Chapter 6

6. Analysis.

The objective of this chapter is to contrast the TT model proposed with the information obtained in the case studies and see if the model really exemplifies the reality of the TT process in Mexico. As mentioned in chapter 5, two transnational companies were visited and interviewed, company “X” and “Y”. Company “X” is currently in the implementation stage of the technology transfer process and firm “Y” is already using laser technology successfully. There was a little problem encountered in company “Y”, because they do not see the application of their laser welding process as a technology transfer, but as an extension of technology. The TT process occurred in 1998, six years ago, and since that management has changed, so we were not able to follow the stages and problems undertaken during the process of development, implementation and diffusion; whereas in company “X” the TT process is taking place now.

6.1. Core Technology.

In chapter 2, it was mentioned that technology can be decomposed into “core technology” and “region-specific technology”. The core technology in the case of laser welding is the laser light itself and its generation. Region-specific technologies are not readily evident, but can be referred to as the adaptations made to the system in order to install it in Mexico.

The main equipment needed for the laser welding process of the car body in “X” is a laser generator; a beam delivery system to guide the laser light with fiber optics from the generator to the processing area; the optics, which can be a welding head with or without filler metal, and the robots which guide the optics. Each of these components of the laser welding installation is provided by a different supplier. The laser generator was supplied by TRUMPF, the optics by HighYAG and Scansonic and the robots by Kuka. All this suppliers have a German origin. When designing and constructing the equipment, the suppliers must have a list of specifications which cover the geographical and environmental characteristics of the Mexican plant. The main changes made to the original technology are the integration of a transformer into the equipment, since in Europe a 400V voltage is used and in the plant in Puebla 440V. It must be taken into consideration that the installation will be operated by Mexicans, therefore the control and visualization modules of the equipment have to be in Spanish. It is important that the suppliers respect the international and national standards for the implementation of the technology in this country. In general, few changes have been made to the original system used in the German plants. Some other adaptation will be described further in this chapter (section 6.3) and a table contrasting core and region-specific technology will be given at the end of the chapter (table 6.4).

6.2 Developmental Stage.

Since the case study was made from the point of view of the technology transferor, and they do not develop the technology, they buy it; this stage should not be called Developmental stage, but Assessment stage instead. The factors to be considered in practice during this stage remain the ones proposed. (See Fig. 4.1)

While carrying out the “Needs assessment”, “X” realized that in order to be competitive in the world market and within the automotive industry, they continuously have to be moving towards new technologies and techniques through the implementation of a highly automated working model, which involves a high quantity and variety of equipment that offers important advantages altogether. With the use of laser welding to assemble the car body, the total quality of the vehicles produced is improved, its stiffness is higher (absorbs more vibrations), the cars are lighter; and it is easier to join more sheet metal plates (stacked on a pile), which results in a reduction of operations. For the former and many other reasons it is of key importance that “X” opts for laser welding as soon as possible given the fact that it is part of a worldwide consortium and other assembly plants within it are already making use of this new technology. This will not only improve the plant’s operations but also will give way for “X” within the consortium to be taken into account for future projects once they’ve proven fast-track technology adaptation and efficient personnel training. The main advantages of laser welding seen by “X” are the use of state-of-the-art technology as an advertising tool, the flexible automation of the production process and the higher production rate.

The “X” plant in Puebla had two or three laser welding stations for the previous car model they were producing, so the laser technology was not completely new. Because of the lack of experience in the field, they did not give the installations the correct maintenance and did not have the methodology to control all the process variables. The few people on charge of the equipment were not specialized and had to know a little bit about everything. It was very hard to keep updated being the technology source so far away. With this previous experience and during the installation of a totally new production line for the upcoming model, a team was formed in order to have specialized and skilled people in each application of the laser technology. This team is on a consortium level and served the exchange of information and experience. For this matter and as a communication tool, “X” has a consortium-wide intranet page called “Expert Room”. This is a very important TT channel.

Some of the characteristics and types of technology were already mentioned in the previous chapter. The technology transferred is laser welding. The 4kW generator creates a laser beam (solid-state, continuous, Nd: YAG, ϕ 6μm) and thus the energy required for the welding. This energy is guided through laser light fiber optics to where it is needed: the joint. The sheet metal plates are positioned and attached to the tool the tool adapter in such a way that the focused laser beam can later be guided to the seam. The welding head mounted on robots moves along the joint line of the seam over the sheet metal. The immense energy density of the focused laser beam causes the workpiece to melt and vaporize. The melted materials behind the welding head then fuse. The melted and mixed materials cool and solidify to form a narrow welding seam. During processing, the welding seam is normally protected from reactions with the air by a shielding gas (argon).

The financial resources destined for this project come from foreign investment in their totality (Germany). The planning and implementation was done by German firms or by the German headquarters with the contribution of the personnel involved in the Mexican plant. This TT project is very important for the consortium, for the new car model aims to recover its position in the U.S. market in the coming four or five years. The investment made in the plant in Puebla is the highest that has ever been made in this plant. The investment made in training is high, too, but the benefits will be reflected when the projected production goals are met. This training is mainly given in Germany by the companies who developed this new laser technology.

At this stage, Government and Politics should be taken into consideration, instead of considering them in the Diffusion stage. There is a history of investment restrictions for the Automotive Industry in Mexico. The basis of the restrictions on foreign investment stem from numerous laws and regulations that have been passed this century in Mexico with the objective of promoting the development of the domestic automotive industry.

On August 25, 1962, the Mexican government enacted a Decree which prohibited the imports of motors for automobiles and trucks and mechanical parts, destined for use therein as of September 1, 1965. This Decree provided that motors and transmissions to be installed in vehicles in Mexico are produced therein with at least 60% of the content coming from parts produced within Mexico. In addition, the Mexican government prohibited the import of vehicles in the same year.

Another Decree was passed in 1972 to limit foreign participation in the auto parts industry. The decree established that foreigners could not hold greater than 40% of the capital stock of companies dedicated to the production of auto parts. The Law to Promote Mexican Investment and Regulate Foreign Investment, published on March 9, 1973, further reinforced the prohibition, providing that foreign participation could not exceed 40% for companies producing automotive parts. Further decrees and regulations were passed during the 1970's and early 1980's which slightly modified the existing regime while at the same time reinforcing the emphasis on Mexican majority capital in the automotive industry.

In line with other market opening policies, the Mexican government passed the Decree for the Development and Modernization of the Automotive Industry. This Decree took effect on June 15, 1990, and provided that the enterprises comprising the automotive sector would be identified either as final assembly plants or auto parts manufacturers. The Decree defined final assembly plants as those which produced automobiles or those carrying out the final assembly thereof. Auto parts manufacturers were defined as those companies whose sales to final assembly plants of components and parts for use as original equipment comprised greater than 60% of their total sales. Auto parts manufacturers were also required to register with the Ministry of Commerce. The Decree discussed the concept of national supplier, defined as enterprises dedicated to the production of specific parts for the automotive industry satisfying a national value added content requirement. Moreover, the Decree further provided that the classification of national supplier would not be granted if the shareholder owning a majority of the capital of such enterprise was a company dedicated to final assembly of automobiles. However, in the case of enterprises registered as national suppliers, the Decree has been interpreted to permit foreign investment up to 100%.

The Decree also permitted a special regime for the importation of new vehicles. Basically, enterprises dedicated to the final assembly of autos must keep a positive balance in their foreign exchange account, which may then be utilized, within limits, to import new vehicles for sale in the domestic market, or the positive balance may be sold or assigned to another similar enterprise for its own use.

In answer to several inquiries, the Foreign Investment Commission confirmed that foreign participation could reach 100% in companies dedicated to final assembly or in enterprises classified as national suppliers, and confirmed the 40% limit on foreign participation in companies producing auto parts as well as 100% foreign investment indirectly through trusts.

NAFTA provides that Mexico may adopt or maintain measures limiting the imports of used vehicles. Mexico is committed to allowing the import of vehicles that are at least ten years old on January 1, 2009. For each two year period thereafter, Mexico will increasingly open its used car market by providing for the increased import of vehicles via lowering of the minimum age requirement for importation, i.e. on January 1, 2011, Mexico must allow the import of vehicles that are at least eight years old, January 1, 2013, six years old, etc. Thus, Mexico is not committed to allowing the unrestricted importation of used vehicles until the year 2019. (Investment Framework, [13])

The timing of the TT is part of the continuous process of being competitive. If a product is made in a German company with a plant in Mexico, the process technology to produce it in Mexico must be the same one that is used to produce it in Germany. This time they transferred the laser technology, but this technological development and changes in the production process were there in prior projects, too. This can be seen in the project of the previous car model. In 1997 there were only four ten year old industrial robots and by 1998 more than 300 robots were installed for the construction of that model. Thanks to the achievements obtained in that and other projects, the headquarters have the necessary confidence in the Mexican labor.

6.3 Implementation Process.

In a global company like “X”, authority is imposed by German workers of the parent company. Transferring Laser welding involves transferring German workers, too. Culturally, people from different countries and backgrounds have different ways to react to different situations. Mexican as well as German workers suffer during the adaptation process to a new job environment, adaptation to a culture and to a way of thinking unfamiliar to their own. The Mexican workers must understand and adapt to the new technology and their new tasks, but there is always a resistance to change. It is very difficult to make workers understand that the implementation of laser welding is not an optional task; it is a must because the company evaluated it positively. Workers who have been doing the same operation for the last 20 years distrust the new technology because it is new and they do not understand its principles. They see the whole system as a magic black box. They are afraid their tasks change, because they do not know how to handle the new technology. This impedes them to see the advantages of laser welding, because they are afraid they might loose their job due to the automation of the process. But although the automation rate of this new production line is of 85-90%, more workforces with new competencies are required, because of the higher production volumes and the higher complexity of the equipment. Once the production line is running, 1250 cars will be produced daily, while the old production line produced only 950 cars per day.

Every implementation process has its difficulties, laser welding, too. The equipment itself has an optimum performance, but in practice there are a lot of factors that have to be considered in order to get the welding seams well done. The operator is not careful enough while running the equipment due to the lack of knowledge and experience. A fully developed safety concept is an absolute must before attempting to use laser installations in an industrial environment. All dangerous areas must be market as such and appropriately shielded, for the workers are not aware of the danger when talking about lasers. The use of high-powered lasers is a potential source of danger which must be particularly secured. Lasers emit a very concentrates beam that can be visible or invisible. In general, most lasers used for welding are visible. This beam of infrared light could focus onto the skin or eyes unless safety precautions are observed. Industrial laser systems are fully locked to prevent any danger to operators.

In the field of laser safety, the standard EN 60825-1 *"Safety of laser products – Part 1: Equipment classification, requirements and user's guide"*, represents a base document which is applicable to all laser products and installations, which is used by "X". It specifies requirements for manufacturers of laser equipment, such as the classifications into hazard classes, labeling and technical requirements. It also specifies actions which should be taken by the user of laser equipment to ensure safe application. Figure 6.1 is a graphical representation of the groups of standards relevant to laser materials processing in the framework of the European Union. (Handbook of Industrial Laser Safety, [14])

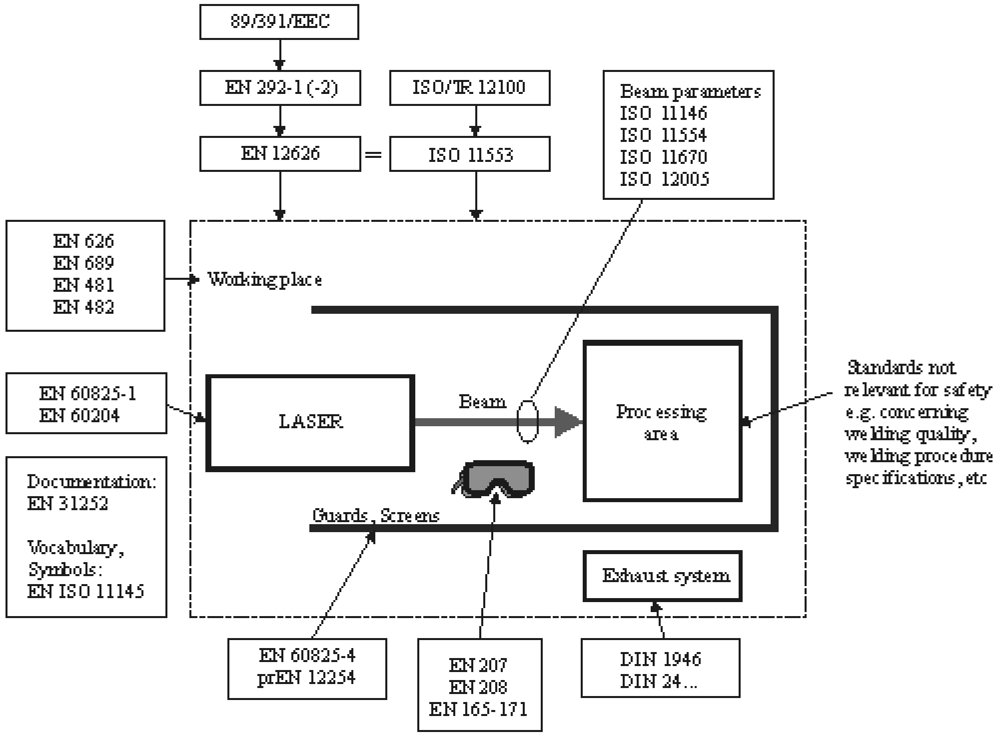

Figure 6.1 Safety standards related to laser material processing.

Laser welding of a car body is very complex, because every welding seam is different. Therefore, during the implementation there are continuous optimizations and recommendations of the supplier companies and the laser welding experts (German consultants). The goal is to develop a plan in which every technical detail is taken into account in order to avoid a bad usage of the equipment. Optimizations done during the implementation process of laser welding in “X” include:

- Reprogramming and change of parameters in the equipment in order to minimize the porous welds.
- Changing fixturing devices of the welding heads.
- Improving exactness in the pressing process of the sheet metal, so that they meet the required tolerances.

- Improving the quality of the welding seams by adjusting the welding speed, degree of penetration and fixturing devices.
- Changing the inclination angle of the welding heads, from perpendicular to 5-7°, so that the reflections of the laser do not damage the optic.

When it comes to financial resources, once the TT project is accepted by the German parent company, there is no need to worry. The Mexican human resources were selected according to their performance in previous projects, but they also have to fulfill the following requirements:

- Intermediate schooling (High school, Technical school, truncated degree, etc.)
- Specialized technicians in resistance welding.
- Experience with soldering equipment.
- Experience with operating robots.

This allows the people involved with the new laser technology to take more advantage of the training courses offered.

Maintenance of the equipment can not be done by “X” personnel. The German suppliers have to do it and it is very expensive, since German technicians have to come from Germany and they have to be paid from the moment they get into the plane. The cost of maintenance is increased by the high cost of the spare parts, too, and the time it takes to give the maintenance itself to the equipment (i.e. maintenance for the laser generator = 16 hours).

The “X” plant in Mexico has been preparing for this TT for over a year now. The project coordinators had to inform themselves about the characteristics of laser technology in order to recognize the training needs, spare parts and infrastructure changes required. Therefore they had to contact the technology suppliers. Their opinion was asked for while doing the design for the new car model and the layout for the new production line. This is a process which starts far before the actual TT takes place.

Mexican research centers and institutions do not participate in this kind of TT processes. None of this technology is actually developed in Mexico. Although “X” has a development center in their Mexican plant, it will disappear by the end of the year, because the headquarters in Germany decided that all the research and development activities are to be carried out in the parent company. All the firms involved in the transfer process are private.

Environmental factors and infrastructure issues should be considered in the implementation process (region-specific technology), instead of being considered during the diffusion of the technology. In terms of infrastructure, the existing facilities had to be adapted for the needs of the laser cabins. The protective cabin collects any possible scattered beams. Because of the accuracy required for laser welding, a damper block had to be constructed underneath the laser cabins, in order to absorb the vibrations caused by the press area, which is next to these facilities. The weather and altitude in Puebla is totally different from the ones in Germany. This is an important factor since the welding heads should operate in a temperature range of 6-23°C. As a result of this the cabins have to be acclimatized and are equipped with an extraction system. The extraction system extracts the vapors and dust produced by welding. Since the laser source or generator is placed above the cabins and tend to overheat, whereas in Germany it is in the cellar, a cooling system of almost the same size of the laser generator had to be installed and with it a new water supply system. A new power system had to be installed to feed the laser systems that require a lot of energy to function, each laser generator needs 110 kW and there are 52 lasers. The equipment had to be “personalized” for the Mexican worker, too, because she/he is not as tall as the Europeans and has not the same strength. A whole anthropometric analysis was developed for this matter.

Anthropometry literally means "measurement of humans." In physical anthropology it refers to one aspect of human variation: The different body sizes and proportions of individuals belonging to different populations. (wordiq.com, [15]) The human body, in its structure and mechanical function, occupies a central place in man-machine design. Failure to provide a few centimeters, which might be critical for the operator of the equipment, can jeopardize performance, operator safety and machine reliability. With proper forethought, these critical centimeters can be provided without compromising the design of the equipment. By using anthropometric data, it is possible to establish proper sizes of the equipment involving human use. Anthropometric data for engineers are best presented in percentiles. Percentile tables (table 6.1) provide a faster and more convenient means of comprehending the dimensional range to be accommodated. Order statistics provide a way of estimating proportions of the data that should fall above and below a given value, called a percentile. (Hertzberg, 1972) The *p*th percentile is a value such that at most (100*p*) % of the measurements are less than this value and at most 100(1- *p*) % are greater. The 50th percentile is called the *median*. Frequency plots of human structural characteristics often approximate, or are assumed to approximate, the normal, bell-shaped, Gaussian distribution. (Engineering Statistics Handbook, [16])

Table 6.1 presents the anthropometric data for the Mexican worker provided by "X", which was given to the equipment suppliers. Structural body dimensions, minimum and maximum value, standard deviation and percentiles are represented in each of the columns.

Designing to fit the "average man" is a serious error. By definition, 50% of any group might suffer from a design sized to the 50th percentile, and this could have serious consequences. For example, the smaller 50% will be unable to reach a control fitted to the average or the 50th percentile operator. The equipment in "X" was designed to include the ranges between the 5th and 95th percentiles of anthropometric data. This will ensure that at least 90% of the population will be suited by the dimensions.

Education and training is the key for successful technology transfer. It is hard to exactly determine the contents of the training courses for each person takes different courses. The goal of these training courses is to form a team of skilled people, with deep knowledge needed to solve problems during the production process; and to have specialized people who can handle and repair the laser equipment. The main teams which are trained are production technicians, maintenance specialists, electronic specialist and planning personnel.

Table 6.1 Anthropometric data used for equipment design in "X".

					PERCENTILES						
	BODY DIMENSIONS (cm)	**MIN.**	**MAX.**	**σ**	**1**	**5**	**25**	**50**	**75**	**95**	**99**
	Weight (kg)	53	102.5	11.75	44.2	52.23	63.63	71.62	79.61	91	98.99
1	Stature without shoes	154.2	181.6	5.97	151.6	155.7	161.5	165.5	169.6	175.4	179.5
2	Stature with shoes	158.3	183.5	5.97	154.9	159	164.8	168.8	172.9	178.7	182.8
3	Shoulder height	125	152.6	5.43	124.9	128.6	133.9	137.6	141.3	146.5	150.2
4	Elbow height	92.2	114	4.23	93.2	96	100.1	103	105.9	110	112.9
5	Arm reach	73.9	94.1	4.03	75.4	78.1	82	84.8	87.5	91.4	94.2
6	Arm breadth	78.5	93	3.23	78.3	80.5	83.7	85.9	88.1	91.2	93.4
7	Abdominal breadth	21.3	36.7	3.19	20.1	22.2	25.3	27.5	29.7	32.8	34.9
8	Chest breadth	29.6	39.4	2.44	29.1	30.7	33.1	34.8	36.4	38.8	40.4
9	Chest circumference	82.5	116.5	7.28	82	86.7	94	99	103.9	110.1	115.9
10	Chest depth	20.9	30	2.10	20.2	21.6	23.6	25.1	26.5	28.50	29.9
11	Shoulder breadth	37.9	46.9	1.92	37	38.3	40.1	41.4	42.7	44.6	45.9
12	Maximum body depth	42.6	60.5	4.15	42.2	45	49	51.9	54.7	58.7	61.5
13	Elbow-to-elbow breadth	80.4	97.3	4.01	79.1	81.8	85.7	88.4	91.2	95	97.8
14	Waist breadth	24.8	39.2	3.0	25.1	27.2	30.1	32.1	34.2	37.1	39.1
15	Elbow-to-middle finger length	40.1	49.1	2.04	39.8	41.2	43.2	44.6	46	48	49.4
16	Hand breadth at metacarpal	7.7	9.5	0.38	7.7	7.9	8.3	8.6	8.8	9.2	9.4
17	Hand breadth at thumb	9.2	11.3	1.09	7.4	8.2	9.2	10	10.7	11.7	12.5
18	Hand length	16.6	20.3	0.82	16.3	16.9	17.7	18.2	18.8	19.6	20.2
19	Knee-to-knee breadth	20	32.9	2.51	19.1	20.2	23.2	24.9	26.6	29.1	30.8
20	Head circumference	54	62.2	1.6	53.4	54.5	56	57.1	58.2	59.8	60.8
21	Head height	20.8	26.1	1.07	21.4	22.1	23.1	23.9	24.6	25.6	26.3
22	Sitting height	79.7	95.1	3.33	77.9	80.2	83.4	85.7	87.9	91.2	93.4
23	Eye height, sitting	68	82.6	3.53	65.3	67.7	71.1	73.5	75.9	79.3	81.7
24	Shoulder-elbow length	29.5	40.6	1.86	30.6	31.9	33.7	35	36.2	38	39.3
25	Shoulder height, sitting	51.8	65.1	2.71	51.5	53.4	56	57.9	59.7	62.3	64.2
26	Elbow height, sitting	16.5	28.9	2.86	16.2	18.1	20.9	22.9	24.8	27.6	29.5
27	Waist breadth, sitting	30.5	43.2	2.48	29.5	31.2	33.6	35.3	37	39.4	41.1
28	Knee height, sitting	47.2	57.7	2.29	46.8	48.3	50.6	52.1	53.7	55.9	57.5
29	Buttock-knee length	45.3	64.9	3.02	50.8	52.8	55.8	57.8	59.9	62.8	64.8
30	Buttock-popliteal length	42.8	54	2.66	41.4	43.3	45.8	47.7	49.4	52	53.8
31	Popliteal height, sitting	33.3	44.8	2.38	35.5	35.1	37.4	39.1	40.7	43	44.6
32	Thigh clearance height, sitting	12.9	21	1.36	12.4	13.4	14.7	15.6	16.5	17.9	18.8
33	Foot length without shoes	22.6	27.5	1.12	22.2	23	24	24.8	25.6	26.7	27.4
34	Foot breadth without shoes	8.1	10.4	0.47	8.2	8.5	8.9	9.3	9.6	10	10.4
35	Foot length with shoes	24.6	30.8	1.34	24	24.9	26.2	27.2	28.1	29.4	30.3
36	Foot breadth with shoes	9.2	11.9	0.58	8.7	9.1	9.7	10.1	10.5	11	11.4
37	Grip diameter	2.4	4.2	0.32	2.6	2.8	3.1	3.4	3.6	3.9	4.2

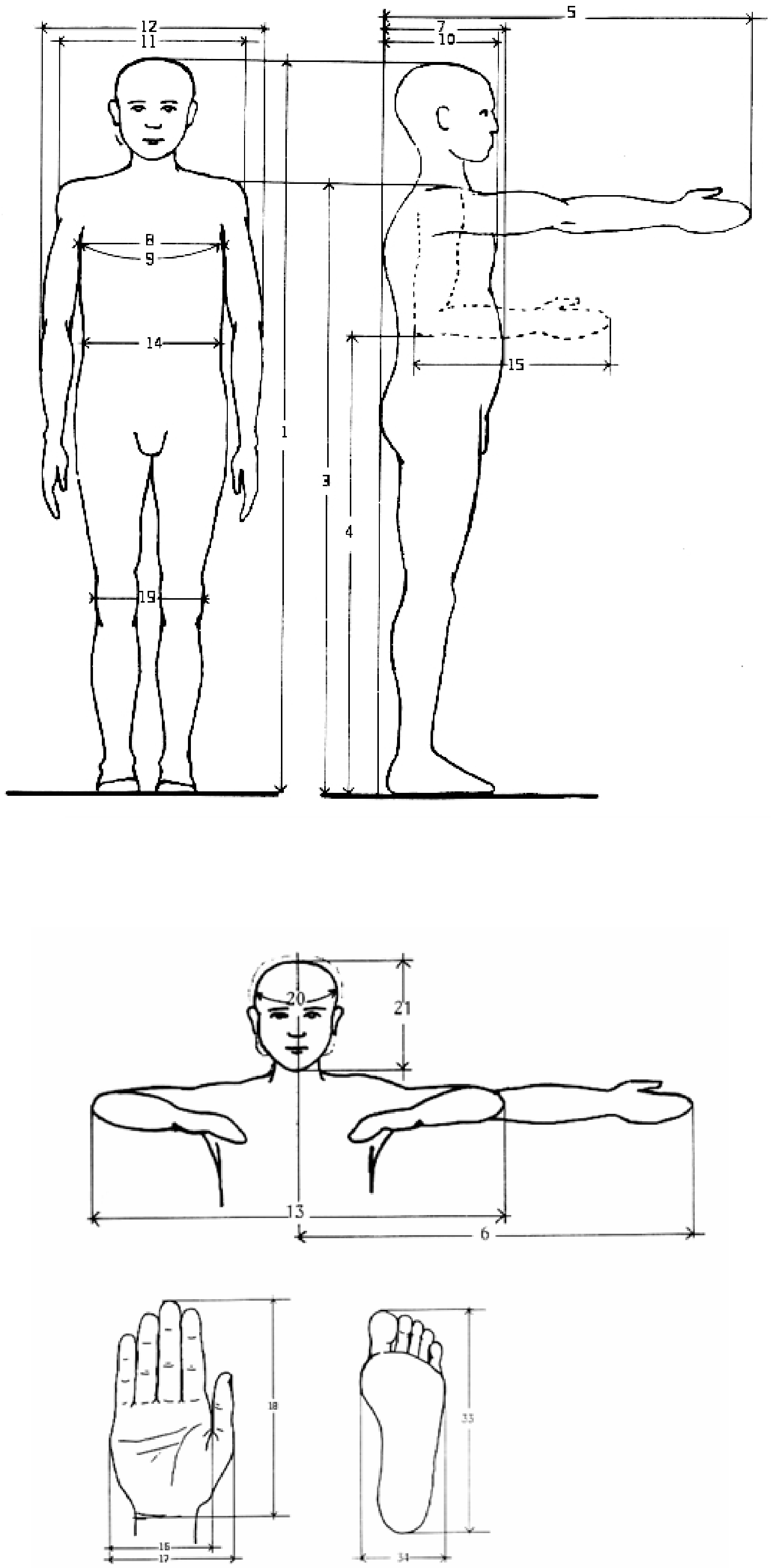

Figure 6.2 Structural Body Dimensions.

The training is controlled and registered in a matrix of skills and completed courses for each group (See table 6.2). Each person gets individual training to reach the full development of the needed skills and fulfill the objectives of their formation. The training courses are given by the suppliers of the technology in their area; this is represented in the fist column of table 6.2. The second column is the number of tools or equipment needed, in order to give the courses. Columns three to eight report the number of “X” personnel of each area (production, mechanic and electric maintenance, “X” training school, presses, maintenance and central planning), who take the offered courses. And finally, columns nine to twelve give the information about the total number of participants, the number of participants per group, the number of groups and the duration of each of the courses offered.

Table 6.2 "X" Training Matrix.

Course	Number of tools	Production	Mechanic Maintenance	Electric Maintenance	Electronic Specialists	Training School	Presses	Maintenance Planning	Central Planning	Participants Number	Persons per Course	Number of Groups	Duration in Hours
		Areas involved											
Robots													
Robot / Robot-controlling (Upgrade)	398	59	8	18	2	1	1	1		90	6	10 5	16 24
Robot / Robot-controlling (Complete training)	398	60	2	2	2	1				67	6	10 1	40 120
Robot / Robot-controlling	14	15				1	1		2	19	6	3	32
Robot / Programing	14			22	4	1	1	2		30	6	5	40
Robot/ Mechanics	14		2	3		1		1		7	6	1	32
Robot/ Electrics	14			12	4	1		1	1	19	6	3	32
Laser application													
Laser welding sources Level 1 & 1 - 2 Mexico	51	66	17		4	2		1	5	95	5	12 5	16 40
Laser welding sources Level 1 - 3 Mexico - Michigan	51	0	9		2	---	1			12	6	3	40
Optic YAG	58	66				2	1	2	3	74	6	15	48
Welding			24	4							6	5	64
Soldering			16	4							6	3	48
Cutting	58		8	2			1			59	6	2	24
Cooling System	51			2		---			1	3	6	1	16
Measuring systems													
Measuring systems (Complete)	2	9	6	18	2	2		2	1	40	6	2 5	8 24
Automation													
Advanced Porgraming			40		4	2				46	10	5	32
Service			40		4	2				46	10	5	24
Basic Software			40		4	2				46	10	5	32
Advanced Software			40		4	2				46	10	5	32
Control Panels			40		4	2				46	10	5	32
Networks			24		4	2							
Ethernet		---	---	22	4	2		1	2	31	16	4	24

6.4 Diffusion.

Since the laser equipment for the new car model is not operating yet, it is hard to describe the actual diffusion happening. But in general, the diffusion on consortium level, within the Mexican plant and its concerning areas is effectively taking place. The diffusion of this new laser technology has been accepted by the workers with dread, since it is a completely new subject and the factors which could modify the old and already familiar working model are not clear. Laser welding is a technology which rapidly spread among the automotive industry for the many advantages it has. Many plants within the Automotive and Autoparts sector are using it, too.

It has been already mentioned that “X” plant in Puebla already had 2 or 3 laser welding equipments. These equipments were not fully automated so there was the need of human intervention during the process. The sixteen new laser cabins are fully automated; the only human factor intervening during the process is for maintenance. The degree of automation should be an influencing factor in this stage, too. Ordinary people think that fully automated equipment would someday replace skilled workers. Experience has shown that the possibilities of automating manufacturing cells have been completely overestimated. Even when considering high standards for process safety that have been achieved in the meantime, technical and organizational errors and failures cannot be completely eliminated. Personnel saved through the automation process are mainly used for process optimization. The qualification profile of a machine operator reveals the picture of a comprehensively qualified skilled worker who is not just competent in the world of numerical control. It is his experience in the field of processing technology that contributes to the steady improvement of the manufacturing process and, in particular, increases utilization ratio. The qualified operator is the one who guarantees high machine usage and long running times without which expensive automated systems would be not profitable (Bitzel et al, 1998). Once again, the key is training the workers to be high skilled.

There are clashing opinions, because there are people who see this TT project as an opportunity to grow and develop professionally. There are people, too, who do not like changes, and this results in difficulties assimilating technological change (resistance to change).

Since people are social by nature, one useful way to classify the sources of resistance is by the various categories of meaningful relationships in which they are participants. These relationships may be categorized as four levels of interaction:

- Individuals with their work.
- Individuals with themselves.
- Individuals directly with others.
- Individuals indirectly with others.

The terms *professional*, *personal*, *social*, and *cultural* are used to identify these four levels of interaction. Resistance can be thought of as behavior that people engage in when these relationships are threatened by changing circumstances. The relationships are highly interrelated, so the four categories are often affected simultaneously by the same circumstances. (Myers, 1997)

Resistance will surely follow where the meaning that people derive from their jobs is threatened. It is easy to see why deep-seated resistance accompanies people's fears that their time will be wasted or that they will not be able to complete assigned responsibilities on time or within budget. Often, people feel that they will simply be trading a set of familiar problems (with well-known work-arounds) for another set of unfamiliar and perhaps more serious problems. In many organizations, where one improvement-of-the-day has been followed by others in rapid succession, there is substantial evidence to indicate that this will be the case.

When threatened, the instinctive reaction of humans is to protect themselves. People constantly monitor their environment, and when in doubt, perceive circumstances first as a threat, then they seek data to confirm or disconfirm their first impression. Slight paranoia seems to be built in, and it applies to intellectual and emotional "threats" as well as physical ones.

When technical change is introduced to an organization, particularly where trust between management levels is low, the immediate reaction of many people will be to perceive any change as threatening. Their first reaction, then, is to protect themselves by resisting. Here again, there may be considerable historical evidence to confirm that this reaction is appropriate. When this is the case, resistive behavior will be immediate and pronounced. If subsequent events confirm initial perceptions, resistance will only increase in intensity as people fight harder to preserve their personal well-being.

Because humans are social by nature, relationships with others are of great importance, and for many, the greatest joys and pains in life result from direct contact and interaction with others. Others' opinions often are more important to people than their own. Because relationships are so much a part of each individual, a threat to a relationship will be perceived much the same way as a threat to the self.

Relationships are often altered when new technologies are introduced. People may find that they will no longer be working with good friends or trusted associates. They may have a new manager or a co-worker who is unknown to them or, worse yet, one whom they do not like or respect. The change may require moving from a familiar facility that is close to home to another facility that will require a longer, more frustrating commute, a move that will result in less time spent with family each day. People will feel threatened in any of these situations, and they will resist.

Culture has a deep and pervasive influence on the rules by which we live. Society programs us from a young age to believe that life *should* be conducted according to a particular set of rules. We *should* think in a particular way. We *should* feel a particular way in particular circumstances. We are similarly programmed by the society in which we live. The rules we learn are part of the very foundation of our lives. They reside in the deepest recesses of our unconscious minds, and because they are not conscious, they are neither discussed nor discussible. When fundamental rules are violated, strong emotions are triggered, and it is often difficult for people to explain why they are angry, worried, or disturbed. When cultural norms are challenged, highly emotional resistance can be expected.

It is possible to deal effectively with resistance to the adoption of new technologies by carefully managing it. Resistance, in this respect, is no different from any other aspect of business—it must be addressed explicitly if it is to be managed effectively. To address it, managers need to anticipate that resistance *will* be present in *every* technology adoption situation. Once resistance issues are brought to the level of awareness, it is possible to use the organizing framework described above (professional, personal, social, and cultural) to predict sources of resistance and to develop mitigation strategies. Measurements can be defined to help managers monitor resistance during change implementation.

Two strategies that play an important role in effective planning and monitoring of resistance are to involve the people who will be affected by change in the planning process and to establish an environment in which it is safe for them to surface resistance. Involvement is critical because it is impossible to anticipate or recognize every factor that may contribute to resistance. People often resist change for good reasons. Because they are the ones who know their jobs and their personal and social situations better than anyone else, it is important to tap into their knowledge, experience, and reactions to the changes that will be made.

Creating a safe environment may be extremely difficult. Many organizations have a history, intended or not, of repressing negative feedback regarding change. The organizational culture, as well as the more general culture in which the organization operates, may well have strict rules, or even taboos, against such feedback. Still, ways can almost always be found to elicit feedback and get resistance out in the open. Once resistance has been expressed and its causes are known, it is possible to deal with it directly in a positive way. As long as resistance remains buried, it is impossible to deal with it effectively.

Consideration of human nature in the adoption of technology would seem to be an obvious requirement, given that humans will ultimately be using the technology. Developers can design certain characteristics into their product packages to capitalize on this nature. Users can anticipate and deal effectively with resistance at its source. The end result of attention to human factors on both sides of the developer-adopter equation can be a technology transfer effort that proceeds smoothly and effectively. (Myers, 1997)

For this matter, it is very important to analyze the background of the people involved in the project. In the case of "X", there are Germans and Mexicans. Germans are normally very hard working because hard work is equated with success and quality (which is very important in Germany). They usually aim at completing their tasks or projects within the assigned period and according to the set time schedule, there has to exist a very good reason to depart from this rule. In German companies, employees are promoted according to individual performance and education is highly valued. That makes Germans often very individualistic in their work style. Germans want to make sure everybody understands because they hate misunderstandings. Very detailed information is given to avoid these misunderstandings. According to that Germans dislike a trial error approach, possible choices should be well planned in advance, selected with care, formulated in written instructions and implemented without errors (providing the sufficiency of the plan) from the top to the bottom. This explains the load of paperwork in German companies: "paper is patient" and trustworthy. For Germans respect is very important. They try to show it (e.g. using surnames and academic titles) and expect to be treated respectfully. The respect somebody is shown depends very much on his rank in the hierarchy but also on his technical knowledge. As mentioned before, education is very highly valued.

Mexicans might not be punctual or respect deadlines and might be absent often, Germans highly value punctuality. When working with them, it is important to set up deadlines a week before the “real” deadlines. Time is a relative concept and deadlines are flexible. What is happening “now” is more important than the future. Because of this sense of “now” and of the uncertain environment, their planning is mostly short term. Mexicans should always be reminded of the deadlines. In case they could not make it to a meeting or did not respect a deadline, they always look for excuses. Always have a back up, because family and friends for most, if not all Mexicans, are more important than any work related issue. Promotions are based on loyalty to their superior. Mexican workers avoid personal competition, they favor harmony at work. They are very sensitive to being “checked upon” and to giving or receiving critical feedback. For Mexicans, the experience and achievements are far more important than his academic qualifications. At times an academic degree would add “value” to the person, but this would diminish if this person is not known in the community.

German work culture is highly hierarchical. Clear chains of command are fixed and respected by everybody. Information, decision and instruction usually process top-down, this is associated with the vertical communication and the general belief, that information is power. Unfortunately this can result in very slow decision making processes and a very slow flow of information, not always the best for the company. In Mexico, decisions are made by the most powerful person in the hierarchy. It is important not to skip over an immediate supervisor, even if he will not be making the decisions. Skipping power would be seen as betrayal. Ideas are not really expected unless it is a managerial position. It is not well seen at all to provide ideas unless asked formally. Although very hierarchical oriented, Germans believe in consensus. This consensus is normally not achieved at somebody's cost, especially not by interfering with superiors; its point is to make everybody feel comfortable. Cooperation not confrontation is the attitude. An advantage of the consensus approach is that everybody can stand behind the taken decisions.

In meetings Germans appreciate serious appearance and behavior because they connect this with a solid business, which refers to both parties involved. Germans do not appreciate joking during meetings as jokes belong in the time after the meeting. Germans are direct and they expect everybody to be honest, constructive criticism is therefore generally accepted. A lot of problems arise from this, because Mexicans take criticism personal. Because Germans see themselves as being very efficient, providing good quality of goods, meeting tight time schedules, they expect their partners to behave likewise. For a Mexican, it is crucial to establish a personal relationship "atmosphere" with a colleague or partner before getting to business. Mexicans need to create an atmosphere of trust and care before making any business deals in a meeting.

In order to successfully work with Mexicans or in Mexico, it is helpful to feel more comfortable with the unexpected, as life in Mexico tends to be unpredictable. Those individuals who like clearly and consistently defined rules (like Germans) will find that life in Mexico will be a continual source of stress. To successfully work together with

Mexicans, it is necessary to enter the world of the Mexican, and be open to the fact that assumptions about how things are done often are not true.

The target group trained to serve as change agents is the team formed in order to have specialized and skilled people in each application of the laser technology, or so-called "Laser team". The structure of the "Laser team" is described in figure 6.3.

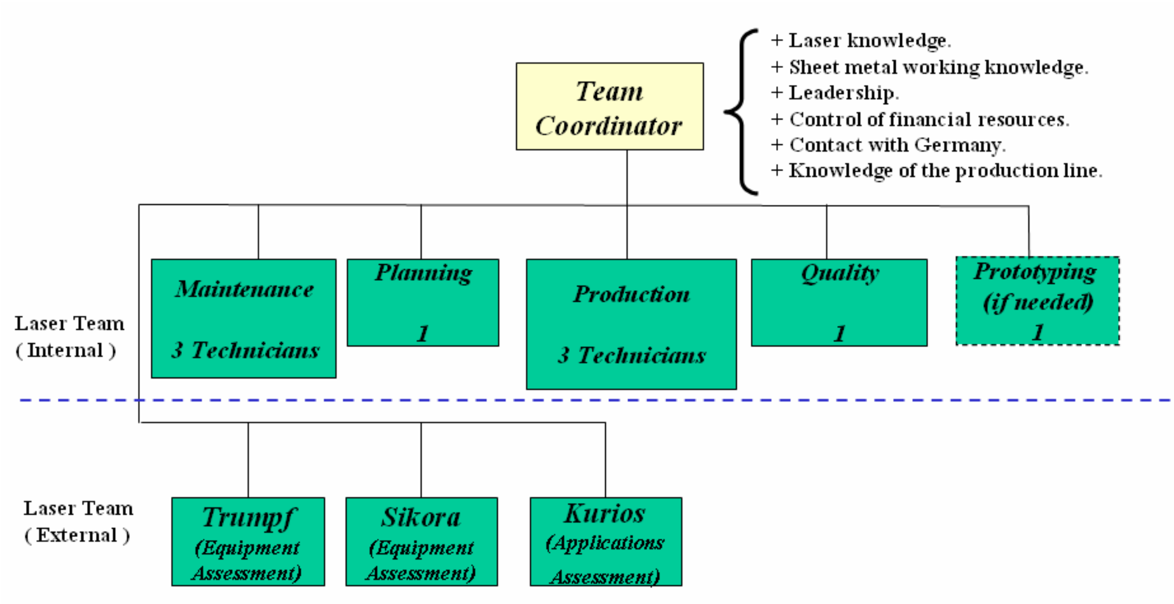

Figure 6.3 "Laser team" structure in "X".

The goal of this laser team is to optimize the quality of the laser welding process and analyze it, and to monitor the product quality. Its responsibilities include:

- Optimize the process.
- Training and quality certification.
- Development of new methods.
- Analysis and solution of repetitive problems.
- Research.

- Control during shifts.
- Optics testing.

6.5 General Barriers involved in the TT process.

Every stage of the TT process has its own issues and barriers, but in an overall view this can be classified into five categories: social, personal, cultural, political and economical. Company "X" identified the main socio-cultural barriers as language, communication and the lack of exactness in the Mexican culture. Language barriers often go hand-in-hand with cultural differences, posing additional problems and misunderstandings in the workplace. The central personal barrier is the deficiency in training and educational matters of the workers. These barriers were already discussed during this chapter. There were no political barriers encountered and the major economic barrier was the timing chosen, given the fact that the investment done to transfer laser technology was done in the time the automotive industry had worse sales result ever.

6.6 Modifications of the proposed TT Model.

After the analysis made from the information obtained from the research in a real automotive company operating in Mexico, some changes were made to the initial TT model proposed. The name of the first stage of the TT model was changed from "Development Stage" to "Assessment Stage". This is because the TT is seen from the point of view of the technology transferor. The factors to be considered during this stage remain the same, only one factor was added, “Government and politics”. In the previous model it was considered during the “Diffusion”, but it is very important to consider the restrictions, laws and regulations during the technology assessment stage.

The “Research centers and institutions” factor was completely eliminated from the model, since most of the technology transferred to Mexico is not developed in the country. Mexican research centers and institutions do not participate in this kind of TT, because automotive technology is not developed in Mexico.

In the “Implementation Process”, “Environmental factors and Infrastructure” was added, because these issues are of key importance during this stage. The technology should be adapted to the local conditions and the infrastructure suited for the new technology. These factors were taken into consideration in the “Diffusion” stage of the previous model.

The only factors remaining in the “Diffusion” of the technology are the “Sociocultural and communication barriers” and the “Target group: Opinion leaders and change agents”. So, the final model looks like this:

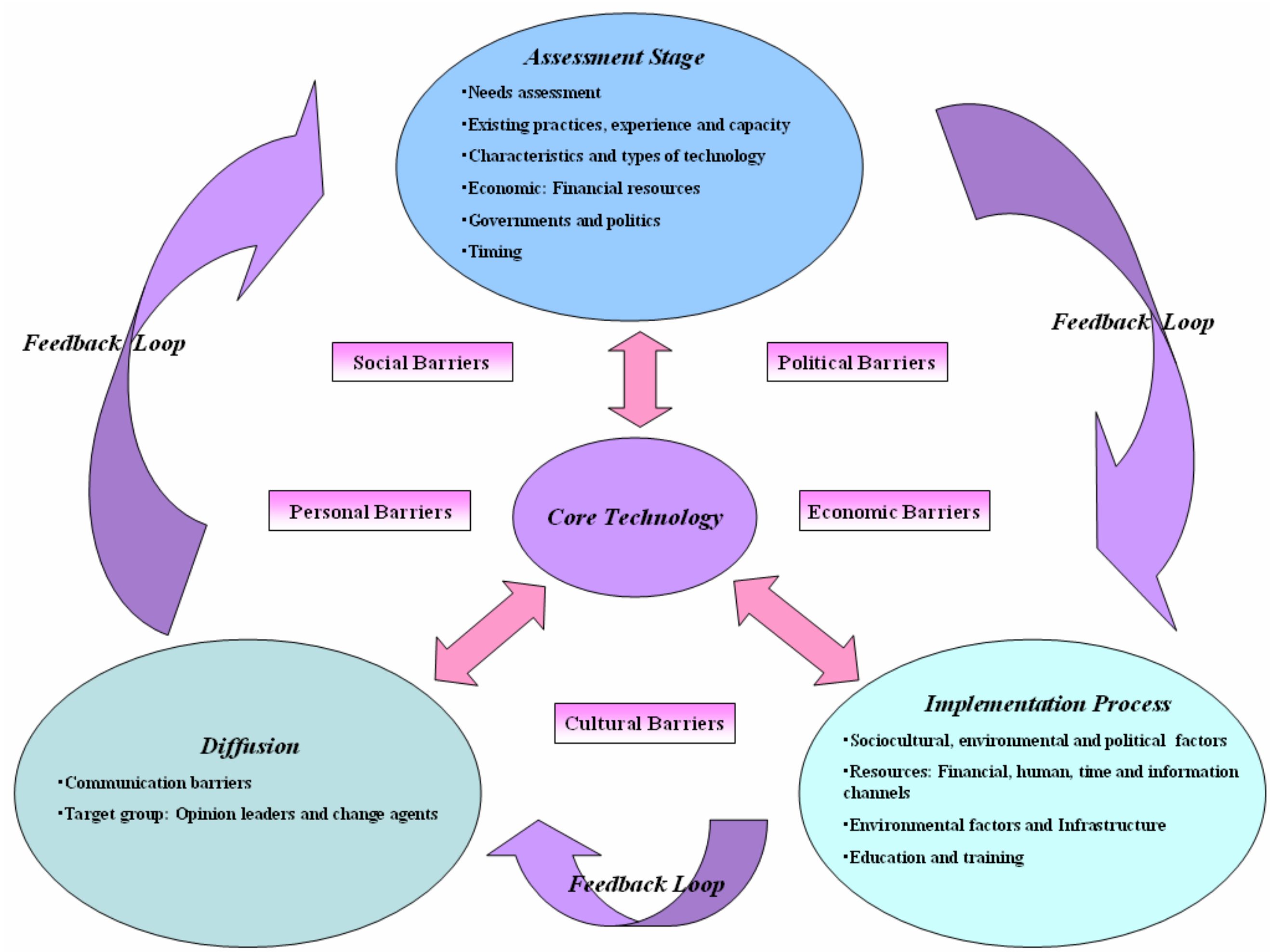

Fig. 6.4 Final TT Model

6.7 Summary.

Table 6.3 Summary and Comparison of TT model versus TT Reality in company “X”.

TT Model	*TT Reality in Company "X"*
Assessment Stage	
Needs assessment	Considered the advantages of the new process technology and used it as a weapon to achieve competitiveness.
Existing practices, experience and capacity	Same technology used consortium-wide; previous experience with technology (semi-automated station)
Characteristics and types of technology	Compared and selected best technology providers in the field. Combined laser welding with use of robots and got higher rate of automation.
Economic: Financial resources	Total foreign direct investment (headquarters).
Governments and politics	Mexican laws, restrictions and regulations for the automotive industry considered. NAFTA very advantageous.
Timing	Chosen in order to stay competitive and to use state-of-the-art technology in production process.
Implementation Process	
Sociocultural factors	German versus Mexican backgrounds (professional, personal, social and cultural). Natural resistance to change.
Resources: Financial, human, time and information channels	Implementation according to budget. Mexican human resources selected according to previous performance and have to meet certain requirements. Previous preparation and training for TT, information about the characteristics of technology and its requirements.
Environmental factors and Infrastructure	Considered in order to adapt the facilities to local conditions and to personalize the equipment for the Mexican worker.
Education and training	Key factor for successful TT. Training matrix to form a team of skilled and specialized people, who know all there is to know about the new technology.
Diffusion	
Sociocultural and communication barriers	German versus Mexican backgrounds (professional, personal, social and cultural). Natural resistance to change.
Opinion leaders and change agents	"Laser team" trained to serve as change agents (most of its participants are Mexicans).
Barriers	
Social and Cultural Barriers	Language barriers go hand-in-hand with cultural differences, posing additional problems and misunderstandings in the workplace.
Personal Barriers	Deficiency in training and educational matters of the workers.
Political Barriers	None
Economic Barriers	Investrment in project done during a hard time for the automotive industry. Crisis due to low sales results.

Table 6.4 Core Technology vs. Region-specific Technology.

Core Technology	***Region-specific Technology***
Laser generator	Voltage transformer
Beam delivery system	Control and visualization systems in Spanish
Optics	Climatization of welding cabins
Robots	Cooling system for laser generator
	Respective power system to feed the cooling system
	Instalations and equipment customized for Mexican worker (anthropometric analysis)