.

Archival Research

The second method for inventorying SLF technology was archival research. A serious language barrier was confronted. Not a lot of information about the SLF's work existed in English. However, we did receive several fact sheets that helped provide a familiarization with the current technology. There was also a limited amount of written material about some of the programs and methods used at SLF. We fully utilized the written information and conducted more interviews, as was necessary, to fill the gaps in our research. This data supplemented the interview data and helped ensure its accuracy. A base understanding of the existing technology and research was a crucial step in performing the theoretical transfer.

Figure 3.1
Inventory of SLF Technology



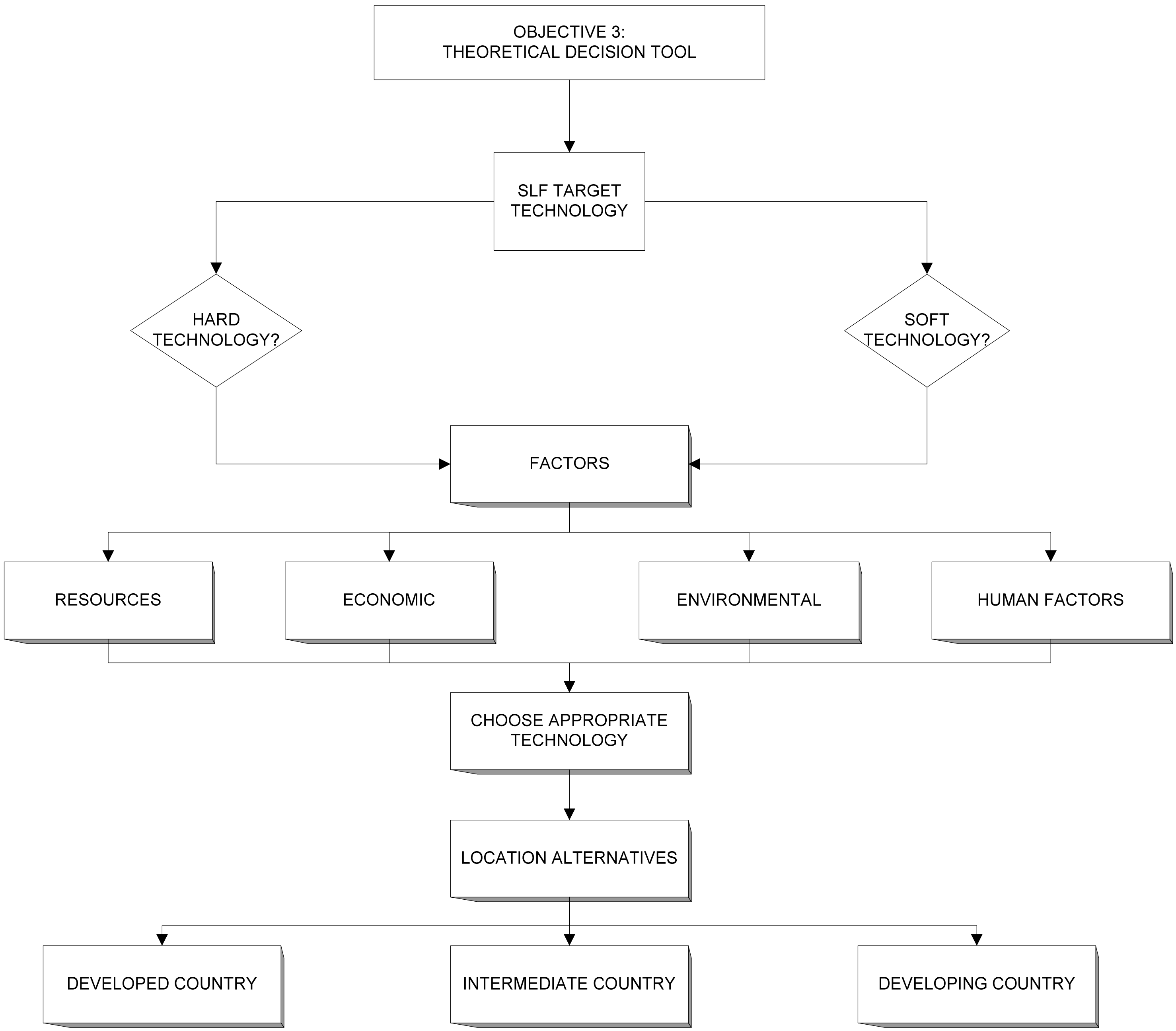
3.2 Development of the Decision Process

The second objective of the project was to create and develop a conceptual transfer process to provide SLF with a basic understanding of technology transfer as it applies to their technology. The process was developed to help the SLF identify key issues to address during the transfer process. It considered the different aspects of technology transfer in a conceptual sense. The general process for this is shown in *Figure 3.2*.

The research conducted in the literature review has shown that the factors affecting the technology transfer depend heavily on the type of technology being transferred. Different technologies require modified processes. The factors to be considered for each technology are similar, but the details and importance of each differ greatly. The different ways factors have to be considered require the SLF to adapt the overall decision process to the specific technology and location.

Once the inventory was complete, we analyzed other technology transfers to create our own SLF specific conceptual transfer process. The case studies and previous research helped to develop a process necessary for the SLF to complete to begin transferring their technologies. The technology specific process of transfer will be developed by the SLF should they choose to transfer them.

Figure 3.2
Preliminary Decision Tool Development Method



Summary

These methodologies were used to accomplish the project objectives. Semi-structured interviews and archival research collected the necessary data from the SLF. Our inventory is a direct result of these two methods. The theoretical transfers used information from the inventory in conjunction with the knowledge gained from the literature review to illustrate the issues of a technology transfer.

Chapter 4: Data Analysis

Introduction

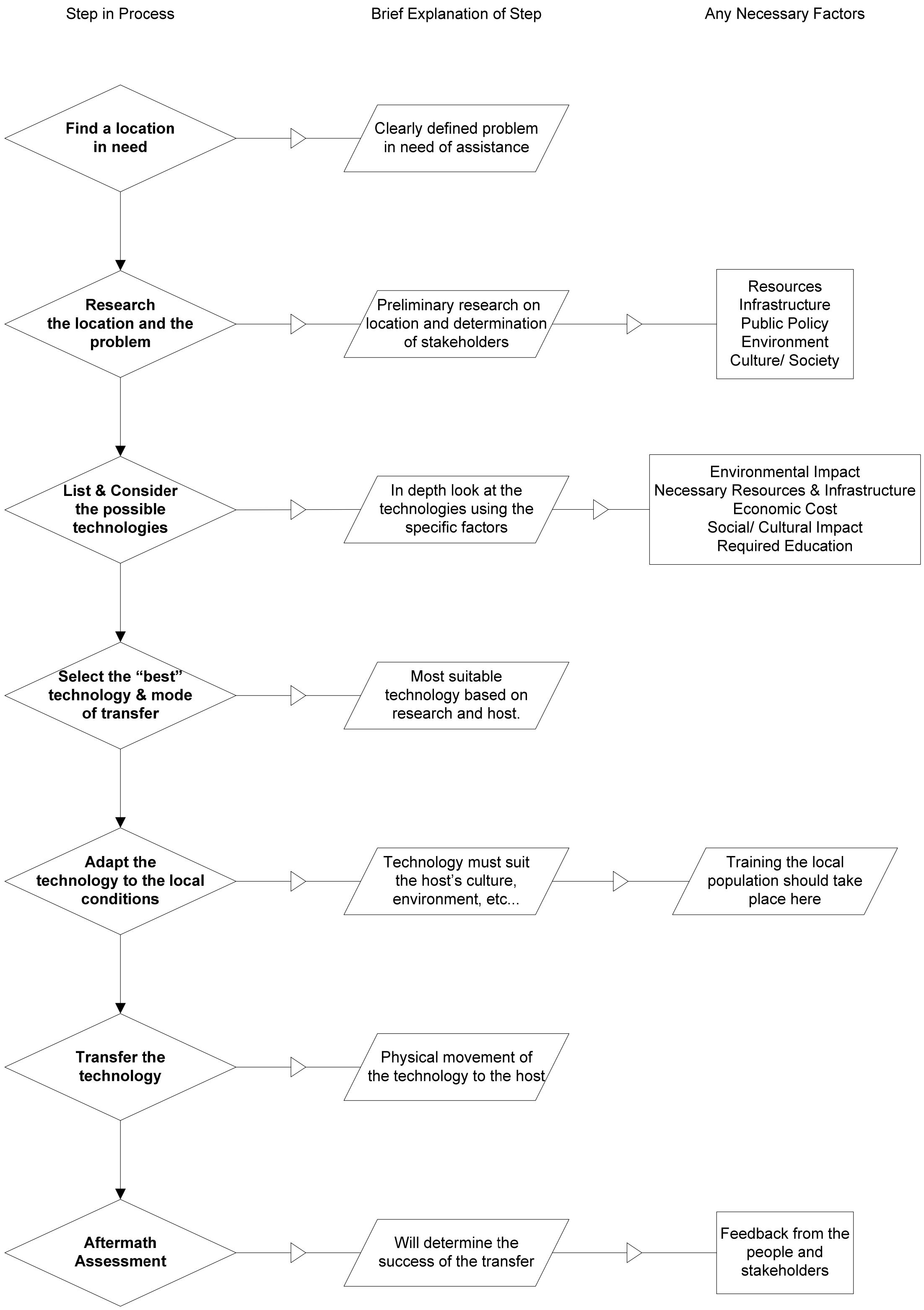
This chapter presents the data gathered by using the procedures described in Chapter Three. Before a transfer analysis could be performed, a conceptual process needed to be developed. Technologies were chosen to represent the categories in of our inventory. These technologies were taken through the theoretical process. At each step, particular concerns were raised and explained. The first stage of our analysis was the development of the conceptual transfer process.

4.1 Conceptual Decision Process

A conceptual decision tool was created to outline the important steps necessary to perform a technology transfer based on our analysis of our literature review and previous models and examples. These steps are shown in *Figure 4.1*. Each step's importance has already been covered in the literature review. This section explains the steps order and importance.

The process presented in this section is written from the view of the technology senders and is applicable to any technology transfer. It was developed to achieve a balance between specificity and applicability. A more specific process is not possible without excluding certain types of technology. This process must be adapted to the both the technology and the location for each separate transfer due to its necessary broadness which leads to ambiguity. The process is a guide for transfers the SLF may conduct.

Figure 4.1
Theoretical Transfer Process

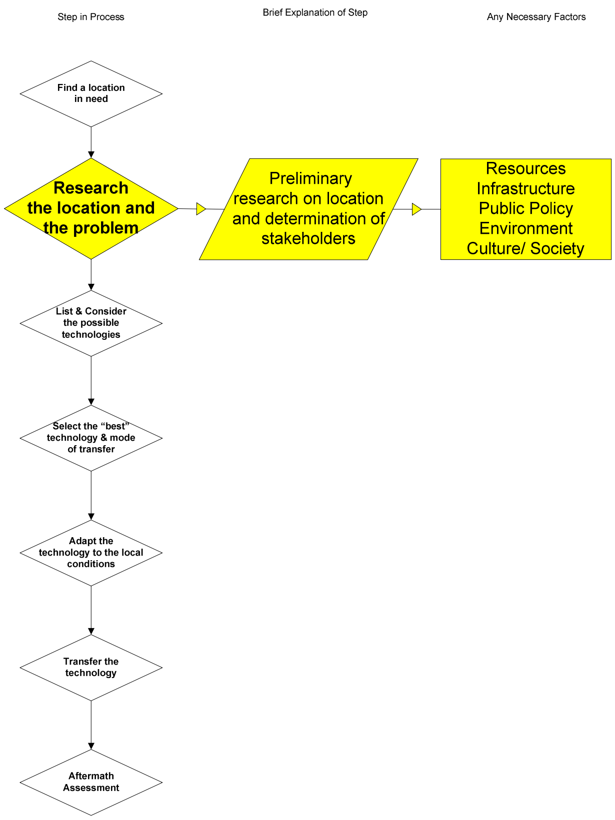


Step 1: Define the location

A technology transfer process depends on the location the technology is being transferred to. A transfer cannot be considered until a destination is determined. Therefore, defining a location in search of a possible technological solution to a problem is the first step in the overall conceptual process. The location must be seeking help and may directly approach the SLF for assistance. This identifies the location's main stakeholders. More stakeholders emerge as research is conducted and the technology is gradually defined.

Step 2: Preliminary Research

Figure 4.2
Theoretical Process: Step 2



The second step of the process is conducting preliminary research on the location and the problem. The data collection provides a basic understanding of the receiving country's condition. An understanding is necessary before any solutions can be considered. The research allows the stakeholders to begin to list technologies that might satisfy the problem. The country's stakeholders are crucial to gathering this data.

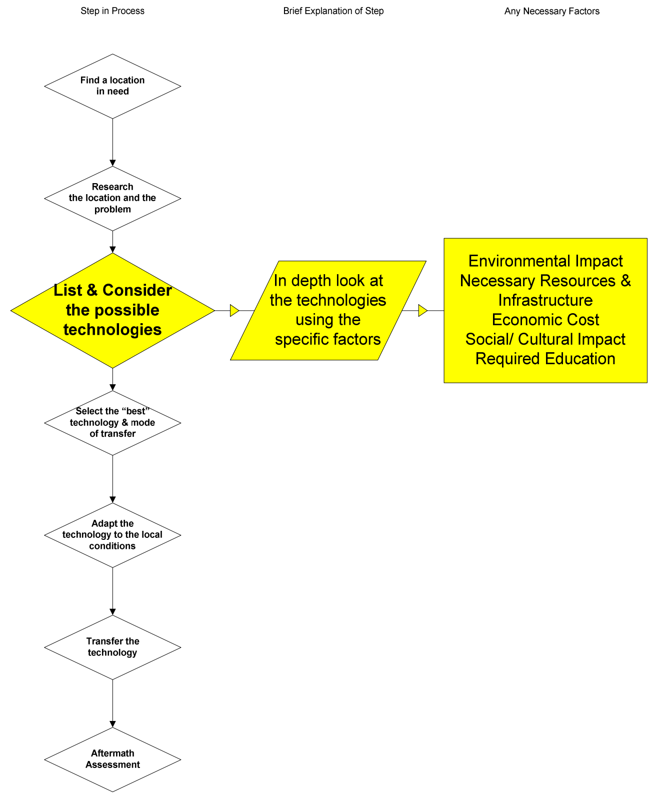
Stakeholders must be identified during this stage because their communication is essential for a successful transfer process. The identification of each specific stakeholder varies between technologies and is discussed in detail later in

Section 4.3. Stakeholders are the main source of data because they have access to the necessary information required. However, their role does not end here. They are also essential when further research is needed on each specific technology.

Step 3: List and Consider Possible Technologies

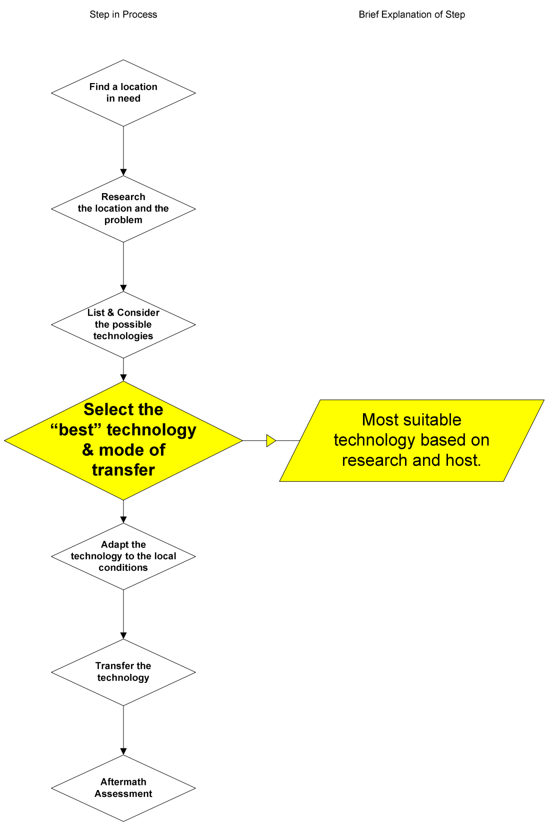
Once a fundamental understanding of the location has been obtained, the potential technological solutions are listed and further researched. For each technology, it is necessary to conduct specific research to determine how the new technology may react. Specific information on all of the factors listed in Section 2.2 must be gathered for each technological solution. The in-depth research helps determine the most appropriate technology based on the impact and possible reaction of each technology.

Figure 4.3
Theoretical Process: Step 3



Step 4: Select the "best" Technology

Figure 4.4
Theoretical Process: Step 4

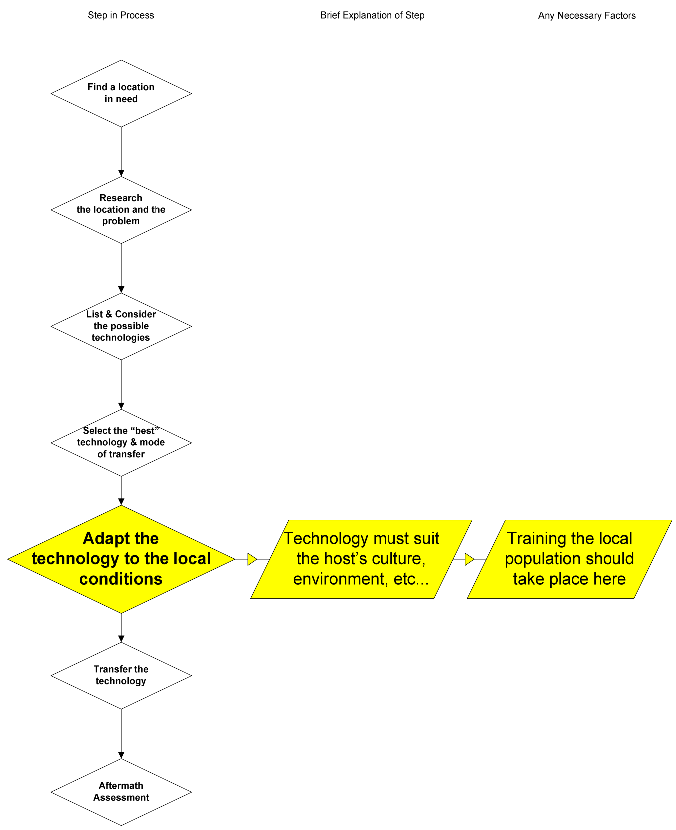


The optimal match between the available technolgies and the resources and conditions of the receiver are determined in this step. From the previous research, enough information should exist to determine which technology is best suited to the receiving country. After the technology is chosen, the mode of transfer from the original owners to the new country must be determined. The mode determines the responsibilities of both sides during the physical transfer. But before the transfer can begin, the technology may need to be adapted. The new society may be unable to use it in its current form, therefore, the technology may need to be adapted.

Step 5: Adapting the Technology

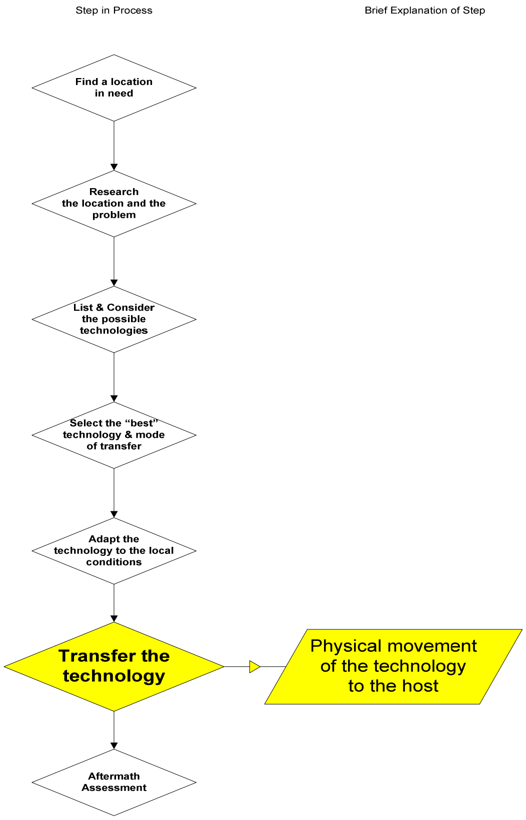
A crucial step in the transfer process is adapting the technology to the new conditions. If this step is not completed, the technology may not fit the conditions of the new country and will ultimately fail. The necessary technological resources will not be exactly the same in the new location. Human resources can be developed over time, but physical resources cannot. The only solution is to transport them. The new location may have an abundance of resources that were not available in the original location. The technology may be adapted to utilize the new resources saving time and money

Figure 4.5
Theoretical Process: Step 5



Step 6: Transferring the technology

Figure 4.6
Theoretical Process: Step 6



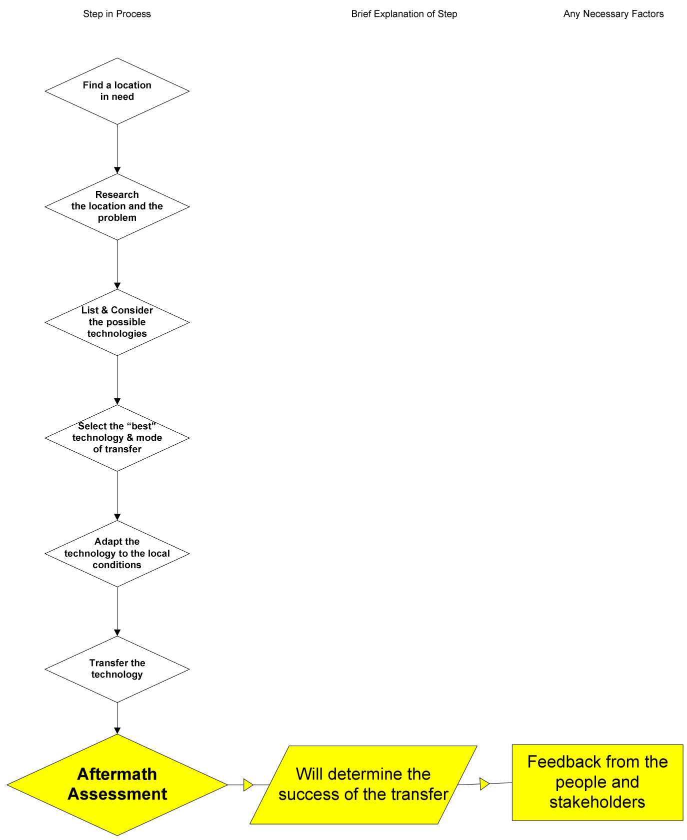
After the adaptation, the next step in the decision process is to transfer the technology via the mode decided on in step four. Any number of problems could occur ranging from construction difficulties to patent concerns. All problems that arise should be dealt with immediately. Despite the previous research, some issues might still exist that were not previously addressed. They must be solved by considering the input from all the stakeholders. If the technology is an applied knowledge, the actual transfer will be the education of the receiving experts or professionals.

Step 7: Aftermath Assessment

Once the transfer is complete and the allotted amount of time has passed, an aftermath assessment determines the status of the new technology. Although our conceptual decision process was carefully designed to ensure a smooth transfer, unforeseen problems may still be raised. Several different aspects should be examined to determine how successful the transfer truly was.

Stakeholders, the technological professionals and the citizens affected by the technology are involved in the examination of the technology's final success. The stakeholders and professionals reveal if further support is needed from the senders. The citizens provide feedback on the technology's usefulness and if the technology was detrimental. The aftermath assessment illuminates all of these issues and perhaps more. It is the first step in reworking the transfer process.

Figure 4.7
Theoretical Process: Step 7



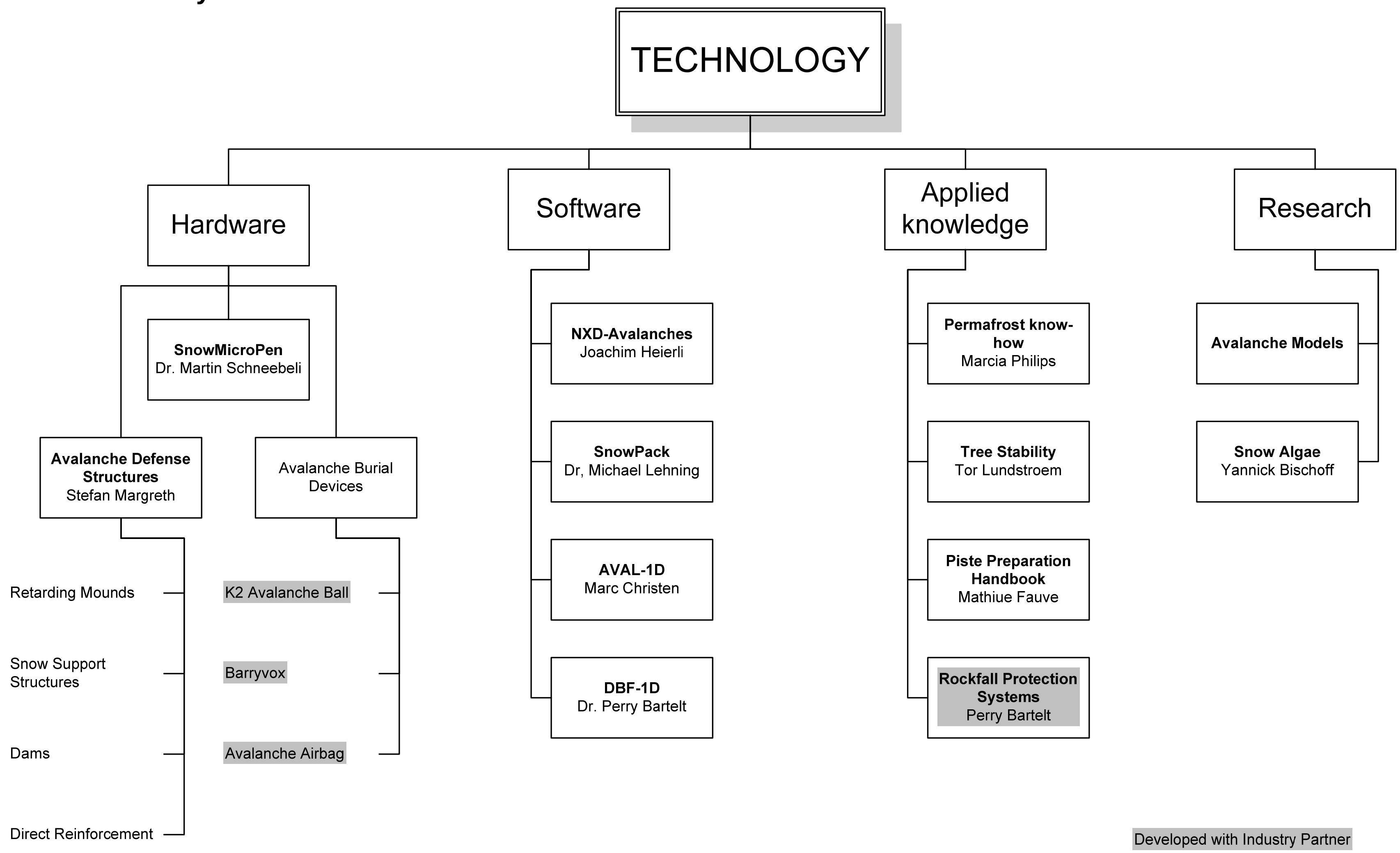
Our transfer process illustrates a general procedure for conducting a technology transfer. It displays the order of each of the steps. The factors to consider at each step are also shown. This is not the only process for a technology transfer, rather it has been derived from research conducted on the transfer process, previous models and examples. In order to utilize the conceptual process, it was necessary to compile a database of SLF technologies.

4.2 Inventory of SLF Technology

The inventory of the SLF technology is a compilation of the data gathered from our interviews and archival research. The data helped us to understand the technologies and research. It also provided a list from which to choose the technologies to analyze for our conceptual decision process. The database provided the SLF with a comprehensive list of the work being conducted at the Institute. No such database existed, so our work was both beneficial for our sponsor and for our project.

The database does not include every technology available at the SLF. In the short amount of time we had in Switzerland, we were unable to gather information on every single project. Over one hundred twenty people are working at SLF, some of which only spend a short period of time there. Their projects are not considered full fledge research projects because they do not last longer than six months, the determining project length. In the database, schematically shown in *Figure 4.8*, the different technologies are organized into the four broad categories: hardware, software, applied knowledge, and research.

Figure 4.8
Schematic of Inventory



The four categories were chosen as the best representation and organization of the data. The technologies were examined for common features and differences. This analysis was used to determine categories would be most useful. We chose each category to group broadly all of the technologies. The hardware category represents physical devices such as avalanche defense structures. A software technology is a computer software program. One example is SNOWPACK, a software package program which simulates snow structure models. Applied knowledge consists of conducted research. This research can be for or in conjunction with an industry or company. The fourth and final category is research. It comprises of research topics without an immediate application, such as the study of algae in the snow's surface.

Most of the technologies are hybrid system in nature. They consist of a component from a different category. Most technologies at the SLF are hybrids, therefore it was decided not to make this a category in our database since it would include most every technology. It would not provide the SLF with any information. The hybrid category would have to be divided into sub-categories based the major technological components. These sub-categories would mimic the four we have chosen.

Inventory Report

The four categories provide the framework for the inventory report. The report provides a basic overview of the research and technologies at the SLF. To develop the report, we interviewed many of the SLF personnel. Our questions and project helped the SLF employees to think about their work in terms of technology transfer. A few examples from the database report are shown in *Figure 4.9.*

Table 4.1
Sample of Inventory

Inventory				
Category	**Name**	**Function**	**Main Researcher**	**Comments**
Applied Knowledge	Risk Index	To evaluate the different risk levels created by natural hazards around the world	Steffi Dannenmann	The index focuses on developing countries and also includes the economic factor
Applied Knowledge	Avalanche Bulletin	To warn civilians of avalanche possibility	Dr. Jakob Rhyner	System using civilians and technological methods to accurately predict the possibility of an avalanche.
Applied Knowledge	Barrier building in Permafrost	Understand how shifting ground effects barriers	Dr. Marcia Phillips	Dr. Phillips is assessing the effect of shifting permafrost on avalanche barriers.
Applied Knowledge	Maintenance of Forest Protection and Safety	To create a tool to determine the best methods to upkeep a forest environment	Tor Lundström	Study the stability of the tree, the mechanical stability, and also incorporate the biological links to the mechanical parameters.
Applied Knowledge	Piste Preparation Handbook	To Educate ski resorts on piste preparation	Mathieu Fauve	Already marketed in Europe and Canada. Unsuccessful at breaking into American market
Hardware	SnowMicroPen	Characterizes snow layers	Dr. Martin Schneebeli	Used by avalanche practitioners to determine the snow microstructure and various layers to help in avalanche warning
Software	NXD-Avalanches	Avalanche Warning	Joachim Heierli	Uses nearest neighbor statistical method to determine potential avalanche risk
Software	AVAL-1D	Calculates avalanche parameters	Marc Christen	Given the amount of snow and width of the avalanche track the program determines velocity, impact pressures and run out distances based on either powder or flow models
Software	DBF-1D	Calculates Debris Flow	Marc Christen/ Dr Perry Bartelt	Will be published in the Spring
Software	SnowPack	Characterizes change in snow layers	Dr. Michael Lehning	Used to determine if weak layers form for avalanche prediction.
Software	InfoBox	Info for security personnel	Manfred Steiniger	Provides 24/7 access to weather data from potential avalanche starting zones. Data can be visualized in many different forms

In the inventory, the technologies are listed by the categories to organize it in a neat and orderly fashion. Under each of the four categories, there are six different fields to explain the technologies and research. They are: name, function, researcher, category, if it is marketed and any additional comments. First the technology is named and its function is stated. These two fields identify the technology and its purpose. The marketability displays which technologies at the SLF are currently on the market and available to other locations. Therefore, the technology is already being transferred. Any additional comments on the technology were also recorded to mention any additional relevant details.

The inventory is the first step in the transfer process. In order to choose which technologies we wanted to focus on, we first needed to have an understanding of the different technologies available at the SLF. These technologies were theoretically transferred using our transfer process to highlight the pertinent technology transfer issues. The theoretical transfers will be discussed in detail in the following section.

4.3 Theoretical Transfer of SLF Technology

A representative technology from each category, except research, was taken through the decision tool. Items from the research category are not directly applicable and are less suitable for this project. They deal with understanding a particular topic. To transfer a research item would be a purely educational process and is therefore not applicable to our project.

Each chosen technology represents its category as a whole. The transfer of these technologies illustrates the possible implications for the entire group. The avalanche warning system is the only example of an extreme hybrid technology we focused on. It provided an example of an inappropriate technology for transfer. However, it highlighted how the system could be broken down into its components. Snow support structures were chosen from the hardware category, the risk index and the avalanche warning process from applied knowledge and NXD-Avalanches from software.

These four representative technologies were taken through our conceptual process to conduct a theoretical transfer. Each stage displays the considerations and issues that arise when trying to complete a transfer. The issues are based on our technology transfer research and the knowledge gained on the technologies. The different considerations based on the location are also shown.

A systematic approach was developed to understand each technology. The literature review stressed certain aspects of the technology to consider for a successful transfer. From this, we knew what information had to be collected. This was standardized to ensure the relevant information was collected for each technology.

A table, shown in *Table 4.2,* was created with headings for each of the elements to consider for transfer. Each technology was analyzed for the specific elements. This provides an overview of the important aspects to consider while conducting the theoretical transfer. Details depending on the location and other less straightforward issues could not usefully be included with a specific heading. These finer details are explained separately.

Table 4.2
Blank Spreadsheet for Analysis

Technology Name	**Researcher:** *The main person behind its development*

DEFINITION: *A brief description of the technology*

APPLICATION: *Where could the technology be used?*

INFRASTRUCTURE: *What elements does the infrastructure of the new location have to possess?*

HUMAN RESOURCES: *What human resources (i.e. labor, knowledge, etc.) are necessary?*

PHYSICAL RESOURCES: *What physical resources (i.e. materials, energy, etc.) are necessary?*

SOCIAL IMPACT: *What are the direct consequences on the society for using this technology?*

ENVIRONMENTAL IMPACT: *What direct consequences does the technology have on the environment?*

STAKEHOLDERS: *Who are the people that must be involved for the transfer to occur successfully?*

ALREADY ON MARKET: *Is the technology already on the market?*

PATENT: *Are there any patents for the technology*

CONFIDENTIALITY: *Is there any confidentiality required when using the technology?*

UNIQUE FEATURES: *What are the unique features of the technology?*

OTHER TECHNOLOGIES: *What other technologies serve a similar function?*

EXPANDABLE TO NATURAL DISASTERS: *Can this technology be used for other natural hazards?*

The defined transfer factors were included in the table. The technology must be identified and its application clearly defined. Then the different aspects, already discussed at length in Section 2.3, are examined for each of the technologies. These factors are: infrastructure, physical and human resources, social and environmental impact, and stakeholders. If the technology is available in the marketplace anyone can purchase it and its transfer would be different. If any patents exist that protect the technology's designs then the continued protection of the technology in the new location will be important. Any confidentiality associated with the technology must be considered when determining the method of transfer and where the SLF would be willing to transfer it.

Unique features of the technology, if any, are included to account for any extraordinary details of the technology. The "other technologies" heading lists similar technologies that fulfill the same technical need but differ slightly their application. This helps the third step in our theoretical decision process (see *Figure 4.1*). Lastly, the technology should be examined to see if it can be expanded to other natural hazards. If significant redevelopment is not required, it would be useful to know its application is wider than the original snow or avalanche purpose. This spreadsheet was used while conducting the theoretical transfers.

4.3.1 Snow Support Structures

The first technology considered for transfer was the SLF's permanent snow support structures. Compared to other technologies little knowledge or expertise is required to use and maintain these structures once they are in place. Therefore, they provide a good representation of the hardware at the SLF. Snow support structures are used to reduce the size and number of avalanches by increasing the stability of the snow. Depending on the particular application, they can be built as solid constructions or flexible wire nets.

Snow support structures have already been successfully transferred to Iceland. For our purposes, we concentrated on the different issues that arise when transferring them to a developing country. The complete table, showing the distinct considerations for this technology, is shown in *Table 4.3.*

Table 4.3
Analysis of Snow Support Structures

Snow Support Structures **Researcher: Stefan Margreth**

ONE SENTENCE DEFINITION
Increases stability of the slope so that avalanches are not released

APPLICATION
Locations where avalanches occur. Used when space is not available for dams or retarding mounds further down the slope.

INFRASTRUCTURE
Networks to gather resources and transport them to the construction site

HUMAN RESOURCES
Considerable snow and avalanche know-how and knowledge of local conditions
Labor to build and maintain structures

PHYSICAL RESOURCES
Materials to build structures

SOCIAL IMPACT
Makes communities safer. Many indirect consequences (increasing land value, relocation of people, etc.)
Visual impact of structures on mountain scenery

ENVIRONMENTAL IMPACT
Changes snow melting patterns affecting temperatures of ground

Table 4.3 (continued)
Analysis of Snow Support Structures

STAKEHOLDERS
Community to be protected by the structures
SLF and local experts
Financers
National and local government and others

ALREADY ON MARKET
Not applicable

PATENT
Patents for particular structures held by private companies

CONFIDENTIALITY
No

UNIQUE FEATURES
None

OTHER TECHNOLOGIES?
Many avalanche defense structures exist that prevent avalanches or mitigate the effects

EXPANDABLE TO OTHER NATURAL DISASTERS
No

Step 1: Defining a location

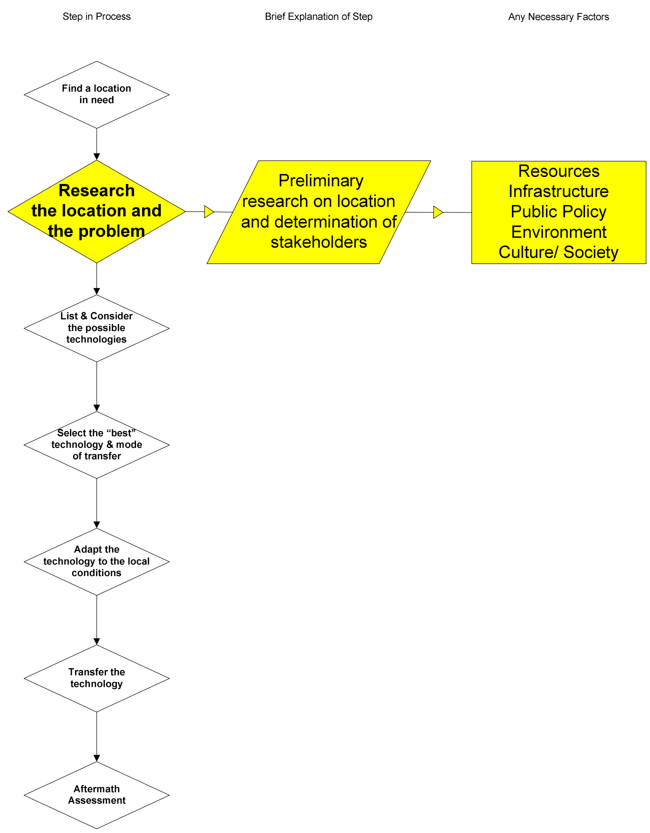
The first step in transferring the technology is defining the location. When the host is aware of the problem and is actively searching for a solution, a successful transfer is more likely to occur. For snow support structures, the location would be any populated mountainous regions where avalanches endanger the citizens. Once the region is identified, the actual mountain slope where the structures are to be built must be determined. Mountain ranges usually have many slopes on which avalanches occur. The most dangerous slopes should be identified first. If more than one dangerous slope exists, some method, such as hazard mapping should be used to determine the best allocation of resources. Whether hazard mapping is specifically used will depend on the location.

Once the region and slope have been identified, the problem the technology transfer aims to solve must be clearly defined. These goals measure the success of the transfer once it is complete. Success will be measured by the increased returned period of avalanches (the time between avalanche occurrences) and the reduced risk to the population living in the dangerous zone.

Step 2: Preliminary Research

The next step is to further research the location and problem. This requires the assistance of stakeholders. Stakeholders must be identified and involved from the very beginning. The location's main stakeholders will be those who actively contacted the SLF for assistance. These are referred to as the "receiving experts." Other stakeholders will be the SLF experts; people threatened by avalanches as well as the national and local government officials of the country who oversee public policies and safety.

Figure 4.9
Snow Support Structures: Step 2



The SLF should identify these stakeholders. Further stakeholders can be identified while working with the previously mentioned stakeholders. There may be cases where the population and (or) government is divided on whether or not the technology transfer should occur. The different opinions about the transfer cannot be ignored. The transfer process should be democratic even if the local government is not. This is a very delicate matter and care must be taken not to alienate any stakeholder. Disagreements between stakeholders during the transfer also need to be dealt with carefully and democratically.

One method by which this could be achieved is the Delphi method. This method will allow all the stakeholders to contribute their ideas and opinions to the transfer process. The monitoring team will ensure the opinions are given equal weight and none are ignored. The differing backgrounds and large numbers of stakeholders are challenges that can be overcome with the Delphi method. Group meetings between all the stakeholders will not always be possible, but can be used to supplement the Delphi method.

The receiving experts and the SLF experts will be the two parties working closest together. The technology will move between these two groups. The receiving experts must gain the same competence as the SLF experts. Only the SLF experts can provide this competence. The receiving experts are responsible for the maintenance of the structures after they are constructed. If the receiving experts are excluded from the transfer process, they may not be willing or able to maintain the completed structures. If involved from the beginning, they would be convinced of the structures value and would have a complete understanding of them.

The national and local governmental officials of the receiving country must also be included in the transfer process. They will operate around the connection between the experts while providing legitimacy to the technology. The government usually provides financial resources for the transfer. Their input is important to determine how the finances are allocated. Furthermore, the safety of the population is the responsibility of the government, so these structures will need their approval. The land these structures are built on may be provided by the government. Without the government, the transfer will be very difficult, almost impossible.

The government controls the public policies of the country. The policies usually control the extent of foreign ownership and management. They manage environmental regulations and public safety. The technology transfer must comply with these policies. The policies will need to change if the transfer violates them. How the government protects its people may also change once this technology is acquired. The previous methods of protection may no longer be necessary or applicable. The policies may need to be updated to take into account the changes the technology brings with it.

When transferring technologies to a developing country, the government, despite its willingness, is often unable to supply all the financial resources necessary to acquire the technology. In many instances, third party financers, such as the World Bank or the Asian Development Bank, will cover the costs the local government cannot. The significance of the financial resources is never stressed enough. Available funds will be crucial for the entire transfer and assessment process. An economic assessment will show the total amount of monetary resources necessary for the transfer. This cannot be completed until later in the process because the technology has not been chosen yet. However, the amount of available monetary resources must be compared with an estimate of the transfer cost to ensure there is adequate financial support.

To research the location, the SLF must cooperate with the stakeholders because they are most familiar with the country. Interviews will be the most efficient method of communication with the government officials about the areas displayed in *Figure 4.9;*

the environment, public policies, resources, and infrastructure. At this stage of the transfer, detailed information on the resources and infrastructure is not necessary.

Focus groups consisting of people from different economic and demographic backgrounds must be employed to learn about the society and culture of the new location. The focus groups participants must always be carefully selected to ensure an accurate representation of the population. Their willingness to use and accept the technology must be verified.

The societies in developed and developing countries should not be considered in the same way. In general, societies of developed countries have a higher level of background education and employ the use of technology more. A new technology will not produce the same affect for them that it will for a developing country. In most cases, the society of a developing country will have to be considered more carefully because their reactions will be based on less understanding and will be more difficult to predict. The consideration of the receiving society's possible reactions will be influenced by the background education and overall familiarity with technology.

The active support of the entire population is not necessary to transfer the technology provided support exists from the major stakeholders. Only a few people from the new society are required to maintain the snow support structures. The transfer will be more complicated if land is to be removed from people to build the structures. Their consent should be obtained before their property is appropriated. However, a few individuals should not prevent an entire community from protecting itself.

Some difficulties will exist while gathering data in the new location. The information the SLF needs may not always be available, as the data may not have been previously compiled by the new location. To overcome this, the SLF will need to conduct new research in the location. Hazard mapping is an example of a particular area where this may be necessary.

The SLF extensively uses hazard mapping to determine where avalanche defense structures are necessary. Hazard maps may not be available in the new location and usually are developed before support structures are built. However, the data to create a hazard map may not be available. The avalanche history of the region is required to construct a hazard map: where and when the avalanches were released and their run out distances (Christen 2003). If these records, and other supplemental data, are missing a complete hazard map will not be possible. The SLF may need to bypass this normal procedural step.

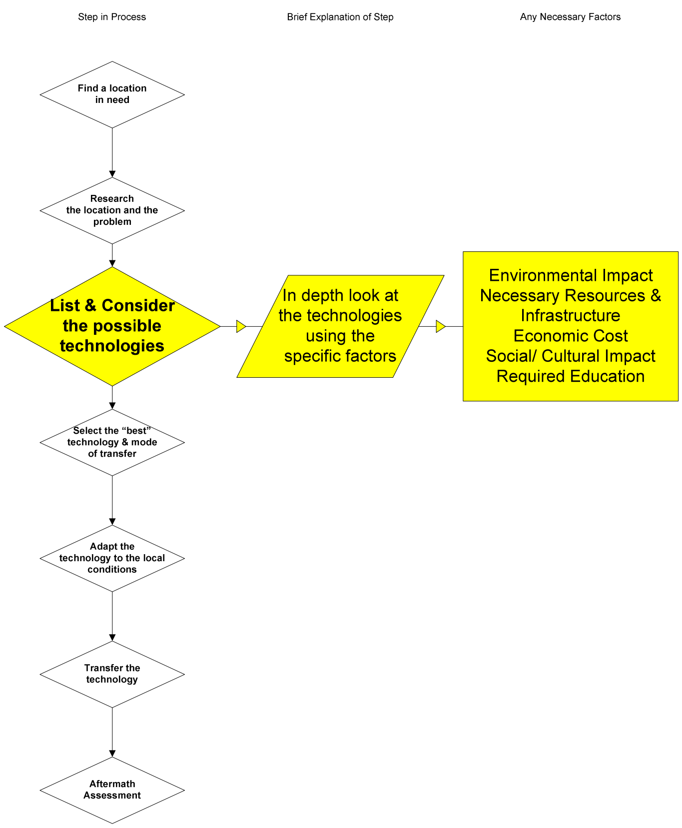
The dangerous slopes can be identified using other methods. The prominent slopes posing the highest threat will be easy to identify and start with. The local people will be aware of which slopes should be concentrated on. There may also be institutes similar to the SLF in the receiving country. They may not use the same techniques as the SLF but they will have the information identify the hazardous slopes.

There will usually be ways data collection problems can be resolved. New methods may have to be developed to collect the data. If the data simply does not exist and cannot be obtained, local knowledge and experience can be used to provide subjective input so a decision can be reached.

By the end of this step, the stakeholders should have an understanding of the country itself and the specific problem technology transfer aims to address. The culture and society should have been carefully examined to use the knowledge gained to predict how the society would react to the new technology. Their background education level must also be determined. Environmental aspects, infrastructure and the public policies should all have been considered. This information is used in the next step, considering other technologies.

Step 3: In-depth research

Figure 4.10
Snow Support Structures: Step 3



In this step a list of possible technological solutions is compiled. A problem can be solved in different ways by approaching it from different directions. However, in this case, the choices for technology are not different enough to affect significantly the research conducted in this step. The possible choices, flexible wire nets or solid steel constructions, are very similar in their resource requirements and impacts. Nonetheless, a choice must be made between the two types of structures. For other types of hardware, the possible choices may be more diverse, making this a more significant step in the process.

To choose the most appropriate technology from this list, further research must be conducted on each specific technology. As shown in *Figure 4.10,* research must be completed on the environmental impact, necessary resources and infrastructure, economic cost, social and cultural impact, and the required education. This will occur through cooperation with the stakeholders, interaction with local people, and independent investigative work as it did for Step 2 of the process. This research must be conducted specifically for each technology being considered.

Physical Data

Physical data is the easiest type of data to collect. Information must be gathered about the particular geography and terrain. The size of the starting zone, snow conditions and other technical aspects must be determined. Local experts may already have this information. If not, it can be collected through observation. Also, the available relevant meteorological data has to be obtained from the local weather service. The government will also be able to provide much of the necessary physical data.

The amount and type of physical resources in the new location and the infrastructure of the country can be obtained from the government. The infrastructure must be taken into consideration for transportation of people, materials, and other necessary items to the mountain construction site. No roads usually exist, even in developed countries. Helicopters, or some other means of transportation, will be a vital tool. All of this information is important and, in most cases, relatively easy to collect through contact with stakeholders or observation.

The environmental impact is another aspect to be considered in this step. This can be performed using the Environmental Technology Assessment method and the Life Cycle Assessment method, which are discussed in more detail in Section 2.3. They have different approaches to assessing the environmental impact of a technology. Therefore each will provide different information for each of the stakeholders to consider.

Lastly, the economic cost of the structures has to be determined. Avalanche defense structures are very expensive to build. In Switzerland, the cost is between CHF 2,000.- to CHF 2,500.- per meter (Phillips 2003). Maintenance costs average out to approximately 0.5% of the construction costs per year (Margreth 2003). The total economic cost should be considered over the entire life cycle of the technology. For these support structures, the lifespan is approximately one hundred years. The construction and maintenance of the technology will ultimately fail if the financial support is inadequate.

A cost-effective analysis will be useful once the life-span cost is determined. A cost effective analysis for each of the technology choices should be performed to help determine which technology to transfer. This analysis will show if the technology is worth the financial cost. A detailed account of this analysis can be found in Section 2.4. For snow support technologies, the costs and effects are very similar. The results obtained from a cost-benefit analysis will not provide useful results in this case. However, it will when different hardware is being transferred and the differences between the choices are greater.

To conduct a cost-effectiveness analysis, the cost and effectiveness have to be quantified. The cost will be determined by the construction and maintenance of the structures. The costs of materials, manufacture, assembly and labor will be summed to quantify the construction costs. Maintenance costs due to items such as spare parts and labor will have to be taken into account. The effectiveness could be measured by the reduced risk to those living in the dangerous zones or the reduced mortality. These numbers will then be used in the cost-effectiveness analysis.

Social Data

More difficult data to collect concerns the social situation of the new location. The possible social impact and reaction to the technology has to be acknowledged. For example, the land snow support structures are built on can no longer be used for skiing or other recreational activities. Also, the structures' visual impact is substantial. People must be willing to accept these changes in exchange for increased safety. In rare cases, superstitions may exist regarding avalanche occurrence and prevention. They may reject the structures based on their own cultural beliefs. An understanding of the social conditions is necessary before the transfer can occur, so any social problems can be dealt with.

The understanding these issues can be accomplished through consensus conferences and focus groups. These two tools are discussed at length in Section 2.4. The participants of citizen panel and focus groups must fully represent the community. People ranging in age, demographic groups, educational backgrounds, and economic status should all be included.

The following is an example of how the focus groups might be conducted: The actual structure of the focus groups depends on the specific location. More than one focus group will be necessary to fully explore the social issues. The population can be divided into groups based on age or some other criteria designed to maximize the interaction between the participants. The different participants for each focus group should be randomly selected to prevent sampling errors. The participants should express their views on the technology. Possible topics for discussion during the sessions are their attitude towards the technology, the worth of the technology in relation to its cost and how the technology would change their daily life. Many other discussion topics exist. If focus groups consisting of participants from previous groups are conducted, they will provide interactions across the population's divisions, such as people from different generations interacting. This will provide further viewpoints to be considered during the transfer.

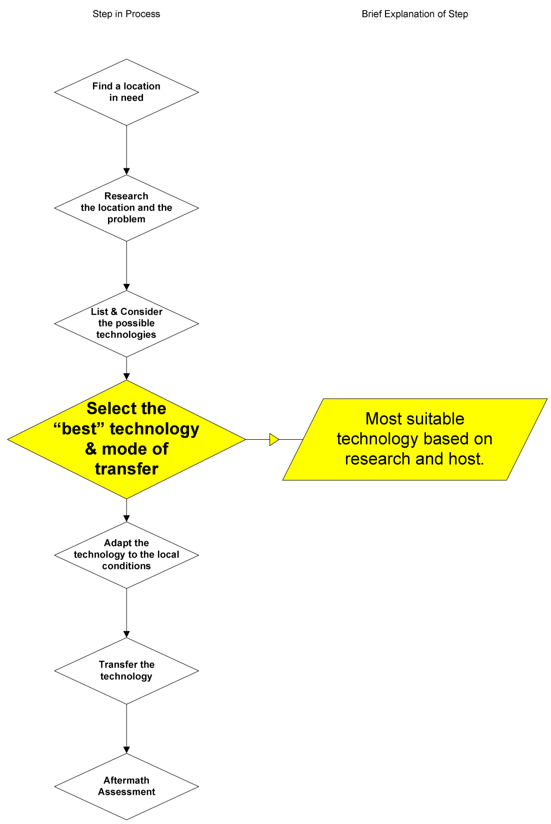
The possible reactions to the new technology can be predicted and managed by using the knowledge gained from contact through focus groups. The language barrier, literacy, and cultural assumptions of the panels should be taken into careful consideration before they commence.

The absorptive capacity of the new country for new technology, as discussed in the literature review, must be examined to ensure the knowledge required to build and maintain the structures can be transferred. Although this knowledge is minimal compared to other technologies, a general education is still necessary to learn the technology specific details. Basic literacy, arithmetic and a grasp of fundamental mechanics are required to learn how to build and maintain the structures. The education level of the receiving experts can be determined through interviews. The transfer may be too costly if this basic education is not in place.

Each of the specific technologies listed as possible solutions is carefully considered for its suitability for the new location in this step. The data is used to determine if the new location meets the requirements of each technology. The possible impact of each technology on the new location is also examined. These two parts decide which technology to transfer. At this stage of the process, the SLF should have a complete understanding of the relevant aspects of the new location.

Step 4: Selecting the technology and mode of transfer

Figure 4.11
Snow Support Structures: *Step 4*



Once the available resources and social situation of the new location has been determined, along with all the technical research, a specific technology must be chosen. As shown in *Figure 4.11,* this choice is based both the host and the research conducted in the previous steps. In the case of snow support structures, the choice is between flexible wire nets or solid steel constructions. The decision is based on technical aspects, as the resources requirements and impact of these two technologies, as well as the maintenance and costs, are very similar. This may not be the case with other technologies. A decision will have to consider the impact each technology will have based on the research.

The mode of transfer is also determined during this step. The host country's level of involvement defines the mode during the construction of the structures. This level depends on its technical capability and infrastructure. For example, while transferring the structures to Iceland, the SLF was not needed in the actual construction process. Iceland was able to construct the structures once they learned how to install and maintain them. In a developing country, this may not be the case. The SLF may be highly involved in the building process, as the country might not posses the tools and support systems required to build the structures.

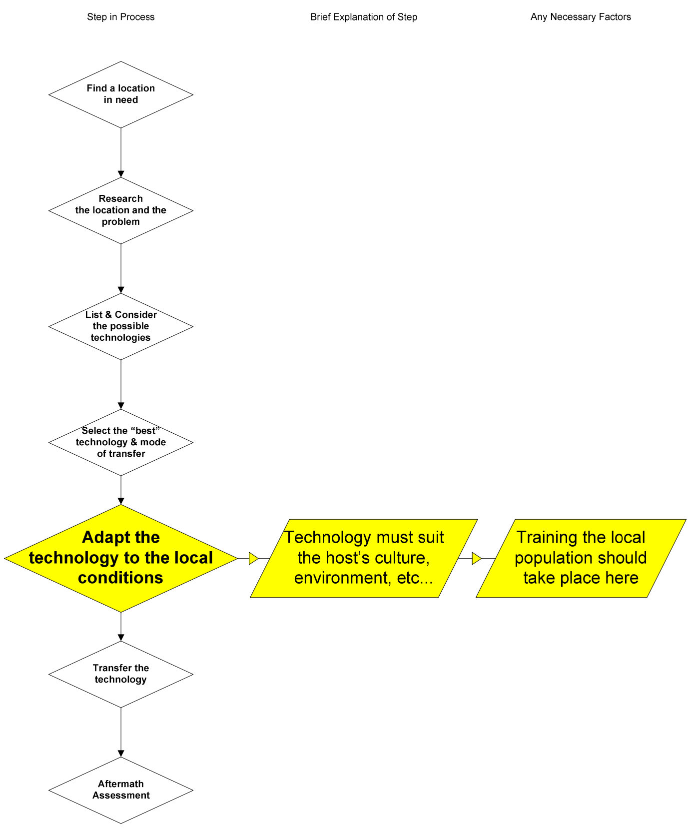
The legal agreement between the SLF and the receiving country should be explicitly written in this step. All the research conducted in the previous steps will illustrate the necessary actions for a successful transfer. Each stakeholder's responsibility and expectation for the actual transfer can be determined. The tasks, such as construction and training, can be assigned to the stakeholders most capable of successfully completing the task. This will define the role of each stakeholder during the physical transfer and help to ensure the transfer occurs smoothly.

Based on the research from step three, the most suitable technology is chosen in this step. An agreement between the stakeholders concerning their specific roles for the transfer is also established. This determines the mode of transfer. However, before this can be done, changes will have to be made to the structures before technology is moved to its new location.

Step 5: Adapting the technology

Once the technology and mode of transfer have been determined, it is necessary to adapt the technology to the specific location. Tests will have to be conducted to determine how the technology should be adapted. This is the most significant part of the transfer. The conditions in the new location will not be the same as those in which the technology was developed. Changes must be made for the technology to function under the new conditions.

Figure 4.12
Snow Support Structures: Step 5



Support structures, and other defense structures, had to be adapted before their deployment in Iceland. The higher snow density in Iceland meant changes were necessary to the Swiss standard for support structures. If this adaptation for the different snow densities had not been performed, the support structures would not have been beneficial to the people of Iceland. This adaptation was easy to recognize because of Iceland's avalanche experts who were familiar with the snow conditions. A developing country may not have this expertise. The SLF may have to study the snow themselves to compensate for this gap in knowledge.

A difference in the snow densities was a factor, among others, that had to be dealt with for the Iceland transfer. Other changes may be necessary to circumvent resource deficiencies and exploit abundant resources in the new location that might not be available in the original country. The information gathered on the resources in the previous steps will be used to determine the necessary adaptations.

While the SLF is in process of adapting the structures, they should supplement the knowledge gaps of the receiving experts, as shown in *Figure 4.12*. Their understanding of the technology is important to its overall success. The amount of training required could be substantial, but if time and effort is not invested the transfer will not succeed. The education is necessary for proper maintenance and repair. The SLF may have to maintain collaboratively the structures for the first few seasons while the training continues. This training should continue through the construction phase and beyond until it is complete.

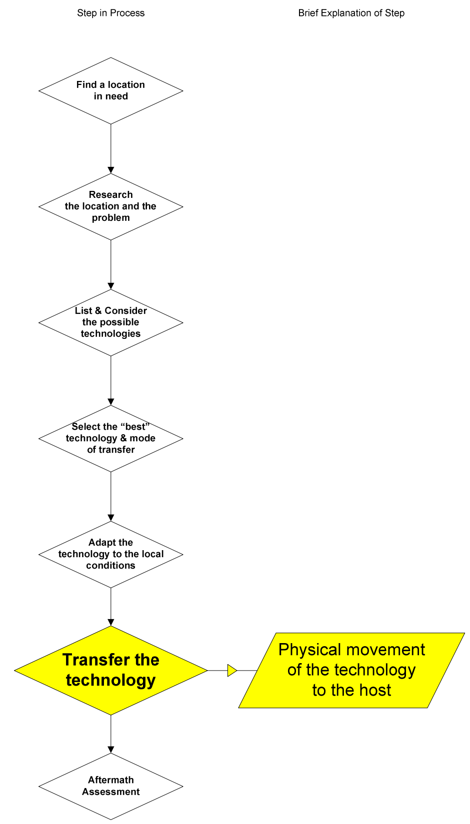
The adaptation is necessary to ensure the technology will function under the new conditions. Although the technology fulfills a similar function in the new location, the conditions could be significantly different.

Step 6: Transferring the technology

Once the adaptation is complete, it will be possible to build the adapted structures in the new location. The construction and installation constitutes the physical transfer of the technology to the new location. This construction should be a smooth process if the previous steps have been efficiently completed. Any problems that arise should be dealt with as quickly and efficiently as possible. Problems include difficulty obtaining materials and transporting them to the site. The fabrication and assembly of the structures might be challenging if it is the first time the structures are being built. Problems must not be overlooked, even if they are minor, as they may indicate more serious issues. If significant information is missing from the previous research, it must be addressed and completed before the transfer proceeds any further.

Figure 4.13

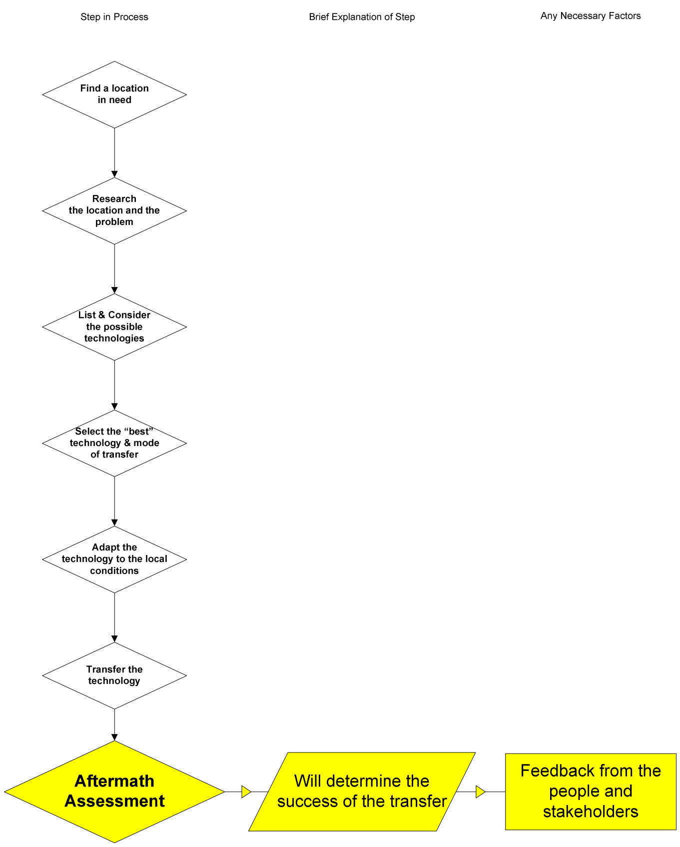
Snow Support Structures: Step 6



The stakeholders must be involved as much as possible in this stage. The training of the receiving experts continues throughout this step. Their involvement will contribute to their independence by increasing their knowledge and experience. This will enable them to conduct their own research and development at a later stage to further meet their needs and their environment. The physical transfer of the technology occurs in this step.

Step 7: Aftermath assessment

Figure 4.14
Snow Support Structures: Step 7



Once the structures have been built and the local personnel trained, the effectiveness of the transfer must be determined. This can only happen after a complete winter season, if not longer, to determine if the avalanche return period has been increased. It will also take some time before the level of maintenance performed by the local people can be judged.

The assessment should include feedback from the citizens and other stakeholders. The experts should be consulted to gain their view on the technology's performance and if the transfer was worth the spent resources. Focus groups will determine if the technology was accepted and if all the stakeholders are satisfied. The impact of the technology on the society should also be determined. This is achieved through focus groups. Feedback will highlight any improvements and changes to make to the technology. The assessment of the structures in Iceland showed more corrosion protection was necessary. The new environment caused the structures to degrade faster. This also increased the required maintenance.

Snow support structures are a hard technology requiring very little knowledge to use. Both the physical resources and the impact of this technology are major aspects for the transfer. Our decision tool can be used for any type of technology. A soft type of technology will next be considered to show the differences in transfer.

4.3.2 Risk Index

The risk index is soft technology developed by the SLF with the potential for transfer of expertise. The risk index does not require physical construction. It compares the risk levels of natural hazards in different countries using mathematical methods. The methods determine a rank for specific criteria such as poverty, corruption, human development and economic impact. A significant amount of research is needed to rank these criteria. The purpose of the risk index is to help determine further courses of action to take against natural hazards. These actions counteract the damages caused by natural hazards. They are not usually performed by the people conducting the risk index. The people requesting the risk index usually decide the action taken against the natural hazard.

The risk index is applicable to any location with a natural hazard because it is not avalanche specific. The SLF conducted a risk index analysis in Latin America. There the SLF analyzed risk on natural disasters such as floods. The SLF did not transfer any of the knowledge behind the risk index analysis. Their work was done specifically for the Inter American Development Bank. Our analysis of this method is displayed in *Table 4.4.*

Table 4.4
Analysis of Risk Index

Risk Index **Researcher: Steffi Dannenmann, Koko Warner**

ONE SENTENCE DEFINITION
Used to evaluate and compare risk level due to natural hazards

APPLICATION
Anywhere that human lives are endangered due to natural hazards

INFRASTRUCTURE
Communication network to gather data

HUMAN RESOURCES
Experts on the method and other people with knowledge to collect relevant data

PHYSICAL RESOURCES
None

SOCIAL IMPACT
Depends on further action based on results of the method

ENVIRONMENTAL IMPACT
No direct impact

STAKEHOLDERS
National Government
Those affected by hazards, the local people
Financers\Facilitators

ALREADY ON MARKET	Patent
Not applicable	None

CONFIDENTIALITY
Method is not confidential. Results or methods used in further steps might be confidential

UNIQUE FEATURES
Not applicable

OTHER TECHNOLOGIES?
New topic, other methods under development

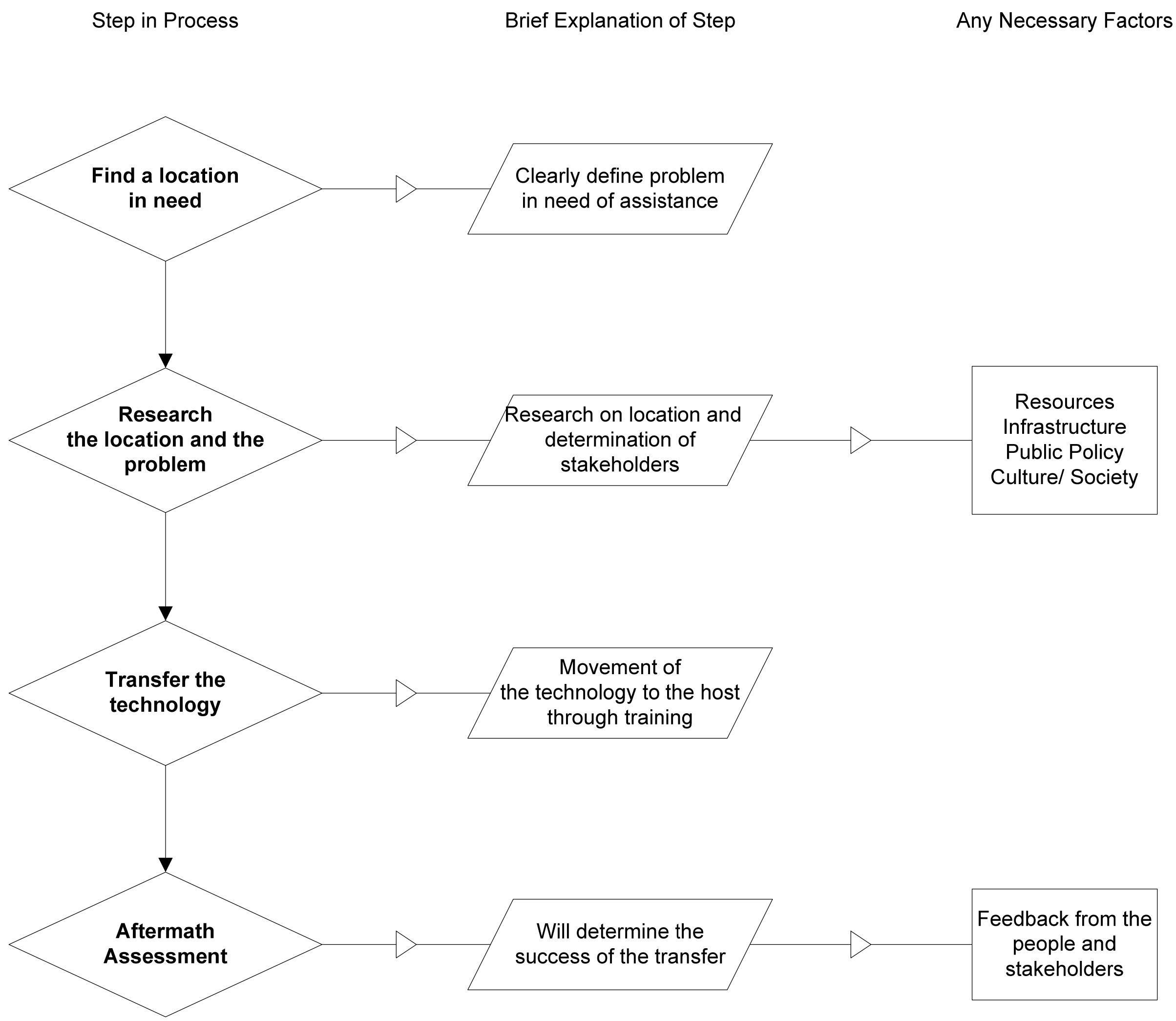
EXPANDABLE TO NATURAL DISASTERS
Yes

Modified Transfer Process

The risk index analysis is a soft technology that requires a modified technology transfer process. The modified process demonstrates the difference between the transfer of a hard and soft technology. The first step in the transfer process, defining a location in a need, is consistent with any type of technology. After the location is determined, research is completed on the location and the problem. This research is a very complex stage. It lays the foundation for a successful transfer. The SLF needs to contact the main stakeholders involved in the transfer process, from government officials to the citizens affected by the natural disasters. The risk index method is usually applied to financial institutions or insurance companies interested in allocating their resources to developing countries. These officials will be the main stakeholders in the host location.

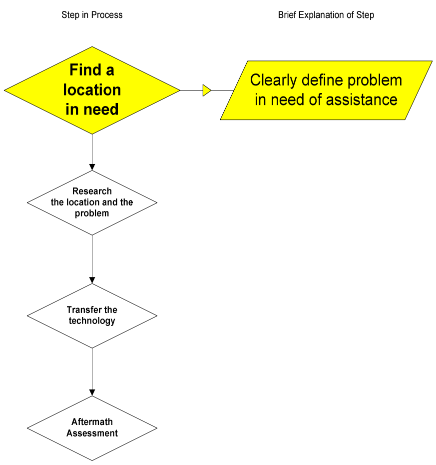
The risk index is a recently developed technology so not many options exist for similar technologies. The topic is currently being researched for new methods but none are complete. The lack of similar technologies reduces the overall transfer process to five stages by eliminating steps three and four; listing the possible technologies and selecting the best technology based on research. This illustrates how the overall transfer process must be adapted to suit the particular technology, as shown in *Figure 4.15*.

Figure 4.15
Risk Index: Modified Transfer Process



Step 1: Define the location

Figure 4.16
Risk Index: Step 1



The first phase of the transfer process is identifying a location affected by natural disasters. As was already mentioned, the risk index analysis is applicable to any natural hazard. An institution at this new location must have a need for a risk index to be conducted to benefit from an analysis. The risk index method could be used in countries suffering huge economic losses or loss of life due to natural disasters (Dannenmann 2003).

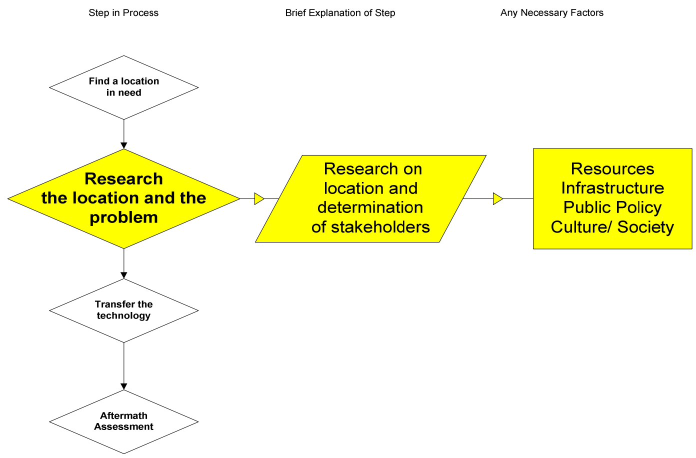
In an active transfer, the stakeholders from the location should initiate the beginning of this process. For the risk index analysis conducted in Latin America, the initial contact was established by the Inter American Development Bank. The Bank's initiative was crucial to the success of the risk index analysis. Active involvement from the stakeholders will help the SLF research the location. This research will help them understand the application of the risk index in the host country. The next step explains the factors the SLF must consider for research on the location.

Step 2: In-depth research

The next step of the transfer process is to research the location in terms of the various transfer factors. Stakeholders from the host country will be the main source of data. In this case, the stakeholders are the experts learning the risk index assessment, financial officers who require the method results for further analysis, the national government officials involved in protecting the population from natural disasters, and the citizens of the country being evaluated. For the study conducted on Latin American countries, experts from the SLF conducted interviews with administrators such as the finance ministers to understand the financial infrastructure of the country. Focus groups consisting of citizens are another way to obtain the public opinion on risk levels.

Figure 4.17

Risk Index: Step 2



The stakeholders must be identified and included from the beginning of the process to provide the necessary information. This communication between stakeholders will be vital to the transfer process. Communication and discussion amongst the stakeholders can be a difficult process given diverse backgrounds, geographical separation and the number of stakeholders. The Delphi method can be employed to overcome this. This method will allow the stakeholders to communicate and discuss the various issues of the transfer. The Delphi method can be supplemented with interviews and meetings for smaller items not requiring input from all the stakeholders. This will allow an understanding of the location to be developed.

Resources

The resources in the host country have to be carefully scrutinized for transfer. The risk index is a soft technology and does not require any direct physical resources. Human resources will be the most critical for the risk index method. The absorptive capacity of the new location must be sufficient. The index requires people with a basic understanding and education of risk level assessment. They should be able to recognize the purpose of risk evaluation and its usefulness. The main stakeholders should identify possible candidates based on these criteria. Once the candidates have been identified, they will become stakeholders themselves. Their educational background must be determined to plan and implement their training. Training varies depending on the background education and is a key factor for the transfer's success. To assess the educational level of these candidates, interviews based on risk assessment can be conducted. If adequate resources exist and the candidates are willing to learn, a large amount of training can be given. However, if time and economic constraints exist, one must ensure the training is completed in the allocated time and budget. Once the training is complete, the governmental policies dictate the extent to which the risk index is employed.

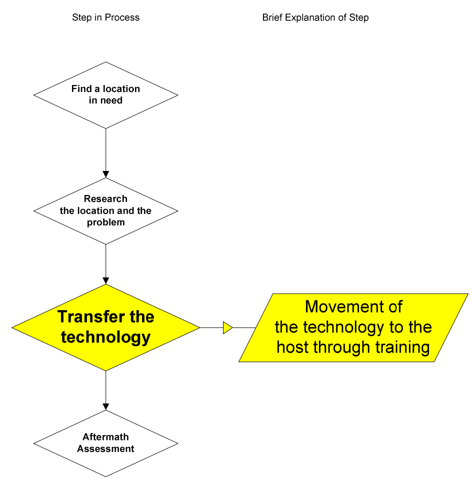
Public Policy

Governmental policies will need to include the importance of assessing and managing natural hazards. The policies will ensure the risk index method is utilized after it is transferred. If these policies do not exist, cooperation with the government officials must begin during the transfer to explicitly form policies reinforcing the need for risk assessment. The transfer would be ineffective if the host does not use its new tool.

Step 3: Training and transfer

The transfer begins once the previous steps have been completed. The transfer will occur through training the new personnel. Despite the amount of time and planning put into the training, problems might still occur. To deal with these problems efficiently, adequate managerial resources must be in place. Decisions made on developing problems can only be made with input from all the stakeholders. Again, effective communication between stakeholders is critical.

Figure 4.18
Risk Index: Step 3

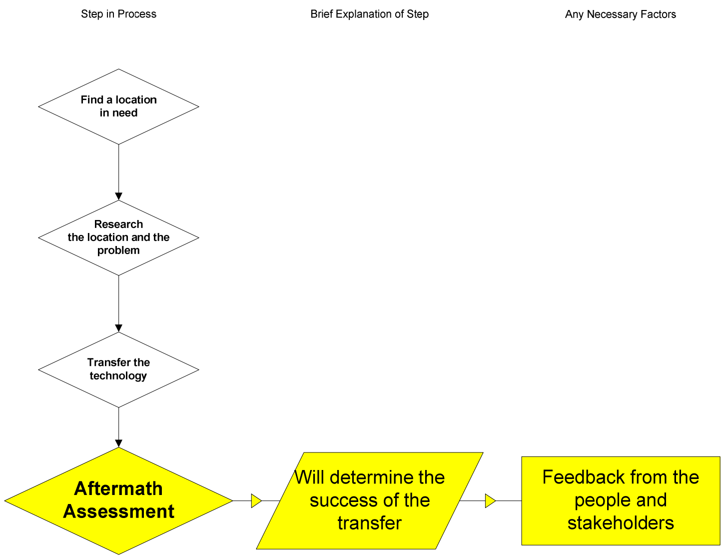


Training in the host country is not always an easy process. Language and other cultural differences are barriers to consider when planning the training. The difference in educational systems will also have to be considered. The SLF must examine the common educational level provided in the host country in relation to the knowledge required for the risk index method. The people being trained should also be tested to ensure a proper understanding of the material. Of all these resources important for transfer, human resources decide the success of the transfer. If the people do not express interest in learning how to conduct and apply such an assessment, the transfer will not fulfil its purpose and hence, would be considered inappropriate.

Step 4: Aftermath assessment

The aftermath assessment is the final step of the transfer process. For this technology, the success of the transfer is measured by observing how effectively the host institution has applied the method. The assessment cannot be performed until the institution has attempted an evaluation. If they have independently conducted their own risk evaluations, the transfer was successful. If this is not the case, more work is required to successfully complete the transfer. Further training may be necessary to fill the previously missed gaps. The knowledge may take some time to become well-established in the new place.

Figure 4.19
Risk Index: Step 4



The risk index method is an example of a soft technology. The educational background and the training required to transfer this knowledge are pivotal for the transfer of the method. The cultural and language differences must be overcome to effectively communicate the necessary knowledge to the host country. The results of the method would be used to direct actions taken in response to the threat of natural hazards.

Not every technology can be grouped as hard or soft. The next technology to be examined is a mixture of both components that raises other illustrative points about technology transfer.

4.3.3 Avalanche Warning System

The Avalanche Warning System is the third and final technology to be evaluated using our decision process. The analysis of the system is displayed in *Table 4.5*. The Warning System is a complex example of a hybrid technology. It is a combination of hard and soft technologies. The inappropriateness of the entire Avalanche Warning System for transfer due to its complex nature is shown. However, the system is able to be divided into its different components and then transferred. This separation of parts is exemplified through the isolation of the overall avalanche warning process and software program.

Table 4.5
Analysis of the Avalanche Warning System

Avalanche Warning System **Researcher: Multiple Personnel**

ONE SENTENCE DEFINITION
Performs avalanche forecasting and predicts the danger on a daily basis during the winter

APPLICATION
Anywhere there are avalanches

INFRASTRUCTURE
Weather Observation Network (observer network, sensing stations, radar measurements)
Data transmission systems, Computer Support Systems

HUMAN RESOURCES
Considerable snow and avalanche know-how
Knowledge of local conditions
Observers for weather and snow conditions and to report avalanche occurrences

PHYSICAL RESOURCES
Computers, Communication Network
Monitoring stations
Equipment to determine snow conditions

Table 4.5 (continued)
Analysis of the Avalanche Warning System

SOCIAL IMPACT
People are informed about avalanche dangers. Measures taken due to avalanche danger affects the people
Education of local people
ENVIRONMENTAL IMPACT
Concentration of people in safer regions
STAKEHOLDERS
Government (National Level)
SLF Experts
Local Public
Facilitators/Financers

ALREADY ON MARKET
Varies depending on component

PATENT
Varies depending on component

CONFIDENTIALITY
Varies depending on component

UNIQUE FEATURES
Specific to Swiss Situation

OTHER TECHNOLOGIES?
Incorporates so many technologies there is no other single systems could be used. Only different arrangements or pieces.

EXPANDABLE TO NATURAL DISASTERS
Varies depending on component

Many hard and soft components are involved in the Avalanche Warning System. It is on of the most complex systems at the SLF. Five main steps exist in the process. They are, sequentially, data acquisition, data processing, and avalanche danger prediction, information broadcast, and transfer of the information into specific measures. Each of these steps requires a certain level of education and infrastructure to function properly.

Data is compiled from two main sources: remote sensing stations and human observers. About two hundred trained individuals are living in Swiss mountain regions, recording daily meteorological data, snow parameters, and observing avalanches (Rhyner et al. 2002). The data is transmitted to the SLF using a form via the Internet.

The human-observed data is supplemented with observations accumulated from remote sensing stations. They obtain data from locations human observers are unable to reach because they are either too high into the mountains or too dangerous for human personnel. In Switzerland, approximately seventy-five remote sensing stations are dispersed throughout the mountainous regions. These stations are either solar powered, or some are close enough to mountain stations to be connected to an external power supply. The sensing stations gather data on snow height, snow and air temperatures, humidity, radiation, and wind parameters (Rhyner et al. ND).

After the SLF has received the data, it is compiled and processed. Two main tools are used to analyze and process the data for avalanche prediction: human knowledge and software programs. The software program SNOWPACK provides some support to the avalanche forecasters, for example the calculation of new snow depth. It models the snow's microstructure and layering by using the basic principles of mass and energy balance to reveal the different snow changes over the course of a season (Lehning 2003, Lehning ND). The model created by SNOWPACK is interpreted for any existing weak layers with the possibility of triggering an avalanche. In addition to this program is the graphical interface system (GIS), which was developed by the Environmental Systems Research Institute, is also employed. GIS allows the forecasters to examine the data more easily through a series of visualizations.

The software program NXD - Avalanches can also be used in an avalanche warning system. Its purpose varies greatly from the previously mention programs. NXD is most efficient when applied to a specific region. The SLF forecasters do not use this program in their avalanche predictions. They have to make predictions for the entire country and found that relying on their own knowledge was more accurate (Rhyner 2003). The actual program is "is a computer program used to evaluate avalanche hazard in a confined region" (Heierli ND).

It uses the nearest neighbor statistical method. The program selects ten past days from its meteorological database whose conditions were similar to the current conditions. What occurred on these days can then be used by the forecasters to analyze and predict what could occur. This software program can be used by a recently established forecasting team focusing their efforts on a specific reason. It would increase their experience and expertise of avalanche prediction.

Behind all of the software programs, a very high level of knowledge and expertise exists. This is the most important component of the Avalanche Warning System. Seven avalanche forecasters work at the SLF to produce the daily warnings. These seven must consider the large amounts of data to determine which information is relevant. The information is inputted into the software programs to process and visualize the raw data. The forecasters examine the processed information and visualizations. From their examination, the forecasters are able to predict the avalanche hazard. In some situations, the abundance of information is not always adequate and the forecasters must rely on their own experience and knowledge to formulate a prediction. Without their expertise, the Avalanche Warning System would be unable to function.

Several information flow systems are currently in place to relay avalanche predictions. The most important information for the public is the daily avalanche bulletin, issued in German, French, and Italian. The Bulletin warns citizens of avalanche prone days for their safety. The Bulletin is transmitted in several types of ways, via the radio, telephone, WAP, Internet and in critical situations, television.

The most important information platform for security services is IFKIS, a web-based system that transmits information from the SLF to the security personnel. They are the people who decide to close roads or railways to protect and (or) evacuate the citizens (Rhyner et al. ND). The second system is InfoBox, an information platform utilized by the public service domain to obtain non-public avalanche data (Rhyner 2003). This software is provided to avalanche personnel in disc form, enabling them to install and receive data from the SLF. InfoManager was then developed from InfoBox. InfoManager vastly improved InfoBox, as it is a completely web-based system and therefore accessible from any personal computer with an Internet connection (Steiniger 2003).

IFKIS-MIS is another information flow system used in the Avalanche Warning System. It is an Internet-based system that provides a platform for different departments of security officials to exchange information concerning protective measures in response to avalanche danger, such as the closing of a major road or railway (Bründl 2003). The information flow in IFKIS-MIS is completely independent of the SLF because the security officials use it to communicate with each other.

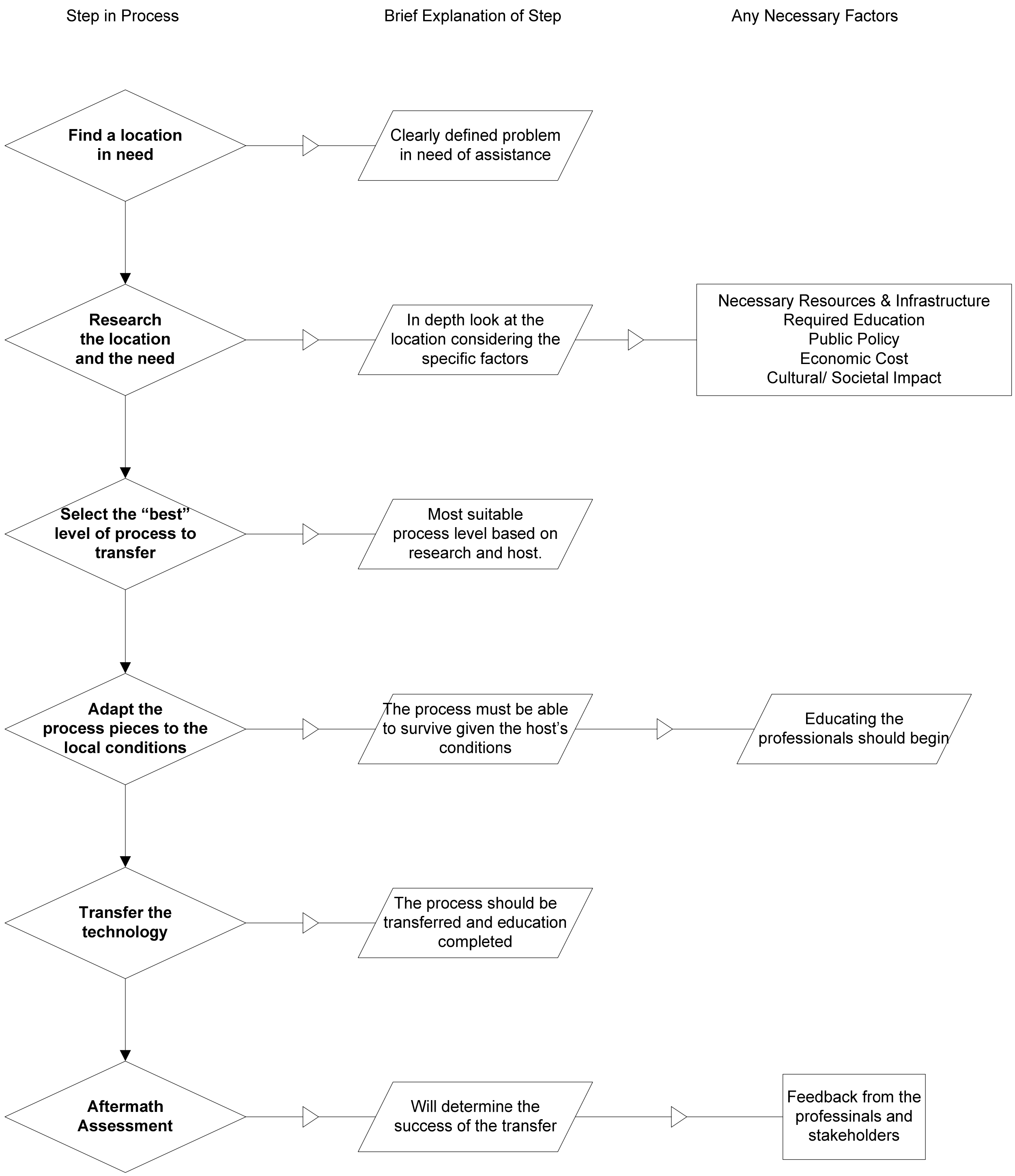
Due to the vastness and complexity of this system, the entire Avalanche Warning System is an inappropriate technology to transfer at once. The amount of knowledge, experience, and infrastructure required to successfully use this program is immense. The system has also been developed specifically for Switzerland; the adaptation necessary to transfer it would be too large for the transfer to be successful. However, components exist within the system that are useful for transfer.

Avalanche Forecasting Process

The overall process of the avalanche forecasting system, without all the software, sensing stations and information flow systems, is a component of the warning system. The process consists of obtaining data to analyze, interpret, and then predicting avalanche danger. This process can potentially begin in a country with need for an avalanche warning system because it does not require all of the extensive components the SLF uses. The transfer will install a simpler form of Avalanche Warning System. Once the process is established, further technology can be transferred to strengthen the new forecasters' skills and increase their accuracy. First though, the process must be successfully transferred and implemented.

The principal process behind the avalanche warning system does not change between warning systems. There is always a set of data to collect and analyze before a prediction is made. Therefore, no other possible choices of technology to transfer exist and the overall transfer process displayed in *Figure 4.1* has to be modified. The modified process is shown in *Figure 4.20*.

Figure 4.20
Avalanche Forecasting Process: Modified Transfer Process



Step 1: Defining the location

For an active technology transfer, the host must contact the SLF for assistance and guidance to create an avalanche warning system. This ensures the host's active involvement. As mentioned in the literature review, if active transfer is not pursued the technology is probably destined to fail. Stakeholder involvement is one way of ensuring the technology's success.

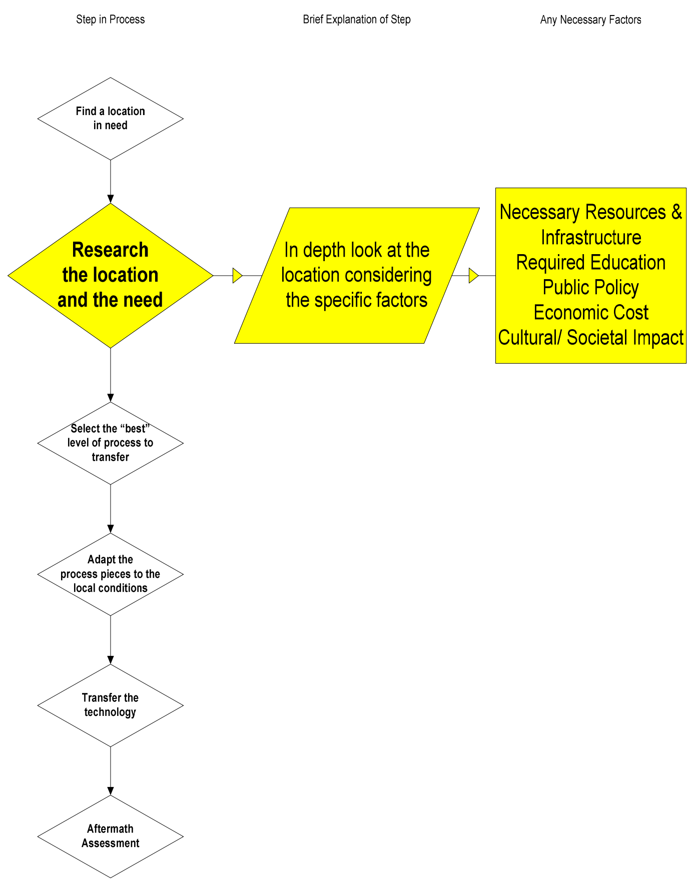
Stakeholders, as examined in the literature review, are any group of people involved in the technology transfer process. The new location's main stakeholder is the group who initiated the project. The SLF is the main sending stakeholder. Other stakeholders involved depend on the type of institution attempting to implement an avalanche warning system.

If the institution is a privately funded organization, the government will not be directly involved in the process. However, if the organization is federally funded, the government will be a very important stakeholder. In this case, governmental stakeholders will be personnel from the public safety department and, depending on the governmental structure, the financing department. If external financial support is necessary to fund the transfer, financers become stakeholders. Other stakeholders involved will be the personnel to be trained for the warning system. If these forecasters already work for an institution, the institution itself becomes a stakeholder. Human observers are also stakeholders in the avalanche warning process. They will be easily identified, although the actual selection of these people may be difficult. The public is not an immediate stakeholder because the accuracy and success of the avalanche predictions needs to be verified before cautions can be transmitted to the public.

Step 2: Research on region

Once initial contact is made and the stakeholders are determined, the second step in the process begins. This step is researching the region to gain an understanding of its current conditions. Contact with the stakeholders is crucial to the success of this research. Through meetings with the stakeholders, information must be gathered on the resources, infrastructure, public policies, and the cultural and social beliefs. Economic cost must also be analyzed during this step. No environmental impact exists from the use of this technology. This knowledge gained from the research will tell if it is possible to transfer the forecasting process.

Figure 4.21
Avalanche Forecasting Process: Step 2



The infrastructure of the new region will determine which level of the forecasting process is most appropriate to transfer. The new forecasters and personnel from the institution, as well as other stakeholders, will be contacted during this research stage. The level of infrastructure at the new forecasting institution is the first thing to determine. This can be accomplished through a series of interviews with the technical support personnel, if they are available at the institute. If the forecasting institute does not exist yet, the infrastructure of the construction location can be determined through interviews with government officials. It should be determined early on if the institution will have the technical support necessary to transfer higher level computer components. Higher level software programs should not be transferred immediately. It may overwhelm the new forecasting personnel with too much technology and information at once.

Just as the institution's infrastructure needs to be examined, so does the country's infrastructure. A communication network needs to be solidly in place for warning system to eventually include a bulletin for the public. The communication network also determines the extent to which human observers will be utilized. Information on the communication network can be obtained from stakeholder involvement.

Research should also be conducted through direct contact with possible human observers. This contact will determine if their technological capability needs to be upgraded for the warning process. Human observations are a crucial resource in avalanche predictions. Human observers will not be useful without the necessary supporting infrastructure to relay the information to the forecasters.

The resources for this transfer are almost entirely human. Apart from the physical resources necessary for the infrastructure, the process for avalanche warning requires labor for data collection and avalanche hazard prediction. The new forecasters should be separately interviewed to determine their level of snow and avalanche expertise.

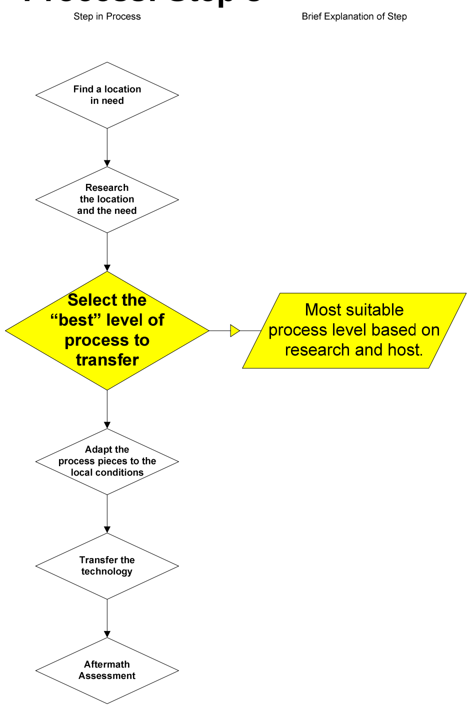
Their education background should also be examined. The transfer process will be much smoother if the new forecasters are proficient in snow and avalanche phenomena. Their current knowledge will only require supplemental information on the avalanche prediction process. If this is not the case, their education must first focus on snow and avalanches before the prediction process can be taught. The teaching method will be discussed later in this section. Their background education and the available time and economic resources will determine the level of the process transferred.

The economic cost of the transfer should be taken into account. The exact cost of the transfer will not be known until the level of the process is chosen. An estimate of the cost of transfer should be determined to ensure adequate monetary resources are available. There must be enough financial support to transfer the process. A cost benefit analysis will not be useful in this case because the process, without the information flow systems or bulletin, does not provide immediate benefits to the new region. The process has to be successful before the information distribution components can be implemented.

The society of the new country should be researched to ensure the usefulness of an avalanche warning system in the future. If the people are not looking for security, the system will probably not be successful as a bulletin. Focus groups should be utilized to determine their attitudes towards avalanches and to predict their response to the possibility of a bulletin. They should consist of people from avalanche threatened areas with different socio- and economic backgrounds. They should express their views towards avalanches and their opinions on the usefulness of knowing the avalanche predictions. Once this information is gained, the research is complete. More research should be conducted as needed to supplement any gaps.

Step 3: Selecting the best level to transfer

Figure 4.22
Avalanche Forecasting Process: Step 3



After the research is complete, the best level of the process to transfer must be chosen. Before a level is chosen, it must be defined. We determined seven levels to consider for transfer. Each level includes a certain amount of human observers, associated education, and software level. The higher levels have one remote sensing station. Six levels are displayed in Table 4.6. Level seven is the entire Swiss warning system. It was included to show the difference separating the level of the SLF and the highest transfer level.

Table 4.6
Levels of the Avalanche Warning System

Levels	Human Observers	Software	Education	RSS*
1	0	0	Minimal	0
2	2	0	Partial	0
3	4	GIS	Moderate	0
4	6	GIS and NXD or SNOWPACK	Average	0
5	8	GIS and NXD or SNOWPACK	above average	1
6	10	GIS, NXD and SNOWPACK	High	1
7	200	GIS, NXD and SNOWPACK	Very High	75
*Remote Sensing Station				

Six different levels are defined for the various transfer levels. The levels differ in the number of human observers, the number of software programs, the amount of education and the number of remote sensing stations. The definitions for each level were based on these four criteria. The levels of education are listed but not strictly defined. The highest level should be equivalent to the education and experience of an SLF forecaster. This education is not limited to snow and avalanches. The SLF has five geographers, one meteorologist and a machine specialist with long-term search and rescue experience. These people have been trained in avalanche predictions based on their backgrounds.

The minimum level, level one, is the simplest level. It does not require external human observers (the forecasters are internal observers), software, or remote sensing stations. It does require a minimal level of education and experience. An example of a level one knowledge is an elementary formal education with some experience in snow and avalanches. The experience should be equivalent to a search and rescue personnel or a mountain guide. A minimal amount of process training would be given to the forecasters for this level. Level one is the most basic level of the avalanche warning system to transfer.

The difference between level one and two is that level two has outside human observers and a greater level of knowledge. Level two expertise exceeds the knowledge required for a level one process, but is not great enough to accurately operate a software program. Level two includes human observers because the new forecasters' background education is sufficient. The external gathering of information from trained human observers will supplement the forecasters' database. The extra data helps the forecasters make more knowledgeable predictions.

Level three enhances level two by the addition of the graphical interface system. The minimum background education should be equivalent to at least an undergraduate degree in a field relating to avalanche predictions. The education should be supplemented with an adequate amount of experience. The experience can be research and (or) a number of years as a mountain guide or a previous avalanche forecaster. More detailed training can be provided with this level of background information. The forecasters should have the necessary education to operate the GIS program. For the GIS software to run efficiently, the supporting infrastructure must be in place. In addition to GIS, level three also has an increased number of external human observers. This increases the amount of data available to the forecasters. The amount was increased because of the increase in the forecasters' expertise and the presence of adequate communication networks. The level of observers continually increases into level four.

Level four is the highest level of the process without including a remote sensing station. The background education for this level should be similar to an average forecaster's. NXD or SNOWPACK should be transferred based on the computer infrastructure and the knowledge of the forecasters. The software program that best suits these two criteria should be selected for training and transfer. They should be supplemented with an increased amount of human observers as well.

Level five is the first level that includes a remote sensing station. The expertise level should be almost equal to the SLF personnel. As in level four, only NXD or

SNOWPACK should be transferred. Transferring only one software program prevents an overload of new technologies. The remote sensing station should be constructed as the training and transfer process are occurring. The station can only be transferred if adequate resources and infrastructure are available in the new region.

The main difference between level five and six are the software programs and the level of expertise. The expertise level should be equivalent to the SLF, though not necessarily in avalanche predictions. Additional training may still be necessary. Both software programs are included due to the high level of expertise and infrastructure. A remote sensing station is also included. This will supplement the data from the human observers. As in the previous step, it should be built in the transfer stage. This level should only be transferred to an established snow and avalanche institution. If the success of transferring a high level is doubted, a lower level should be adopted immediately.

Now that each level has been defined, the selection criteria will be discussed. They are: computer infrastructure, background education, communication network, and financial resources. These are researched in step two of the transfer process. Further research should be conducted if not enough information exists to make an educated decision. Once a sufficient amount of information is available, each criteria may be analyzed based on the different levels of transfer.

Each criterion fulfills a special purpose in determining the best transfer level. The computer infrastructure will have to support the software programs and remote sensing stations. New methods will be easier to incorporate if a higher the level of expertise exists. For example, it will be easier for the new forecasters to learn more about avalanches if they are already knowledgeable in the area. Therefore, the higher the level of expertise, the higher the level of the warning system can be transferred.

The existing communication network will determine the number of human observers that can be effectively employed. It will also determine if the remote sensing station will be able to transfer its data to the forecasters. The last criterion to consider is the financial aspect. There must be enough financial backing to transfer the chosen level. A lower level may need to be transferred while supplemental financial resources are sought.

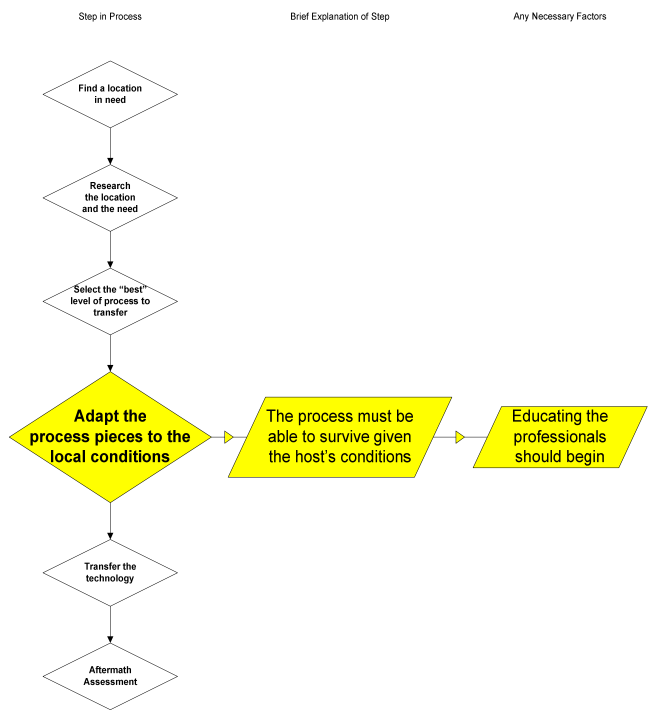
Each of these criteria should be carefully examined and matched with its appropriate level. For example, the computer infrastructure may only be able to support GIS, not neither NXD nor SNOWPACK and certainly not a remote sensing station. In this situation, the computer infrastructure is ranked as a three. If the infrastructure cannot support any software programs, it is a two. If it can support GIS, NXD, and SNOWPACK, its ranking would be a four. If a remote sensing station can also be supported, the ranking would be a six. Each of the criteria should be individually examined to determine the appropriate level it could support.

Once this is complete, the average of all the rankings should be calculated. This determines the level. The chosen level cannot exceed the level that the infrastructure can support. If the infrastructure is inadequate the transfer will fail. Therefore, the highest level chosen transferred must match the infrastructure. Deficiencies in background education or other criteria can be overcome more easily than an inadequate infrastructure. If the average level is not greater than the infrastructure level, the average would be transferred.

Step 4: Adapting the Process

Once the level is chosen, it has to be adapted to comply with the conditions of the new region. The process for gathering data may need adaptation. It will depend on the level of the existing infrastructure and the level of the process. If an Internet system is not in place, different means of communicating the information will be necessary. A telephone could replace the Internet. Reports could be called in by leaving a message or talking to a person to input the data into the system. If software programs are being transferred, they need to be translated into the native language. Also, the computer systems will need to match the requirements for the program. They will need to be installed if they are not in place to ensure the programs function properly. In this case, the location adapts to the technology.

Figure 4.23
Avalanche Forecasting Process: Step 4

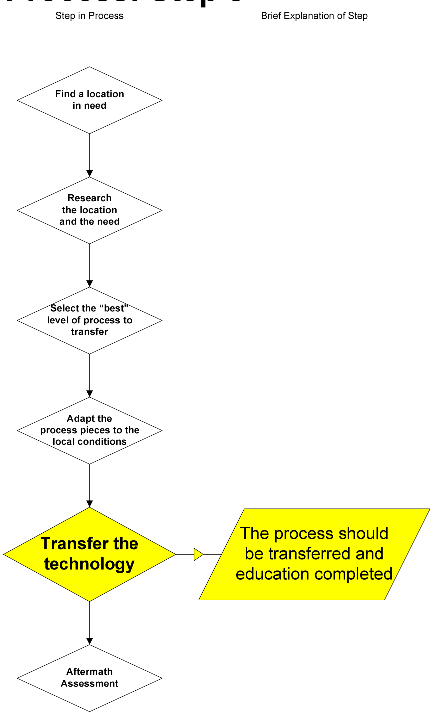


During the adaptation process, the new forecasters should begin their training. The education should be carefully planned to ensure greatest efficiency. The actual content of the education depends on their current knowledge. The training should be cooperative to ensure the new forecasters are learning. Language and culture barriers should be recognized and overcome before teaching the forecasting crew. The transfer process will occur more smoothly by training the forecasters during this stage. It also enables the SLF experts to identify knowledge gaps at an earlier stage and prepare to fill them.

Step 5: Transferring the technology

The transfer process begins after the adaptation is complete. The transfer is largely educational. The education should be completed and the new forecasters prepared to operate an avalanche warning process. Any holes in their knowledge recognized during the adaptation process should be filled and any supplementary information taught.

Figure 4.24
Avalanche Forecasting Process: Step 5



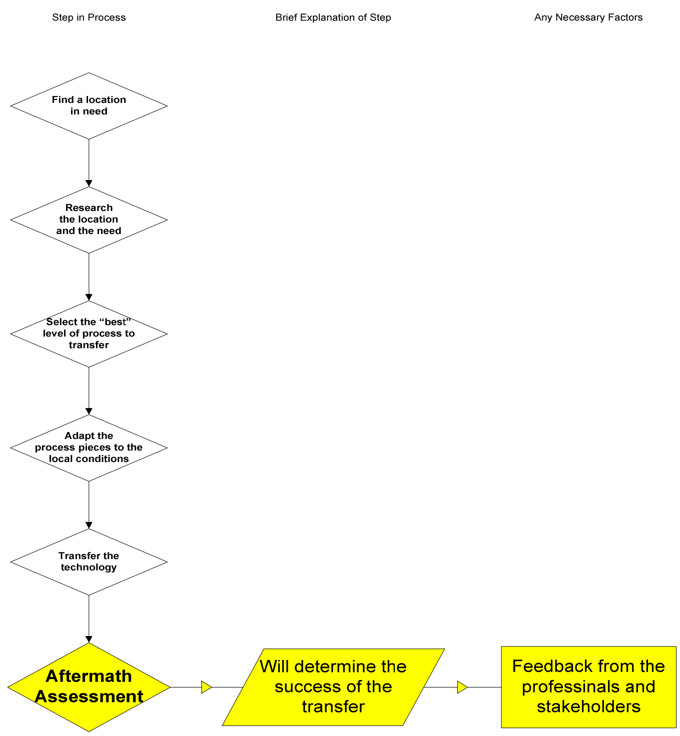
The human observers' education is also completed during this stage. The information they will provide the forecasters with is crucial to the success and accuracy of the avalanche predictions. This step must not be under-emphasized. The education of the observers must be very thorough and complete. The content of the education should be adapted from the training the SLF provides its observers. Again, any language and culture barriers must be recognized and overcome before the training begins.

Any software program or other components should be transferred at this time. If any problems arise, they should be dealt with quickly and efficiently. This prevents delays in the transfer process. The SLF should ensure the new forecasters are correctly using any software programs. The success of the observers' measurements and transfer of knowledge should also be securely in place.

Step 6: Aftermath assessment

Once the education and transfer process is finished, the aftermath assessment may begin. At least one full avalanche season should be allowed between the completion of the transfer and the beginning of the aftermath assessment. This will evaluate the actual success of the program in the new region. The accuracy of the new forecasters will establish the success of the transfer. The accuracy is determined by comparing the number of predicted avalanches that occurred, the number of unpredicted avalanches and the number of avalanches predicted that did not occur. If the program was unsuccessful and the forecasting was imprecise, a new method of transferring the process should be determined. This may require a different method of educating the forecasters or the level of the process reduced. A lower level will reduce the require knowledge required for the forecasters. The infrastructure may have been unable to support the systems therefore reducing the technological level would increase the computer programs' efficiency. If the process

Figure 4.25
Avalanche Forecasting Process: Step 6



had a high level of accuracy, more components may be transferred to increase their efficiency and knowledge.

The purpose of the avalanche warning system is to protect lives. If avalanche danger is predicted t is necessary to alert the officials and the public. There is no purpose in transferring the process if the final goal does not include the warning of people. However, the process must be well established before warnings can be issued. Once the process is established, the systems for distributing the information can be transferred.

The avalanche warning process is an example of transferring the base level of a technology. By only transferring the base components, the host is not overwhelmed with new technologies and is able to advance their expertise with time. In some cases, transferring the process will not be necessary. An avalanche warning system may be newly established. In this situation, certain components of the avalanche warning system can be transferred to help the new forecasters to expand their expertise and knowledge of avalanche prediction.

NXD-Avalanches

The transfer of a single software program out of the avalanche warning system demonstrates this supplemental transfer. This type of transfer can be performed by isolating a software program from the SLF's warning system and transplanting it into another system. Many software programs are currently used in the Avalanche Warning System at the SLF, which were mentioned previously. They are SnowPack and GIS (the graphical visualization software). NXD – Avalanches can also be used if the forecasting is concentrated on one region. These three programs require certain hardware and knowledge to operate them. The component selected for transfer is the

NXD - Avalanches program, a technology from the software category of the inventory. An analysis for this technology is shown in *Table 4.7.*

The SLF forecasters do not use NXD – Avalanches in their own forecasting. The software is not applicable to a wide region. In our process, NXD is used to help new avalanche forecasters expand their knowledge and experience. The new forecasters should only be concentrating their efforts on a specific region. As the region starts to expand, the use of NXD should diminish.

Table 4.7
Analysis of NXD – Avalanches

NXD-Avalanches	**Researcher: Joachim Heierli**
DEFINITION: Computer-based forecast tool to help evaluate avalanche hazards using the nearest neighbor statistical method	
APPLICATION: Any place where snow poses a danger	
INFRASTRUCTURE: Electrical grids for the computer Support and maintenance for computer	
HUMAN RESOURCES: Knowledge of snow stability and avalanches Ability to gather accurate weather and snow conditions Computer literacy	
PHYSICAL RESOURCES computer, equipment to measure weather and snow data	
SOCIAL IMPACT The ultimate aim is increased public safety on roads, railways, ski resorts and in settled areas. This improvement is difficult to measure.	
ENVIRONMENTAL IMPACT No direct consequences	

Table 4.7 (continued)
Analysis of NXD – Avalanches

STAKEHOLDERS
Avalanche forecasters, researchers, public being protected. Government in some cases.

ALREADY ON MARKET
Yes

PATENT
None

CONFIDENTIALITY
No

UNIQUE FEATURES
Uses statistical nearest neighbor method

OTHER TECHNOLOGIES?
Any other technology that helps forecast avalanches, not necessarily computer-based (the forecast horizon of NXD is 24 hours.)

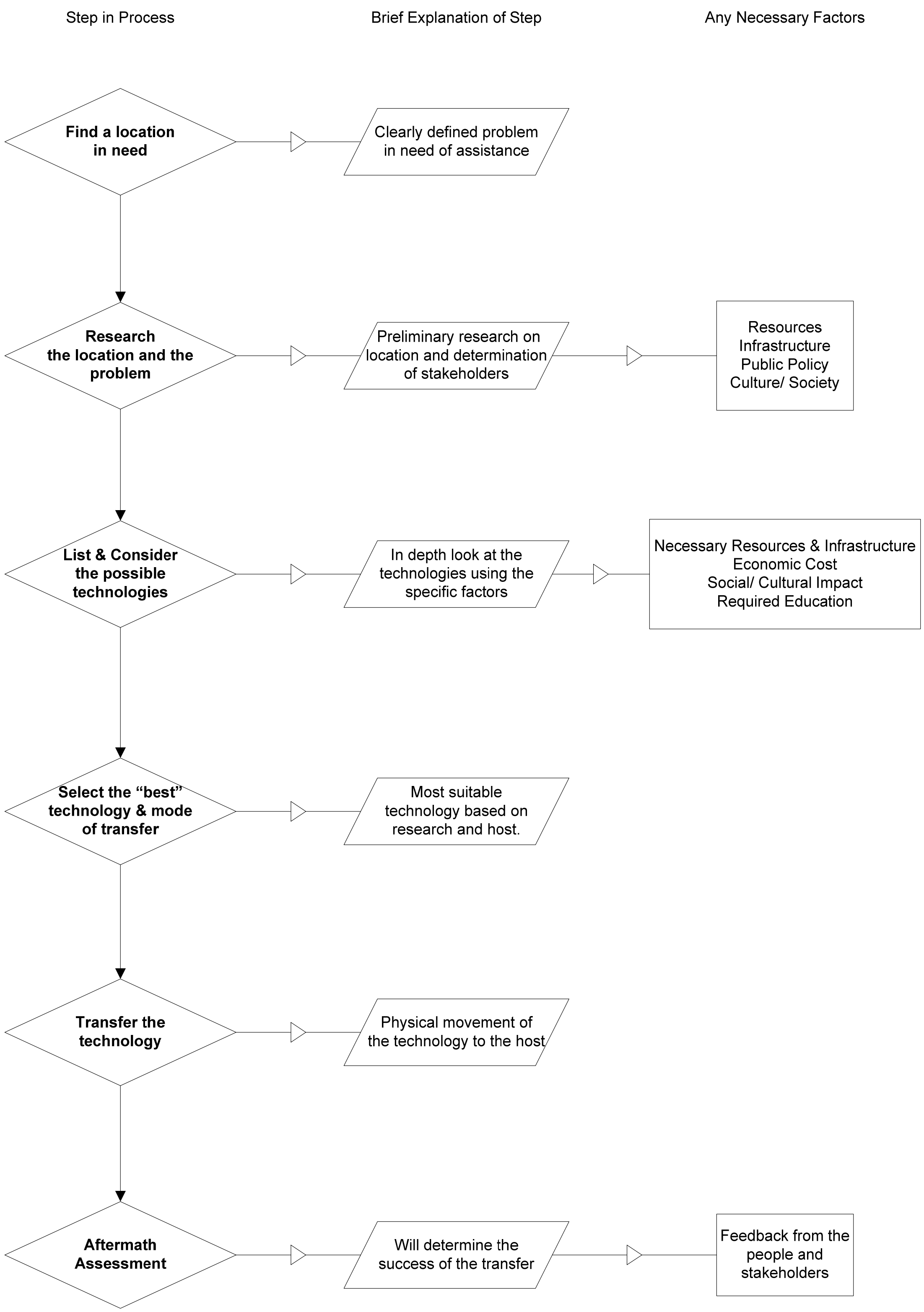
EXPANDABLE TO NATURAL DISASTERS
No

Modified Transfer Process

The transfer of this technology is different because, unlike the technologies considered earlier, it is a software program. The theoretical transfer process must be adapted for the specific technology. The modified process is shown in *Figure 4.26*. The actual code of the software does not need to be changed depending on the location where it is installed.

Figure 4.26

NXD – Avalanches: Modified Transfer Process



Step 1: Defining the location

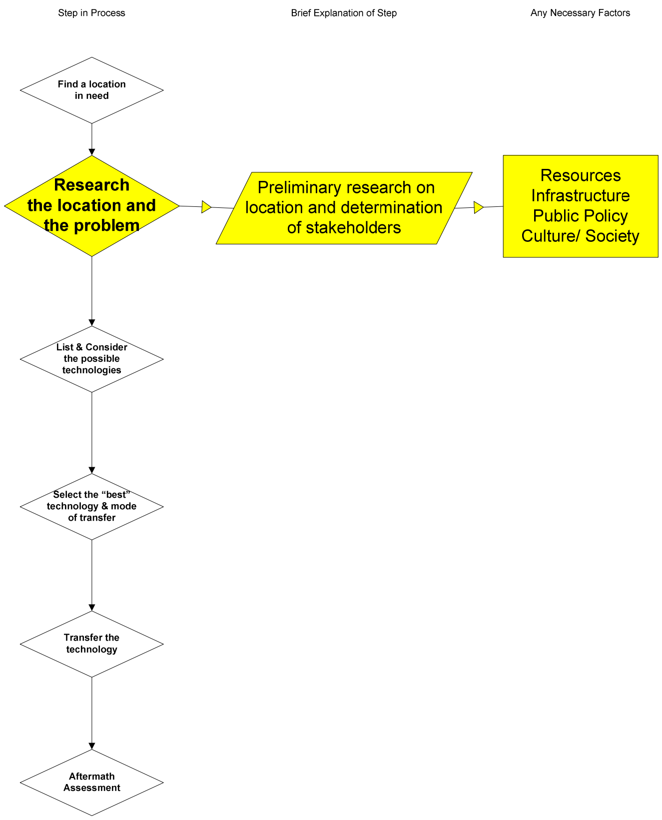
The first step is defining the new avalanche warning system where the technology will be introduced. In order for a supplemental transfer to occur, the avalanche warning system should be recently established and focused on a specific region. The aim of the transfer should be explicitly stated from the beginning of the process. The people involved in the warning system should be looking for ways to improve their warning system. These people will be important stakeholders in the transfer process.

Step 2: Preliminary research

Once the location is determined, the stakeholders must be identified. The main stakeholders are the experts at SLF and the new forecasters. The transfer occurs between these two groups. The role of the region's government depends on its involvement in the warning system. If the warning system is governmentally owned, their role will be larger than if the system is a private enterprise. In most cases, third party financers or facilitators does not exist in the transfer of software programs. The cost to obtain and transfer the software is much less than for a typical technology transfer. The government or warning system should be able to provide the financial resources.

After the region and main stakeholders are determined, research must be done on the region. Compared to our previous transfers, the research necessary for a software program is limited. The infrastructure of the new warning system should be carefully examined. The sophistication of the tools and methods currently in use will determine if a software program is transferable. If the new forecasting system is governmental, the policies relating to the forecasting agency will be important. These policies state the specific functions of the avalanche warning system and the resources available to fulfill these functions. How the system operates is determined by these policies and should be considered to ensure compatibility with an outside software program

Figure 4.27
NXD - Avalanches: Step 2



The societal impact of the new warning system should be examined. , A thorough assessment must be done to determine this impact. There are several ways to gather information to assess the impact. The SLF could compile surveys concerning the new bulletin and its usefulness. A survey is limited, as the number of responses received is uncertain. Therefore it should be supplemented with other data gathering techniques. Focus groups gather people together to discuss the topic at length. It will help different opinions flow concerning the warning system.

The extent and reasons for public use of the avalanche bulletin should be examined. Problems in relaying the bulletin to the public should be addressed before trying to improve the actual predictions. A software program will be more useful if used to make better predictions.

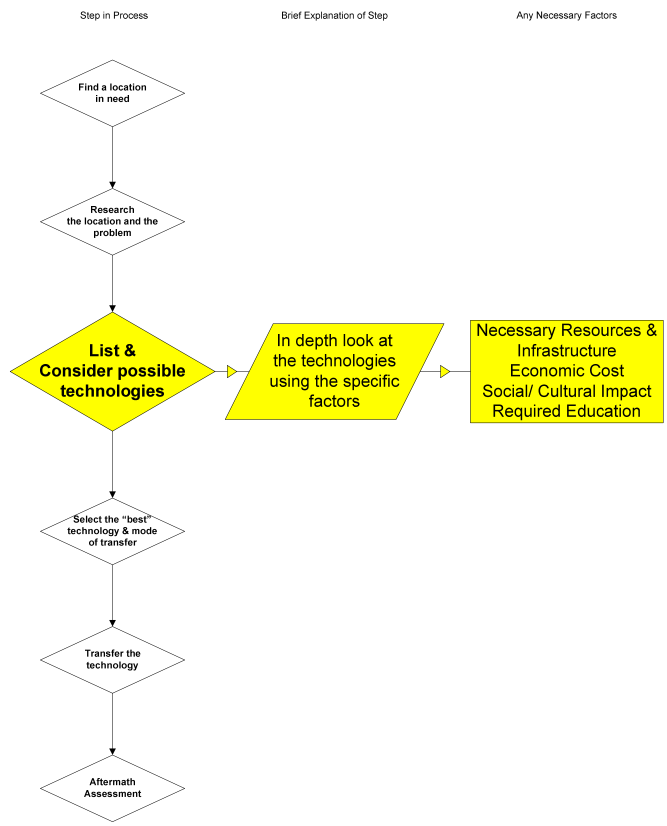
The new forecasting system itself should be examined. Every warning system should always be seeking ways to improve and increase their experience. If the new warning system has unacceptable inaccuracy, introducing a software program usually will not solve the problem. The problem will need to be solved by other means, depending on their specific problem. A different warning system component may need to be transferred. If the system is successful and plans to expand its tools or experience to increase their accuracy, then a software program will be suitable to transfer. For this transfer, we assumed a new avalanche forecasting system was seeking ways to increase its experience.

Step 3: In-Depth Research

Once the preliminary research is complete, the technological solutions must be considered in-depth. Research should be done considering the requirements for each software program able to help the forecasting team expand their experience and knowledge. The necessary resources and infrastructure, economic cost, societal impact and required education of each technology should all be examined before choosing which technology to transfer.

The existing computer infrastructure, along with other factors, will determine which software program can be transferred. Software programs have certain requirements, such as specific operating systems, hard drive capacity or minimum amounts of memory. A software program cannot be transferred until computer requirements are met. Computers require a reliable power supply, spare parts and certain skills. Training can be given to improve the forecaster's computer literacy, but physical requirements are more difficult to satisfy.

Figure 4.28
NXD - Avalanches: Step 3



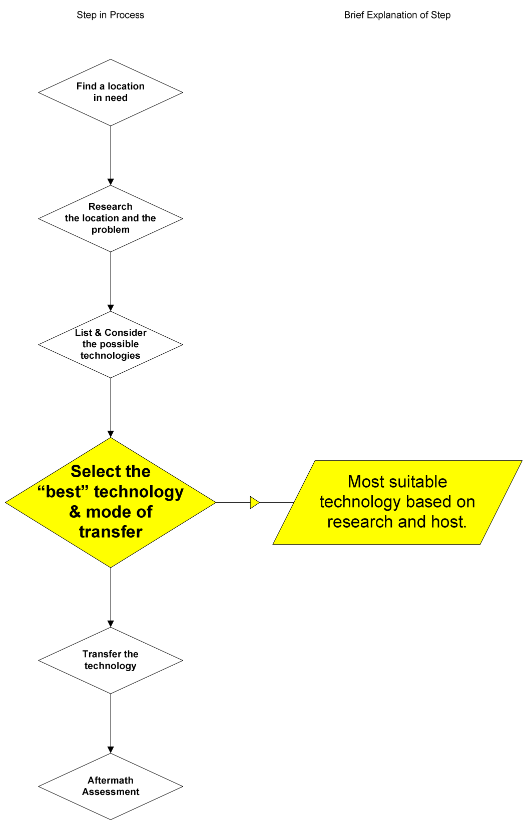
The education required to run each program should be examined and compared with the forecasters' current knowledge. If a large knowledge gap exists between the required and possessed education, then that technology may not be the best to transfer. It may require too much new information to run the program efficiently and smoothly. Focus groups and interviews can be used to research this. The SLF forecasters know the knowledge required to use the programs and will determine if the new forecasters possess this knowledge.

The cost of the technology should be determined before any financial resources are spent. The cost of the transfer is determined by the amount of new training and the necessary computer resources. A cost benefit analysis should be performed using this information. For this situation, the analysis equation, explained in Section 2.4, will need adapting. Improving the accuracy level of a warning system will not directly reduce risk since this relationship cannot be directly proven. The reduced risk should be replaced with the increased accuracy and experience. This will produce useful and accurate cost-benefit ratio.

Step 4: Selecting the technology and mode of transfer

Once the in-depth research is complete, the most appropriate technology and method of transfer can be determined. In this case we have chosen NXD – Avalanches, but it could be any of the components from the SLF warning system. This program is based on the nearest neighbor method. It is a software program that trajectorizes a vector based on the snowfall, height, and settling of the snow (Heierli 2003). The computer uses a statistical method to compare this trajectory with similar ones from past days. This method determines ten past days with similar conditions. These days provide examples of possible events for the day in question. To make the actual prediction, a large amount of knowledge and experience is needed.

Figure 4.29
NXD - Avalanches: Step 4



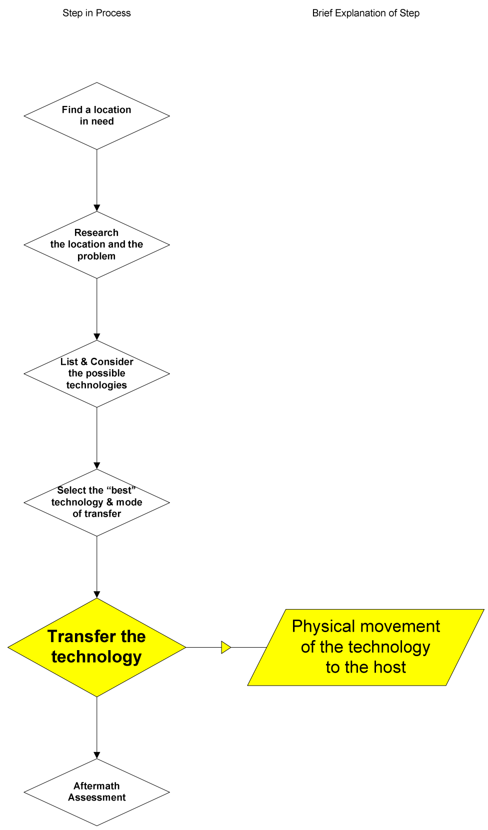
NXD - Avalanches requires certain versions of Windows and other hardware components. The meteorological history of the region of the region must also be available. This program's performance increases with the amount of history available.

The mode of transfer will be a relatively minor consideration for this technology. The transfer will consist of making the necessary computer requirements available, installing the software and training the new forecasters. The role of each of the stakeholders must be decided for each of these steps. This will determine the method used to transfer the technology.

Step 5: Transferring the technology

Figure 4.30

NXD - Avalanches: Step 5

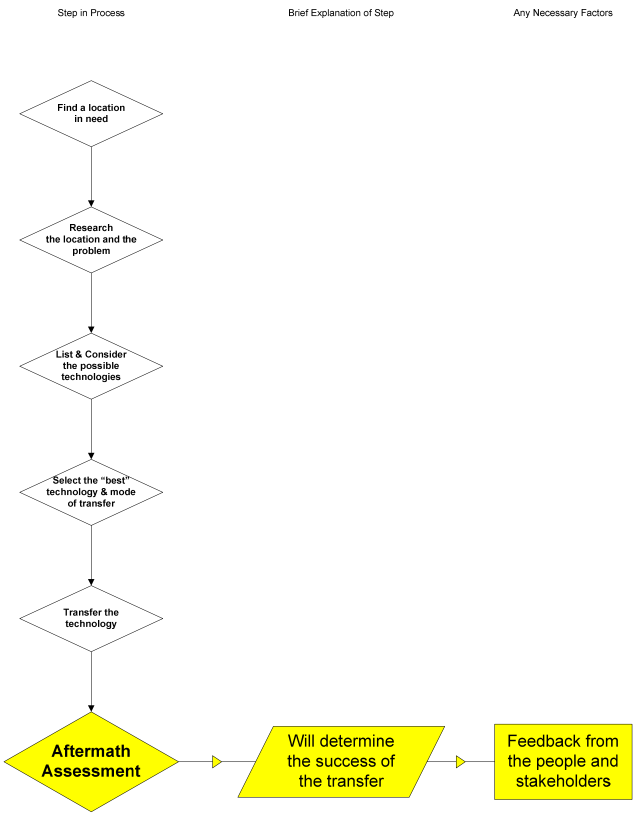


The training should begin after the technology is chosen, in this case NXD - Avalanches. The type of knowledge required to use NXD is similar to forecasting knowledge. The nearest neighbor days must be able to be interpreted and combined with other information. The training should be determined by the education level of the new forecasters. Any cultural and language differences should be carefully considered while conducting the training.

Since NXD is a software program based on meteorological data, it is not necessary to adapt the software to the new region. The correct operating system and hardware is in place for the program to run effectively. If the technical requirements are met, the program can be installed onto the computer. The only adjustment necessary is to place the meteorological data into a particular for so the software program can use it. This usually takes two to three days (Rhyner 2003).

Step 6: Aftermath Assessment

Figure 4.31
NXD - Avalanches: Step 6



Once the training process is completed, the forecasting system should use the software for at least one avalanche season before an aftermath assessment begins. In some cases, the new forecasting system may need support from the SLF during the first season. The continued involvement will allow the SLF to observe the new forecasters as they use the new technology and to make adjustments as is necessary. A full assessment is only completed after the forecasters have independently used the software for an entire season. The assessment should compare the accuracy and experience of prediction during the season with a comparable former season completed without NXD. This assessment will show how successfully NXD was used and if NXD was the correct program necessary to transfer. If NXD was used competently, but there was no significant increase in the accuracy or expertise, a different software program may have been needed to be transferred. The assessment will also identify any problems that should be addressed. This assessment should be conducted in the same manner as described for the previous technologies.

The collaboration between the SLF and the new location should continue after the transfer is complete. The continued collaboration will increase the flow of information between the two forecasting systems resulting in a mutually beneficial situation.

Summary

The database served multiple functions. Before we could choose which technologies to conceptually transfer, we needed an understanding of the technologies at the SLF: However, a comprehensive list did not exist. Therefore, for our own understanding and knowledge, we needed to research the technologies and compile a list of each technology with its importance and function. It provided the SLF with a comprehensive list of their technology and research while also providing us with an understanding of the technologies.

Three main representative technologies were conceptually transferred from our inventory. Each exemplified very important issues and concerns of technology transfer. Snow support structures represented the hardware category. They protect citizens by preventing the occurrence of avalanches. The risk index is an applied knowledge that evaluates and compares the risk of a location, which in turn helps decide the course of action taken against the natural hazards. The avalanche warning system is an example of a complex technology that is very inappropriate to transfer all at once. However, it components may be removed from the technological system and transferred separately. The avalanche warning system also has high social impact as it warns citizens about imminent avalanche danger.

Theoretically transferring each of the four technologies (2 main and 2 components) had many implications. The first was to help the Institute view their technologies from a technology transfer perspective. This perspective will hopefully illuminate factors concerning their own technologies they were not previously aware of. It is also meant to provide the SLF additional tools and knowledge for conducting future transfers.

Chapter Five: Conclusion

Technology is embedded in society. Therefore, technology transfer is not the simple relocation of a technology from one region to another. It requires the analysis of many important factors for a transfer process. Social assessment tools are used to examine each of these factors. In addition to this, stakeholder input also plays a key role in deciding the success of a transfer. The central theme of this paper is: technology transfer is a social process involving the people of the new country.

Representative technologies from each of the categories were chosen to be theoretically transferred. These technologies highlighted the social process of technology transfer. The avalanche warning system demonstrates how varying levels or components of the same technology can be transferred. A seemingly complex technology was reduced to its constituent part to make the transfer manageable. This could be performed for any technology

The theoretically transferred technologies were chosen based on their representation of their category. They were not chosen based on their potential for transfer. A possible continuation of our project is to determine specific technologies that may be researched for an actual transfer rather than a conceptual one. Technologies from a specific category may be more appropriate to transfer.

Many software technologies are currently on the market and already being transferred around the world. The SLF may assess each of these technologies to determine the optimal pricing for them. The software programs may not be priced at their own market values.

Our transfer process concentrated on a geographical technology transfer. An extension to our project could focus on transferring technology from academia to industry. Areas of research that appeal to both the SLF personnel and different industry partners could be further explored. While the SLF already conducts several research projects in conjunction with the industry, an outside evaluation of their success in this type of transfer will be beneficial for the SLF.

These are just a few ways to expand on our project. In every endeavor, the social impact of the technology is huge and cannot be ignored. Many people do not realize their relationship technology until it is harmful. If societal effects are considered when transferring a technology, the transfer will be able to benefit the new location.

Bibliography

Amara R (1991). "Views on futures research methodology" in Futures Vol 23, No 6, 645-649.

Ammann, W. PhD, personal interview, November 4, 2003.

Bartelt, P. PhD. (ND) Rockfall Protection Technology Fact Sheet

Bebi, P. PhD, personal interview, November 3, 2003.

Bischof, Nicole, personal interview, October 30, 2003.

Brown, K. M. (1998) Sandia's Science Park: A New Concept in Technology Transfer Issues in Science and Technology Online, Winter http://www.nap.edu/issues/15.2/brown.htm

Bull, C. & Hazeltine, B. (1999) Appropriate Technology: Tools, Choices and Implications. London: Academic Press

Bründl, M. PhD, personal interview, November 5, 2003

Bründl, M, PhD. (ND) IFKIS Fact Sheet

Centre on Transnational Corporations (United Nations). (1987) Transnational Corporations and Technology Transfer: Effects and Policy Issues. New York, United Nations.

Christen, M, personal interview, October 30, 2003

Christen, M. (ND) AVAL-1D Fact Sheet

Christen, M. (ND) DBF-1D Fact Sheet

Clarke, R. (1973) The pressing need for Alternative Technology Appropriate Technology in Third World Development, 1984

Coates, V. T. (2001) The need for a new office of technology assessment The Futurist, Washington, Volume 35, Issue 5, September/ October. 42-43

Dannenmann, S, PhD, personal interview, October 28, 2003

Dean, C. C. (1995) Barriers to International Technology Transfer" Business Forum; Winter/Spring

Ebbin, S. & Kasper, R. (1974). Citizen Groups and the Nuclear Power Controversy. Cambridge, MA, MIT Press,

Eckaus, R.S. (1977) Appropriate Technologies for Developing Countries Washington D.C: National Academy of Sciences.

Evans, D. (1979) Appropriate Technology and Its Role in Development Appropriate Technology in Third World Development, *1984*

Fauve, M, personal interview, November 4, 2003

Föhn, P, PhD, personal interview, November 7, 2003

Forest Service National Avalanche Center (FSNAC) (Accessed on 9/26/2003) NXD- 2000 http://www.fsavalanche.org/NAC/techPages/NXD.html

Galbraith, JK (1958) The Affluent Society Boston: Houghton Mifflin Co.

Ghosh, P.K. (1984). Appropriate Technology in Third World Development: Preliminary Report from a Workshop on Appropriate Technology, Morrilton, AK: Winrock International Conference Center, December 1978, 9

Goh, A.-T. (July 2003) Knowledge Diffusion, Supplier's Technological Effort and Technology Transfer via Vertical Relationships http://www.sess.smu.edu.sg/events/Paper/Aiting.pdf

Goulet, D. (1994). Participatory Technology Assessment: Institutions and Methods Technological Forecasting and Social Change, Volume 45, Issue 1, 47-62
Hall, B. H. (2002) The Assessment: Technology Policy. Oxford Review of Economic Policy, Volume 18, Number 1
Hansen, A. & Clausen, C. (2003) Social shaping perspectives in Danish technology assessment Technology in Society, Volume 25, Issue 3, August, 431-451
Hay, J. E. & Noonan, M. (2000) Anticipating the Environmental Effects of Technology: A manual for decision-makers, planners and other technology stakeholders.   *United Nations Environment Programme Division of Technology, Industry and Economics* http://www.unep.or.jp/ietc/Publications/Integrative/EnTA/AEET/index.asp
Heierli, J, personal interview, November 4, 2003
Heierli, J. (ND) NXD – Avalanches Fact Sheet
Hellstrom, T. (2003) Systemic innovation and risk: technology assessment and the challenge of responsible innovation. Technology in Society, Volume 25, Issue 3, 369-384
Hudspith, R. (2001) Using a Consensus Conference to Learn about Public Participation in Policymaking in Areas of Technical Controversy. Political Science, June
Joyner, B. E. (2002) Communication technology in international technology transfer: Breaking time and cost barriers. American Business Review. Volume 20, Issue 2, 17 – 27.
Lang, T. (2003) An Overview of Four Futures Methodologies. http://www.soc.hawaii.edu/future/j7/LANG.html
Lee, Y. S. (1996) Technology Transfer and the Research University: a Search for the Boundaries of University – Industry Collaboration Elsevier Science. 843 – 863.
Lehning, M. PhD, personal interview, November 5, 2003
Lehning, M. PhD. (ND) SnowPack Fact Sheet
Leuenberger, F, personal interview, October 31, 2003 and November 5, 2003
Linstone H (1978). "The Delphi Technique" in Handbook of Futures Research Fowles J (Ed) Greenwood Press, Westport
Lundström, T, personal interview, November 3, 2003
MacKenzie, D. & Wajcman, J. (1999) The Social Shaping of Technology. Philadelphia: Open University Press
Madu, C. N. (1992) Strategic Planning in Technology Transfer to Less Developed Countries. New York: Quorum Books.
Margreth, S, personal interview, November 4, 2003
Margreth, S. and Johannesson, T. (1999) Adaptation of the Swiss Guidelines for supporting structures for Icelandic conditions.
Margreth, S, Johannesson, T, Lied, K, and Sandersen, F. (1996) An overview of the need for avalanche protection measures in Iceland.
Meister, R, personal interview, November 3, 2003

Mukherjee, S.K. (1984) Analysis of five case-studies on the acquisition and assimilation of foreign technology in India Case-Studies in the Acquisition of Technology (II) New York: United Nations
Minchener, A. J. (2000) Technology transfer issues and challenges for improved energy efficiency and environmental performance in China International Journal of Energy Research Vol. 24 1011-1027
Morgall, J. M. (1993) Technology Assessment, A Feminist Perspective. Philadelphia: Temples University Press
Neufeldt, V. (1990) Webster's New World Dictionary. New York: Pocket Books.
Office of Technology Assessment US Congress. Cost Benefit/Cost Effectiveness of Medical Technologies: A Case Study of Orthopedic Joint Implants. NTIS order #PB82-120833 Washington, D.C. US Government Printing Office, September1981
Ottmer, B, personal interview, October 28, 2003
Pack, H. (1999) Exporting, externalities, and technology transfer. Policy Research Working Paper, February. Washington, DC: World Bank, Development Research,
Phillips, M., PhD, personal interview, November 3, 2003
Phillips, R. G. (2002) Technology business incubators: how effective as technology transfer mechanisms? Technology In Society, Volume 24, Number 3, August.
Pielmeier, C. PhD, personal interview, October 30, 2003
Postman, N. (1992) Technopoly, The Surrender of Culture to Technology. New York, Vintage Books.
Purtranto, K., Stewart, D. & Moore, G. (2003) International technology transfer and distribution of technology capabilities: the case of railway development in Indonesia. Technology in Society, Volume 25, Issue 1, January 43-53.
Ramanathan, R. (2002) Successful Transfer of Environmentally Sound Technologies for Greenhouse Gas Mitigation: A Framework for Matching the Needs of Developing Countries Ecological Economics, Volume 42, Issues 1-2, 117-129.
Rhyner, H, personal interview, November 6, 2003
Rhyner, J. PhD, personal interview, October 31, 2003 and November 17, 2003
Rhyner, J. PhD, Bründl, M, Etter, H-J, Steiniger, M, Stöckli, U, Stucki, T, Yimmerli, M, and Ammann, W. (ND) Avalanche Warning Switzerland Consequences of the Avalanche Winter 1999.
Robinson, R (1988). The International Transfer of technology: theory and practice. Cambridge, MA:Ballinger.
Saggi, K. Trade, Foreign Direct Investment, and International Technology Transfer: A Survey http://econ.worldbank.org/files/1103_wps2349.pdf
Samli, A. C. (1985) Technology Transfer: Geographic, Economic, Cultural and Technical Dimensions Westport, CT: Quorum Books
Schilling, A, personal interview, October 28, 2003
Schneebeli, M. PhD, personal interview, October 30, 2003
Schneebeli, M. PhD.(ND) SnowMicroPen Fact Sheet

Sclove, S. L, Ph.D. (2001) Notes on Likert Scales. http://www.uic.edu/classes/idsc/ids270sls/likert.htm
Simmonds C (1977). "The Nature of Futures Problems" in Futures Research: New Directions
Steiniger, M, personal interview, November 3, 2003
Steiniger, M. (ND) InfoBox Fact Sheet
Steiniger, M. (ND) IFKIS InfoManager Fact Sheet
Stewart, Charles T. Jr. and Yasumitsu Nihei (1987) Technology Transfer and Human Factors Lexington Books, Lexington Massachusetts
Swiss Federal Institute for Snow and Avalanche Research (SLF) Davos. (2002)
TFG (1994) Relevance Tree and Morphological Analysis http://www.futurovenezuela.org/_curso/12-tree.pdf
Turoff, M and Linstone H. A. (2003) The Delphi Method:Techniques and Applications. http://www.is.njit.edu/pubs/delphibook/index.html
Tulbure, I. "Considerations regarding evaluation methods in Technology Assessment" http://www.itas.fzk.de/e-society/preprints/newapproaches/tulbure.pdf Accessed on September 28, 2003
US Embassy (2002) Text: Working for a Sustainable World – Environmental Stewardship, Pt. 1" http://usembassy.state.gov/tokyo/wwwhg10466.html
VTET, Using Delphi Techniques in Assessing Needs for VTET. (2003) http://www.voctech.org.bn/virtual_lib/Programme/Regular/Emerging99/Using%20Delphi%20Technique.htm
Warner, K, personal interview, November 6, 2003
Wie, L. (1995) International Technology Transfer and Development of Technological Capabilities: A Theoretical Framework Technology in Society Vol. 17 No. 1, 103-120
Wiesinger, T, personal interview, November 6, 2003

Appendix A: Inventory

Inventory			
Category	**Name**	**Function**	**Main Researcher**
Applied Knowledge	SnowPack Piste	Use SnowPack to characterize pistes for race or tournaments	Sven Bethke
Applied Knowledge	Maintenance of Forest Protection and Safety	To create a tool to determine the best methods to upkeep a forest environment	Tor Lundström
Applied Knowledge	Avalanche Bulletin	To warn civilians of avalanche possibility	Dr. Jakob Rhyner
Applied Knowledge	Piste Preparation Handbook	To Educate people on piste preparation	Mathieu Fauve
Applied Knowledge	Avalanche Installations in Permafrost	To determine how structures can be built in permafrost regions	Marcia Phillips
Applied Knowledge	Influence of the surface properties on friction of Skis on Snow	To study friction mechanism between ski and snow	Team Snow-Sport
Applied Knowledge	Forest Management Tree Stability	To determine how best to manage forests to increase tree stability	Kalberer Matthias
Applied Knowledge	Operations of SnowMicroPen		Christine Pielmeier
Applied Knowledge	Risk Index	To determine the different risk levels created by natural hazards around the world	Steffi Dannenmann
Applied Knowledge	Development of simulation method for ski binding system	To simulate binding system when driving curves while considering snow mechanics to use in implementation of design/development of an integrated system	Anton Lüthi
Applied Knowledge	Road Safety Test Installations	Test installations on tunnel-roof traffic, public transportation, railways, etc.	
Applied Knowledge	Wind-tunnel	Modeling deposition of drifted snow, deflecting barrier, accumulation, etc…)	Jean-Daniel Rüedi
Applied Knowledge	Debris Flow Model	Development and comparison of friction relations for application to practical problems	Brian McArdell
Applied Knowledge	Influence of near-bank blockage on driftwood occurrence in torrents		Christian Rickli
Applied Knowledge	Avalanche Dynamic Projects	To study the dynamic properties of avalanches	

Inventory			
Category	**Name**	**Function**	**Main Researcher**
Applied Knowledge	ALPSCAPE: Vulnerability of the Alpine Landscape and Habitat: Simulation of future landscapes and development of support tools	To develop support tools for regional decision making	Peter Bebi
Applied Knowledge	Tree Stability and Natural Hazards	To test the trees for stability	Tor Lundstroem
Applied Knowledge	Avalanche Protection Methods	To be able to assess snow safety without complicated tools	Roland Meister
Hardware	Debris Flow Sensoric Installations	Sensoric installations for debris-flow	
Hardware	Snow Parameter Sensing System	Allow accurate calibration of remotely sensed data for improved forecasting of Hydro Power Resources	Martin Schneebeli and Manfred Stähl
Hardware	IMIS Inter-cantonal Measuring and Information system		Luca Egli
Hardware	ABS Avalanche Airbag	Prevents burial in avalanche	
Hardware	Avalanche Burial Search Devices	To help find buried people in an avalanche	
Hardware	SnowMicroPen	Characterizes snow layers	Dr. Martin Schneebeli
Research	Effects of grazing on the forest dynamics		Andrea Mayer
Research	Winter Climate Change in Snow-Rich Environments: Effect on Artic and Alpine Plant Communities	To determine the effect of climate change on the plant communities	Sonja Wipf
Research	Biological and physiological aspects of tree stability	To determine what aspects affect tree stability	Andrea Foetzki
Research	Historical reconstruction of avalanche occurrences using dendrological techniques	To determine avalanche history of region by examining woody plants	Alejandro Casteller
Research	Habitat Useage and Activity Models of Steinbuck and Chamois in Winter	To study the behavior of these animals	Tobias Jonas
Research	Micro-Compositional Tomography	To represent Snow metamorphosis in a 3D model	
Research	EcoIMIS: Ecological Evaluation of IMIS-Data	To evaluate data from sensing stations	Sibly Brugger and Witzig Jonas
Research	Experimental property of constitutive law of snow flow		Felix Tiefenbacher

Inventory			
Category	**Name**	**Function**	**Main Researcher**
Research	Land use changes in Swiss mountain regions: Evaluation and simulation		Ariane Walz
Research	Models for re-afforestation on wind blasted areas	To determine how forests retreat in wind blasted areas	Anja Rammig
Research	Protection effect of dead trees against Natural Hazards		Ammann Martin
Research	Vegetation effects on superficial soil movements	Validation of the new approach	Martin Frei
Research	Quantitative stratigraphy of snow cover		Margret Matzl
Research	Crystal growth in multi-element snow systems	Characterize development of crystals	Thomas Kämpfer
Research	Fracture properties of snow and their application to dry-snow slab avalanche release	To examine the mechanic properties relevant to release of slab avalanches	Christian Sigrist
Research	Evaluation of avalanche endangerment to tourist transportation equipment		Lukas Stoffel
Research	Rockfall-forest interaction	Determine the protection activity of mountain woodland against rockfall	Perry Bartelt
Research	Uncertainty modeling in Avalanche release area and Hazard Mapping		Urs Gruber
Research	Interaction between snow cover and permafrost in the Alps: Coupling of SnowPack and Ground Heat Flux Models	To study the interaction using these two models	Martina Luetschg
Research	Regional forest fire forecast models		Andreas Felber
Research	Tree Stability: Structural Dynamics	To determine the structural dynamics of trees	Martin Jonsson
Research	Fine-scale Modeling of the Wind Field and Associated Snow Transport		Norbert Raderschall
Research	Rock population in snow: Examination of the action of snow cover and weather on the mobility rocks	To determine how rock movement is affected by snow cover and weather	Tobias Jonas
Research	Mobility of the snow alga Chlamydomonas nivalis	To determine how the alga moves in the snow	Yannick Bischoff
Research	Hydrothermal processes in the active layer and their	To determine how these process influence the other layers	Armin Rist

Inventory			
Category	**Name**	**Function**	**Main Researcher**
	influence on the underlying permafrost in steep Alpine scree slopes		
Software	IFKIS MIS	An information system for inter-cantonal communication of measures	Michael Bründl
Software	AVAL-1D	Calculates avalanche parameters	Marc Christen
Software	NXD-Avalanches	Avalanche Warning	Joachim Heierli
Software	InfoBox	Info for security personnel	Manfred Steiniger
Software	IFKIS InfoManager	To provide security personnel with relevant information as efficiently as possible	Manfred Steiniger
Software	SnowPack	Characterizes change in snow layers	Dr. Michael Lehning
Software	DBF-1D	Calculates Debris Flow	Marc Christen and Perry Bartelt
Software	NXD-Avalanches: Product support, design and development of web forecasting	To support software and develop web interface for	Joachim Heierli
Software	Observer and Sensing Station Network Database	Collects and stores data from the Observers and Sensing Stations	Monique Aebi

Appendix B: Interview Summaries

Dr. Walter Ammann
Head of the SLF
November 5, 2003

- The SLF is interested to see how technology transfer is viewed from the outside.
- It is a special effort for English speaking people?
- ITT in terms of selling services, ie consulting, and making money!!
    - Support people and improve living situations for those dealing with natural hazards.
    - An example could be hazard mapping
- IDB- completed project
    - Carribean and South American countries
    - The bank spent 1 billion US dollars
    - Koko would be a good
- Cooperate with the World Institute for Disaster and Risk Management
    - Could probably contact them to get a brochure.
    - They hope to open a branch in Davos to help aid Asia and Africa
    - Mainly consulting work
    - The Bank already has offices in Asia and Africa
        - Nairobi
        - Contact with Gern Agency for Tech. Cooperation
            - $20-$25 billion
        - Mozambique has flooding problems
- Post-doc education of Africans here
- Jolynn Soben
    - Risk Index- something to help decision
        - Hazards
        - Sustainability
        - Poverty reduction
- Physical devices transferred through companies (Rockfalls)
    - Avalanche steel wire nets
- Consulting
    - Software is as hard as it gets
- Consulting delicate-retain independency

Steffi Dannenmann
Risk Index
October 28, 2003

- You're involved in the international aspect here, correct? What universities or other institutes world wide do you have contact with?
    - World Institute for Disaster Risk Management
    - Established several years ago with ### and Swiss Reinsurance
    - Try to work with World Bank and do projects in Latin America and Central American. Work with Inter American Development Bank
        - IDB~ member countries
            - Jamaica
            - Honduras
            - Niagara
            - El Salvador
            - Bolivia
            - Dominican Republic
                - Did not work out in end
            - Peru
        - Went to banks and offices there
        - Talked to finance minister, people with saying on natural disasters and look at how bank helped the projects
        - Look at usefulness of projects, if money was being used properly
        - Talked to people in a private way, much more open with their opinions
        - Jamaica and Honduras both had small scale flooding when she traveled there
        - People had no system for garbage removal which produced flooding
        - Honduras~ flooded market place
    - Evaluation of approach on natural hazards
    - Mixture between consulting and research
    - Research has been developed on project basis
    - Risk Cycle
        - Developed and discussed
        - Transfer knowledge international risk assessment
        - Continue to try to get more and more projects similar to the Latin American one.
- So have you transferred any technology or is it all knowledge
    - Mostly knowledge
    - Only been here since January, real technology not developed
    - Our group is mainly knowledge transfer.
    - It will develop with time
    - Risk index
        - Hot spots around world
        - Focusing on developing countries
        - Not only on disaster aspect but also on economy aspect
        - Very hot, very controversial

        - When give money to one country, leave out others, mistakes being made
    - Lots of work being done but not published
    - Tool in it's own sense
- Swiss Federal Campus (Cenate)
    - Online Course
    - Integrate own curriculum online
    - Learning units online
        - Professors teach part of class then assign projects to do online
    - Developing stage
    - Professors all over Switzerland
    - Way to integrate all collegiate levels

Joachim Heierli
NXD-Avalanches
November 4, 2003

- We received a fact sheet concerning NXD-Avalanches; we were wondering if you could tell us more about it?
    - o Well basically what it's doing is predicting when avalanches occur. It looks at the weather for one particular day, today for example, today you want to forecast. IT compares the weather today which is trajectorized by a certain vector for example by snow fall, snow height, the settling of the snow. So today is trajectorized by this vector, now you take all of this and put it in a database and try to find the ones that match this day. So this is the statistical method that is known by the statisticians. So there is an arbitrary thing about how you compare weather from one day to another. It's not really clear, there is an arbitrary search. Finally you have ten nearest days with similar weather pattern. You then look at the avalanches that happened on those ten particular Then you take this as an example of what could happen today
- I noticed the fact sheet lists the software requirements needed to run the program, is there a level of knowledge needed to run the program as well?
    - o I would say so, yes. Absolutely. You have to interpret the data. The program only gives you what happened on those days. But what do you do with that? You have to interpret. If you have no idea about avalanches, it's useless. If you have an understanding of avalanches then it can help to give you examples, these examples won't match very well with what will happen today. You have to think, interpret and mix it with other data that you have collected. For example, if you just take NXD and use it alone, the prediction made will be very bad.
    - o In easy cases, these are the cases where there are lots and lots of avalanches. NXD performs well here.
    - o Where avalanches are rare, it is difficult. Then solely NXD makes a bad decision
    - o If you take this one puzzle piece with of the whole then it's going to help you. It gives you another light.
- What other programs do you use NXD with to predict avalanches?
    - o Well then there are several methods developed. This is targeted for the outside. No one here at SLF uses NXD. That's for the decision makers for guides in valleys that have to close roads and to stop railways from running.
    - o That's one user group; another user group is the ski resorts who have to ensure the skier is safe on the slopes. This is the easiest situation. They use explosives so they have more information about the snow stability.
    - o The guys in the valleys don't use explosives so they have no experiments and therefore have less data. And they are rarer, like earthquakes, they are much harder to predict.
- Where do you get the data NXD uses? Does it all have to be imputed manually?

- No, you have a choice. If you want to make your own measures you can make them. If not there is a network of about 70 observations stations at an altitude of 2,500 to 3,500 meters. They collect all sorts of snow and weather data. You can use the data these machines collect just by pushing a button.
- Or the other possibility is automatic weather stations, which have about the same number of stations. They usually observe at lower altitudes, 2000 to 1500 meters. SO they observe input this data in the database and get the inventory.

- How many years does it take for the database to be accurate?
    - It depends on every installation. The remote stations had not been built when NXD was and it requires about, it depends on the base rate, at low frequencies it would be 5-6 years. The more data you have, the better the predictions.
    - Another problem is an exchange of ownership. For example, take Davos. Parsen have used NXD for many years and have recorded since 1965, for these 40 years there have been 4 different bosses. Each boss had a different idea of how much explosives to use. This is reflected in the database. For example, if the most recent owner for the past decade uses much more explosives than the previous 3 owner and 3 decades, then 30 years of data are worthless b/c of the explosives. You can't mix the two because it gives an error; it's not the same condition.
- You said they had been using it for 40 years, so when was NXD put on the market?
    - They have not been using it for 40 years; they have kept a database for that period of time. I think NXD was invented at SLF in 1983, and then it was improved until 1989. Since then it has not been improved very much, maybe the software but not the method.
- Do you know where you have sold the program to?
    - Yes, of course. There are about 40 customers through out the world. Kazakhstan, Canada, Switzerland, the US
    - Does have a list we looked at, lists all of the customers and everything, Get a copy?
    - The list is labeled by cantons and regions.
- Do these people contact you or do you market the program?
    - Yes of course they contact us. We distribute fact sheets at conferences such as the IGS, the International Glacier Symposium or at other places. We are not pushing it, we just have it and let people know and if they want it then they ask.
- Is there something else that you are working on right now?
    - Yes, as I told you before there are other models. This is just one which is purely statistical. You can put some physics in there by calculating other avalanche specific data from the input data, but it remains statistical. So there are other approaches. There are many other statistical methods; there are some attempts to make more physical based models. Rules can be either statistical or physical. This is only for SLF bulletin, it's not for

outside. Now they have no operational modeling tool running. They had one a few years ago but they were unsatisfied.

- Now I have a question for you, what is your goal here?
  - Dr. Stöckli invited us to come here and look at technology transfer. Right now we are trying to gather and idea of the technology and research topics here to create a database. Then we are going to try to look, out of those technologies, which could be moved to a developing with a natural hazard problem to help them solve their problem. So for example, if Chile needed the avalanche barriers to help protect them, we would look at how to go about that process.
- Okay, you need a lot of inside knowledge already I think. In this respect NXD is a method you can export, contrary to physical which are very much bounded to where you make the rules. You take the snow of Japan or New Zealand and Canada, it is much different. Because of how the temperature is and the humidity in the snow, much higher snowfall for example in Japan. SO if you have a physical method you usually can't export it because it’s only good for the region it was developed in. NXD is very good in this respect because as long as you have an accurate database that you have observed locally it will work. When you have to experiment what kind of variables are important to selecting ht e10 neighbor days. A test run is needed.
- It all depends on the frequencies; at very low frequencies it is hard to predict an avalanche where at very high frequencies it is easier.

Stefan Margreth
Avalanche Defense Structures
November 4, 2003
(From written notes)

He works on consulting for avalanche structures and hazard mapping all around the world. This consulting within Switzerland is performed for cantons and Communes.

A large consulting project was performed for Iceland. After a particularly harsh winter for them in 1995 they came to the SLF looking for help. The SLF worked with them for 3 months to develop and adapt the avalanche structures to their needs. Similar consulting was performed for Japan. In both cases the countries approached the SLF. No marketing was performed on the SLF's side. These countries pay handsomely for the SLF expertise. Cost run between CH 1,000 and CH 1,750 per day for the SLF to work on a problem.

There are also connections with Chile, Canada and the USA.

The technology that has been adapted for other people are the avalanche defense structures. These include snow support structures and catching dams that either deflect or stop the snow. These are usually to protect transportation lines, or in one particular case, protecting electrical power lines. The hazard mapping guidelines were also adapted to local conditions. The more important parameters for the hazard mapping are the impact pressure of the avalanche and the return period of the avalanche. Hazard maps are also being adapted to take in account risk, not just avalanche frequency and size.

Jakob Rhyner
Avalanche Warning
October 31, 2003

I will try to give you a short overview of what my division is doing. The subject of my division is virtual center and avalanche warning. We are responsible for the avalanche warning in Switzerland. I think concerning technology transfer two people to contact are (cannot understand). A brief overview will still be useful for you.

Every two years there is the International Snow science workshop. This is where the practitioners meet. This paper was written for this. Read it and then come back with questions. I will now try give to you a brief orientation. I will send it as a PDF. There is nothing confidential in it.

Avalanche warning in Switzerland began in 1936. Avalanches were a huge problem. The villages were not secure. This does not occur in countries where it is not necessary to build in dangerous areas, as population pressure forces us to here.

The first trials to predict avalanche dangers were conducted in (German name?) (vice-full-wojck ?) by seven people. 7 people still do the avalanche predicting. What has changed very much is the original people worked by themselves, whereas now the 7, if I include everyone in research and prediction, it is about 30-40 people, out of which 30 are in this department.

So why has it increased so much? This is easiest understood if we look at how the data flows in avalanche warning. This is based on a lot of measurements throughout spits. Measurements are made by people living in mountainous regions and by ski resorts. The information is standardized. The 7 are under huge pressure during the winter to issue this avalanche warning everyday even with all the uncertainties. It is not always done in a scientific way. There are about a hundred of these observers which send in the information through a form on the internet. Sometimes the observers are mountain folk who are not familiar with computers, and so had to be trained, even if very simply. It is not a burden for them because they get something back from it and so it works. This goes into the central avalanche database of Switzerland stored here.

The other half of the information comes in through automatic sensing stations. They measure temperature and snow height and other weather factors. The map shows where the locations are. Why automatic and manual observations? The automatic stations are usually high in the mountains where humans cannot go or where it is too dangerous. We prefer the human information because it turns out to be better. However we still need the information for the areas where humans cannot go. It is important to understand that when there is an extremely intense weather situation the automatic weather station gets buried by the snow and so cannot give information, a clear drawback, where this does not happen to human observers. I won't go into the details. There are limitations to automatic sensors. Human beings are much more robust.

In addition to this is the weather data which is always very important. Our people do not get enough from the national weather service. They have to look at the models themselves to determine what the weather will be. Maybe they are not as professional as the national meteorologists, but they still do important work here.

So all this information goes into the central information. Info from skiers is also very important. They can report avalanches. This does not go into the database, but into the heads of the 7 who issue the avalanche warnings. They somehow process this.

Then this information is then visualized in various ways. The information is combined both automatically and synoptically. The actual avalanche information issued is usually a piece of text and then there is a chart of Switzerland where the different colors mean different danger levels. It is a worldwide danger level scale.

This daily info goes out to 3 kinds of user groups. The first is the security services. They are interested in the info only in critical situations and are the most important. In most cases it goes to skiers need the information all the time. And when it gets very dangerous they don't need the information at all because they don't go skiing. There are 2 different sets of information. There is the skier information. Then there is the information that does not go to the public. We try to predict avalanches as far ahead as possible. Avalanches can only be predicted 3-4 days in advance, beyond this is simply not possible, too uncertain. 4 absolute maximum. We try to approach the security people 4 days in advance so that they have enough time to implement the various responses, such as road closures and evacuations. They have to know as early as possible. This information is very uncertain. When these people get the information they have to decide if they are going to change their plans or not. If this information went to the public they would be swamped by phone calls from the public. This information platform is InfoManager. It was developed here. It is a bit different from the usual information tools. We have to do it in extremely close contact with the users. We have to ensure that the people are happy with how it is used or else they simply won't use it and then there would be no avalanche predictions. The training courses always include a feedback component.

This is normally in the winter.

What we saw is an interesting situation in crisis management. If decisions have to be made very quickly then there can be stupid results. Parallel road and railway, the railway was closed but the road was left open. Different organizations are responsible for each, but in avalanches the dangers are the same. We were asked to look for solutions to this problem. To solve it we used a web-based "chat" platform where they can inform each other about measures they have taken or removed. You also get a history of the measurements taken. They get no new information from this platform, but it allows horizontal info flow, instead of just the vertical. The horizontal flow cannot be standardized as the vertical can. The users have to much more involved and interactive to use it. Another problem is that usually the system is sleeping, because there is no crisis, and we have to ensure that it will actually function and wake up quickly enough. It raises the question are we troubling the people with too much technology, maybe we are pushing too hard. We have to very carefully decide how much technology is too much. It is not like sold software, where if the person buys it and then does not use it then it is his problem, but for us if they do not use the technology then it worsens the crisis management. It might be better if we did nothing than push useless technology upon the security people. (Chart of Quality of warning vs. quality of technology). This is why we have to have a different way to transfer technology. This is a special kind of technology transfer. You have to be extremely careful.

And then there is the domain of Joachim Heierli. With all this technology the human element is still much more important. The models and software and things are still a long way away from being useful by themselves. They are still mostly used in the reversed manner. No one would revise their decision based on what the technology tells them. We are confident this will change in the future. The data is still best processed by the people. The NXD works on the nearest neighbor method. When we were growing up, we would ask the grandfather. This is how the software works by comparing the metrological data with past situations. 10 closest matches. They would never make decisions based on this single element. It is only used as a memory support.

This is the only piece in which we are interested in selling, the avalanche predictions to the security people. The other information is available free to the public.

- You brought up some important points in the presentation about the project. Areas you wanted to look at concerning technology transfer
    - This was maybe a silly proposal. For you to look at TT is extremely challenging given the time you have? But then my advisor said let them go their own way.